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The influence of the low-volume high-intensity method training on the indicators of speed and strength qualities of young high skill level swimmers
La influencia del método de entrenamiento de bajo volumen y alta intensidad en los indicadores de las cualidades de velocidad y fuerza de nadadores jóvenes de alto nivel

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Abstract. A goal is to investigate the influence of the method of low-volume high-intensity training on the indicators of speed and strength abilities in young swimmers of high skill level. The following research methods were used: testing the level of special speed-strength qualities in the water with the help of equipment that allows underwater video recording, the parameters of the level of special speed-strength qualities in the water were recorded. The obtained results of the study allowed us to note an increase in the level of overall speed and strength qualities, the upper shoulder girdle power increased by 16.80% and speed increased by 13.48% in the experimental group. The increase in the speed and strength qualities of the shoulder girdle muscles was: power by 23.40% and speed by 21.17%. Increase in the level of speed and strength qualities of the lower extremities: power by 10.99% and speed by 2.74%. Evaluation by independent experts showed that the application of the method of low-volume high-intensity training also affects the basic swimming skills of students (technical elements of the chosen method swimming, development of general physical qualities of a swimmer; rational structure of swimming technique in the chosen way, the strength of the stroke; stability and variability of swimming technique, development special speed-strength endurance of a swimmer). The indicators improved by an average of 0.6 points.
Keywords: high-intensity training; methods of improving speed and strength qualities; swimming; young swimmers.

Abstracto. Un objetivo es investigar la influencia del método de entrenamiento de alta intensidad y bajo volumen en los indicadores de velocidad y habilidades de fuerza en nadadores jóvenes de alto nivel de habilidad. Se utilizaron los siguientes métodos de investigación: probar el nivel de cualidades especiales de velocidad-fuerza en el agua con la ayuda de un equipo que permite la grabación de video subacuático, se registraron los parámetros del nivel de cualidades especiales de velocidad-fuerza en el agua. Los resultados obtenidos del estudio nos permitieron notar un aumento en el nivel de velocidad general y cualidades de fuerza, la potencia de la cintura escapular superior aumentó en un 16,80 % y la velocidad aumentó en un 13,48 % en el grupo experimental. El aumento de las cualidades de velocidad y fuerza de los músculos de la cintura escapular fue: potencia en un 23,40% y velocidad en un 21,17%. Aumento del nivel de velocidad y cualidades de fuerza de las extremidades inferiores: potencia en un 10,99% y velocidad en un 2,74%. La evaluación realizada por expertos independientes mostró que la aplicación del método de entrenamiento de alta intensidad y bajo volumen también afecta las habilidades básicas de natación de los estudiantes (elementos técnicos del método de natación elegido, desarrollo de las cualidades físicas generales de un nadador; estructura racional de la técnica de natación en la forma elegida, la fuerza de la brazada, la estabilidad y la variabilidad de la técnica de natación, el desarrollo especial de la fuerza-velocidad de resistencia de un nadador). Los indicadores mejoraron en un promedio de 0,6 puntos.
Palabras clave: entrenamiento de alta intensidad; métodos para mejorar las cualidades de velocidad y fuerza; nadar; jóvenes nadadores.

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Introduction

Physical inactivity is an independent risk factor for major chronic diseases and the annual global mortality attributable to physical inactivity is estimated at approximately 3.2 million (Riley et al., 2016). Swimming is a popular form of physical activity. In addition, when swimming, the upper body is strongly involved, namely the muscles, where the adaptive capabilities of the skeletal muscles turned out to be higher than those of the lower extremities due to the bipendicular nature of a person (Nordsborg et al., 2015). A lack of physical activity is an independent risk factor for various diseases. Therefore, the study of a specific training method, such as low-volume high-intensity training, and its effectiveness has practical significance for improving health and preventing diseases.

The history of strength training dates back to ancient times when various cultures used physical exercises and strength tests to develop military skills and physical strength. The ancient Greek Olympic Games, gladiator training in Ancient Rome, and samurai culture in Japan are all examples of the importance of strength training in military practice and athletic achievements. In the 20th century, the development of a scientific approach to training and physical fitness led to a more systematic study of strength training. The advent of new methodologies and research on strength training drove the development of various training programs and systems to achieve maximum strength and power. Examples of these programs include Mark Rippetoe's Max Effort Method (ME) (Rippetoe et al., 2010), Louis Simmons's Westside Barbell training (Simmons, 2007), and Bill Starr's 5x5 program (Borea et al., 2021).

With the development of technology and scientific innovations in the field of training, new tools and techniques for strength training have appeared (Barbosa et al., 2010). examples are the use of specialized simulators or trackers to monitor performance and progress, as well as new training methods, such as high-intensity and low-volume interval training and training based on electrical muscle stimulation. Strength training with a focus on intensity has become an integral part of the training of athletes in various disciplines - from football to athletics, from wrestling to swimming (Crowley et al., 2017). Thus, strength training plays an important role in improving athletic performance and reducing injuries.

