

Relationships between the parameters of physical development, speed and strength fitness, and special work capacity of highly skilled combat athletes

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Abstract.

Objective: Study of relationships between the parameters of physical development, speed and strength fitness, and special work capacity of highly skilled wrestlers at the pre-competitive preparation stage. **Material and methods:** The study involved highly skilled freestyle and Greco-Roman wrestlers and judokas – Candidate Masters (CM), Masters of Sport (MS), International Masters of Sport (IMS), and Merited Masters of Sport (MMS) aged 18 to 31 years. From 13 to 76 highly skilled wrestlers were examined in different indices. To characterize the physical fitness structure (PFS) of wrestlers the indices of physical development, speed and strength fitness, and special work capacity were recorded at the pre-competitive preparation stage. To evaluate physical work capacity, wrestlers performed specialized tests with throws of a partner of equal weight at the maximum speed - in 3 series of 15 throws each. All in all 86 indices of PFS of combat athletes were registered. **Results:** It was revealed that the qualification of combat athletes is one of the key determinants specifying the relationship between the PFS parameters and the level of wrestlers' special work capacity; appropriate models have been developed. PFS improvement in wrestlers' professional development is characterized not only by the development of individual indices of its morphological and speed and strength component, but a change of their ratios, partial role, and interrelations. This reflects one of the mechanisms of PFS reorganization aimed at providing a high level of special work capacity of combat athletes in the process of enhancing their qualification. The key criteria of morphofunctional reserves of highly skilled wrestlers include a) decreased percentage of fat and increased muscle and bone components, muscular development index; b) increasing speed and strength qualities and stability of high work capacity maintenance during a specialized test; c) increasing the specific weight of the special work capacity factor in PFS of combat athletes. **Conclusions:** The qualification of combat athletes is one of the key determinants specifying the level of development and interrelation of morphofunctional and speed and strength parameters of the PFS with the level of special work capacity of highly skilled wrestlers. The improvement of the PFS of highly skilled wrestlers is characterized by a decrease in the fat component, an increase in the body circumferences and muscle component, an increase in the speed and strength qualities, and special work capacity.

Keywords: combat athletes, structure, physical fitness, interrelations, models.

Introduction

Fitness structure (FS) of combat athletes is determined by their physical development [Zaccagni, 2012; Ferreira Marinho et. al., 2016], speed and strength [Bojko, Dan'ko, 2004; Gierczuk et al., 2018], functional [Danko, Grygorenko, Orliuk, 2014; Chernenko et al., 2020; Pryimakov et. al, 2020], psychological [Ziv, Lidor, 2013], technico-tactical, and moral and volitional fitness [Ziv, Lidor, 2013; Arziutov et al., 2016, Tarakanov et al., 2020].

FS as an integral parameter determines “competition form” and the level of athletes' special work capacity. It is manifested differently in combat athletes depending on skill level, sex, age, body mass, etc. [Latyshev N., Latyshev S., 2008; Jagiełło et al., 2018; Bahman et al., 2016; Pryimakov et al., 2013; 2020].

The diversity of factors determining FS, competition form, and special work capacity of combat athletes implies a systematic approach to the study of an integral activity of the athletes' body.

Methodologically, the system approach envisages a complex study of athletes' FS with account for the level of development, correlation, and interrelation of its key components determining the level of special work capacity of combat athletes as the final result of the integrative activity of their body.

However, the works of most authors are usually devoted to highlighting individual aspects of FS of highly skilled wrestlers without the analysis of their ratios and interrelations, providing the level of the competition form and work capacity. For instance, a number of works present the material covering the level of physical development and physical fitness according to endurance indices [Latyshev, 2010; Bahman et al.,

2016], speed [Gierczuk et al, 2018], speed and strength and strength endurance [Bojko, Dan'ko, 2004; Gierczuk et al., 2018], functional state [Danko, Grygorenko, Orliuk, 2014; Pryimakov, 2016; 2020], bodybuild [Bahman Mirzaei et. al, 2016]. That is, they are not systemic.

