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**Original Article**

# Using static-dynamic exercises to improve strength performance in elite brazilian jiu-jitsu athletes

YURUI TROPIN[1], LEONID PODRIGALO[2], VYACHESLAV ROMANENKO[3], YULIYA KOVALENKO[4], NATALYA BOYCHENKO[5], OLHA PODRIHALO[6], OLEKSANDR VOLODCHENKO[7]
[1,3,5]Martial Arts Department, Kharkiv State Academy of Physical Culture, UKRAINE
[2,6]Medical and Biological Foundations of Sports and Physical Culture Department, Kharkiv State Academy of Physical Culture, UKRAINE
[4]Ukrainian and Foreign Languages Department, Kharkiv State Academy of Physical Culture, UKRAINE
[7]Athletism and Strength Sports Department, Kharkiv State Academy of Physical Culture, UKRAINE

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**Abstract**:
*Problem statement:* There is a need to assess the effectiveness of integrating static-dynamic exercises into the training routines of elite Brazilian Jiu-Jitsu athletes to enhance their strength performance. This study aims to determine whether such exercises can lead to enhancements in strength, endurance, or other pertinent physical attributes crucial for Brazilian Jiu-Jitsu athletes. The authors aim to address potential gaps in existing training methodologies and advocate for evidence-based strategies to optimize athletic performance in this specific context. *The purpose* of this study is to examine the impact of static-dynamic exercises on the strength of Brazilian Jiu-Jitsu athletes. *Material and Methods*: the study involved 20 elite athletes. They were divided into two groups: a control group comprising 10 athletes (age: 20.06±1.02 years; weight: 81.49±3.83 kg; height: 178.5±4.27 cm) and an experimental group comprising 10 athletes (age: 19.97±1.09 years; weight: 81.99±3.55 kg; height: 177.4±3.85 cm). The training program for the experimental group included static-dynamic exercises. *Results*: at the end of the study, a 50% reliable improvement in results was observed among the athletes in the experimental group: pull-ups for 20 seconds ($U=81.0$, $p<0.05$), sit-ups for 20 seconds ($U=78.5$, $p<0.05$), pull-ups ($U=79.0$, $p<0.05$), push-ups ($U=77.0$, $p<0.05$), and bent-arm hang ($U=77.5$, $p<0.05$). These tests are indicative of muscle strength in the abdominal and shoulder girdle. *Conclusions*: the use of static-dynamic exercises has been found to enhance the strength performance of elite Brazilian Jiu-Jitsu athletes. The increase in strength performance results among athletes in the experimental group ranged from 4.5% to 22.0%, while the increase in the control group ranged from 0.5% to 3.2%. It is recommended to incorporate the developed training programs into the preparation of Brazilian Jiu-Jitsu athletes' performance.
**Key Words: elite athletes, exercise routines, martial arts, physical fitness.**

## Introduction

Sports play a significant role in our lives, not only as a source of entertainment but also as a powerful tool for maintaining health, developing physical and psychological qualities, and achieving high performance in competitions. In modern society, sports have become an integral part of culture, bringing together people of different ages and nationalities. One of the key aspects of successful engagement in a particular sport is effective training. The optimization of the training process, along with the use of advanced methods and technologies, has become a crucial factor in achieving high athletic performance. In this regard, scientific research in sports plays a decisive role, providing coaches and athletes with new knowledge and methods to enhance their performance (Simion et al., 2010; Potop & Cretu, 2018).

Modern sports are characterized by intense competition and the pursuit of maximum results, which place high demands on various types of athlete preparation. In a highly competitive environment, where minimal differences in an athlete's preparation can determine success, the importance of meticulous training cannot be overstated (Chaouachi et al., 2009; Volodchenko et al., 2017).

In modern combat sports, only talented athletes can achieve high competition results (da Silva et al., 2015; доставить Tropin et al., 2022). The ability of a combat athlete to perform well in competitions depends on the optimal correlation of their anthropometric data, technical-tactical mastery, and physical and psychological qualities (Manolachi et al., 2022; Korobeynikov et al. 2023).

To effectively design the training process, it is necessary to understand the main characteristics of competitive activity. The specificity of the sport determines its influence on the morphofunctional features of athletes. These factors should be considered when selecting and predicting success in combat sports (Dulceanu, & Mihailescu, 201; Podrigalo et al., 2022).


