

**National Sports Academy**

**“Vassil Levski”**

Department of Tourism, Mountaineering and Orienteerin



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## **CONDITIONING TRAINING IN SPORT CLIMBING**

### **ABSTRACT**

Sofia, 2025г.

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**CONDITIONING TRAINING IN SPORT CLIMBING**

**ABSTRACT**

of a dissertation submitted for the award of the educational and scientific degree  
**“Doctor” (PhD)** Scientific specialty: **Theory and Methodology of Sport Science**  
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The dissertation was discussed and approved for public defense by the Department of Tourism, Mountaineering and Orienteering.

The dissertation is presented in a total volume of 391 standard pages, of which 221 pages comprise the main body of the work and 170 pages include appendices. The author references 163 sources in printed and electronic form. In the bibliography, these sources are differentiated and classified into two main groups: authors in Cyrillic and Latin scripts (112 sources) and a second group comprising 51 online sources.

The theoretical and analytical sections of the dissertation are accompanied by 57 tables (predominantly containing mathematical and statistical numerical data) and 60 figures presenting various graphical visualizations.

The numbering of tables and figures in the abstract corresponds exactly to that in the dissertation.

The public defense of the dissertation will take place on February 18. 2025. at 1:00 PM, in Hall A3 of the National Sports Academy “Vassil Levski”, Studentski Grad, Sofia.

## **1. GENERAL CHARACTERISTICS OF THE DISSERTATION**

The dissertation is devoted to the study of **conditioning training in sport climbing**—a contemporary and dynamically developing sports discipline that requires the integrated development of physical, technical, and psychological qualities. In the context of the growing popularity of sport climbing and its establishment as an Olympic sport, the need for scientifically grounded and practically applicable training models for athletes has become particularly significant.

The study examines the theoretical foundations of conditioning training, the specifics of motor activity in sport climbing, and the possibilities for targeted influence on the main physical and psychological qualities through a systematized training process. Special emphasis is placed on the development and experimental validation of a specialized training program adapted to the specific requirements of the sport and to the individual characteristics of the participants.

## **2. RELEVANCE OF THE PROBLEM**

The relevance of the present research is determined by the increasing demands on the physical and psychological preparedness of climbers, as well as by the limited number of systematized scientific studies in Bulgarian practice specifically addressing conditioning training in sport climbing. In training practice, the application of empirical approaches or models borrowed from other sports is frequently observed, often without sufficient consideration of the specific characteristics of climbing activity.

The lack of comprehensive and long-term conditioning programs combined with objective and subjective monitoring of training effects necessitates the conduct of targeted scientific research in this field. The present dissertation responds to these needs by offering a scientifically substantiated and practically.

## **3. INTRODUCTION**

Sport climbing has established itself as a contemporary and dynamically developing sports discipline that requires a high level of comprehensive preparation, integrating physical, technical, tactical, and psychological components. In recent years, the sport has experienced significant growth both in terms of mass participation and

competitive activity, which necessitates continuous improvement of the training models and methodologies applied in the preparation of climbers.

Conditioning training occupies a central role in the training process, as it forms the foundation for the effective acquisition of technical skills, stable performance under competitive conditions, and the reduction of injury risk. The specific characteristics of motor activity in sport climbing require targeted development of strength, strength endurance, coordination, flexibility, and psychological resilience, with these qualities developed in close interdependence.

Despite the growing interest in sport climbing, training practice often relies on empirical approaches or models borrowed from other sports that do not sufficiently account for the specific demands of climbing activity. This situation highlights the need for scientifically grounded research aimed at the development and validation of specialized conditioning training programs adapted to both the requirements of the sport and the individual characteristics of athletes.

The present dissertation is focused on exploring the possibilities for optimizing conditioning training in sport climbing through the application of a systematized and purposefully designed training process. By developing, implementing, and experimentally validating a specialized conditioning training program, the study seeks to enhance training effectiveness and contribute to the expansion of scientific knowledge in this field.

#### **4. WORKING HYPOTHESIS**

It is hypothesized that the development and application of a conditioning training program for sport climbing, tailored to the individual characteristics of climbers and the specific requirements of competitive disciplines, will contribute to the achievement of integrated conditioning preparedness, thereby ensuring progress in technical, tactical, and psychological training.