While analyzing the physical fitness structure (PFS) of wrestlers, the authors refer to its key components separate aspects of physical development and physical fitness: body proportions [Shariat et al, 2017], content and proportions of the body mass components [Zaccagni, 2012; Ferreira Marinho et al, 2016; Konstantinova et al., 2019; Jagiello et al., 2018], the development level of motor qualities – speed and strength [Gierczuk et al, 2018], special endurance [Latyshev, 2010; Bahman Mirzaei et al., 2016], coordination abilities [Klimenko, 2010], and other qualities.

At this time, the parameters of physical fitness structure are usually considered by researchers without taking into account the partial role and interrelations of individual parameters in the general FS of athletes.

Only in a few studies, the relationship between individual components of wrestlers' FS have been investigated - anthropometric indices and strength of kicks in taekwondo [Gorski, Orysiak, 2019], body composition, aerobic strength, and muscular endurance of cadet wrestlers [Kolenkov, 2005; Bahman Mirzaei et al., 2016], physical and technical fitness of athletes [Arziutov et al., 2016].

A number of works present material devoted to the study of special work capacity dependence on individual components of combat athletes' FS: functional [Danko, Grygorenko, Orliuk, 2014; Kolenkov et al, 2012; Chernenko et al, 2020], physical [Bojko, Danko, 2004; Chaabene et al, 2017], morphological [Gorski, Orysiak, 2019]. However, these works lack an in-depth analysis of their interaction with other FS components, without analyzing their mutual interaction in the process of ensuring a high level of special work capacity.

At the same time, it is known that their development is interdependent, the mechanisms of development of some qualities are synergistic while others are antagonistic [Pryimakov et al., 2020] and changeable in ontogenesis, that a wrestler with a higher level of motor qualities development is able to demonstrate a more complex technique [Gierczuk et al, 2018; Gorski, Orysiak, 2019].

In this regard, the development of physical fitness criteria of wrestlers, their differentiation by different methods, indices, weight categories, gender, age, qualification cannot be considered sufficient. The problem of revealing the regularities of the optimal PFS formation in wrestlers, its improvement is relevant, and its qualitative solution is possible only on the basis of a systematic approach [Artyukhov, 2009; Pryimakov et al, 2016].

In accordance with the principles of the systematic approach, it has been assumed that the special fitness of combat athletes is determined not only by the level of development of fitness structure individual components but their correlation and interrelations as well [Pryimakov et al., 2020]. This determines the PFS specificity of combat athletes of different qualifications and different weight categories [Kolenkov et al., 2012; Pryimakov, 2013; 2019].

The extreme importance and insufficient study of the issue in question determined the choice of the direction and goals of the research.

The objective of this work is to study the relationship between the parameters of physical development, speed and strength fitness, and special work capacity of highly skilled wrestlers at the pre-competitive preparation stage.

Material and methods

Participants. Highly skilled combat athletes, as well as members of National teams of Ukraine in free-style and Greco-Roman wrestling, judo: Candidates (CM) and the Masters of sport (MS), International Masters of sport (IMS), and Merited Masters of sport (MMS) were examined. From 13 to 76 wrestlers of different qualifications aged 18-31 years took part in different researches.

Study protocol was approved by Ethic Committee University. The research was fulfilled in compliance with WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects (2013).

Procedure. To characterize the FS structure of the combat athletes, the parameters of physical development, speed and strength fitness, and special work capacity of highly qualified wrestlers at the pre-competitive preparation stage were recorded.

Of the parameters of physical development of athletes circumferential, transverse, and longitudinal dimensions of the body were recorded, whereas of those of speed and strength fitness - the results of standing upward jumps, the number of pull-ups and push-ups to exhaustion, time of rope climbing with the help of hands.

To estimate the level of special work capacity wrestlers performed specialized for each type of combat sport throws of the partner of equal weight at the maximum speed (15 throws in each of 3 series). The total time spent for the performance of 45 throws, time of one throw, dynamics of work capacity during testing were analyzed.