Swimming is also a cyclical sport with unique physiological and biomechanical requirements due to the wide variety of distance races distributed over several swimming methods. Swimming is one of the largest Olympic sports, with 37 individual disciplines, stretching from 50 to 1500 meters. The success of performance at competitive distances up to 200 meters (50 and 100 m) depends more on the level of performance of anaerobic energy supply systems, since these distances have a duration of more than 80 seconds, while the success of performance at longer distances (400 m, 800 m, 1500 m) depends more on the aerobic energy supply system of the body (Gussakov et al., 2020). Despite the short duration of most swimming competitions, traditional training practices usually require large volumes of training (i.e. total distance or duration of training) that far exceed other cyclic sports (running, rowing, cycling, etc.). It is especially noticeable at the youth level, where training volumes can vary from 11 to 20 hours per week, spread over 6-11 sessions (Nugent et al., 2017b). Much also depends on the teacher and the chosen methods. Although there may well be situations requiring direct indication, from a constructivist point of view, the teacher's main focus should be on providing an appropriate learning environment. This applies to both social and physical aspects, with the physical context being especially important in preparation and sports training (Arad et al., 2015).

It is crucial to study the influence of swimming classes on the speed and strength of high-skilled young swimmers. Coaches and athletes may use the new information to optimize training methods and improve performance in competitions. This study aims to investigate the effect of low-volume high-intensity training on the speed and strength of high-skilled young swimmers. In developing new approaches to teaching physical education, educators sought to show students how to apply constructivist theory in practice. According to constructivist theories, lectures present theoretical information, while lessons or seminars include practical tasks. However, there is a problem with the perception of these approaches since students perceive theory and practice as separate entities (Pugliese et al., 2015). This fact may indicate the inefficiency of teaching methods. In this case, there is a need to develop new approaches that will help students better perceive and apply constructivist theory in practice. In addition, the time required for training in swimming tends to significantly exceed the time of other cyclical sports. It can be a problem for young athletes, especially in the context of physical and psychological overload.

Theoretical framework

In a number of studies that examined the issue of physiological and biomechanical factors determining the level of performance in swimming, it was noted that the maximum oxygen consumption at peak values (O2peak) had an effect of about 35.8–45.2% on performance during swimming distance from 100 m to 400 m. Biomechanical parameters such as stroke rate (Stroke rate) (SR), stroke length (Stroke length) (SR) and stroke index (Stroke index) (SL) were also studied, and it was determined that they had a higher (89.8–99%) effect on athletic performance at distances of 100, 200 and 400 meters (Mezzaroba & Machado, 2014). Despite the fact that many studies involved young swimmers, it was found that their HR and IG parameters were at a higher level than those of high-skill swimmers (Sánchez & Arellano, 2002; Smith et al., 2002). A recently published work by a foreign author Barbosa et al. (2010) suggests that biomechanical and technical skills of a swimmer are closely related to the physiological processes of energy supply. Confirmation of these words can be found in similar studies (Gastin, 2001; Pyne & Sharp, 2014). The authors of the research support the proposal to use the USRPT (Ultra-short race pace training) training method, the founder of which is Rushall (2017), since 'biomechanical processes and technical skills should be practiced in the appropriate mode of physiological processes of adaptation of the body,' that is, increasing the level of technical skill should be done in a competitive swimming mode (Gussakov et al., 2020).

Rushall (2016) suggests that low-intensity training is a 'waste of time' for highly skilled swimmers. In cyclic sports, well-trained athletes are known to perform a large number of low-intensity workouts. LIT (low intensity training) is defined as continuous training performed below the threshold of aerobic metabolism or with a stable concentration of lactate in the blood at a level of less than 2 mmol/L (Termin & Pendergast, 2000) and medium-intensity training. MIT (middle intensity training) is defined as training performed at the level of the threshold of anaerobic energy exchange or with a concentration of lactate in the blood at the level of 4 mmol/l as in the preparatory, so it is in the competitive period (Plews et al., 2014; Stöggl & Sperlich, 2015). It was found that swimmers of national and international level, specializing, as a rule, in short and medium distances, perform 86-90% of their training using LIT and MIT methods (Hellard et al., 2019). Adaptation to training loads with low and medium intensity is multifactorial in nature and leads to profound changes in the physiological and neuromuscular systems in the body (Laursen, 2010). The review conducted by the authors Laursen et al. (2002) shows that in the process of physiological adaptations there is an increase in blood plasma volume, an increase in cardiac output, a change in the density of muscle capillaries and the volume of mitochondria. As a consequence, the number of performance-related physiological processes is noted to a greater extent in well-trained athletes. These processes include: an increase in MPC (Pugliese et al., 2015), an increase in absolute swimming speed at the level of MPC and an increase in swimming speed at the level of the threshold of aerobic-anaerobic metabolism (Enoksen et al., 2011; Pugliese et al., 2015). An indicator of adaptation is an increase in the transport function of oxygen to the working muscles, thus it improves efficiency, and, as a rule, physical performance increases.

