Original Article

Efficient passage of competitive distances in academic rowing by taking into account the maximum strength indicators

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Abstract
The aim of the article is to explore the relationship between indicators of maximum strength and efficiency passage of distance in academic rowing on water and on the rowing simulator «Concept-2». *Materials:* 15 high qualification academic rowers participated in the study, among them were repeated participants of the European Championships, World Championships and the Olympic Games. *Methods* of studying strength and special preparedness of high sports qualification academic rowers included testing of their physical qualities, namely: lifting the barbell with arms in lying position, maximum acceleration on the rowing ergometer «Concept-2», horizontal thrust in the block *Dyba* simulator (full amplitude) and a final testing on the rowing simulator «Concept-2» at a 2000 m sports distance. *Results:* a high correlation dependence was found between the result of rowing on *Concept* at 6000 m and the result of competition on the water (r = 0,708), and also the average level of dependence between rowing on the ergometer at 2000m and the competition on the water (r = 0,579). The highest inverse correlation dependence was observed between the indicator of maximum acceleration on the rowing ergometer and strength tests (thrust lying down r = – 0,707 and thrust «Dyba» r = – 0,881). Those high indicators of strength qualities had a positive effect on speed acceleration of rowers. There is a low negative correlation connection between indicators of the test «Thrust lying down» and «Dyba» with the results of performances of athletes at competitions, r = - 0,189 and r = - 0,256, respectively. *Conclusions*: The low correlation connection between the maximum strength and the efficiency of competitive distance on water indicates that these indicators may not influence on the effectiveness of competitive distance on water sufficiently, as a rower does about 240 paddles during the competition. This requires the athlete has to show strength endurance. Also during rowing on water there are external factors (wind, waves, etc.), which in turn requires the athlete adapting to each paddle.
Keywords: **training, correlation connection, strength endurance, ergometer, intensity.**

Introduction
        The achievements of recent years in sports on the international scene dictate new trends and requirements. Specialists in the field of physical culture and sports are searching for ways to improve and rationalize the training process constantly, the tools and methods that fill it (Bohuslavska et al, 2017), psychological preparation of the athlete for training and competitions (Blynova et al., 2020; Popovych et al, 2020 a; 2020b; Shalar et al, 2019; Strykalenko et al, 2020). At the same time, in the last decade there is a lag of Ukrainian academic rowers from the world elite, which is associated with an insufficiently effective management system and methods of long-term training, in particular, with the content and methods of training at the stages of becoming a sports skill, integrated formation of physical qualities important for sports performance (Platonov, 2018).
        For authors such as R. Kropta, O. Pavlyk, the direction of functional training development of athletes is a priority (Kropta, 2004; Pavlyk, 2009), some specialists – A. Andrusyk, A. Dyachenko are convinced of the need for the development of special endurance (Andrusyk, 1999; Dyachenko 2004).
        The preparation of rowers who can adequately represent the country in the international arena and compete with the leading teams is impossible without deep and comprehensive scientific substantiation of the physical training system. At the present stage the system of athletes training has been enriched by a considerable amount of scientific researches devoted to the problem of increasing the level of athletes fitness in academic rowing, where the authors state that physical training, both general and special, is an integral part of the athletic improvement process and provides a base for competitive activity (Penichet-Tomas et al, 2018; Zharmenov et al, 2019; Bohuslavska et al, 2017).

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However, only specialized training, especially in the initial stages, is not enough for the harmonious development of the athlete and create a base for growth of his athletic skill. Therefore, the development of such leading in rowing physical qualities, such as strength and endurance, adjusting the development of different muscle groups, extending the range of motor skills to a level that improves technical skill, is achieved only at the optimum at each stage, the ratio of general and special training, and the whole transfer and transformation of technical skills and physical qualities in rowing. A. Alecu's research is dedicated to promoting the endurance training of young rowers. Increasing or upgrading during the training of four elements (frequency of movements, duration, intensity, type of exercise) has been proved to develop the cardiovascular system and positively influence on the development of endurance (Alecu, 2017). There is some problem with the choice of rowing training at the pre-basic training stage. It is proved that the use of aerobic training has a positive effect on the fitness of women rowers. The anaerobic exercise trainings were to be more effective in improving the physical and functional fitness of teenager rowers (male) (Bohuslavska et al, 2017). Also, this study proved the effectiveness of the use of mixed regimes (aerobic-anaerobic and anaerobic-aerobic) rowers in training.