All in all 86 indices of the combat athletes' PFS were recorded in the experiment. The work presents the analysis of the key indices, which were determined during the primary processing.

Statistical analysis. Methods of correlation, regression, and factor analysis [Borovikov, Ivchenko, 2006] were used to process the experimental material. Statistical software package STATISTICA 13,5 was applied. Appropriate mathematical models were developed.

Results

Table 1 presents physical development indices of wrestlers of relatively low (CM) and high (MS, IMS, MMS) qualification.

Table1. Comparative characteristics of physical development individual indices of wrestlers of relatively low (CM) and high (MS, IMS, MMS) qualification

Parameter groups	Indices	CM			MS, IMS, MMS			P
		$\bar{X}$	$\pm m$	n	$\bar{X}$	$\pm m$	n	
Circumferential dimensions, cm	neck	38,2	0,24	32	39,4	0,44	14	<0,05
	thorax at rest	94,1	0,94	32	98,5	1,37	19	<0,05
	thorax on inhalation	96,0	0,96	32	101,2	1,52	19	<0,01
	thoracic excursion	4,4	0,24	32	5,8	0,62	19	<0,05
	Tensed shoulder	32,5	0,49	32	34,5	0,5	27	<0,01
	hip	54,2	0,61	32	59,1	1,5	27	<0,01
Skin and fat folds, mm	Under the scapula	12,5	0,62	32	10,5	0,45	27	<0,05
	On the shoulder anteriorly	5,9	0,41	32	4,6	0,24	27	<0,05
	On the shoulder posteriorly	12,1	0,7	32	9,7	0,65	27	<0,05
	On the forearm	9,1	0,71	32	7,2	0,56	14	<0,05
	On the hip	10,3	0,76	32	8,3	0,35	14	<0,05
Body composition, %	Muscular component	49,9	0,53	32	51,3	0,75	13	>0,05
	Fat component	17,2	0,74	32	13,8	0,5	14	<0,001
	Bone component	17,4	0,26	32	16,7	0,37	14	>0,05
Physical development	Quetelet index	390,3	7,5	32	427,3	7,88	27	<0,01
	Muscle development index	6,8	0,68	32	9,2	0,76	27	<0,05

The results reflect the specificity and direction of long-term adaptation rearrangements in the morphological component of wrestlers' FS structure - with qualification increase the percentage of the fat component decreases, a tendency to a decrease in the bone component, an increase in the body surface and muscle component, and an increase in the index of muscle development is manifested.

In the face of increasing the muscular component and the muscle development index, the thickness of skin and fat folds on the cheek, shoulder, forearm and hip, under the spatula, significantly decreases in highly qualified wrestlers. Correlation analysis showed the negative interrelations of muscle and fat ($r=-0.565$, $p<0.0008$), fat and bone ($r=-0.469$, $p<0.007$) components of physical development in highly qualified wrestlers. Positive dependencies were revealed between the muscle and bone components ($r=0.421$, $p<0.01$), as well as, between the bone component and the muscle development index ($r=0.514$, $P<0.003$),

The revealed relationships indicate that among the mechanisms underlying the changes in the proportions of the components of athletes' body composition along with an increase in their skills, a decrease in the fat and an increase in muscle and bone components, the muscle development index plays an important role.

Analysis of the factor structure of the morphometric component of wrestlers' PF allowed to identify 5 generalized factors, the total influence of which can explain the variability of 73.87% of primary data (Fig. 1): 1) the factor of the general level of physical development (43.66% of the total dispersion); 2) the specific weight factor of the fat component (12.32% of the total dispersion); 3) the factor of the upper and lower extremity length (7.03% of the total dispersion); 4) the specific weight factor of the bone component (6.4% of the total dispersion); 5) the factor of the body circumferential dimensions (4.46% of the total dispersion).