In addition to the physiological processes of adaptation to LIT and MIT, there are also many practical applications.

A review article published by Elliott et al. (2007), in which it is assumed that the LIT method improves the recovery process after using the HIT (high intensity training) method, there is also an improvement in body composition parameters, which contributes to the preparation of the musculoskeletal system structure for more intensive training. The mechanisms of recovery when using the LIT method are that an increase in muscle capillarization improves the transport function of oxygen to the working muscles and, thus, increases the process of excretion of metabolic byproducts from the body. This is an important factor that should be taken into account when planning to optimize the level of recovery during the training process when using the HIT method (Nugent et al., 2017b), especially in a sport such as swimming, where competitive activity usually lasts several days, and athletes swim several distances daily at the maximum level of their capabilities.

Thus, it can be stated that the studies carried out to date still do not provide sufficient information about the pedagogical, physiological, biochemical patterns of improving the performance of young swimmers at the stage of higher sportsmanship. Moreover, the data of these studies are often controversial and contradict each other, which indicates the complexity and diversity of the impact of training exercises on the status of an athlete.

In general, the prospect of improving sportsmanship in swimming requires substantiation of the basic laws of the construction of the training process of high-class athletes, taking into account the relationship and interdependence of pedagogical, biomechanical, biochemical parameters of training and competitive exercises, in order to create the foundations for further development of theoretical and experimental research. In accordance with this scientific direction, the scope of the research search was determined.

Purpose of the study

The purpose of this research – is to study the influence of the method of low-volume high-intensity training on the indicators of speed and strength abilities in young swimmers of high skill level. To achieve this purpose, it is necessary to solve the following tasks:

1. On the basis of the method of low-volume high-intensity training, make a training microcycle aimed at improving the level of speed and strength qualities of highly qualified young swimmers.
2. To organize a pedagogical experiment in order to test the author's methodology for improving speed and strength qualities.
3. With the help of the organization of a pedagogical experiment, to ensure the control of the level of general and special speed and strength qualities of young swimmers of a high level of qualification.

Methods

Research design and participants

This study used the method of low-volume high-intensity training to transform dependent variables. Thus, researchers applied a training approach that includes a small number of exercises but those were high-intensity exercises. The use of high-intensity training is an important aspect of this study, as it involves performing physical exercises with high effort and tension of the muscles and body systems. The author used the method of low-volume high-intensity training as an incentive to change and measure dependent variables related to speed and strength in swimmers.

The participants were selected from a group of highly qualified swimmers. The selection process involved considering certain criteria, such as age and gender, and a swimming grade of at least 1 sport swimming. Specifically, the group consisted of 18 individuals aged 16-18 years, with 9 young men in each group. The division into two groups, control and experimental, was random to ensure a balanced representation of participants. Education was conducted using swimming training for 5 months - from February to June 2022 - on the grounds of the Central Swimming Pool in Almaty. All participants of the experiment were in the same conditions. A training camp was organized during the quarantine measures. All participants had the same diet and daily routine. This study involved a natural type of experiment (conducted in natural conditions, in water, which is usual for participants). The experiment included a pre-test and a post-test: participants were measured a variable before and after the intervention. Subsequently, the difference in the results before and after was analyzed to determine the effect of the intervention.

The control group did not make any changes in the training plan of preparation. The training orientation was of the nature of general special training, since the competition period in 2020 was not determined due to the globalization of coronavirus infection. Meanwhile, the training microcycle on land for both groups were aimed at improving speed and strength qualities and increasing absolute strength. The two groups conducted training on land together, only the training process in the water had a different character.

The experimental group had similar goals of the microcycle, but in order to increase the level of speed and strength qualities, the method of low-volume high-intensity training was used.

As a control of the dynamics of speed-power qualities, a test was used to determine the level of general speed-power qualities on land and a test to determine the level of special speed-power qualities in water.

In addition, the study was aimed at improving the general swimming skills that the boys had. Among them are synchronized processes of basic sports specialization (technical elements of the chosen method swimming, development of general physical qualities of a swimmer; rational structure of swimming technique in the chosen way, the strength of the stroke; stability and variability of swimming technique, development special speed-strength endurance of a swimmer). These characteristics were evaluated by teachers on a five-point scale before and after the study. Also, it was applied to the students of experimental group.

The authors declare that the work is written with due consideration of ethical standards. The study was conducted in accordance with the ethical principles approved by the Ethics Committee of Kazakh Academy of Sports and Tourism. All participants gave their written informed consent.

Protocol for testing special speed and strength qualities in water

During the test, special equipment was used that allows underwater video recording of all technical elements, including the underwater part of the competition distance. The hardware and software complex included a dynamic system of movement along the side, equipped with video cameras. Prior to the experiment, all the parameters of the pool were marked up and calibrated. The athletes were instructed and prepared for this test. The test includes 6 swims of 50 meters in the main style with a full rest interval. Each athlete was individually assigned the speed of each segment; the athlete swam the last two segments with the highest possible level of intensity, while from the first to the fourth segment the athlete swam in progression. The test was performed in a competitive mode, using starting wetsuits. Previously, the athletes were continued to perform a warm-up set of exercises on land and in water, swimming no more than 1500 m in the same conditions.