## **5. AIM, OBJECTIVES, OBJECT, AND SUBJECT OF THE STUDY**

### **5.1. Aim of the Study**

The aim of the study is to experimentally establish the effectiveness of an original and innovative conditioning training program designed for advanced climbers engaged in competitive activity.

### **5.2. Objectives of the Study**

To achieve the stated aim, the following main objectives were formulated:

1. To conduct an informational review of specialized sources, including scientific literature and online resources, and, on the basis of a focused theoretical analysis, to clarify the essence of the scientific problem related to conditioning training in sport climbing and to formulate the research hypothesis.
2. To specify the methodological constructs and the conceptual framework of the dissertation research. Within this context, to develop an original specialized conditioning training program for climbers according to their competitive orientation.
3. To examine climbers' attitudes and motivation for participation in the sport-pedagogical experiment, as well as their evaluation of the applied innovative conditioning training program.
4. To create the necessary conditions and resources for the experimental implementation of the original conditioning training program.
5. To construct the research instrumentation (methodology) of the study.
6. To analyze the results of the empirical research and to provide an assessment of their significance.

### 5.3. Subject, Object, and Research Contingent

**Subject of the study** - The subject of the study is the integrated impact on the conditioning preparedness of competitive sport climbers through a specialized and innovative conditioning training program.

**Object of the study** - The object of the study comprises the preliminary attitudes, motivation, and expectations of climbers regarding the proposed paradigm of programmed conditioning training, as well as the dynamics of quantitative indicators used to monitor and assess changes in the physical and functional preparedness of participants in the sport-pedagogical experiment.

**Research contingent** - The research contingent includes a total of **46 advanced climbers** with systematic training experience (four training sessions per week), distributed into four groups as follows:

- Control Group – Men (CG-M): 12 participants
- Control Group – Women (CG-W): 11 participants
- Experimental Group – Men (EG-M): 12 participants
- Experimental Group – Women (EG-W): 11 participants

All participants had prior training experience and a high level of sports qualification.

### 5.4. Specialized conditioning training program for advanced climbers

**Purpose of the Program** - The presented conditioning training program is designed for **advanced climbers** engaged in systematic training activity but not involved in a structured competitive calendar. Its primary objective is to support the development of both general and sport-specific physical qualities necessary for effective and safe participation in sport climbing.

The program was implemented within the framework of an experimental study involving two groups:

- an **experimental group**, which trained according to the newly developed conditioning program, and

- a **control group**, which followed an independent training plan based on the *Methodological Guide to Mountaineering for Sports Schools and Clubs* (Malchev, 1985), with an emphasis on general physical preparation.

The training program was tailored to the age-related and functional characteristics of the participants, as well as to the specific demands of climbing as a sport characterized by complex motor requirements. To monitor training effectiveness, **pre- and post-testing**, **questionnaire surveys**, and a **training diary** were employed.

**Structure and Periodization:** The experimental conditioning training program was organized into **two macrocycles** with a total duration of **27 weeks**. Each macrocycle included mesocycles and microcycles structured in accordance with the principles of training periodization. The main objective was to ensure progressive loading, adaptation, and sustainable development of conditioning qualities essential for sport climbing.

The program was designed to promote comprehensive development of motor and psychophysical qualities. Within each weekly cycle, training focused not only on strength, endurance, and agility, but also on speed, explosive power, flexibility, coordination, balance, precision, and reaction speed. These qualities were developed through purposefully selected exercises incorporated into the training plans and described in detail in **Appendix 2**.