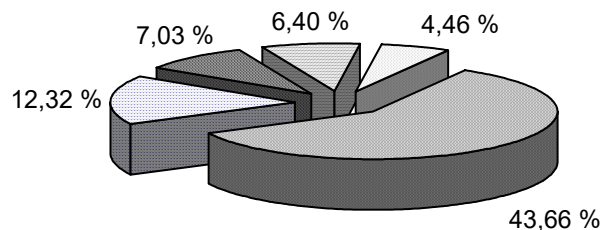


Fig. 1. Key factors of the morphometric component of wrestlers' physical fitness: – general level of physical development; – fat component; – length of extremities; – bone component; – body circumferential dimensions.

Fig. 1 presents the ratios of physical development integral factors in the structure of morphometric component of wrestlers' PF.

Subsequent analysis showed that morphometric indices manifest a certain relationship with qualifications, speed and strength fitness, special work capacity of wrestlers.

It is noteworthy that of the morphological parameters of the PF, the greatest relationship with the qualifications of the combat athletes is manifested by the body circumferential dimensions. The group of indices averaged coefficient of correlation of circumferential dimensions (r) with the qualification of the combat athletes constitutes 0.64 ± 0.01 ($p < 0.01$).

Due to the fact that the parameters of physical development of combat athletes improve with the increase of skill level [Bojko, Dan'ko, 2004; Ferreira et al, 2016; Pryimakov, Mazurok, Omelchuk, 2019], regression models of the dependence of the body circumferential dimensions (as the most informative parameters of athletes' physical development) on the qualifications of athletes were developed (Table 2).

Table 2. Model characteristics of the dependence of physical development individual parameters on the qualifications of wrestlers

No.	Physical development dependent parameters	Regression equation*	r	p
1.	neck circumferential dimensions, cm	$35,292 + 2,4045 \cdot x$	0,660	0,00004
2.	lower forearm circumferential dimensions, cm	$5,1660 + 0,2406 \cdot x$	0,660	0,000001
3.	lower hip circumferential dimensions, cm	$8,6807 + 0,6319 \cdot x$	0,609	0,00002
4.	thorax circumferential dimensions, cm	$87,06 + 5,324 \cdot x$	0,700	0,0002
5.	Tense shoulder circumferential dimensions, cm	$30,213 + 1,562 \cdot x$	0,640	0,0001
6.	Quetelet index, g/cm	$337,49 + 42,370 \cdot x$	0,622	0,00002

*Note: x – qualification of wrestlers; r – correlation coefficient.

Model characteristics presented in Table 2, reflect linear, mainly average in strength, dependences of the studied parameters of physical development on the qualifications of the wrestlers. The highest dependences are manifested by the circumferential dimensions of the neck ($r=0.660$, $P<0.00004$), thorax ($r=0.700$, $P<0.0002$), relaxed ($r=0.63$, $P<0.01$) and tense ($r=0.640$, $P<0.0001$) shoulder, forearm ($r=0.660$, $P<0.000001$), and thigh ($r=0.609$, $P<0.00002$).

Table 3 shows the indices of speed and strength fitness and special work capacity of wrestlers of high (MS, IMS, MMS) and relatively low (CM) qualifications

Table 3. Indices of speed and strength fitness of wrestlers of high (MS, IMS, MMS) and relatively low (CM) qualifications

Indices	MMS, IMS, MS (1)			CM (2)			Significance of differences	
	$\bar{X}$	$\pm m$	n	$\bar{X}$	$\pm m$	n	$t_{1,2}$	P
Age, years	23,1	0,36	110	19,0	0,35	36	8,15	<0,01
Weight, kg	78,4	1,75	110	76,1	2,78	36	0,70	>0.05
30 m running, s	4,33	0,02	106	4,44	0,03	36	2,62	<0,01
Standing long jump, cm	249,6	2,87	42	236,1	4,03	20	2,73	<0,01
4 m rope climbing, s	6,04	0,17	101	6,84	0,34	36	-2,11	<0,05
Pull-ups in 10 s, number	9,9	0,12	103	9,0	0,31	36	2,63	<0,01
Pull-ups to exhaustion, number	35,4	0,88	103	30,5	2,31	36	1,96	<0,05
Push-ups, number	72,8	1,74	103	60,6	3,16	36	3,39	<0,01
Total time of performing 45 one hand forward bending throws, s	88,2	1,70	105	109,1	3,56	36	5,30	<0,01
800 m running, min	2,48	0,03	45	2,58	0,1	10	0,96	>0,05

The data presented in Table 3, indicate that highly qualified athletes exceed those of relatively low qualifications in terms of indices characterizing their speed and speed and strength capacities, the level of special work capacity.