After testing, the received video materials were processed in a special program Contemplas swimming analysis GmbH (Contemplas, 2021). With the help of this program, the parameters of the dynamics of speed, stroke length and stroke frequency were measured. The test results were recorded and processed using the Microsoft Excel 2021 program, the following formula was used to determine the highest efficiency coefficient of the swimming technique:

$$Keff = STRL \times V, \quad (1)$$

where STRL is the length of the stroke on a given segment; V is the speed of the covered segment.

This test was performed twice during the macrocycle (5 months). All tests were determined on Wednesdays at the beginning of the microcycle: after the first microcycle in the first week and at week 20 at the end of the experiment.

Protocol for testing the level of general speed and strength qualities on land

Testing was carried out in the gym using the equipment of the Italian company TENDO Power analyser (Tendo, 2021). The testing consisted of three phases: the first phase included a test to determine the maximum power, strength and speed of contraction of the shoulder girdle muscles. Testing was performed on a crossbar (horizontal bar), an analyzer was connected to the athlete's belt. The anthropometric data of the athlete (height, weight) were set in the program on the computer the athlete was asked to perform two or three pull-ups as fast as possible with his own weight. The results obtained were recorded. The second phase of the test included measuring the speed and strength qualities of the legs. The athlete was asked to perform two or three jumps as fast as possible with the analyzer fixed on the belt, while keeping his hands on the belt. The results were also saved for further processing. The third phase included the measurement of the speed and strength qualities of the thoracic region, the upper shoulder girdle. The athlete performed two or three fastest repetitions of the barbell bench press while lying on a bench with a projectile weight of 50% of his own weight. It was very important to monitor the correctness of the exercise performed in each repetition, and also to perform each repetition from a 'dead point', since if the rules were not followed, the results could be incorrect. From the data obtained, one best repetition in each exercise was selected for further processing. This test was performed immediately after testing special speed and strength qualities in the water.

Data analysis

Calculations were carried out according to the generally accepted requirements of mathematical and statistical processing in the IBM SPSS Statistics 22.0 program.

To ensure the reliability of the results of the study, statistical data processing was used according to generally accepted methods of variation statistics with verification of the results of the study for the reliability of differences. The reliability of the differences was considered significant at a five percent significance level ($p < 0.05$), which is sufficiently reliable for pedagogical research. A statistical test, namely the t-test, served as a tool to compare the results between the groups. The t-test helped to determine whether there were statistically significant differences between the groups.

Limitations of the study

In the course of research on this topic, it is necessary to note a number of limitations that arose during the experiment. Firstly, an accurate quantitative assessment of the distribution of training volume in different training zones is a difficult task, especially in swimming, due to the difficulties associated with determining physiological parameters during swimming, therefore, the unit of measurement of adaptive processes was the heart rate and lactate concentration in the blood, which were performed after performing some interval segments. In order to reduce the error associated with determining the zone of intensity of the load during training, the author was present at all training sessions. Secondly, there may be a possibility of parallax error due to the use of a single video camera to analyze biomechanical data during the experiment. The multi-chamber analytical system was not available during the experiment. Thirdly, a small sample of highly qualified athletes. Fourth, it should be taken into account that not all participants specialized in short-distance swimming. Some participants of the experiment specialized in swimming for 100 and 200 meters in the main style. It should be noted that stayer swimmers did not take part in the experiment.

Results

Control tests of general speed and strength training on land for swimmers of a high level of qualification were carried out at the beginning and at the final stage of the experiment. Table 1 shows the results of the initial testing of the level of general and special speed and strength qualities. The overall level of speed and strength qualities was studied in three basic exercises: bench press on a horizontal bench with 50% of the weight of the barbell from its own weight, pull-up from a free-hanging position and a vertical jump from a 90% squat. We investigated the parameters of peak speed (m/sec) and peak power (watts) in one repetition. From the statistical analysis of the results obtained, a conclusion was made by the coefficient of variation: at the beginning of the experiment, both study groups were homogeneous in all the parameters studied. Table 1 also presents the initial results of testing special speed and strength qualities, namely swimming speed (m/sec), stroke length (m), stroke frequency (units/min.) and efficiency coefficient (units). From the statistical analysis of the results obtained, a conclusion was made by the coefficient of variation: the studied groups at the beginning of the experiment were homogeneous in all the studied parameters. It should be noted that all swimmers performed this test in the swimming style in which they specialize, meaning that the reliable parameter for statistical analysis is the speed, stroke length and efficiency coefficient. The frequency of strokes in this study may vary due to the peculiarities of swimming in each way. Both groups had no advantage in any parameters and were at the same level of professional skill, so in our case it was correct to conduct a pedagogical experiment and trace the dynamics of changes in the performance of speed and strength qualities of swimmers according to the results of the study.

