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**Original Article**

# Theoretical and methodological foundations for the use of innovative simulators of locally directed impact during the training process of highly qualified armwrestling athletes

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**Abstract**
**Purpose:** A comparative analysis of strength indicators during the training process according to the experimental training program using innovative training equipment of locally directed action during the training of highly qualified armwrestling athletes. **Material:** The study involved 16 high qualification armwrestling athletes weighing between80 and 100 kg. Group 1 – 8 (93.57 ± 0.94) kg, Group 2 – 8 (94.06 ± 0.95) kg. The athletes trained for one year: group 1 – according to the experimental program using innovative training equipment, group 2 – according to the traditional program. During the study, strength indicators were determined in 4 competitive exercises at the beginning and at the end of the experiment. Strength indices in all test exercises were measured in a static mode by an FB5k series electrical tenzodynamometer (Poland) with an accuracy class of up to 100 g, which was mounted on a special arm-sport table using a specially made block device. The created design was called the "ARM1 Device". During the statistical analysis, the following parameters were calculated: arithmetic mean (x̄), standard deviation (B) (using Student t-test) and coefficient of variation (V), correlation analysis (using the Wilcoxon test). **Results**: A comparative analysis of the indicators of strength training among armwrestlers from the 1st and 2nd groups at the end of the study shows that their increase for the 1st group was more pronounced. Thus, an experimental training program using innovative locally directed simulators is more effective. This statement is confirmed by the dynamics of strength in all four test exercises with both left and right hands for athletes from the 1st group. An increase in strength training results ranged from 3.38% to 7.57%. The average increase was 5.06%. A comparison of the mean values by the nonparametric Wilcoxon criterion indicates that the difference between them is statistically significant (W = 2.52 □ W0.05 = 5). **Conclusions**: The performed analysis confirmed that the experimental training program was effective and allowed to significantly improve the strength indicators of highly qualified armwrestling athletes. This improvement occurred owing to the use of more time for static exercises by 46% and 70% for participating in competitions. Innovative local training equipment allowed to provide competitive movements without involving additional muscle groups. The experimental program, which used the innovative simulators of locally directed action, provided a significant development of the strength capabilities of those muscle groups that were directly involved in the fulfillment of certain strength motor actions.
**Keywords: armwrestling, armsport, training equipment, training program**

## Introduction

Modern armwrestling is an exciting and affordable sport that exposes the athlete to maximum loads and stress. According to[Bezkorovainyi et al.,2019], based on the mechanism of application of efforts and the duration of an increase in strength, this sport is as peed–strength sport. However, according to other experts [Voronkov et al.,2010; 2014], among elite athletes in competitive exercises, the strength component during arm wrestling, in most cases, is essential.

It is known that the development of motor qualities of qualified athletes causes considerable difficulties. This occurs because this category of athletes during many years of training used various means and methods of strength training. The functional systems of the body and the muscular system of these athletes are adapted to heavy loads [Podrigalo, Istomin, & Galashko, 2010]; therefore, the search for scientifically based and effective training methods for qualified armwrestlers is timely.

Strength is used in many sports as a measure of athlete fitness. There is information on the content of this indicator for analyzing the state of handball players [Manchado, Cortell-Tormo, & Tortosa-Martinez, 2018], water polo [Barrenetxea-Garcia, Torres-Unda, Esain, & Gil, 2019], lacrosse [Labott et al., 2019], and weight lifting [Pavlov, Kudryavtsev,& Revyakin, 2017]. This indicator is one of the main criteria for the development of strength [Karakurt, & Aggon, 2018].


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In many sports, various training equipment and specialized equipment are currently actively used to increase the effectiveness of training programs. Researchers are actively involved in studying these issues [Piven, 2016]and in the development of simulators for the development of arm strength [Vodlozerov et al., 2003]

However, though there are many discussions about the effect of using various simulators and specialized equipment, currently, there are many questions that need further clarifications and solutions.