The advantage of highly qualified athletes is most pronounced in a special work capacity test (difference constitutes 23.8%, $p<0.01$), during push-ups (difference constitutes 16.8%, $p<0.01$), and rope climbing (difference constitutes 13.2%, $p<0.05$).

Table 4 presents the results of testing of the wrestlers of three groups of various qualifications (1 gr. - MMS and IMS; 2 gr. - MS; 3 gr. - CM) during speed and strength test with throws to evaluate the level of special work capacity.

Table 4. The time of performing 15 throws in 3-series and the index of work capacity decrease (in%) in wrestlers of various qualifications during specialized test.

Qualification	Series of throws, s					Work capacity decrease, %	Time of 1 throw, sec
		1	2	3	Σ_{1-3}		
MMS, IMS	$\bar{X}$	25,0	25,0	25,3	75,3	1,12	1,673
	$\pm m$	0,60	0,75	0,93	2,21	0,11	0,048
	n	36	36	36	36	36	36
MS	$\bar{X}$	31,2	31,3	31,3	93,9	0,10	1,980
	$\pm m$	0,61	0,75	0,85	2,13	0,01	0,07
	n	76	76	76	76	76	80
CM	$\bar{X}$	34,7	34,8	37,9	107,4	9,20	2,390
	$\pm m$	1,16	1,33	1,62	3,99	1,31	0,09
	n	35	35	35	35	35	35

The direction of improving the motor function of the wrestlers while increasing their qualifications from CM (107.4 ± 4.0 sec) to MS (93.9 ± 2.1 seconds), IMS (74.5 ± 2.2 seconds), and MMS (71.4 ± 4.0 seconds) is characterized by increased number and intensity of throws. It is noteworthy that less qualified wrestlers (CM) at lower intensity of performed throws, manifest a more pronounced degree of work capacity reduction by the end of testing. The results reflect higher functional reserves of the most qualified athletes. Analysis of the structure of the speed and strength component of PF of highly qualified wrestlers allowed identifying 4 generalized factors, the total influence of which can explain the variability of 89.2% of the primary data (Fig. 2).

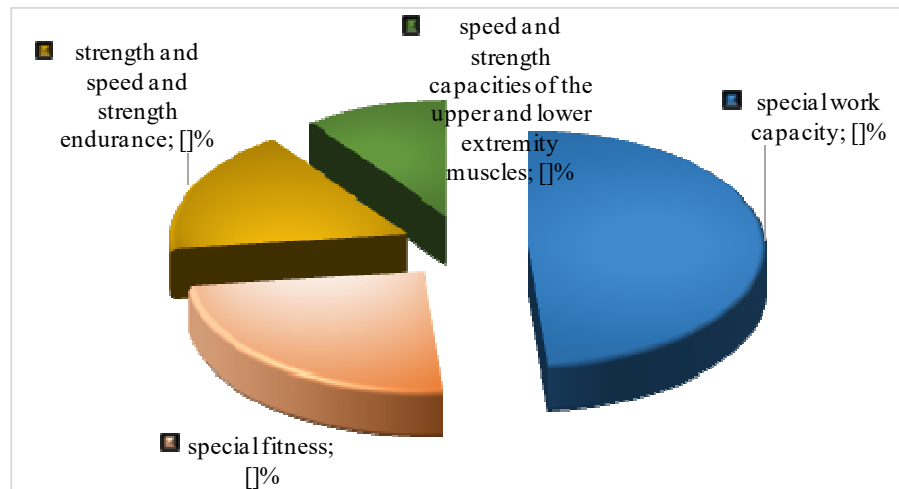


Fig. 2. Key factors of speed and strength fitness structure of highly qualified wrestlers.