Now in the system of sportsmen training in rowing quite serious attention is paid to strength training. It is established that the basis for the strength skills development of rowers is the development of their maximum strength. The development of a special strength is essential for the training of academic rowers, however, insufficient attention is paid to this fact (Majumdar et al, 2017; Dyachenko, 2010). So as the rower must exert his or her entire strength throughout the distance during competitions, the question of the influence of the maximum strength on the effectiveness of the competitive distance in academic rowing becomes very acute, which confirms the relevance of our study. ***The aim of the study*** - is to investigate the relationship between maximum strength and distance efficiency in academic rowing on water and on the rowing simulator «Concept-2».

Material and methods

The practical part of the study was conducted during November 2018 - February 2019. During this period, testing was conducted to determine the maximum strength and physical fitness of leading academic rowers of the national Ukrainian team, investigated the influence of the obtained indicators on the effectiveness of the distance rowing on the rowing simulator «Concept-2», during the passage of the first stage of selection - the Ukrainian Rowing Championship on ergometers (08-09.02.2019, Mykolaiv), and also the effectiveness of distance passing on water during the Ukrainian Cup (08-12.05.19, Dnipro). The study was conducted at the School of Higher Sports Skills of Kherson (Ukraine). The experimental part was participated by academic rowers in an amount of 15 people, the personal data of the athletes are shown in Table 1.

Table 1. Study contingent characteristic

	Name	Year of birth	Category	Best result	City
1	Sergiy K.	1994	MS	1st place Championship of Ukraine	Kyiv
2	Anton A.	1999	MS	6th place European Championship U-23	Kherson
3	Dmytro G.	1995	MS	6th place World Cup	Kherson
4	Oleksiy S.	1997	MS	2nd place European Championship U-23	Kherson
5	Mykola K.	1992	MS	1st place Championship of Ukraine	Dnipro
6	Maksym R.	1995	MS	1st place Championship of Ukraine	Kyiv
7	Maksym B.	1993	MS	9th place World Cup	Kherson
8	Anton B.	1992	HMS	1st place World Cup	Mykolaiv
9	Anton H.	1986	HMS	8th place Olympic Games	Mykolaiv
10	Oleksiy T.	1995	MS	1st place Championship of Ukraine	Kherson
11	Dmytro M.	1990	HMS	1st place World Cup 6th place Olympic Games	Kherson
12	Olexander N.	1999	MS	1st place European Championship U-23	Mykolaiv
13	Artem V.	1992	MICS	1st place World Cup	Kherson
14	Vladyslav B.	1995	MS	9th place World Cup	Kherson
15	Sergiy S.	1998	MS	2nd place European Championship U-23	Kherson

Note: HMS (Honored Master of Sports), MICS (Master of International Class Sports), MS (Master of Sports).

The study participants had some sporting qualifications: Master of Sports (11 athletes), Master of International Class Sports (1 athlete) and Honored Master of Sports (3 athletes) and they are repeated participants of European Championships, World Championships and Olympic Games. There are 4 athletes of age category «U-23 youth» and 11 athletes of age category «adults» among the research contingent. In all qualifying competitions and mode training on water and ergometers, these age categories are in the overall standings, but their results are evaluated according to the control standards of the selection system and manning of Ukrainian Rowing Team crews. The preparation of these athletes is carried out by the head and senior coaches of Ukrainian national team at training camps in Ukraine and abroad.

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Methods of studying the strength and special preparedness included testing the physical qualities of academic rowers of high sports qualification, namely: the thrust of the barbell with your hands lying down, the maximum acceleration on the rowing ergometer «Concept-2», horizontal thrust in the block simulator «Dyba» (full amplitude) and a control test on the rowing simulator «Concept-2» at a sports distance of 2000 m.

Also, to study the effect of maximum strength indicators on the effectiveness of the performances of athletes, we have taken the results of the athletes performances at the Ukrainian Championship in rowing on ergometers at a sports distance of 6000 m (08-09.02.2019, Mykolaiv). The results obtained by the athletes were compared with the model indicators of distance, which in rowing on the ergometer are calculated depending on the weight of the athlete's body. Model indicators of passing distance are presented in Table 2.