Thus, with an increase in training loads using technical means, there are factors that limit the effectiveness of sports and technical skills of athletes. For example, excessive adherence to the use of exercise machines can cause a decrease in the adaptability of athletes to other types of loads [Burdukiewicz et al., 2018]. In addition, performing motor actions using the proposed training devices is not always adequate for the biomechanical features of competitive movements of armwrestling athletes, which great lyreduces the training effect of using the device for both physical quality training and for solving the motor task [Harcarik, 2013].

Modern scientific research [Nikulin, & Filatov,2010] has established the consider able value of static loads for the development of athletic power abilities. However, there are few studies aimed at using specialized training equipment using static exercises during the strength training of armwrestlers [Gibadullin, Imangulov, & Kozhevnikov, 2014; Mazurenko, 2019].

Recently, [Podrigalo, Iermakov, & Romanenko, 2019] indicated that in armwrestling, the number and complexity of injuries increased during training and especially during competitions at various levels. Previously performed analysis [Ahamed et al.,2013] has shown that most injuries are associated with insufficient special physical and poor technical readiness.

Therefore, the search for an effective methodology for the use of modern innovative locally directed action simulators during the training of armwrestling athletes is of particular relevance. It is expected that the use of authoring training devices of locally directed action will create an “artificial environment” for determining the optimal methodology for increasing the power potential of armwrestlers.

**Materials and methods**

*Participants.* The study involved 16 high qualification armwrestling athletes weighing between80 and 100 kg. Group 1 (n = 8, 93.57 ± 0.94 kg) included 2world championship winners, 3participants of the world championships, and 5experienced athletes; group 2(n = 8, 94.06 ± 0.95 kg) included 1 world championship winner, 3 participants of the world championships, and 5experienced athletes.

*Design of the study*

Athletes from both groups trained for one year. Group 1 trained according to the experimental program using innovative training equipment, and group 2 trained according to the traditional program. Innovative author's simulators of locally directed impact were used during the training process of group 1. Specifically:

– specialized armwrestling table [patent № 2014137364/12 (060482), dated 17.10.2014]

– an adjustable block – a simulator, with the help of which a large number of strength exercises of local influence are performed;

– "mechanical arm" – a simulator that naturally imitates a fight with an opponent on the table;

– Mazurenko machine – simulates a hook fight with a sparring partner;

– a universal trainer for the development of the strength of the forearm, hands, and fingers; the use of a universal trainer improves the strength of the hands and the coordination of movements;

– IRON HAND exercise machine (patent № 402899) – a device for training the muscles of the forearm and fingers;

– special handles for these simulators [Mazurenko, Kamayev, & Bezkorovainyi, 2019].

Group 2 athletes trained according to the traditional training program using a well-known previous generation of simulators.

The total number of hours in the annual macrocycle of training of athletes from group 1 was 709 h compared to 704 h for group 2. The experimental program, in addition to the use of author's simulators, differed from the training plan of group 2; specifically, there was a significant increase in static exercise time (46%) and hours for participation in competitions (by 70%). Moreover, there was a reduction in the number of hours devoted to dynamic exercises (by 11%) and 39% less time spent sparring at the table.

Based on the analysis of the questionnaire results of highly qualified trainers and athletes and video materials, 4strength test exercises were identified that had a significant impact in hand wrestling. These exercises include bending of the fingers, stretching with a hammer, hook, and bending of the hands. Strength indicators in these exercises were measured at the beginning and at the end of the annual macrocycle.

Strength indices in all test exercises were measured with an FB5k series electrical tenzodynamometer (Poland) with an accuracy class of up to 100 g, which was fixed on a specialized armwrestling table using a specially made block device. The created design was called the “ARM1 Device”.

During the measurement of the strength of the muscles of the hands, the subject faced the table, grabbed the device holders with his hand, and squeezed them with maximum force without tearing the elbow of the working arm from the table. The distance between the holders of the device easily changed and was selected individually for each subject.