Statistical analysis showed that the special work capacity of wrestlers closely correlates with the level of qualification; the higher the qualification, the higher the speed of throws performance ($r = -0.740$, $p < 0.00001$).

The regression model presented below (1) and the coefficient of determination ($d = 0.548$) indicate that 54.8% of the result variation in the test of special work capacity can be explained by the influence of the qualification factor ($F(3.13) = 52.2$, $p = 0.00001$). That is, by the level of special fitness, whereas the rest of the variation of special work capacity indices is determined by factors that were not taken into account in this analysis.

$$Y = 132,2 - 18,04 \cdot x \pm 14,1 \quad (1)$$

where: Y – test time, s; x – wrestlers' qualification.

According to the level of special work capacity and speed capacities of the two groups of the most qualified athletes (IMS and MMS), only a tendency to its increase from IMS to MMS is manifested.

In the process of analyzing the interrelationships between the key morphometric indices and the special work capacity of wrestlers, the corresponding regression models were developed (Table 5).

Table 5. Regression models (Y) and the coefficient of determination (d) of the dependence of special work capacity level on the key indices of physical development of highly qualified wrestlers

№	Regression equation (Y)*	d, p
1.	$Y_1 = 302,05 + 6,012x_1 - 3,77x_2 - 4,15x_3 \pm 11,7$	$d=0,529$, $p<0,01$
2.	$Y_2 = 91,372 + 1,358x_1 - 1,372x_2 \pm 2,69$	$d=0,691$, $p<0,01$
3.	$Y_2 = 63,684 + 2,52x_4 - 0,983x_2 - 0,0987x_5 \pm 3,45$	$d=0,511$, $p<0,01$
4.	$Y_1 = 213,4 + 78,5x_6 + 3,3x_1 + 1,12x_7 + 122,4x_8 + 19,5x_9 - 5,96x_3 - 3,45x_2 - 76,3x_{10} \pm 42,5$	$d=0,953$, $p<0,001$
5.	$Y_1 = 4,9 + 0,35x_4 + 0,04x_{11} - 0,029x_{12} - 0,021x_5 - 0,097x_3 - 0,07x_2 \pm 0,19$	$d=0,845$, $p<0,001$

*Legend: Y_1 – total time expended for performing 15 throws in three series, sec. Y_2 – time expended for performing 15 throws in the first series, sec. x_1 – hip circumferential dimensions, cm; x_2 – chest circumferential dimensions at rest, cm; x_3 – neck circumferential dimensions, cm; x_4 – forearm circumferential dimensions, cm; x_5 – head circumferential dimensions, cm; x_6 – relaxed shoulder circumferential dimensions, cm; x_7 – skin and fat folds under scapula, mm; x_8 – body surface; x_9 – muscle development index; x_{10} – tense shoulder circumferential dimensions, cm; x_{11} – skin and fat folds on a hip, mm; x_{12} – skin and fat folds on a chin, mm.

The coefficients presented in the models indicate that the special work capacity level of wrestlers depends on physical development parameters in different ways.

Different values of the coefficients of determination (d) imply that the predictive value of the models is unequal. Thus, the predictive value of the first model (which included the circumference of the neck, chest, and hip) and the third one (which included the circumference of the chest, forearm, and head) is approximately the same.

The values and the ratio of these parameters of the models can explain the variability of the result in the special work capacity test in 52.8% and 51.1% of cases, respectively.

The predictive value of the second model (which included the circumference of the hip and chest) is higher. It indicates that the variability of the result in the special work capacity test is determined by the ratio and values of the indicated morphometric parameters of the model in 68.4% of cases.

The predictive value of the 4th and 5th models is even higher - high dependences of special work capacity level on the ratio of the key morphometric parameters of physical development ($r = 0.919-0.976$, $p = 0.000001$) were revealed. High coefficients of correlation and determination reflect the highest informativity of these models.