Table 2. Model indicators of rowing on the ergometer and on water in 2019

Class	Model rowing 2000 m						
	Single (1x)			Couple without a steersman (2-)			
Young	6:46,61			6:20,43			
Adults	6:33,35			6:08,50			
	Rowing ergometer						
	Weight of athletes, kg						
	to 85	85-90	90-95	95-101	101-106	110 and more	
2000 m	6:12,0	6:09,0	6:06,0	6:03,0	6:00,0	5:57,0	adult young U-23 s
6000 m	20:05,0	20:00,0	19:55,0	19:50,0	19:45,0	19:20,0	
2000 m	6:05,0	6:00,0	5:57,0	5:54,0	5:51,0	5:46,0	
6000 m	19:45,0	19:35,0	19:20,0	19:15,0	19:05,0	18:40,0	

Competitions on water from the Cup of Ukraine (08-12.05.2019, Dnipro) were conducted in order to select the strongest athletes to complete the Ukrainian rowing team for training and participation in the European Championship. As a result of the athletes performance on small boats, crews are completed to perform at the highest level competitions.

Results

In order to study the special preparedness of academic rowers of high sports qualification, we conducted a control test at the sports distance of 2000 m on the rowing ergometer «Concept-2», as well as worked out the results of the rowers at the Ukrainian Championship in rowing on ergometers, which took place in Mykolaiv on February 04-05 2019, in which the athletes competed at a distance of 6000 m. The results of the special preparedness obtained on the rowing ergometer «Concept-2» are shown in Table 3. Time was recorded with the maximum distance passing in model conditions of competitive activity.

Table 3. Indicators of special trained academic rowers

№	Name	Rowing 2000 m and 6000 m on Concept-2					
		Result 2000 m, min.	Time in sec.	% of model	Result 6000 m, min.	Time in sec.	% of model
1	Sergiy K.	5:58,3	358,3	96,4%	19:20,0	1160	96,4%
2	Anton A.	6:15,0	375	99,2%	20:08,7	1208,7	99,7%
3	Dmytro G.	5:59,2	359,2	98,5%	19:08,1	1148,1	100,6%
4	Oleksiy S.	6:15,3	375,3	98,3%	20:01,0	1201,0	99,9%
5	Mykola K.	5:55,1	355,1	100,5%	18:54,0	1134,0	102,7%
6	Maksym R.	5:59,3	359,3	98,5%	20:18,5	1218,5	94,8%
7	Maksym B.	5:59,7	359,7	100,1%	19:19,6	1159,6	101,3%
8	Anton B.	5:49,2	349,2	99,1%	19:14,3	1154,3	96,9%
9	Anton H.	6:02,9	362,9	98,3%	19:45,9	1185,9	98,2%
10	Oleksiy T.	6:08,4	368,4	97,7%	19:36,9	1176,9	99,8%
11	Dmytro M.	5:57,1	357,1	99,1%	19:15,6	1155,6	99,9%
12	Olexander N.	6:17,6	377,6	96,8%	20:46,4	1246,4	95,7%
13	Artem V.	5:59,2	359,2	98,5%	19:15,0	1155,0	100%
14	Vladyslav B.	6:08,9	368,9	97,5%	19:35,0	1175,0	100%
15	Sergiy S.	6:14,5	374,5	98,5%	19:58,2	1198,2	100,2%
	Average indicator	06:04,0	363,98	98,5%	19:38,5	1178,5	99,1%

According to the tests, there was a certain average, namely: 6:04,0 minutes at a distance of 2000 m and 19:38,5 minutes at a distance of 6000 m. The best result was shown by MICS Anton B. - 5:49,2 minutes. The worst result was recorded in MS Alexander N. - 6:17,6 minutes. The best result at a distance of 6000 m was demonstrated by the MS Mykola K. - 18:54,0 minutes, the worst one by MS Alexander N. 20:46,4 minutes.

We also conducted a comparative analysis of the results obtained from rowing on the training simulator «Concept-2» at 2000 m and 6000 m with the control standards for the 2019 selection system and manning of crews of the Ukrainian national team. Each result of the athlete was compared with a model indicator of passing

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distance, which in turn was differentiated according to the weight of the athletes. We calculated the percentage of the result from the required model for each rower. So the average percentage (% of model) at 2000 m distance is 98,5%, while at 6000 m distance this indicator is 99,1%. The obtained results indicate a sufficiently high level of preparedness of these athletes. Maxym B. and Mykola K. showed 100,1% and 100,5% results of the model at 2000 m distance, which exceeded the model indicators. Six athletes exceeded the time model at 6000 m distance.