The special computer program ‚AXIS FM‚ allowed to process the measurement data in real time (on-line) and the previously collected data from the memory of an electrical tenzodynamometer (of-line). AXIS FM is compatible with the operating systems Windows XP, Vista, and Windows 7.

The statistical analysis of the obtained data was performed using the licensed program STATISTICA 10. During the statistical analysis, the following parameters were calculated: arithmetic mean ($\bar{x}$), standard deviation (B) (using Student's t-test), coefficient of variation (V) (using the Wilcoxon test), and the correlation matrices were constructed including Pearson coefficients based on the obtained results.

**Results**

The strength indicators of group 1 athletes in the four test exercises are shown in Table 1. A comparative analysis of the strength training indicators of group 1 and 2 athletes at the end of the study suggests that the experimental training program using innovative locally directed simulators is more effective. This statement is supported by the dynamics of strength in all four test exercises for both left and right hands of athletes from group 1. The magnitude of increase in the results of strength training ranged from 3.38% to 7.57%. The average increase was 5.06%. A comparison of the mean values by the nonparametric Wilcoxon criterion indicates that the difference between them is statistically significant ($W = 2.52 < W_{0.05} = 5$).

**Table 1. Dynamics of changes in strength readiness indices of armwrestling athletes from group 1 at the beginning and at the end of the experiment (n = 8)**

| Arm | Strength before the experiment (kg) | Strength at the end of the experiment (kg) | Increase rate | | | V (%) | |
|---|---|---|---|---|---|---|---|
| | | | % | t | P | before | at the end |
| Flexion of the fingers | | | | | | | |
| left | 50.68 ± 1.03 | 54.23 ± 1.10 | 7.0 | 2.36 | <0.05 | 5.75 | 5.74 |
| right | 52.81 ± 0.90 | 56.81 ± 0.91 | 7.57 | 3.13 | <0.05 | 4.82 | 4.53 |
| Stretch with a hammer | | | | | | | |
| left | 59.08 ± 0.94 | 62.24 ± 0.91 | 5.34 | 2.41 | <0.05 | 4.51 | 4.14 |
| right | 61.83 ± 0.57 | 64.98 ± 0.92 | 5.09 | 2.48 | <0.05 | 3.98 | 4.01 |
| Hook | | | | | | | |
| left | 81.88 ± 0.75 | 84.65 ± 0.69 | 3.38 | 3.09 | <0.05 | 2.59 | 2.31 |
| right | 85.00 ± 0.78 | 87.98 ± 0.84 | 3.51 | 2.61 | <0.05 | 2.6 | 2.7 |
| Bending of the hand | | | | | | | |
| left | 66.86 ± 0.58 | 69.67 ± 0.50 | 4.20 | 3.66 | <0.01 | 4.46 | 2.03 |
| right | 70.63 ± 0.79 | 73.73 ± 0.89 | 4.39 | 2.61 | <0.05 | 3.17 | 3.42 |

The indices of strength in four test exercises among armwrestling athletes from group 2 are shown in Table 2. The indices of increase in strength readiness ranged from 1.87% to 3.77%, and the average value of increase was 3.02%. The difference in the mean values of this group according to the nonparametric Wilcoxon test is not statistically significant ($W = 5.73 > W_{0.05} = 5$).

For the armwrestlers from group 1, all strength indicators significantly ($P < 0.05–0.01$) improved; for the armwrestlers from group 2, the changes were insignificant ($P > 0.05$).

The comparative analysis of indicators of the coefficient of variation (V) shows that among the athletes from group 1, the homogeneity indicator of the group improved on average by 3.22% (from 3.73 to 3.61%); however, in group 2, the average value of the variation of test results increased from 4.25% to 7.1%, which suggested an increase in the heterogeneity of the group.