**Table 2. Structure and Periodization of the Experimental Conditioning Training Program**

Training Stage	Weeks	Cycle Type	Primary Focus
□ <b>Baseline Assessment</b>	1	Microcycle	Testing and questionnaire survey – data collection
□ <b>First Macrocycle</b>	Weeks 2–13	3 Mesocycles	Comprehensive development of basic and specific conditioning
□ First Mesocycle	Weeks 2–5	4 Microcycles	General and specific conditioning – development of strength, flexibility, and explosive power
□ Second Mesocycle	Weeks 6–9	4 микроцикъла	Specific endurance, strength, and agility – targeted development



□ <b>Third Mesocycle</b>	Weeks 10–13	4 Microcycles	Combined development and consolidation of motor qualities through complex loading
□ <b>Transition Week</b>	Week 14	Microcycle	Recovery, flexibility, psychological resilience
□ <b>Second Macrocycle</b>	Weeks 15–26	3 Mesocycles	Repetition of structure with increased intensity and volume
□ <b>Final Assessment</b>	Week 27	Microcycle	Final testing and questionnaire survey – evaluation of program effects

For ease of interpretation, a color-coding system was used in the original table to denote different stages and their functional orientation. The explanation of the color codes is presented below.

### Legend (Color Coding of Training Stages)

- □ **Baseline / Final Assessment** – testing and questionnaires
- □ **First Macrocycle** – comprehensive development of basic and specific conditioning
- □ **Basic Conditioning** – moderate load, foundation building
- □ **Specific Conditioning** – targeted development of key qualities.
- □ **Combined Development** – complex loads and consolidation
- □ **Transition Week** – recovery and psychological adaptation.
- □ **Second Macrocycle** – repetition with progression.
- □ **Final Summary** – data collection and evaluation

## 6. METHODS AND ORGANIZATION OF THE STUDY

The study was conducted with the participation of an **experimental group** and a **control group**, with the training process organized within the framework of a long-term macrocycle structured into mesocycles and microcycles. To assess the effectiveness of the conditioning training program, **anthropometric, functional, and**

**sport-specific tests** were applied, alongside **questionnaire-based methods** aimed at monitoring participants' motivation, self-assessment, and psychological resilience.

The collected data were processed using appropriate statistical methods, enabling an objective evaluation of observed changes and comparisons between the groups.

### **Field Testing – Test Battery**

In order to ensure an objective assessment of the program's effectiveness, a test battery was applied, comprising **validated anthropometric measurements** and **functional tests specific to sport climbing**. Testing was conducted in two stages—**baseline (Week 1)** and **final (Week 27)**—in compliance with standardized requirements.

The test battery included measurements of **seven anthropometric indicators** and **twelve functional tests** specific to sport climbing (see Tables 4 and 5).

Testing was carried out under standardized protocols and conditions, ensuring **reliability, repeatability, and safety**.

All tests were conducted in a controlled environment. The results were recorded in individual protocols and subjected to statistical analysis. Graphs, tables, and photographic materials were used to visualize the data and facilitate interpretation by specialists.

## **7. MAIN RESULTS OF THE STUDY**

The analysis of the experimental data indicates that the implementation of the developed specialized conditioning training program in sport climbing led to **positive and statistically significant changes** in the examined indicators among participants in the experimental group.

The most substantial improvements were observed in indicators related to **sport-specific upper-limb strength, strength endurance, and coordination**, which are of direct importance for the effective execution of climbing movements. Concurrently, positive dynamics were recorded in **general physical fitness**, reflected in improvements in flexibility, speed, and agility.

**Table 57. Statistical Significance of Changes by Tests (*Student's t-test*)**

<b>№</b>	<b>Test (Full Name)</b>	<b>Group</b>	<b>Sex</b>	<b>d%</b>	<b>t</b>	<b>P(t)</b>	<b>Significance</b>
1	Standing forward bend depth	EG	M	1.48	3.99	99.79%	✓
1	Standing forward bend depth	EG	F	2.30	4.72	99.94%	✓
2	Measurement of isotonic grip strength using a dynamometer	EG	M	5.46	4.31	99.88%	✓
2	Measurement of isotonic grip strength using a dynamometer	EG	F	4.35	1.03	67.54%	✗
3	Maximal isotonic elbow flexion with additional weight	EG	M	14.52	4.10	99.82%	✓
3	Maximal isotonic elbow flexion with additional weight	EG	F	11.83	8.86	100.00%	✓
4	Isotonic lat pull-down with maximal load	EG	M	15.08	5.90	99.99%	✓
4	Isotonic lat pull-down with maximal load	EG	F	10.29	2.93	98.64%	✓
5	Number of movements on a fixed climbing route	EG	M	24.03	5.18	99.97%	✓
5	Number of movements on a fixed climbing route	EG	F	10.96	5.98	99.99%	✓
6	Time to complete a random route (“spray wall”)	EG	M	5.23	7.27	100.00%	✓
6	Time to complete a random route (“spray wall”)	EG	F	16.53	6.01	99.99%	✓
7	Time to complete a fixed route on a climbing wall	EG	M	13.09	7.19	100.00%	✓
7	Time to complete a fixed route on a climbing wall	EG	F	11.79	2.22	95.15%	✓