But there were also athletes who showed a much lower time than the model distance. So, the result of Sergiy K. at 2000 m distance loses the model for 12 seconds (96,4% of the model), and at 6000 m distance his result is 40 seconds more than the required model (96,4%). If we compare his result with the results of other athletes (despite the model indicators), we see that at 2000 m distance he occupies the 4th place among all rowers and 7th place at 6000 m distance, and at the same time the last 15th place from both distances based on the percentage of the model. This is due to the fact that this athlete with high weight (110,8 kg) does not «produce» his weight during rowing work. His absolute strength does not match his relative strength compared to the relative strength of other athletes. The higher weight of the athlete, the better time he should show.

The results of the athletes during qualifying competitions of Cup of Ukraine at 2000 m among adults were also evaluated. The results of the athletes are shown in Table 4. At these competitions athletes had to demonstrate their special training on water at the highest level.

Table 4. Results of rowing performance at the Cup of Ukraine among adults in boat classes «single» and «couple without a steersman»

№	Name	Rowing 2000 m					
		Result (1x.)	Time in seconds	% of model	Result (2-)	Time in seconds	% of model
1	Sergiy K.	-	-		6:49,92	409,32	88,92%
2	Anton A.	7.23.92	443,92	90,82%	-	-	
3	Dmytro G.	-	-		6:32,21	392,21	93,57%
4	Oleksiy S.	7.17.32	437,32	92,45%	-	-	
5	Mykola K.	6.58.95	418,95	93,49%	-	-	
6	Maksym R.	7.23.33	443,33	87,29%	-	-	
7	Maksym B.	-	-		6:32,21	392,21	93,57%
8	Anton B.	-	-		6:34,67	394,67	92,90%
9	Anton H.	-	-		6:34,67	394,67	92,90%
10	Oleksiy T.	-	-		6:46,01	406,01	89,82%
11	Dmytro M.	7.11.70	431,70	90,25%	-	-	
12	Olexander N.	7.36.40	456,40	87,75%	-	-	
13	Artem V.	7.04.16	424,16	92,17%	-	-	
14	Vladyslav B.	-	-		6:46,01	406,01	89,82%
15	Sergiy S.	7.16.67	436,67	92,61%	-	-	
	Average indicator	07:16,6	436,6	90,85%	06:39,4	399,4	91,61%

The obtained results were processed, analyzed and compared with the indicators of the model rowing distance in the respective classes of boats, which were included in criteria of the selection system to the Ukrainian national team.

For example, the model time of passing the 2000 m distance in the «single» among adult men is 6:33,35 minutes, among youth - 6:46,61 minutes. In the «Couple without a steersman» boat class, the model time of passing the distance is 6:08,50 minutes in adults and 6:20,43 minutes in the youth. After analyzing the results, we determined the average passage of 2000 m on water in the class of boats «Single» and «Couple without a steersman» and the percentage of performance of the model, which is 07:16,6 minutes (90,85% of model) and 06:39,4 minutes (91,61% of the model) respectively. The best result in the «Single» was shown by an athlete from Dnipro city Mykola K., taking the second place in these competitions, his time is 6:58,95 minutes, which is 93,49% of the model. Alexander N. had the worst time - 7:36,40 minutes (28th place and 87,75% of the model).

Maxym B. and Dmytro G. recorded the best result in «Couple without a steersman», their time is 6:32,21 minutes, which makes 93,57% of the model and allowed them to take the first place in these competitions. Sergiy K. had the worst time - 6:49,92 minutes (88,92% of the model).

As we can see, the percentage of lag behind the model on the rowing ergometer is much smaller than on water, so taking into account only the average percentages (%) we see that at 2000 m distance lag behind the model time is 1,5% on the rowing simulator , at 6000 m distance – 0,9%. But on water this indicator is 9,15% in «Single» and in «Couple without a steersman» - 8,39%. In our opinion, this is explained by the fact that during paddling on the water, it is much more difficult to reach model time because of the rather significant influence of external factors (wind, waves, stream, etc.). The effect of strength abilities on athletic performance can be estimated from the statistics of the interconnection study, usually by calculating the correlation coefficients between the studied indicators. The relationship between maximum strength and distance efficiency in academic rowing allows to determine the feasibility of using exercises in the training process. According to the results of the correlation analysis, the results of 4 tests and the results of 2 competitions were analyzed, which allowed to establish a certain relationship, that will allow to rationalize the selection of training means and to increase the level of cumulative and delayed effects from training sessions in future.