Corresponding Author: YURUI TROPIN, E-mail: julawa09@gmail.com

Tropin et al. (2021) identified the features of basic combat styles among wrestlers based on an analysis of competitive activity: playing combat style, tempo combat style, and strength combat style. The analysis also allowed the authors to develop profiles and training tasks for wrestlers of each combat style. Similar studies have been conducted in kickboxing, where a methodology for individualizing training for qualified kickboxers was developed and implemented based on the characteristics of each fighting style (Pityn et al., 2017).

Plush et al. (2022) investigated the physical and physiological characteristics of mixed martial arts (MMA) fighters. The authors found that MMA has several potential competitive styles, and the aforementioned characteristics can vary among successful athletes and influence training program design.

James et al. (2016) identified the characteristics of striking and grappling combat athletes and determined that different physiological profiles exist for wrestlers and striking athletes. They recommended that wrestlers develop speed-strength qualities with exercises that increase maximum strength while striking athletes use light loads with more rapid movements.

Slimani et al. (2017) analysed and evaluated anthropometric, physiological, physical, and psychological characteristics of kickboxers with consideration to activity profile and injury epidemiology. They determined that these characteristics influence performance and can serve as a guide for training.

Mala et al. (2019) compared morphological symmetry among elite athletes in six combat sports (judo, karate, fencing, wrestling, taekwondo, and kickboxing). This study revealed morphological differences among practitioners of different combat sports and contributed to the development of practical recommendations for improving the training process.

The level of development of physical qualities largely determines the tactical and technical preparation of athletes. For example, the ability to selectively demonstrate significant muscle effort allows combat athletes to successfully perform tactical and technical combinations and timely counterattacks, which increases the reliability of implementing technical and tactical actions (Coswig et al., 2018; Latyshev et al., 2022). It has been established that specialized physical fitness is one of the key factors in achieving the highest results in competitive wrestling (Tropin et al., 2023).

Ambrozy et al. (2021) established correlations between specific physical preparedness and indicators of technical and tactical mastery of Jiu-Jitsu athletes. They found that athletes with higher physical preparedness were more active and effective in attack.

Andreato et al. (2017) studied competitive Brazilian Jiu-Jitsu matches and found that aerobic power contributes to maintaining high intensity throughout the entire match, delaying fatigue, and achieving quick recovery between matches. Speed-strength is used for both offence and defence, particularly in executing throws, while strength endurance is utilized to maintain the grip on the opponent's gi, a special clothing used for training. Given this dynamic of Brazilian Jiu-Jitsu matches, athletes should have a high level of strength conditioning. These findings are supported by other studies (Detanico et al., 2017; Ambroży et al., 2021).

The importance of this research is driven by the need to find new effective methods to enhance athletic performance, including in Brazilian jiu-jitsu. The anticipated results will expand theoretical knowledge in sports science and provide practical recommendations for coaches and athletes aiming to maximize their physical capabilities. Consequently, static-dynamic exercises may become a vital tool in the arsenal of modern training methodologies, contributing to the improvement of strength metrics and physical fitness of elite athletes.

The study will examine various training protocols that include static-dynamic exercises and analyze their impact on physical fitness. The obtained data will substantiate the inclusion of static-dynamic exercises in training programs and develop recommendations for their optimal use to achieve the highest sporting results.

Based on this information, **the purpose of this study** was to investigate the influence of static-dynamic exercises on the strength performance of elite Brazilian Jiu-Jitsu athletes.

## Material & methods

*Participants*

The study involved 20 elite Brazilian Jiu-Jitsu athletes. All participants held purple belts and competed in national and international tournaments. To be included in the sample, athletes were required to have practised Brazilian jiu-jitsu for a minimum of 9 years, train at least 10 times per week, and fall within the weight range of 75 kg to 85 kg. Additionally, athletes were not allowed to have any limitations or restrictions that would hinder or impede the execution of any procedures in this study, such as recent injuries or illnesses.

Those who did not pass all evaluations or had an attendance frequency of less than 75% in the training sessions were excluded. A total of 25 elite athletes were invited to participate in the study, out of which 4 were excluded for failing to meet the 75% attendance frequency requirement in the training program, and 1 left the study for personal reasons. Therefore, the participants were divided into two groups: a control group of 10 athletes (age: 20.06±1.02 years; weight: 81.49±3.83 kg; height: 178.5±4.27 cm) and an experimental group of 10 athletes (age: 19.97±1.09 years; weight: 81.99±3.55 kg; height: 177.4±3.85 cm). The groups were formed randomly. Informed consent to participate in the study was obtained from all participants. The study program and design were discussed and approved at a meeting of the Bioethics Committee of the Kharkiv State Academy of Physical Culture.