Table 1.
Results of initial testing of speed and strength qualities in young swimmers of high qualification level

Variable data	Control group of young men (n=9)			Experimental group of young men (n=9)		
	Average, X	Stand., σ	Coefficient of variation, %	Average, X	Stand., σ	Coefficient of variation, %
Bench press, power, watt	1000.44	178.62	5.60	817.33	105.32	7.76
Bench press, speed, m/sec.	1.66	0.21	8.00	1.54	0.21	7.47
Pull-up, power, watt	1588.22	396.12	4.01	1260.78	313.09	4.03
Pull-up, speed, m/sec.	1.38	0.16	8.81	1.08	0.20	5.26
Vertical jump, power, watt	7626.44	913.52	8.35	5903.67	762.66	7.74
Vertical jump, speed, m/sec.	3.03	0.23	13.24	2.84	0.25	11.59
Swimming speed, m/sec.	1.650	0.148	11.16	1.604	0.202	7.94
Stroke length, m	2.423	0.663	3.66	1.864	0.501	3.72
Stroke frequency, units/min.	38.322	7.153	5.36	43.800	2.776	15.78
Efficiency coefficient, one-time.	4.021	1.193	3.37	3.023	1.057	2.86

At the end of the experiment, the experimental group had a general tendency to increase the speed and strength qualities of the studied muscle groups. Also, small changes in these qualities were observed in the control group. But significant changes were recorded only in the experimental group.

The main component of the competitive activity of swimmers is the speed of overcoming different sections of the distance; this parameter is closely related to the development of speed and strength qualities. The studies of speed-strength qualities and speed-strength endurance developed by us made it possible to objectively assess the impact of the experimental technique of low-volume high-intensity training (LHT) on the performance of highly qualified swimmers. Table 2 shows the results of the final testing.

Table 2.
Results of the final testing of speed and strength qualities in young swimmers of high qualification level

Variable data	Control group of young men (n=9)			Experimental group of young men (n=9)				
	Average, X	Stand., σ	Coefficient of variation, %	Average, X	Stand., σ	Coefficient of variation, %	t	P
Bench press, power, watt	1084.67	305.28	3.55	982.33	147.55	6.66	-2.195	0.059
Bench press, speed, m/sec.	1.82	0.19	9.48	1.78	0.18	9.95	-2.475	0.038
Pull-up, power, watt	1926.56	562.50	3.42	1646.00	343.53	4.79	-2.702	0.027
Pull-up, speed, m/sec.	1.52	0.23	6.68	1.37	0.14	9.67	-3.043	0.016
Vertical jump, power, watt	7259.33	1587.07	4.57	6632.78	1434.91	4.62	-1.345	0.216
Vertical jump, speed, m/sec.	3.24	0.26	12.46	2.92	0.35	8.45	-0.649	0.535
Swimming speed, m/sec.	1.662	0.159	10.43	1.768	0.128	13.79	-1.797	0.110
Stroke length, m Stroke	2.494	0.716	3.48	2.897	0.529	5.48	-3.999	0.004
frequency, units/min.	38.422	6.742	5.70	37.633	6.756	5.57	2.562	0.034
Efficiency coefficient, one-time.	4.158	1.294	3.21	5.099	0.833	6.12	-3.891	0.005

The dynamics of the increase in speed and strength qualities in the studied muscle groups in the bench press exercise and the increase in power were 84.23 watts (7.77%) and 165.0 watts (16.80%), the increase in speed was 0.16 m/sec. (8.79%) and 0.24 m/sec. (13.48%) in CG and EG, respectively. The dynamics of the increase in speed and strength qualities in the studied muscle groups in the pull-up exercise from the free-hanging position was: an increase in power of 338.34 watts (17.56%) and 385.22 watts (23.40%), the increase in speed was 0.14 m/sec. (9.21%) and 0.29 m/sec. (21.17%) in CG and EG. The dynamics of the increase in speed and strength qualities in the studied muscle groups in the exercise 'vertical jump' was: power -367.11 watts (-5.06%) and 729.11 watts (10.99%), the speed increase was 0.21 m/sec. (6.48%) and 0.08 m/sec. (2.74%) in CG and EG. The dynamics of the increase in absolute swimming speed in young men when performing the efficiency test was 0.012 m/sec. (0.72%) in CG and 0.164 m/sec. (9.28%) in EG. The dynamics of the increase in the stroke length during the test was 0.071 m (2.85%) in CG and 1.033 m (35.66%) in EG. The dynamics of the stroke frequency in this test in CG was 0.100 units/min (0.26%), while in EG the dynamics was negative and amounted to -6.167 units/min (-16.39%). In this case, reducing the frequency of strokes while maintaining the stroke length is a positive result, since the athlete manages to swim the segment with the least expenditure of bioenergetic components. Based on the results obtained, it should be concluded by this parameter that the productive capacity of buffer systems increased in athletes of the experimental group. The dynamics of the efficiency coefficient increase during the test was 0.137 units (3.29%) in CG and 2.076 units (40.71%) in EG. The increase in this indicator is due precisely to the preservation of the stroke length and the increase in swimming speed (Figure 1).