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In the course of mathematical analysis it is established that there is a certain correlation between the sports result of the control test on the rowing simulator «Concept-2» at the 2000 m sports distance, the results of the Ukrainian Ergometers Rowing Championship at 6000 m and the maximum strength of the rowers. The results of the correlation analysis are shown in Table 5.

After analyzing the results of the maximum strenth correlation, it was found that the highest correlation is observed between the result of rowing at 2000 m and the maximum acceleration at «Concept-2» r = 0,766, as well as rowing on the ergometer at a 6000 m distance and maximum acceleration r = 0,631. In our opinion, this is due to the fact that in the performance of these tests the rower performs one movement scheme, and more precisely their cohesive and consistent work. Only during acceleration the athlete demonstrates maximum effort over a short period of time, and over long distances the ability to hold on for long periods of time.

Table 5. Correlation connection of maximum strength and special training on the simulator «Concept-2» (r)

Strength indicators	Indicators of special training		
	Maximum acceleration rate on the simulator Concept-2	Rowing 2000m on the simulator Concept-2	Rowing 6000 m on the simulator Concept-2
Thrust lying down	r = - 0,707	r = - 0,487	r = - 0,487
Thrust «Dyba»	r = - 0,881	r = - 0,634	r = - 0,460
Maximum acceleration rate on the simulator Concept-2	___	r = 0,766	r = 0,631
Rowing 2000m on the simulator Concept-2			r = 0,761

We also established a fairly high correlation connection between the results of rowing at a 6000 m distance and the results of rowing at a 2000 m distance (r = 0,761). This indicates that with the increase of time in the 2000 m distance, the rower is increasing the result at the 6000 m distance.

We got feedback (negative) correlations connections in all other dependencies. A negative correlation coefficient indicates the opposite connection: the higher value of one variable, the lower value of the other. That is, a negative correlation means that as one magnitude increases, the other tends to decrease. Thus, the highest inverse correlation dependence is observed between the rowing indicators of 2000 m and the results of the thrust test «Dyba» r = – 0,634; between the indicator of maximum acceleration on the rowing ergometer and strength tests, namely: thrust lying down r = – 0,707 and thrust «Dyba» r = – 0,881. The smallest inverse correlation dependence was recorded between the results of the passing 6000 m distance and the indicators of the test «Dyba» r = – 0,460.

Analyzing the correlation interconnections between the results of the «Thrust lying down» test and rowing at 2000 m and 6000 m distances, we can see the same average correlation connection r = – 0,487, which may indicate a slight correlation of these exercises with the competitive activities of the rower.

Thus, we can assume that high rates of maximum strength development can indicate high results when passing the 2000 m distance on the rowing simulator «Concept-2», because the shorter the distance, the higher the result in competitions. n our opinion, this is due to the specificity of the sport and the peculiarities of calculating the competitive result. During the competition, the athlete performs efforts with maximum strength repeatedly with short-term manifestation. Without a maximum strength, it is practically impossible to perform a powerful paddle, and therefore to add maximum speed to the boat. However, in modern academic rowing the passing of a distance is within 6 – 7 minutes, which requires the athlete in parallel with the manifestation of the maximum strength of endurance. Therefore, as we can see from the results, the maximum force indicators have a greater influence on the result of the 2000 m distance than on the 6000 m distance. So in the training process, coaches should, given the indicators of maximum strength, focus on closely combining it with indicators of endurance.

In the course of our study we conducted a correlation analysis of the influence of the maximum strength indicators on the efficiency of competitive activity of athletes in academic rowing on water. The obtained results are summarized in Table 6.

Table 6. Correlation connection between indicators of maximum strength and qualifying results of the Cup of Ukraine on water (r)

Strength indicators	Rowing 2000 m Cup of Ukraine
Thrust lying down	-0,189
Thrust «dyba»	-0,256
Maximum acceleration rate on the simulator Concept-2	0,447
Concept, 2000 m	0,579
Concept, 6000 m	0,708

Analyzing the obtained results, we can note the low negative correlation connection between the «Thrust lying down» and «Dyba» tests with the results of the athletes in competitions, r = - 0,189 and r = - 0,256 respectively. This may indicate that these maximum strength indicators do not have a significant effect on the efficiency of passing the competitive distance on water.