*Organization of research*

The study lasted for 8 weeks. Pre- and post-testing of the athletes' strength was conducted using a battery of tests. The control group continued their formal training without any intervention, while the experimental group was doing static-dynamic sets of exercises. The protocol of static-dynamic exercises consisted of two complexes. The first set included push-ups, barbell squats, and dumbbell lateral raises (performed on Mondays, Wednesdays, and Fridays). The second set included pull-ups, sit-ups, and hyperextensions (performed on Tuesdays, Thursdays, and Saturdays).

During *the push-up exercise* athletes assumed a prone position with their hands placed shoulder-width apart, fingers and toes on the floor, and body forming a straight line. Athletes performed full-range-of-motion push-ups with their elbows bent to a 90-degree angle and maintained the position with their arms flexed at a 90-degree angle. The starting position for the *barbell squats* was with the barbell on the shoulders, feet shoulder-width apart, toes slightly turned out, and the back and legs straight. The weight of the barbell was evenly distributed on both legs. The athlete squatted and then stood up with the barbell on the shoulders, returning to the starting standing position. The angle of knee flexion should be 90 degrees, and the position should be held with the knees bent at a 90-degree angle. The weight of the barbell was 50% of the maximum.

*The dumbbell lateral raises* involved starting with the feet shoulder-width apart, a straight back, slightly bent arms, and the dumbbells almost touching the legs with palms facing the thighs. The athlete raised the arms to the sides (with a 90-degree angle between the arms and the torso) and lowered them back to the starting position (strictly in the plane of the torso). The elbows do not bend while doing the exercise. The position should be held with raised arms at a 90-degree angle relative to the torso. The weight of the dumbbells was 5 kg.

The starting position for *the pull-ups* was hanging from a bar with arms slightly wider than shoulder-width, a straight back, and a slightly raised chin. The athlete performed a pulling movement upwards until the chin reached the bar, and then lowered back to the starting position. The position should be held with the arms bent at a 90-degree angle.

*The sit-ups* assumed the starting position of lying on the back with knees bent, feet flat on the floor, and hands behind the head. The athlete raised the upper part of the torso towards the knees and then returned to the starting position. The exercise involved holding the position with the torso bent.

*The hyperextension* was performed on a Roman chair. The starting position involved the athlete pressing the thighs against the support and securing the legs while being bent over with the head down. Then the athlete began to lift the torso and arms by contracting the muscles that straighten the spine. The exercise involved holding the position with a straightened torso.

The exercises were distributed in such a way as to ensure alternating loads on the muscles of the legs, arms, back, abdomen, and overall effect. Each exercise was performed in sets of 3 repetitions (1st set: 10 seconds – performing the exercise, 10 seconds – holding the position in the tense phase, 10 seconds – performing the exercise, 30 seconds – rest; 2nd set: 10 seconds – performing the exercise, 10 seconds – holding the position in the tense phase, 10 seconds – performing the exercise, 30 seconds – rest; 3rd set: 10 seconds – performing the exercise, 10 seconds – holding the position in the tense phase, 10 seconds – performing the exercise). The rest between exercises lasted 3 minutes. This time of recovery was arbitrarily chosen based on material and technical support for education. The exercise tempo was moderate. The sets were performed at the end of the main part of the training session. The time to complete one set was 14-15 minutes. The pause intervals were composed of passive recovery. Along with performing the entire protocol, athletes received verbal encouragement, and the intervals were monitored using a pre-set stopwatch. An example of performing the first set of exercises is as follows: the exercise routine consists of three sets of three exercises. Each exercise consists of a series of three movements: 10 seconds of performing the exercise, followed by 10 seconds of holding the position in a tense phase, and another 10 seconds of performing the exercise. This is followed by a rest period of 30 seconds between each exercise and a longer rest period of 3 minutes between each set.

The exercises included are:

1) push-ups, where the individual performs the exercise by bending and straightening the arms while in a lying position, followed by the tense phase hold, with a total duration of 30 seconds per set;

2) barbell squats, where the individual performs the exercise by bending and straightening the legs while holding a barbell, followed by the tense phase hold, with a total duration of 30 seconds per set;

3) lateral raises with 5kg dumbbells, where the individual performs the exercise by raising the arms laterally with dumbbells, followed by the tense phase hold, with a total duration of 30 seconds per set.