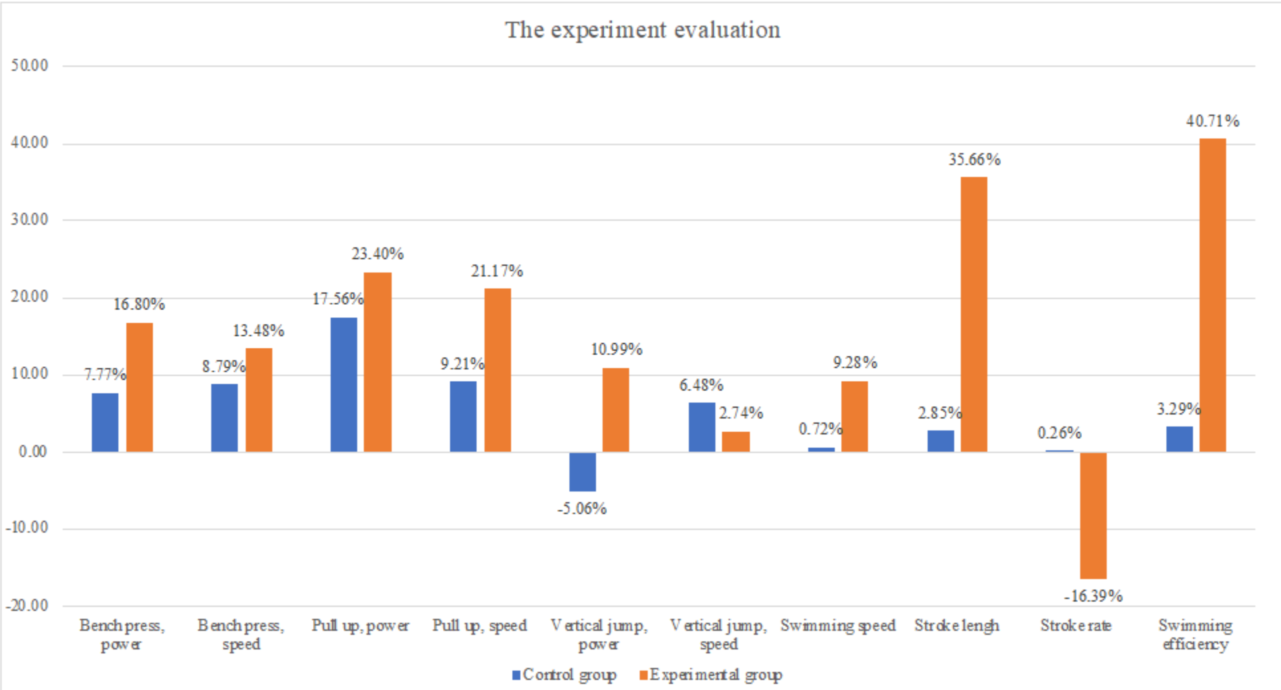

Figure 1. The experiment evaluation

To conduct statistical analysis between the control and experimental groups, the study used a t-test for independent samples. The table includes a t-value and a p-value for each variable obtained as a result of the t-test analysis. The t-value represents the calculated t-value for comparison between the control and experimental groups. The p-value, in turn, indicates the level of statistical significance. Below is Table 3 with the results of the t-test for each variable.

Table 3.
The t-test results regarding differences in young high-skilled swimmers

Variable	Control Group (n=9)	Experimental Group (n=9)	t-value	p-value
Bench press, power, watt	1084.67	982.33	-2.195	0.059
Bench press, speed, m/sec.	1.82	1.78	-2.475	0.038
Pull-up, power, watt	1926.56	1646.00	-2.702	0.027
Pull-up, speed, m/sec.	1.52	1.37	-3.043	0.016
Vertical jump, power, watt	7259.33	6632.78	-1.345	0.216
Vertical jump, speed, m/sec.	3.24	2.92	-0.649	0.535
Swimming speed, m/sec.	1.662	1.768	-1.797	0.110
Stroke length, m	2.494	2.897	-3.999	0.004
Stroke frequency, units/min.	38.422	37.633	2.562	0.034
Efficiency coefficient, one-time	4.158	5.099	-3.891	0.005

Note: The t-value represents the calculated t-value for the t-test, and the p-value indicates the level of statistical significance.