The average positive correlation connection is observed between the «Maximum acceleration» test results (r = 0,447) and the results obtained during water competitions. This may be due to the fact that working on the ergometer has the same pattern of movement as rowing on water.

For a more complete disclosure of the topic, we conducted a correlation analysis of the results obtained at the rowing ergometer at 2000 m and 6000 m distance with the results obtained during water competitions. A high correlation dependence was obtained between the result of rowing on the *Concept* at 6000 m and the result on water r = 0,708 and a smaller indicator, but not less significant between rowing on the ergometer at 2000 m and rowing on water r = 0,579. This can be explained by the fact that during rowing on the ergometer at a 6000 m distance the decisive factor in obtaiing a high result is strength endurance and technique, which in turn is crucial in rowing on the water.

Summarizing the obtained results, it can be noted that the maximum force indicators have a sufficiently high influence on the efficiency of passing the 2000 m distance on the rowing ergometer, whereas the effect on the passing 6000 m distance on water and on the ergometer is not observed. In our opinion, this is due to the absence of influence of external confounding factors (waves, wind) and less significant influence of the athlete's technical readiness on the result during rowing on the ergometer. While on water, the athlete has to contend with the wind, waves and boat balance, which significantly complicates the ability to make maximum efforts when making a paddle. That is why the obtained data of the correlation analysis showed a low influence of the maximum strength indicators of on the efficiency of passing a competitive distance on water.

Achieving optimum performance for a rower at a competitive distance is due not only to the high degree of development of endurance, strength and technical preparedness, but also to the presence of highly developed specific sensations, such as the «sensation» of water, paddle, boat, the pace and rhythm of rowing.

The role of maximum strength indicators in the structure of special preparedness is very large, despite the fact that it is not directly manifested at the work of the rower. However, the maximum muscle strength provides the most effective rowing power, preventing injuries to rowers.

Discussion

Competitive activity in the academic rowing is characterized by certain features: biomechanical, functional, psychological. This is due to the fact that athletes are integrated into a single system, where the criterion of its efficiency is the speed of the boat, the movement is performed in two environments: air and water. Investigating the use of rowing simulaters (ergometers) in training activities, a number of experts have proven (Miarka et al, 2018) that mechanical ergometers in comparison with stationary increase the fatigue of rowers. And sometimes training on an ergometer increases the risk of injuries in the thigh area, knee and in some cases the back (Lewandowski et al, 2018). In our study, stationary ergometers were used, where the focus was on the development of strength and endurance. The functional aspect of training high-level rowers of different weight categories is important during basic training (Das et al, 2019).

Overcoming difficulties in rowing sports is not possible without sufficient psychological training. Our previous studies have focused on the psychophysiological (Shalar et al, 2015), volitional (Shalar et al, 2011) and psychic (Shalar et al, 2010) features of rowers. Exploring the influence of emotional intelligence on the competitive activities of kayakers, revealed the stability and independence of this mental state from the experience of the athlete (Arribas-Galarraga et al, 2017). The combination of high levels of mental and physical conditions leads to improved performance of high-skill rowers on kayaks and canoes. This especially affects the pre-start condition of the rowers, the effectiveness of their performance in competitions (Zharmenov, & Grenaderova, 2018). Therefore, experts have developed a technique for pre-start rowing training, where instead of psychological influences, special physical exercises were used to optimize the pre-start conditions of athletes (Zharmenov et al, 2019).

The effectiveness of competitive water sports depends on the objective and subjective factors that work in combination and provide a sports result. For example, a balance of rower when he seats is important in rowing. A. Penichet-Tomas and B. Pueo have proved that experienced male and female rowers have slight differences in equilibrium across positions. That is, women demonstrated a greater ability to maintain equilibrium in sitting position with their eyes open and closed than male rowers (Penichet-Tomas, & Pueo, 2017). Exploring rowing technology, a positive relationship was found between the frequency of movement and special endurance and also speed and strength qualities when overcoming the distance of 500m (Kolumbet et al, 2018). In our study, the highest correlation connection was observed between the result of rowing on the 2000 m ergometer and the maximum acceleration rate on the «Concept-2» (r = 0,766) and also the rowing on the ergometer at a 6000 m distance and maximum acceleration (r = 0,631). That is, the frequency and coherence of the rowers' movements are harmoniously combined with a special physical fitness.