Example of performing the second set of exercises:

– Pull-ups (10s - exercise execution, 10s - hanging position on bent arms, 10s - exercise execution), rest (30s); pull-ups (10s - exercise execution, 10s - hanging position on bent arms, 10s - exercise execution), rest (30s); pull-ups (10s - exercise execution, 10s - hanging position on bent arms, 10s - exercise execution), rest (3 minutes).

– Sit-ups (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution), rest (30s); sit-ups (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution), rest (30s); sit-ups (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution).

– Hyperextension (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution), rest (30s); hyperextension (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution), rest (30s); hyperextension (10s - exercise execution, 10s - holding the tension phase, 10s - exercise execution).

*Measurement*

To assess the level of strength fitness all tests used were verified for accuracy and reliability (Ambroży et al., 2022; Wąsacz et al., 2022) and were tested in the previous study. (Tropin et al., 2021). Before each testing, athletes from both groups participated in a standard 15-minute warm-up consisting of exercises to prepare the body for physical exertion. The warm-up included static and dynamic movements of the arms, torso, abdomen, back, and legs.

–*100 m Sprint Test*. This test provides information on an athlete's speed-strength abilities. Test participants take a position in a high starting stance behind the starting line and maintain a motionless state. Upon the coach's signal, they must cover a distance of 100 meters as quickly as possible. Two attempts were given, with a two-minute rest period between each attempt. The result of the test is the best time taken to complete the distance with an accuracy of a tenth of a second.

– *Pull-ups for 20 s.* This test characterizes the speed-strength abilities of the muscles in the shoulder girdle. The subject grabs the bar with an overhand grip and hangs. Upon a signal, the subject flexes arms at the elbows and pulls the body up high enough for the chin to be above the bar, and then returns to a relaxed hanging position without resting. The athlete performed the maximum number of movements possible at a maximum pace for 20 seconds. The number of complete pull-ups (chin above the bar) within 20 seconds was recorded. The test was performed only once.

– *Push-ups for 20 s.* This test assesses the speed-strength capabilities of the shoulder girdle muscles. The subject assumes a front plank position with hands shoulder-width apart. Upon a signal, the subject performs push-ups (lowering until touching the ground) with full arm extension, aiming for maximum speed and the highest possible number of repetitions within 20 seconds. The number of repetitions within 20 seconds was recorded. The test was conducted only once.

– *Sit-ups for 20 s.* This test delivers information on the speed-strength abilities of the core muscles. The subject lies on a mat with legs spaced 30 cm apart and knees bent. The hands are clasped, resting against the back of the head, while the legs are hooked onto a ladder or any stable object to maintain contact with the ground. Upon a signal, the participant sits up, touching the elbows to the knees, and then returns to the starting position. The athlete performed the maximum number of movements possible at a maximum pace for 20 seconds. The number of repetitions in 20 seconds was recorded. The test was performed only once.

– *Standing Long Jump Test*. This test indicates the speed-strength abilities of the leg muscles. The test participant stands with the toes at the line, swings the arms backwards, then forcefully brings them forward, propelling oneself with the legs and jumping as far as possible. Two attempts were given, with a two-minute rest period between each attempt. The result of the test is the distance jumped in centimetres in the best of two attempts. The length of the jump was measured as the distance from the starting point to the nearest point of landing.

– *Pull-ups Test.* This test characterizes the muscular endurance of the shoulder girdle muscles. The athlete performed the maximum number of repetitions possible at a self-determined optimal pace. Measurement was conducted based on the number of completed repetitions.

– *Push-ups Test* characterizes the muscular endurance of the shoulder girdle muscles. The subject assumes a front plank position with hands shoulder-width apart. Upon a signal, the subject performs push-ups (lowering until touching the ground) with full arm extension. The athlete performs as many repetitions as possible. The optimal pace of exercise execution is determined by the individual. Measurement is done based on the number of completed repetitions. The test was conducted only once.

– *Squats with a Partner of Equal Weight*. This test provides information on the muscular endurance of the leg muscles. The subject begins performing exercises from a standing position, with feet shoulder-width apart. A partner sits on the subject's shoulders. The athlete performed the maximum number of repetitions possible at a self-determined optimal pace. Measurement was conducted based on the number of completed repetitions. The test was performed only once.

– *Hanging Leg Raises Test*. This test shows the muscular endurance of the core muscles. The subject, starting from a hanging position on a gymnastic wall, performs leg raises until hands can grip the wall. The athlete performed the maximum number of repetitions possible at a self-determined optimal pace. Measurement was conducted based on the number of completed repetitions. The test was performed only once.