The models presented above reflect the dynamics of wrestlers' PFS improvement according to the key criteria of their physical development in the process of a long-term adaptation process.

Correlation analysis of the interrelations between the key speed and strength indices and special work capacity level of wrestlers of different qualification groups demonstrated the following characteristic feature: paired relationships between individual speed and strength indices and the results in individual tests are weaker than multiple correlation coefficients.

For instance, if the values of paired correlations between the time of performing throws, as an index of wrestlers' special work capacity, on the one hand, and the number of push-ups in 10 seconds, the time of rope climbing, the number of squats with a partner, the number of pull-ups, the total number of push-ups - on the other hand, are equal to -0.570, ($p < 0.01$), - 0.350 ($p < 0.05$), 0.100 ($p > 0.05$), -0.360 ($p < 0.05$), -0.290 ($p > 0$, 05), respectively, then the multiple correlation coefficient between them is significantly higher (Table 6). This suggests that the level of special work capacity manifestation is largely determined by the ratio and interconnections of speed and strength indices.

The step-by-step regression method allowed developing models that reflect the dependence of the result in special work capacity test on the key speed and strength indices of wrestlers' PFS (Table 6).

Table 6. Regression models of the dependence of the result in special work capacity test on the key speed and strength indices of wrestlers.

№	Regression equation*	r	,p
1.	$Y=87,2+0,31x_1+0,564x_2+0,32x_3+2,66x_4-0,186x_5-4,62x_6 \pm 12,6$	0,754	<0,001
2.	$Y=155,48-3,624x_6$	-0,570	<0,01

*Legend: Y – total time expended for performing throws in three series, sec; x_1 – rope climbing speed, x_2 – number of squats with a partner, x_3 – weight of athlete, x_4 – number of pull-ups; x_5 – number of push-ups; x_6 – speed of push-ups (number in 10 s); r – correlation coefficient, p – significance level.

Three parameters characterizing the manifestation of speed and strength qualities - the number of push-ups (in 10 seconds) (x_6), the speed of rope climbing (4 m) (x_1), the number of squats with a partner (x_2) - have the greatest influence on such an index of special work capacity, as the time of performing 15 bending hip-rolls in 3 series (Y). The weight of an athlete (x_3), the maximum number of pull-ups (x_4), and push-ups (x_5) were also included in the regression model, however, the degree of their impact on the efficiency of athletes when performing throws is weaker than those noted above.

Individual values of special work capacity predicted using the developed model (Table 6, model № 1) were close to the actual results obtained in the experiment, which confirms the informativity of the model characterizing the dependence of the result in special work capacity test on the key speed and strength indices of wrestlers of high qualifications.

Factor analysis showed that in two groups of wrestlers of different qualifications, 4 key factors were identified, determining by 74.65% (for MS, IMS, and MMS) and 84.99% (for CM) the level of their speed and strength fitness. Of these, the dominant factors of the PF structure, which determine the speed and strength preparation of athletes in both groups, are those of special work capacity (31.36% and 42.22% for the first and second groups, respectively) and speed-strength endurance (18.06% and 18.81%, respectively).

Discussion

As a result of conducted studies, the interrelationships of the parameters of physical development, speed and strength fitness, and special work capacity of highly qualified combat athletes were investigated.

Analysis of studies by various authors [Bojko, Dan'ko, 2004; Latyshev, 2010; Kolenkov et al, 2012; Bahman Mirzaei et al, 2016; Shariat et al, 2017], as well as our previous ones [Pryimakov, Mazurok, Omelchuk, 2019; Pryimakov et. al, 2020], and these studies have shown that speed and strength fitness, physical development, and special work capacity of highly qualified wrestlers are important components of the general fitness structure of highly qualified athletes.

However, in the works dealing with the study of the fitness structure of combat athletes, the results of studies of its individual components are mainly presented: physical [Chaabene et al, 2017; Jagiello W., Dornowski, Jagiello M., 2018], functional [Coswig et. al., 2016; Konstantinova et al, 2019; Pryimakov et al, 2020], technical and tactical [Adam, Klimovicz, Pujszo, 2016; Arziutov et al., 2016; Karelin et al., 2021], and other components.