**Table 2. Dynamics of changes in strength readiness indices of armwrestling athletes from group 2 at the beginning and at the end of the experiment (n = 8)**

| Arm | Strength before the experiment (kg) | Strength at the end of the experiment (kg) | Increase rate | | | V (%) | |
|---|---|---|---|---|---|---|---|
| | | | % | t | P | before | at the end |
| Flexion of the fingers | | | | | | | |
| left | 50.36 ± 1.16 | 52.18 ± 1.38 | 3.61 | 1.01 | >0.05 | 6.52 | 7.48 |
| right | 52.09 ± 0.98 | 53.65 ± 1.24 | 2.99 | 0.84 | >0.05 | 5.32 | 6.54 |
| Stretch with a hammer | | | | | | | |
| left | 59.14 ± 1.12 | 61.13 ± 1.44 | 4.77 | 1.21 | >0.05 | 5.36 | 6.67 |
| right | 60.89 ± 1.03 | 62.48 ± 2.12 | 2.61 | 0.68 | >0.05 | 4.79 | 9.6 |
| Hook | | | | | | | |
| left | 81.13 ± 0.79 | 83.32 ± 1.63 | 2.66 | 1.21 | >0.05 | 2.75 | 5.54 |
| right | 84.29 ± 0.91 | 85.87 ± 2.43 | 1.87 | 0.61 | >0.05 | 3.06 | 8.01 |
| Bending of the hand | | | | | | | |
| left | 67.03 ± 0.82 | 68.96 ± 1.51 | 2.87 | 1.12 | >0.05 | 3.46 | 6.2 |
| right | 69.57 ± 0.68 | 72.19 ± 1.72 | 3.76 | 1.42 | >0.05 | 2.77 | 6.74 |

Thus, the training program according to the experimental methodology of using innovative simulators allowed to significantly increase the strength indices of highly qualified armwrestlers in all test exercises both for the left (Fig. 1) and right hands (Fig. 2).

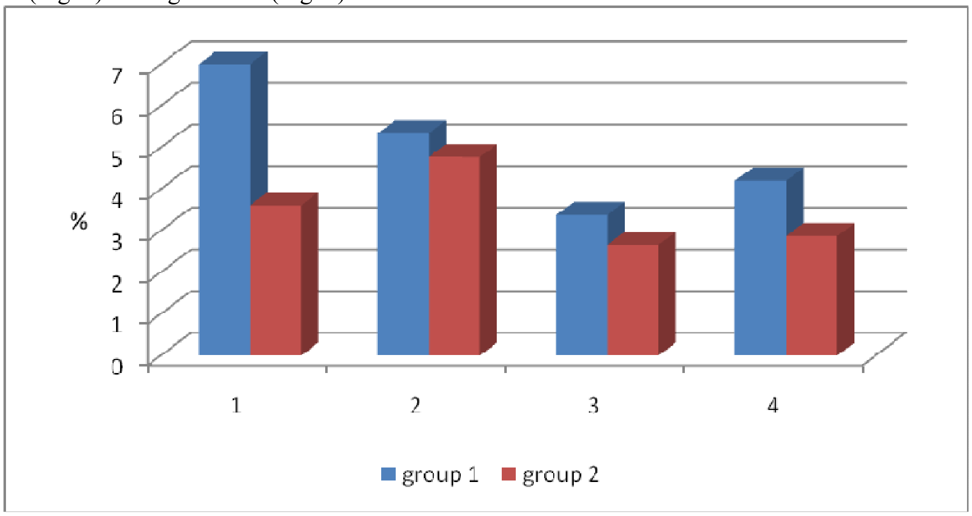


Fig. 1. Dynamics of the growth of power indices of the left hand in groups of armwrestling athletes
Note: 1 – flexion of the fingers, 2 –stretch with a hammer, 3 – hook, 4 – flexion of the hand