– *Bent-Arm Hang Test*. This test determines the static endurance of the arm muscles. The athlete performs a chin-up on a bar and holds the position for the maximum amount of time possible. The duration of maintaining the position was evaluated in seconds as long as the subject's chin remains above the bar, and the stopwatch was started when the independent hanging began. The test was conducted only once. The hanging time is measured with a precision of 0.1 seconds.

The results of the testing at the beginning and end of the study were recorded in a special protocol.

*Statistical Analysis*

*The obtained data were analysed* using the computer software package Statistica 10.0 (StatSoft, Inc., USA) and licensed spreadsheet software Excel (2010). The mean (Mean), standard deviation (SD), and median (Me) were calculated. To present the data distribution, an interquartile range was used, indicating the first quartile (25% percentile) ($Q_1$) and the third quartile (75% percentile) ($Q_3$). The statistical significance of differences was assessed using the Mann-Whitney test (U), with a significance level set at $p<0.05$. The use of non-parametric tests to assess differences between groups is justified by the small sample size and the nature of the data distribution, which deviated from the normal distribution. Non-parametric tests are robust and suitable for analyzing data with non-normal distributions or small sample sizes.

**Results**

The results of the assessment of the level of strength training at the beginning and the end of the pedagogical experiment are presented in Tables 1 and 2.

**Table 1.** *The results of the strength fitness testing at the beginning of the study*

| Tests | Experimental group | | | | | Control group | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Me** | **$Q_1$** | **$Q_3$** | **Mean** | **SD** | **Me** | **$Q_1$** | **$Q_3$** |
| 100 m Sprint Test (s) | 14.14 | 0.46 | 14.25 | 13.90 | 14.47 | 14.01 | 0.79 | 14.35 | 13.45 | 14.57 |
| Push-ups for 20 s (n) | 19.1 | 3.28 | 18.5 | 17.00 | 20.75 | 19.3 | 2.75 | 19.5 | 17.25 | 21.75 |
| Pull-ups for 20 s (n) | 11.2 | 1.62 | 11.0 | 10.25 | 12.00 | 11.3 | 2.58 | 11.0 | 10.00 | 11.75 |
| Sit-ups for 20 s (n) | 14.4 | 2.88 | 14.5 | 12.25 | 16.75 | 15.2 | 3.16 | 15.5 | 13.25 | 16.75 |
| Standing Long Jump (cm) | 199.6 | 11.37 | 201.5 | 191.0 | 207.2 | 197.6 | 16.02 | 201.5 | 188.8 | 209.5 |
| Pull-ups (n) | 17.0 | 3.94 | 16.5 | 14.25 | 18.75 | 16.7 | 3.97 | 15.5 | 14.25 | 18.50 |
| Push-ups (n) | 55.9 | 6.26 | 55.5 | 50.00 | 61.50 | 56.9 | 6.19 | 56.5 | 53.0 | 61.5 |
| Squats with a Partner of Equal Weight (n) | 13.1 | 3.07 | 12.5 | 11.00 | 15.50 | 13.5 | 3.69 | 12.5 | 10.25 | 16.75 |
| Hanging Leg Raises (n) | 14.1 | 4.01 | 14.5 | 10.25 | 17.75 | 13.6 | 4.12 | 11.5 | 10.25 | 17.75 |
| Bent-Arm Hang (s) | 42.7 | 2.75 | 42.0 | 41.00 | 43.75 | 43.5 | 3.03 | 42.5 | 41.25 | 44.75 |

SD – standard deviation, Me – median, $Q_1$ – first quartile, $Q_3$ – third quartile.