8	Isometric hold in the “full lock-off” position	EG	M	5.15	6.43	100.00%	✓
8	Isometric hold in the “full lock-off” position	EG	F	13.37	6.77	100.00%	✓
9	Isometric hold in a neutral position (dead hang)	EG	M	3.98	5.64	99.98%	✓
9	Isometric hold in a neutral position (dead hang)	EG	F	15.52	8.88	100.00%	✓
10	Isometric hold on a climbing edge – 20 mm	EG	M	7.21	6.62	100.00%	✓
10	Isometric hold on a climbing edge – 20 mm	EG	F	14.88	12.34	100.00%	✓
11	Isometric hold on a spherical grip (“sloper ball”)	EG	M	7.33	5.67	99.99%	✓
11	Isometric hold on a spherical grip (“sloper ball”)	EG	F	12.20	4.96	99.96%	✓
12	Maximum number of pull-ups from a dead hang	EG	M	8.62	5.12	99.97%	✓
12	Maximum number of pull-ups from a dead hang	EG	F	26.92	5.90	99.99%	✓

In order to more clearly identify the indicators most strongly affected by the experimental conditioning training program, the results were systematized into **three thematic domains**, corresponding to the functional orientation of the applied tests. Although this grouping does not represent a statistical factor analysis in the strict sense, it serves as an analytical synthesis highlighting the program’s impact on the core components of climbing performance.

The structure of the analysis is based on the objectives of the tests as defined in the methodology and includes the following domains:

## 7.1 Isometric Holding and Control

This domain includes tests assessing **static strength, holding capacity, and control in climbing-specific positions.**

**Table 58. Isometric Holding and Control – Degree of Improvement (d%)**

№	Test	EG – Men (d%)	EG – Women (d%)
8	Isometric hold in the “full lock-off” position	5.15%	13.37%
9	Isometric hold in a neutral position (dead hang)	3.98%	15.52%
10	Isometric hold on a climbing edge – 20 mm (“edge hang”)	7.21%	14.88%
11	Isometric hold on a spherical grip (“sloper ball”)	7.33%	12.20%

## 7.2 Strength Dynamics and Pulling Movements

This domain comprises tests evaluating **active strength, maximal effort, and movement repeatability.**

**Table 59. Strength Dynamics and Pulling Movements – Degree of Improvement (d%)**

№	Test	EG – Men (d%)	EG – Women (d%)
3	Maximal isotonic elbow flexion with additional weight	14.52%	11.83%
12	Maximum number of pull-ups from a dead hang	8.62%	26.92%
4	Isotonic lat pull-down with maximal load	15.08%	10.29%

### 7.3 Climbing-Specific Performance and Route Work

This domain includes tests assessing **efficiency in route completion and sport-specific endurance**.

**Table 60. Climbing-Specific Performance and Route Work – Degree of Improvement (d%)**

<b>№</b>	<b>Test</b>	<b>EG – Men (d%)</b>	<b>EG – Women (d%)</b>
7	Time to complete a fixed route on a climbing wall	13.09%	11.79%
6	Time to complete a random route (“spray wall”)	5.23%	16.53%
5	Number of movements on a fixed climbing route	24.03%	10.96%

The results reveal significant improvements in both time-based and movement-based route tests. Participants from the experimental group demonstrated faster route completion times and a higher number of effective movements on fixed climbing routes. These changes reflect improved movement economy, coordination, and sport-specific endurance.

#### Visual Summary of Results

For a visual synthesis of the results, **Figure 29** presents a grouped bar chart illustrating the degree of improvement (d%) by sex and thematic domain.