Analyzing the heterogeneous indices of wrestlers' FS, the authors did not consider their interconnections in the process of the body integrative activity aimed at ensuring high sports results [Adashevskiy, Dylewski, Iermakov, 2011; Tarakanov et al, 2020]. The analysis of a complex of heterogeneous indices was made out without taking into account the methodological principles of the systems approach [Artyukhov, 2009], according to which the special work capacity of athletes is determined not only by the level of development, but the ratio and interconnections of different components of the FS as well [Pryimakov et al, 2020].

In some complex studies, the authors noted the importance and necessity of a systematic analysis of the fitness structure of combat athletes [Danko, Grygorenko, Orliuk, 2014; Ferreira Marinho et al., 2016; Gierczuk et al, 2018; Karelin et al, 2021]. However, they failed to analyze the correlation and interconnection of different FS indices of combat athletes in providing a high level of special work capacity.

In this regard, the material presented supplements the analytical studies of various authors, as well as specifies and clarifies the materials of our earlier studies [Pryimakov et al., 2016] with the results of a comprehensive and systematic analysis of FS structure of highly qualified wrestlers in the process of its improvement.

From the standpoint of a systematic approach, the ratios and interconnections of the morphological and speed and strength components of the PFS in the process of determining the special work capacity of highly qualified combat athletes have been studied.

This approach permitted to determine the most informative indices of the morphological and speed and strength components of the FS affecting the level of athletes' special work capacity: circumferential dimensions of the chest, neck, hip, shoulder, the index of muscle development, skin and fat folds under the scapula, the number of push-ups, the speed of rope climbing, the number of squats with a partner. With an increase in the skill of athletes, their ratio changes: the percentage of fat decreases, whereas that of muscle and bone components increases, the index of muscle development increases, speed and speed-strength capacities, special work capacity increase, and their interconnections improve.

Changes in the structure of PF of wrestlers with advanced qualifications reflect the mechanisms and criteria for its improvement in the process of long-term adaptation to specialized physical loads.

The key criteria for the morphofunctional reserves of highly qualified wrestlers include a) a decrease in the percentage of fat and an increase in muscle and bone components, an index of muscle development; b) the number and intensity of performed throws and the stability of maintaining high work capacity level without its reducing in a specialized test; c) an increase in the specific weight of special work capacity factor in the general structure of PF.

The novelty of the findings also lies in the fact that the developed coefficients of factor analysis and the constructed regression models allow to quantitatively express and predict the level of special work capacity of combat athletes depending on the level of development, ratios, and interrelationships of individual morphometric and speed and strength indices of athletes' FS. They also reflect the dynamics of the PFS improvement of high-class wrestlers according to the key criteria of their physical development and speed and strength fitness in the process of a long-term adaptation process.

Conclusions

The qualification of combat athletes represents one of the major determinants, which determines the level of development and interrelation of morphofunctional and speed and strength parameters of FS with the level of special work capacity of highly qualified wrestlers.

PFS improvement of highly qualified wrestlers is characterized by a decrease in the fat component, an increase in the body circumferential dimensions and muscle component, an increase in speed and strength qualities, and special work capacity.

The highest impact on special work capacity level of wrestlers is exerted by the circumferential dimensions of the chest, neck, hip, shoulder, the index of muscle development, the number of push-ups, the speed of rope climbing, the number of squats with a partner.

An increase in the level of the special work capacity and speed and strength capacities along with an increase in the body circumferential dimensions and the muscle component, a decrease in the fat component, and a change in their ratios and interconnections are important criteria for the reorganization of the FS, its improvement while increasing the skill level of highly qualified wrestlers.

The models developed in the experiment can be used to model, assess, and predict the level of special work capacity of highly qualified wrestlers at the stage of maximum realization of individual capacities.

Conflict of interests. The authors declare that there is no conflict of interests.

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