**Table 2.** *The results of strength readiness testing at the end of the study*

| Tests | Experimental group | | | | | Control group | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Me** | **$Q_1$** | **$Q_3$** | **Mean** | **SD** | **Me** | **$Q_1$** | **$Q_3$** |
| 100 m Sprint Test (s) | 13.16 | 0.47 | 13.20 | 12.78 | 13.45 | 13.81 | 0.85 | 14.25 | 12.90 | 14.47 |
| Push-ups for 20 s (n) | 22.7 | 3.19 | 22.5 | 20.25 | 25.75 | 19.8 | 2.29 | 20.0 | 18.25 | 21.75 |
| Pull-ups for 20 s (n) | 14.0 | 1.63 | 14.0 | 13.25 | 15.00 | 11.8 | 2.57 | 11.0 | 10.25 | 12.00 |
| Sit-ups for 20 s (n) | 17.9 | 1.19 | 18.0 | 17.25 | 19.00 | 15.7 | 2.98 | 16.0 | 14.25 | 17.00 |
| Standing Long Jump (cm) | 209.1 | 6.40 | 208.0 | 205.5 | 214.8 | 198.6 | 13.93 | 201.5 | 188.8 | 209.5 |
| Pull-ups (n) | 20.1 | 2.47 | 19.5 | 18.25 | 21.00 | 17.1 | 3.57 | 15.5 | 15.00 | 18.50 |
| Push-ups (n) | 61.7 | 2.58 | 62.0 | 59.75 | 63.00 | 57.4 | 5.66 | 56.5 | 53.25 | 61.50 |
| Squats with a Partner of Equal Weight (n) | 16.8 | 2.62 | 16.0 | 15.25 | 18.75 | 13.7 | 3.47 | 12.5 | 11.00 | 16.75 |
| Hanging Leg Raises (n) | 16.7 | 2.04 | 17.5 | 16.25 | 18.00 | 13.9 | 3.84 | 12.0 | 11.01 | 17.75 |
| Bent-Arm Hang (s) | 47.6 | 3.41 | 48.5 | 45.50 | 49.75 | 44.3 | 2.83 | 43.5 | 42.0 | 46.50 |

SD – standard deviation, Me – median, $Q_1$ – first quartile, $Q_3$ – third quartile.

The results of the testing indicate certain dynamics of changes in the indicators obtained during the study. The increase in the strength training results among athletes in the experimental group is significantly higher in all tests, ranging from 4.5% to 22.0%, while in the control group, it is lower, ranging from 0.5% to 3.2% (Figure 1).

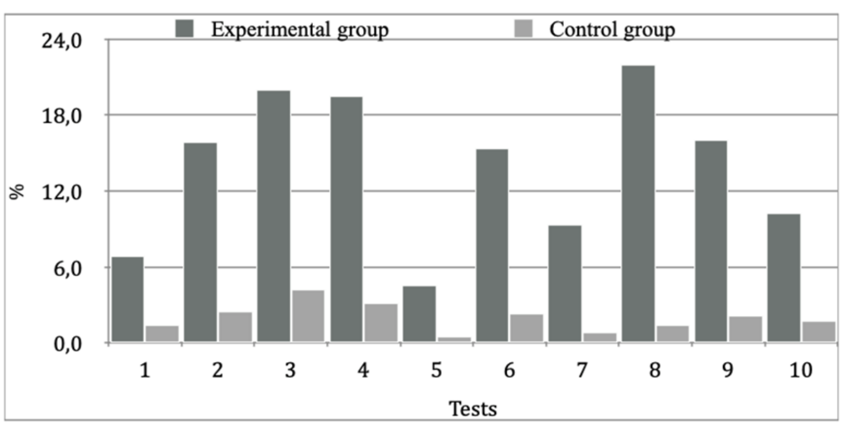


Figure. 1. Dynamics of changes in indicators during the study.

Tests: 1 – 100 m Sprint Test; 2 – Push-ups for 20 s; 3 – Pull-ups for 20 s; 4 – Sit-ups for 20 s; 5 – Standing Long Jump; 6 – Pull-ups; 7 – Push-ups; 8 – Squats with a Partner of Equal Weight; 9 – Hanging Leg Raises; 10 – Bent-Arm Hang

To compare the severity of indicators in two independent samples, the non-parametric statistical Mann-Whitney test was used. The results of comparing the indicators of the experimental and control groups are presented in Table 3.

**Table 3.** *Comparison of strength testing results between groups at the beginning and end of the study*

| Tests | Pre-Test | | Post-Test | |
|---|---|---|---|---|
| | U-test | p-value | U-test | p-value |
| 100 m Sprint Test (s) | 48 | 0.9093 | 27 | 0.08801 |
| Push-ups for 20 s (n) | 45 | 0.7324 | 75 | 0.06272 |
| Pull-ups for 20 s (n) | 55.5 | 0.699 | **81** | **0.01984** |
| Sit-ups for 20 s (n) | 44 | 0.676 | **78.5** | **0.03202** |
| Standing Long Jump (cm) | 51 | 0.9698 | 72.5 | 0.09518 |
| Pull-ups (n) | 53 | 0.8494 | **79** | **0.0302** |
| Push-ups (n) | 45 | 0.7306 | **77** | **0.04298** |
| Squats with a Partner of Equal Weight (n) | 48 | 0.9092 | 75 | 0.06252 |
| Hanging Leg Raises (n) | 51 | 0.9695 | 69 | 0.1566 |
| Bent-Arm Hang (s) | 42 | 0.5666 | **77.5** | **0.04026** |

CI – confidence intervals, statistically significant values are bolded.