### Thematic Domains of the Most Strongly Affected Indicators:

1. Isometric holding and control;
2. Strength dynamics and pulling movements;
3. Climbing-specific performance and route work.

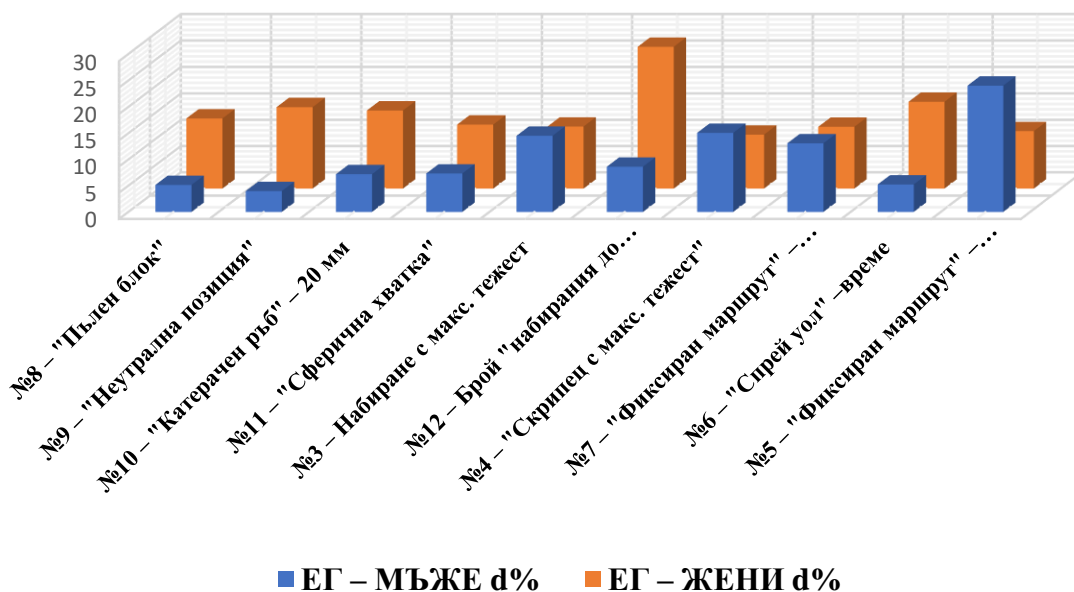


Figure 29. Indicators Most Strongly Affected, Grouped by Thematic Domains

*English translation:*

### Test Labels

- No. 8 – Full lock-off
- No. 9 – Neutral position (dead hang)
- No. 10 – Climbing edge – 20 mm
- No. 11 – Spherical grip
- No. 3 – Pull-ups with additional weight
- No. 12 – Maximum number of pull-ups
- No. 4 – Lat pull-down (maximal load)
- No. 7 – Fixed route – time
- No. 6 – Spray wall – time
- No. 5 – Fixed route – number of movements

The visualization confirms the analytical conclusions derived from the Student's t-test and thematic grouping. Clear dominance is observed in improvements related to **isometric holding, strength dynamics, and route-specific performance**. Among

women in the experimental group, particularly pronounced progress was observed in tests related to endurance and control during hanging positions, indicating effective adaptation to the specific demands of climbing activity. Among men, significant improvements were recorded in maximal strength, number of movements per route, and explosive pulling strength, reflecting effective development of force-related components critical for competitive climbing.

The control group also exhibited certain positive changes; however, these were characterized by lower statistical significance and smaller magnitudes of improvement. This further emphasizes the role of the experimental conditioning training program as the primary factor underlying the observed results.