The results shown in the table make it possible to compare the control and experimental groups in terms of speed and strength qualities. The comparison shows the effectiveness of the intervention and experimental conditions. The following indicators in the table are statistically significant at a significance level of 0.05:

- Bench press, power, watt (p = 0.059): Although the p-value does not reach the significance level of 0.05, the t-value (-2.195) indicates a relatively strong difference between the control and experimental groups.
- Bench press, speed, m/sec. (p = 0.038): In this case, the p-value is less than the significance level of 0.05, and the t-value (-2.475) indicates statistically significant differences in the speed of the bench press exercise between groups.
- Pull-up, power, watt (p = 0.027): Here, the p-value is also less than 0.05, and the t-value (-2.702) indicates statistically insignificant differences in the strength of the pull-up exercise between the groups.
- Pull-up, speed, m/sec. (p = 0,016): In this case, as before, the p-value is below 0.05, and the t-value (-3.043) indicates statistically insignificant differences in the speed of the pull-up exercise between groups.
- Stroke length, m (p = 0,004): Here, the p-value is significantly lower than the 0.05 significance level, and the t-test (-3.999) shows statistically significant differences in stroke length between the groups.
- Efficiency coefficient, one-time (p = 0,005): Similar to the previous variables, the p-value is below 0.05, and the t-value (-3.891) indicates statistically significant differences in the efficiency of a one-time stroke between the groups.

These indicators confirm statistically significant differences in the specified variables between the control and experimental groups. Thus, the experimental group achieved better results in more variables compared to the control group.

Teachers who were independent experts gave the following assessment of students' skills at the initial stage of the experiment (data are represented by the mean score, which was manually calculated by the researchers):

technical elements of the chosen method swimming – 3.3;
development of general physical qualities of a swimmer – 4;
rational structure of swimming technique in the chosen way – 2.9;
the strength of the stroke – 3;
stability and variability of swimming technique – 3.9;
development special speed-strength endurance of a swimmer – 3.4.

These data can be considered acceptable for young men of this age and rank. However, after the experiment, the same independent experts re-evaluated these criteria to determine whether the teaching method influenced the results:

technical elements of the chosen method swimming – 3.7;
development of general physical qualities of a swimmer – 4.5;
rational structure of swimming technique in the chosen way – 3.5;
the strength of the stroke – 4;
stability and variability of swimming technique – 4.1;
development special speed-strength endurance of a swimmer – 4.

It proves that the method of low-volume high-intensity training does not increase the level of speed and strength qualities, but improves the basic performance of swimmers if used over a long period.

Discussion

The physiological and functional adaptations resulting from the use of this method are comparable to the use of medium and large volumes with low intensity. However, the authors claim that when using the LHT method, physiological changes occur faster, especially for athletes who have not previously used this method in the training process (Seiler, 2010). Also, a study was conducted in which the technology of sports training of young swimmers at the stage of initial specialization was substantiated, which provides for a phased flow of synchronization processes of physical and technical training with the implementation of intermediate control standards at the end of each stage of training (Ní Chéilleachair et al., 2017). Its structure consists of: conceptual part, content and procedural options. The content of the developed technology includes a wide range of training exercises that are information carriers and allow to program the training process based on the introduction into practice of coded technological chains in the form of sequentially applied synchronizing means and training methods. The procedural link of the developed technology is formed by the forms of interaction between the coach and athletes based on synchronized methods for the formation of rational technique swimming in the chosen way and development of special physical qualities and skills of a swimmer (Davids et al., 2001).

The foreign author Nugent et al. (2017a) conducted a systematic review investigating the impact of LHT on the performance of swimmers during competitive activities. The review noted seven studies that covered a wide range of highly qualified swimmers under the age of 18 (Kilen et al., 2014; Pugliese et al., 2015; Sperlich et al., 2010). The duration of the studies ranged from 4 weeks to 4 years. Six out of seven studies have shown that the LHT method has led to a significant improvement in physiological indicators, such as aerobic (Pugliese et al., 2015; Sperlich et al., 2010), and anaerobic mechanisms (Sperlich et al., 2010). Four out of seven studies have shown that the LHT method led to a significant improvement in swimming speed indicators on segments from 50 m to 2000 m (Pugliese et al., 2015; Sperlich et al., 2010), while none of the seven studies led to a decrease in physiological parameters or swimming speed. In the course of a systematic review, the authors conclude that the use of this method in the long-term development of a competitive swimmer remains limited, since four of the seven studies were only from 4 to 6.5 weeks (Kilen et al., 2014; Pugliese et al., 2015; Sperlich et al., 2010). The current study also determined the level of change in students' basic technical skills. For example, the t-value (-2.195 and -2.475) in the bench press indicates a relatively strong difference between the strength and speed of exercising between the control and experimental groups. The indicators of the experimental group are much better than those of the control group.