Based on the comparison of the results of testing athletes in the experimental and control groups, it can be concluded that at the beginning of the pedagogical experiment, the groups did not have statistically significant differences (U-test, p-value >0.05). At the end of the pedagogical experiment, the results of the athletes in the experimental group improved compared to those in the control group. In 50% of the tests, there were statistically significant differences (U-test, p-value <0.05), specifically in the tests: Pull-ups for 20 s; Sit-ups for 20 s; Pull-ups; Push-ups; Bent-Arm Hang (Table 3).

**Discussion**

The objective of the research was to test the effectiveness of the proposed static-dynamic sets of exercises. An 8-week program was used in the study, which was considered sufficient to improve the level of preparedness of athletes in various sports. For example, Nesen et al. (2018) found that the use of a set of speed-strength exercises on a coordination ladder and with punching balls for 8 weeks increased the technical preparedness of 13-14-year-old handball players.

Branco et al. (2022) studied the effects of an additional strength program on the general and specific physical preparedness of judokas. After 8 weeks of strength training, the results of the general and specific preparedness were significantly better in the experimental group of judokas.

Çakır & Ergin (2022) found that performing basic exercises for agility, explosive strength, and balance, three times a week for 8 weeks, had a positive effect on the agility of young female volleyball players.

Genç & Ciğerci (2020) determined that using plyometric training three times a week for 8 weeks had a positive effect on the motor abilities of 13-14-year-old handball players. Similar research was conducted by Kurniawan et al. (2021) in judo. The authors found that an 8-week plyometric training program with active-passive recovery positively affects the endurance and leg strength of male judokas.

Bayrakdaroğlu et al. (2020) compared the effects of strength, plyometric, and set training methods on the movement speed of combat athletes. After 8 weeks of the proposed training methods, a statistically significant difference was found in the mean velocity (MV), mean propulsive velocity (MPV) and peak velocity (PV) obtained in the loaded-squat jump exercise (p<0,05).

To assess the effectiveness of a developed program, the dynamics of strength indicators were evaluated. This research method is commonly used in sports science. It allowed for the establishment of the efficiency of the developed programs in Greco-Roman wrestling (Tropin et al., 2021), boxing (Bu, 2022), taekwondo (Strelchuk et al., 2022), and wheelchair basketball (Maksym et al., 2018).

The main objective of the experiment was to increase the strength readiness indicators of Brazilian Jiu-Jitsu (BJJ) athletes through the implementation of sets of static-dynamic exercises. Various approaches to increasing strength indicators in BJJ have been previously described. Ovretveit & Toien (2018) identified that maximal strength training was an effective approach to rapidly increasing maximum strength, power, and muscular endurance in BJJ athletes.

Da Silva et al. (2015) developed practical recommendations that would be useful for the strength training of BJJ athletes. These recommendations can be used as a benchmark in diagnosing and developing individual strength programs, as well as for monitoring the load on the upper limb muscles during training periods for BJJ athletes.

Follmer et al. (2021) found that BJJ wrestlers presented greater rapid and maximal strength imbalances at extreme compared to mid-point angles of range of motion. Results may benefit coaches in developing strength exercises focusing on these specific angles to potentially reduce the risk of elbow injury and improve the performance of BJJ wrestlers in competition.

The research procedure involved comparing a control group with an experimental group of Brazilian Jiu-Jitsu athletes, which is a common research design in sports science. Manolachi et al. (2022) identified the most effective strength fitness program for preparing female athletes for hand-to-hand combat by comparing the results of two groups in a pedagogical experiment. This program is expected to enhance athletes' adaptive reserves and level of preparation.

Podrihalo et al. (2023) compared the results of taekwondo athletes of different ages using the tapping test. Therefore, athletes were divided into three age groups. The results of the tapping test were directly related to the athletes' age, indicating an increase in the strength of nervous processes among older athletes due to regular training.

Okun et al. (2020) conducted a study that revealed differences in anthropometric measurements of girls aged 9-12 who practised canoe slalom and kayaking. The results of the study indicated that kayak girls had advantages in most measurements compared to their peers who practised canoeing, although the differences between them were minor.