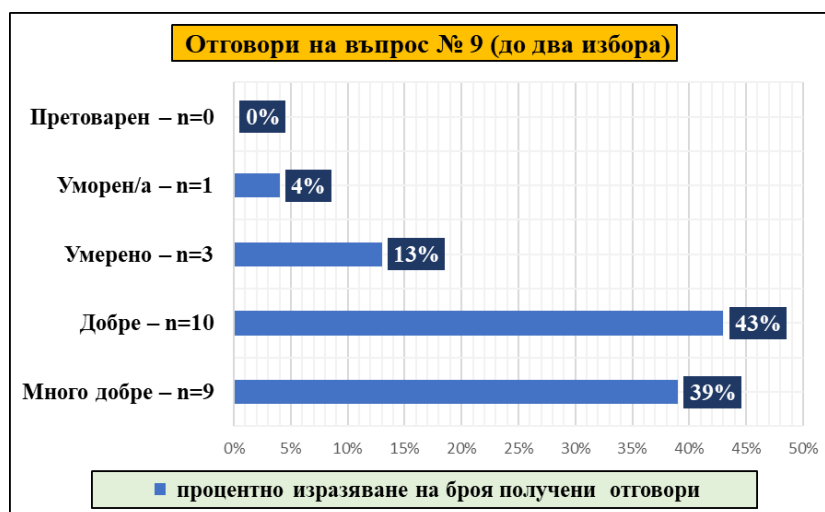
The results of the questionnaire survey complement the objective test data by revealing changes in **motivation, self-assessment, and perceived effectiveness of the conditioning training program** among the participants. While the questionnaire data are predominantly subjective in nature, their value within the context of the present study is substantial.

### **Perception of the Program and Final Feedback (Experimental Group Only)**

This section of the questionnaire was aimed at assessing the perceived impact of the experimental conditioning training program, as well as participants' subjective impressions regarding its content, intensity, and overall effectiveness. The control group did not complete this section, as its members trained according to a standard program based on the methodology of Malchev, traditionally applied in sports schools.



***Question No. 9: How did you feel physically during the program?***



***Fig, 51. Physical Perception During the Program(Experimental Group Only)***

***English translation:***

**Responses to Question No. 9 (up to two choices allowed)**

*Overloaded* –  $n = 0$       0%  
*Fatigued* –  $n = 1$       4%  
*Moderate* –  $n = 3$       13%  
*Good* –  $n = 10$       43%  
*Very good* –  $n = 9$       39%

## Legend

**Question No. 10: What improvements did you notice? (Select up to two options)**



**Fig. 52. Perceived Improvements (Experimental Group Only)**

**English translation:**

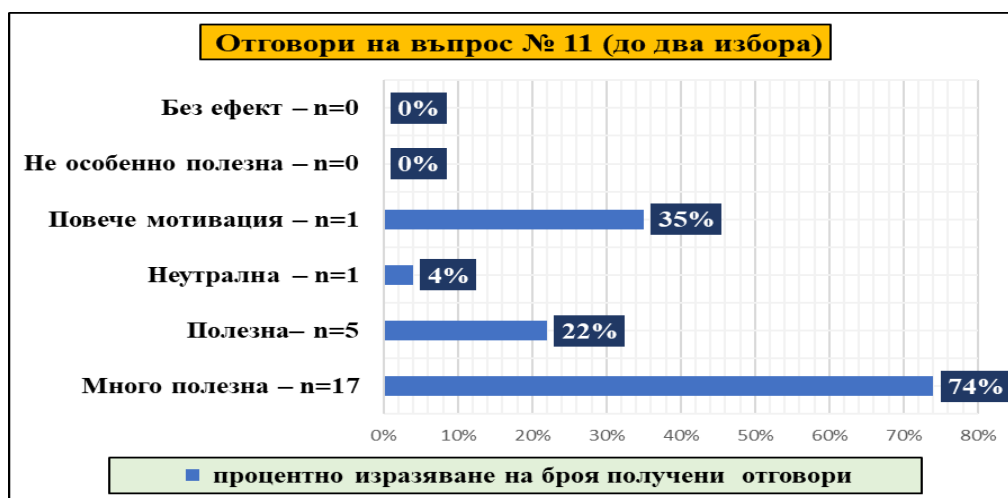
**Responses to Question No. 10 (up to two choices allowed)**

No noticeable changes –  $n = 1$  4%  
Improved flexibility –  $n = 6$  26%  
Increased motivation –  $n = 8$  35%  
Improved endurance –  $n = 11$  48%  
Improved technique –  $n = 12$  52%  
Increased strength –  $n = 15$  65%