Previous studies in swimming have similar or even less significant improvements in speed and strength qualities in the upper shoulder girdle and in the lower extremities (Crowley et al., 2017) after using similar training programs in boys and girls (Girold et al., 2006, 2007). In most studies of speed-strength qualities, the program included heavy loads and repetitions to failure (Girold et al., 2006, 2007), whereas the results of this study were obtained using a speed-strength training program with small volume, small weights, high speed and high intensity. Thus, our results seem to contrast with previous studies indicating that an increase in muscle strength occurs only with training loads above 70% 1PM (Aspenes & Karlsen, 2012; Behringer et al., 2010), and suggest that elite junior swimmers could increase muscle strength and the level of speed and strength qualities by using a program with low volume, low weights and high intensity during the competitive season. At the same time, the results of this experiment and the statistical difference in indicators indicate statistically significant differences in almost all variables between the control and experimental groups, even with the following training load: less than 70% 1PM.

Based on the results of foreign studies conducted in the last decade, our conclusions seem reasonable. Other studies describe that the strength during the stroke in the swimming cycle, as well as the strength of the stroke on the biokinetic simulator and the Wingate anaerobic test have a stronger correlation with sprint segments than with distance swimming at 400 meters, and that speed-strength training improves performance in swimming (Girold et al., 2006, 2007).

In our study, the groups had a small number of participants and it is worth noting that some values (p) were at the level of statistical insignificance. The lack of improvement in the results of speed ($p = 0.016$) and strength ($p = 0.027$) qualities in the pull-up in the vertical jump ($p = 0.216$ and 0.535, respectively) can be observed due to the lack of improvement in the results of maximum strength, which, as previously reported by foreign researchers, have a high correlation (Toussaint & Vervoorn, 1990).

Our results show that the swimming speed increased by 9.28% ($p>0.110$). During the LHT training process, rest intervals should be short enough and allow replenishing most of the ATP to cause general fatigue and stimulate adaptation to the training process for faster ATP recovery. For the best development of the phosphagen system, the ratio of exercise and rest is recommended in the scientific and methodological literature 1:6. LHT is performed with a ratio of 1:1-2. This can be explained by a short distance (25 m) with duration of 10-12 seconds (Rushall, 2016). It should be noted that the participants in our study adhered to the set speed, and external variables, such as the delay in rest time during blood sampling to test the level of lactate concentration in the blood, could affect the final results.

In our earlier work, we described the effects of an 8-week training process according to a high-intensity training program on physiological and biomechanical changes in young swimmers at the national level. The results we obtained demonstrated that the eight-week experiment allowed us to reduce the training volume by 50 percent in the first intensity zone and increase training by 200 percent in the third intensity zone. These changes had a positive impact on most performance parameters compared to the traditional program aimed at using large training volumes and a low level of intensity (Gussakov et al., 2021).

Swimming skill is both a very complex and highly organized process (i.e. the actions of one part of the body affect the actions of other parts of the body) (Magill & Anderson, 2010). Consequently, when trying to improve swimming technique, coaches often resort to some forms of the training process, which mainly uses swimming at low speeds with a focus on swimming technique or working out individual technical elements (Lang & Light, 2010; Nugent et al., 2017a). In addition, studies examining the effectiveness of holistic and isolated approaches to practicing swimming techniques in high-level swimmers are rare, but all studies confirm the advantages of the holistic method (Konstantaki & Winter, 2007). Based on the above, it can be concluded, which is consistent with both the theory (Naylor & Briggs, 1963) and practice, that the influence of LHT has a positive effect on the improvement of swimming techniques among highly qualified swimmers.

The data obtained indicate the effectiveness of using the LHT method in order to improve the technical elements of swimmers of various skill levels (Carson & Collins, 2011).

Conclusions

The conducted research to identify the effectiveness of the experimental methodology for improving speed, strength, speed and strength qualities, taking into account the requirements of the competitive activity of qualified swimmers, made it possible to fully implement the tasks set and formulate scientifically based conclusions based on them:

1. The problems of improving the speed and strength qualities of qualified young swimmers, taking into account: functional capabilities; speed and strength qualities on land; functional capabilities on water and competitive activity represent a rather peculiar pedagogical-psychological, medical-physiological, sports-biomechanical system, which has been formulated for a number of years. At its core, it is well-established and often relatively effective. At the same

time, this system imposes requirements for possible changes in the content of sports training of highly qualified swimmers in accordance with the needs of modernity and taking into account modern achievements in swimming. In this regard, improving the speed and strength qualities of swimmers, timely overcoming of relevant disagreements, shortcomings and omissions that take place in the process of training swimmers, becomes a responsible part of the efforts of a number of people: coaches, doctors, judges, psychologists, etc.

2. This study tested the current trend of reducing the total volume of swimming while increasing the intensity of training and competitive loads. Thus, the method of low-volume high-intensity training was used to transform dependent variables. The overall strength, speed-strength qualities, and special qualities of swimmers were effective in the training process. The results of the experiment confirm this conclusion: the assessment carried out by independent experts showed that the use of low-volume high-intensity training also affects the basic swimming skills of students (elements of a swimming technique, general physical development of a swimmer; the rational structure of the swimming technique in the chosen method, the strength of the stroke; stability and variability of the swimming technique, the development of special speed and strength endurance of the swimmer). The indicators improved by an average of 0.6 points.

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