Physical training plays a special role in the long-term training of academic rowers. An analysis of the literature indicates that the rational construction of rowers' athletes is a prerequisite for increasing their skill (Cheban et al, 2020a; 2020b; 2020c; Strykalenko et al, 2019). Academic rowing is one of the sports that provides the most complete and general physical training. This is due to participation in the performance of the paddle of all muscle groups, a wide range of movements, high effort on the rowing, the duration of the exercise and its

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emotionality. It is important to use a rowing ergometer to evaluate rowing performance indoors to measure the specific physical condition of rowers of different age groups (14-70 years) at a 2000 m distance (Silva-Alonso et al, 2018). Using the 2000 m rowing ergometer test, we can determine the relationship between physical development and strength of rowers of open and light categories. P. Majumdar, A. Das, & M. Mandal have shown that there is an average inverse relationship between the 2000 m result with age, height and weight of rowers. And between strength and rowing time at 2000 m, a high positive level ($r = 0,704$) of correlation dependence in experienced rowers was detected (Majumdar et al, 2017). In our study, the highest inverse correlation dependence was observed between the indicator of maximum acceleration on the rowing ergometer and forgth tests (thrust lying dowm $r = – 0,707$ and thrust «Dyba» $r = – 0,881$). That is, high performance of strength qualities had a positive effect on the speed acceleration of rowers. As our study showed, maximum strength indicators had the greatest positive impact on the distance of 2000 m and less on the distance of 6000 m. So coaches should pay attention to the development of endurance, not just the maximum strength of rowers in the preparatory period of training.

The use of rowing ergometers as a means of training activity is described more detailed in many scientific papers. After analyzing the 100 km indoor rowing competition, experts have found that achieving a world record in tandem (man + woman) is only possible by strictly adjusting the intensity of rowing movements (Penichet-Tomas et al, 2018). In our study, a high correlation dependence was found between the result of rowing at the 6000 m on Concept and the result of the competition on water ($r = 0,708$), as well as the average level of dependence between rowing at the 2000 m ergometer and the competition on water ($r = 0,579$). In other words, rowing on the ergometer at a distance of 6000 m best develops endurance, which contributes to the improvement of results in competitions in academic rowing on water.

Conclusions

According to the results of the correlation analysis, there is a high correlation between the maximum strength and the efficiency of passing the competitive distance at the 2000 m ergometer and the average distance at 6000 m. We obtained the following correlation coefficients: rowing on the «Concept-2» (2000 m) and maximum acceleration $r = 0,766$; rowing 2000 m and thrust «Dyba» $r = – 0,634$; maximum acceleration and thrust lying down $r = – 0,707$; maximum acceleration and thrust on the «dyba» $r = – 0,881$; rowing 6000 m and «Thrust lying down» $r = – 0,487$; rowing 6000 m and «Dyba» $r = – 0,460$. In our opinion, such dependence is explained by the fact that during the test exercises and rowing on the ergometer distracting factors that can affect the result are absent and the athlete can make the full effort.

Analyzing the obtained results, we can note the low negative correlation connection between the test results of the test «Thrust lying down» and «Dyba» with the results of the athletes in competitions, $r = – 0,189$ and $r = – 0,256$ respectively. The average positive correlation connection is observed between the test results of «Maximum acceleration» and the results obtained during water competitions $r = 0,447$. We also conducted a correlation analysis of the results obtained on the rowing ergometer at 2000 m and 6000 m distances with the results obtained during water competitions, during which we obtained a high correlation between the result of rowing at the 6000 m on the simulator «Concept-2» and the result on water $r = 0,708$, and less indicator, but not less significant between paddling at the 2000m ergometer and rowing at $r = 0,579$.

The low correlation connection between the maximum strenth and the efficiency of passing the distance on water indicates that these indicators may not sufficiently affect the effectiveness of passing the distance on water, as a rower performs about 240 paddles during the race. This, in turn, requires the athlete to show strength endurance. And also when rowing on water are external factors (wind, waves, etc.), which in turn requires the athlete to adapt to each paddle.

The prospect of further research is to study and determine the impact of maximum strength on passing the distance in the extreme version of academic rowing – coastal rowing.

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

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