## Legend

*Percentage distribution of the number of responses received*

**Question No. 11: How do you evaluate the conditioning training program overall?**



**Fig. 53. Overall Evaluation of the Program – Experimental Group**

**English translation:**

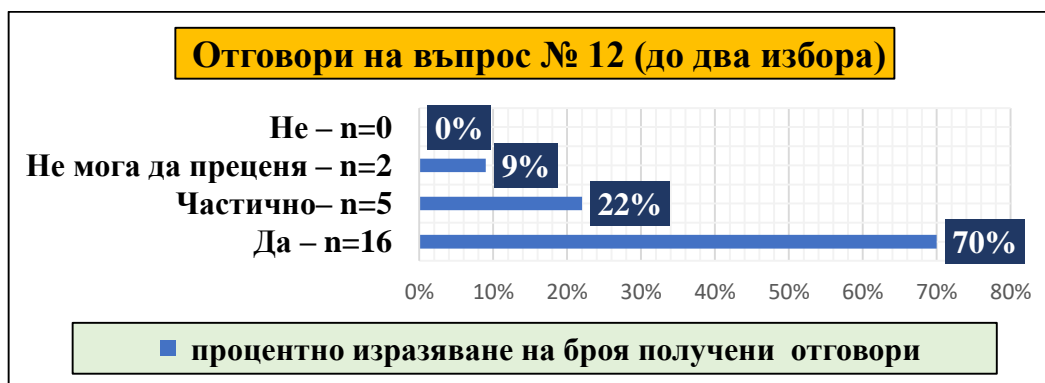
**Responses to Question No. 11 (up to two choices allowed)**

No effect –  $n = 0$       0%  
Not particularly useful –  $n = 0$       0%  
Increased motivation –  $n = 1$       35%  
Neutral –  $n = 1$       4%  
Useful –  $n = 5$       22%  
Very useful –  $n = 17$       74%

**Legend**

*Percentage distribution of the number of responses received*

**Question No. 12: Do you consider that the program helped you improve your climbing performance?**



**Fig. 54. Subjective assessment of the effect on performance in the experimental group**

**English translation:**

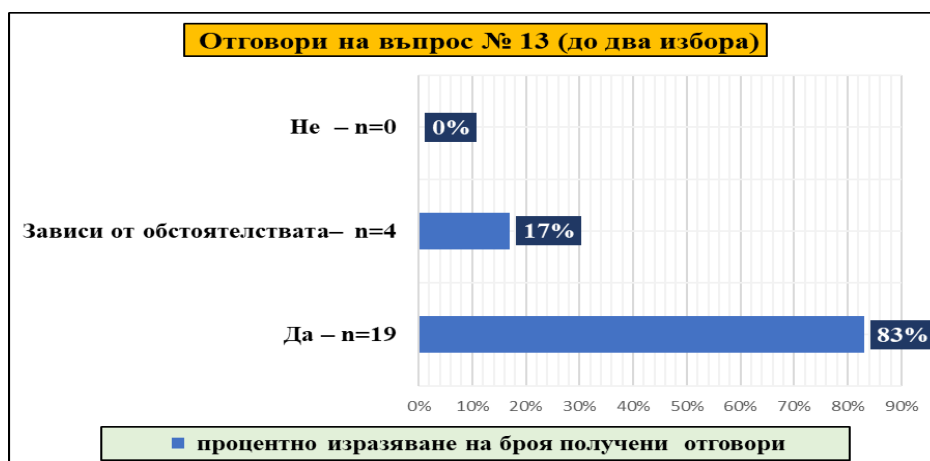
**Responses to Question No. 12 (up to two choices allowed)**

No – n = 0      0%  
 Unable to assess – n = 2      9%  
 Partially – n = 5      22%  
 Yes – n = 16      70%

**Legend**

Percentage distribution of the number of responses received

**Question 13: Would you participate again in a similar program?**



**Fig. 55. Willingness to participate again – experimental group**

### ***English translation:***

#### **Responses to Question 13 (up to two choices)**

Distribution of responses to the question “Would you participate again in a similar program?” among participants:

- *No – 0% (0 participants)*
- *Depends on the circumstances – 17% (4 participants)*
- *Yes – 83% (19 participants)*

#### ***Legend***

*Percentage distribution of the number of responses received*

Although the survey primarily provides subjective data, its value in the context of the present study is significant. Self-assessments, motivational attitudes, and perceptions of the program outline trends that complement the objective results and reveal additional aspects of its effectiveness. The observed consistency between internal experience and external indicators among participants in the experimental group suggests that the program affects not only the physiological but also the psychophysiological level. These observations will be discussed in the context of functional and specific outcomes in the next section.