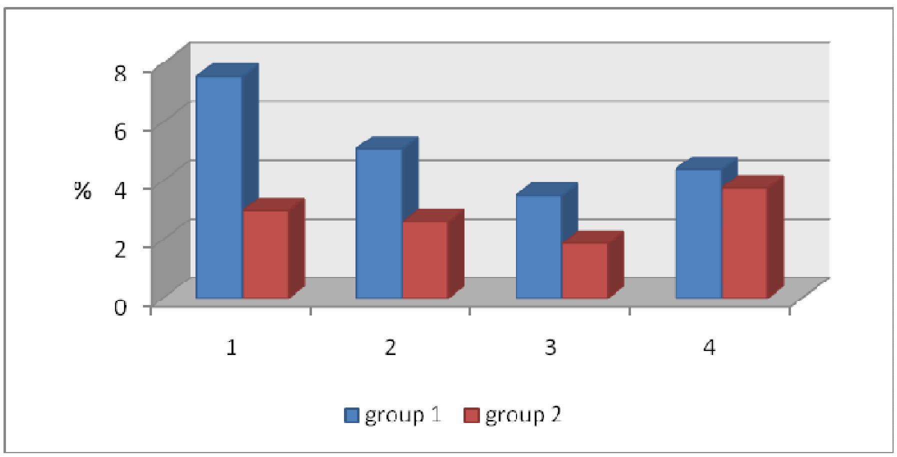


Fig. 1. Dynamics of the growth of power indices of the right hand in groups of armwrestling athletes
Note: 1 – flexion of the fingers, 2 – stretch with a hammer, 3 – hook, 4 – flexion of the hand

To determine the peculiarities of correlations between all indicators of left and right hand strength in all test exercises, an analysis of correlations between them at the beginning and end of the study was performed. The results of the analysis are shown in Table 3.

**Table 3. Dynamics of the number and direction of correlation coefficients between strength indicators at the beginning and at the end of the experiment**

| Levels of correlations | Number and direction of correlation coefficients | | | |
|---|---|---|---|---|
| | group 1 | | group 2 | |
| | early | at the end | early | at the end |
| High level (r > 0.7) | 3 | 0 | 6 | 6 |
| Average level (r = 0.5–0.7) | 5 | 3 | 1 | 2 |
| Low level (r < 0.5) | 6 | 18 | 13 | 16 |
| Negative level (r < 0) | 14 | 7 | 8 | 4 |

The comparative analysis of multiple correlations between 28 indicators of strength of highly qualified armwrestlers allowed to establish that the implementation of the experimental program is accompanied by a significant change in the quantitative and qualitative indicators of correlations between the strength data of athletes from group 1. Thus, at the beginning of the experiment, there were 3 cases of strong correlation, 5 – average, 6 –weak, and 14 –negative. At the end of the experiment, there are no strong-level connections; the average correlation level decreased to 3 cases, and the weak level increased by 3 times and amounted to 18 cases. The negative correlation was reduced by 2 times, i.e., from 14 to 7 cases. At the same time, the average indicator of the modulus of correlation coefficient (r) at the end of the experiment in this group decreased by 19.64% from 0.326 to 0.262.

Such dynamics of changes in correlations is observed against the background of significant increases in strength indicators of athletes from group 1.

For the athletes from group 2, the changes were different. Thus, the number of strong correlations remained at the level of 6 cases; the connections of the middle level increased to 2 cases, and the weak level increased from 13 to 16 cases. The number of negative correlations was halved, i.e., from 8 to 4 cases. Such dynamics of changes in athletes of this group was accompanied by an increase in the average indicator of the correlation coefficient (r) by 28.3%, i.e., from 0.304 to 0.390. For athletes from group 2, the changes in correlations were also accompanied by positive dynamics of strength indicators but this increase was not significant.

Thus, a significant increase in the power indicators of highly qualified armwrestlers when using locally directed simulators during the training process is accompanied by a significant weakening of the correlation dependence of intermuscular interaction. Thus, an increase in strength indicators in test exercises is explained by an increase in the functional capabilities of individual muscle groups, which directly ensures the fulfillment of test strength exercises.

The established significant decrease (by 50%) in negative correlations at the end of the study indicates that training using exercise devices helps to reduce the negative effect of certain muscle groups during powerful muscle tensions.