Podrihalo et al. (2021) performed a comparative analysis of morpho-functional characteristics and somatotype features of arm wrestling and weightlifting athletes. Specific somatotype features important for improving the level of expertise in these sports were identified. Grip strength in static and dynamic modes was found to be a predictor of success in these sports. The authors proposed using these indicators for monitoring the functional state of athletes.

Sadeghipour et al. (2021) conducted a study on the effects of WB-EMS training and resistance training on body composition and maximal strength in trained women. The participants were divided into three groups: the first experimental group performed WB-EMS training, the second experimental group performed resistance training, and the third control group did not receive any intervention. The results showed that both types of training could improve maximal strength, although each type of training had its advantages.

Piatysotska et al. (2023) investigated differences in psychomotor abilities among athletes of cyclic sports (short track), combat sports (karate, taekwondo), and e-sports. It was found that e-sports athletes had significantly better choice reaction time ($p<0.05$) than combat sports athletes. The results of short-track speed skaters did not differ significantly from combat sports athletes and e-sports athletes ($p>0.05$). In the tapping test, the total number of movements and the average number of movements in 5 seconds tended to be higher in e-sports athletes compared to short-track speed skaters and combat sports athletes. Combat sports athletes showed the fastest reaction time to changes in the size of objects in the Size-test, while short-track speed skaters showed the slowest reaction time. These findings suggested a trend towards better results in this type of reaction among combat sports athletes compared to short-track speed skaters and e-sports athletes.

Wąsacz et al. (2022) conducted a comparison of the physical fitness profiles of athletes in Thai boxing and Brazilian Jiu-Jitsu. The study determined that athletes in Brazilian Jiu-Jitsu demonstrated better results in strength tests, including static strength, relative strength, shoulder girdle strength, and functional strength. For abdominal strength endurance, push-ups, back muscle strength, barbell squats, and barbell bench press, higher but insignificant differences were observed in the BJJ group. There were no differences between the groups in static balance, simple reaction time to a visual stimulus, trunk flexibility, explosive strength of lower limbs, and the resulting index of maximum anaerobic work and agility test results.

The results of the study indicated that the experiment had a positive impact on the level of strength training in the experimental group. Significant improvements were observed in tests assessing the condition of the abdominal and shoulder muscles ($p<0.05$). Shoulder muscle strength was essential for an athlete to win in Brazilian Jiu-Jitsu, which was consistent with previously obtained results (da Silva et al., 2015; Wąsacz et al., 2022; Lopes-Silva et al., 2022).

Recent studies have shown that strength training influences the success of combat athletes in competition. Ambroży et al. (2021) found that Brazilian Jiu-Jitsu athletes with higher strength training were more active and effective in attack. Specific strength indicators showed a significant correlation with technical-tactical parameters.

Korobeynikov et al. (2023) determined that the ability to perceive and process external information during a fight was the basis of a boxer's strength qualities. Elite boxers with high levels of special work capacity had a higher speed of verbal information recall, which positively impacted the course of the fight.

Manolachi et al. (2022) revealed that accelerated growth of the functional capabilities of mixed martial arts (MMA) athletes was observed during high-intensity strength training under anaerobic alactic energy supply conditions. The use of this type of strength training was supposed to strengthen the adaptation reserves of athletes during the specialized basic training phase. These changes in performance indicators would also improve the strength training of MMA fighters in the shortest possible time, which was of great importance in preparing them for competitions.

Almeda et al. (2023) found that Brazilian Jiu-Jitsu athletes who placed greater emphasis on developing strength and power in their training process and had greater experience with resistance training consistently demonstrated better performance in competitive activities.

In conclusion, it can be said that an athlete with a high level of strength training is more successful and efficient in performing technical-tactical actions in competitions (da Silva et al., 2022; Párraga Montilla et al., 2022; Wasik et al., 2023). Additionally, strength training is effective in protecting against injuries commonly associated with contact sports (Ambroży et al., 2022; Follmer et al., 2021).

**Conclusion**

The study examined the effectiveness of incorporating static-dynamic exercises into the training regimen of elite Brazilian jiu-jitsu athletes. The research spanned eight weeks. The results indicated that the inclusion of static-dynamic exercises has been found to promote an increase in strength performance indicators among elite Brazilian Jiu-Jitsu athletes. The experimental group demonstrated increasing strength performance results ranging from 4.5% to 22.0%, while the control group showed an increase ranging from 0.5% to 3.2%. The obtained results will not only substantiate the inclusion of these exercise routines in the training programs of Brazilian jiu-jitsu athletes but also develop recommendations for their optimal use to achieve the best athletic performance in other types of martial arts.

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