**Discussion**

Armwrestling refers to sports in which the level of hand strength development is important to achieve success. It has been confirmed that the main predictors of success in arm wrestling include muscle development, physique strength, and values of conditional moments' strength of segment extremities [Sharma, & Kailashiya, 2017].

This study evaluates a new training program for highly qualified armwrestlers using innovative training devices of locally directed action. The analysis of previous generation simulators showed that a decrease in their effectiveness was associated with the artificial spatial limitation of the power load. They do not allow simultaneous coordinated loading of the muscles that provide the performance of competitive exercises. They require the simultaneous activation of several spatial degrees of freedom of the musculoskeletal system and many muscle groups. This does not correspond to the goals and objectives of training of highly qualified athletes [Sotsky, 2018].

In addition, the biomechanical efficiency of devices used for the development of motor qualities is markedly reduced owing to the need to reduce inertia and energy dissipation [Sotsky, 2017].

Taking into account the lack of traditional simulators of locally directed action to ensure the variability of loads and activation of stimulus during the performance of strength exercises, the authors developed innovative simulators; the main task of these simulators was to provide compensation for the shortcomings of technical and strength readiness of athletes [Cherkesov, 1999].

Traditional simulators are also designed for locally directed action to develop strength by involving many muscle units in motor actions. Most of them are designed for teaching motor actions, developing strength and motor endurance, and increasing joint mobility. They are aimed at using in mass physical culture and sports for the development of strength capabilities of muscle groups [Nikulin, & Filatov, 2010].

The developed innovative simulators had a local focus on a specific competitive movement; when performing competitive exercises, the use of additional muscle groups was practically excluded.

A previous study, which is based on the ergonomic approaches,[Podrigalo et al., 2017] has shown that highly skilled athletes have a significantly higher arm strength, hand flexion, forearm muscle strength, and arm pronation and supination.

The obtained results complement the data on the use of special training programs for athletes [Harcarik,2013]; specifically, an experimental training program for athletes significantly increased their strength capabilities.

According to[Kochkarov, 2005], simulators are essential for the formation of a positive transmission of motor actions, and the discrepancy between training and competitive actions when using simulators can create an opposite effect for active muscle groups in a real competition.

Our data confirms the results of previous studies [Cherkesov, 1999; Kochkarov, 2005],which showed that highly qualified armwrestling athletes have higher static strength indicators than lower-trained athletes.

Brush strength is the most important parameter in armwrestling. All athletes from group 1 are characterized by high results of power indicators of a brush; the higher are the results of these indicators, the higher is the success of competitive activity. Similar data have been shown by other authors [Podrigalo et al.,2020]. A previous study [Akpina et al.,2013] has also confirmed that arm muscle strength is an important measure of performance in armwrestling.

Victory largely depends on the athlete's ability to squeeze the opponent's hand as hard as possible. This technique was used by researchers [Iermakov, Podrigalo, & Jagiełło, 2016] to predict success in martial arts. The importance of the maximum grip frequency was confirmed for success in judo and sambo. This test does not high significance for success in karate and taekwondo. The authors have recommended the test as a screening to monitor the athletes' condition in martial arts [Szabolcs et al., 2018;Kons et al., 2018].

The obtained results of changes in athletes' power indices show correlations between them, which are due to changes in intermuscular relationships and interactions under the influence of training loads [Rovnaya et al., 2019].

**Conclusions**

The performed analysis confirmed that the experimental training program was effective and allowed to significantly improve the strength indicators of highly qualified armwrestlers. This result was obtained because more time was spent on static exercises (by 46%) and on participating in competitions (by 70%). Innovative local training equipment allowed to provide competitive movements without involving additional muscle groups.

The experimental program, which used innovative simulators of locally directed action, provided a significant development of the strength capabilities of those muscle groups that were directly involved in the fulfillment of certain strength motor actions. This confirms the effectiveness of innovative simulators in the strength training of highly qualified armwrestlers.

**Conflict of interest**

The authors declare no conflict of interest.

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