The comparative analysis between the experimental and control groups confirms the effectiveness of targeted conditioning training based on a systematic structure and controlled load.

Analysis of the baseline values shows that the experimental and control groups are comparable in height and body mass, both for men and women. The differences between the mean values are statistically insignificant, confirming the homogeneity of the initial sample and the validity of subsequent comparisons.

- For men, the average height is approximately 178–180 cm, and body mass is around 72–74 kg.
- For women, the average height is around 165–167 cm, and body mass is around 58–60 kg.
- BMI values fall within the normal weight range, without extremes or risk deviations.

## **Changes Following the Training Program**

After the completion of the program, minimal changes in body mass and BMI were observed, which are not statistically significant but are physiologically explainable:

- In men from the experimental group, a slight increase in body mass was recorded (on average +0.8 kg), which can be interpreted as muscle hypertrophy resulting from the strength components of the program.
- In women, body mass remained stable, but there was a slight decrease in BMI, which may be associated with improved physiological proportion—reduction in fat mass and increase in muscle tone.

Although statistically minor, the observed anthropometric changes have functional significance, particularly in a sport like climbing, where the ratio of strength to body mass is critical.

- The slight increase in body mass among men in the experimental group, combined with improvements in strength parameters, suggests muscular adaptation rather than fat accumulation.
- The stability of body mass in women, combined with improvements in isometric endurance, indicates a qualitative change in body composition without unnecessary load on the musculoskeletal system.

The results confirm the effectiveness of the program while maintaining stable anthropometric indicators—a key factor in strength-oriented sports.

## **Discussion of functional and sport – specific test resault**

The results obtained from the functional and sport-specific tests, presented in Section 5, demonstrate a clearly expressed positive dynamic in the experimental group, both among men and women. The purpose of this discussion is to synthesize these findings, interpret them in the context of the applied conditioning training program, and identify the key trends that emerged.

### **Strength Indicators and Isometric Endurance**

Tests assessing **isotonic strength** (weighted pull-ups, lat pull-down, grip strength) revealed statistically significant improvements in the experimental group, particularly among male participants. These results indicate effective development of maximal and submaximal force production capacities.

Among women, although baseline values were lower, a higher relative percentage of improvement was observed, suggesting efficient adaptation to the applied training stimuli.

The **isometric endurance tests** (full lock-off, neutral hanging position, edge hold, spherical grip hold) demonstrated the highest levels of statistical significance. This confirms that the program was particularly effective in developing **static endurance**, a key performance factor in sport climbing, where prolonged holding of demanding positions is frequently required.

### **Climbing-Specific Route Performance**

Tests related to **number of movements** and **time required to complete routes** showed significant improvements in the experimental group, with especially pronounced effects among female participants.

In male climbers, greater variability was observed; nevertheless, the changes remained statistically significant. The improvements in time-based tests (spray wall and fixed route) indicate enhanced **movement organization, efficiency, and motor economy**, which are directly associated with improved climbing performance.

### **Comparison Between Experimental and Control Groups**

The aggregated results of the functional and sport-specific tests indicate that:

- The **experimental group (EG)** achieved greater improvements across all major indicators, particularly in isometric endurance, climbing-specific efficiency, and dynamic pulling strength.
- The **control group (CG)** also demonstrated positive trends; however, these were characterized by smaller magnitudes of change and fewer statistically significant results.

These findings confirm that the conditioning training program represents the primary factor contributing to the observed improvements, rather than nonspecific effects of time or general training activity.

### **Differences between Men and Women**

Among male participants, improvements were most pronounced in **strength-related tests**, including weighted pull-ups, lat pull-downs, and isometric holding.

Among female participants, despite lower baseline values, a higher relative percentage of improvement was observed, particularly in **endurance-related and climbing-specific efficiency tests**.

These findings suggest that the conditioning training program is both **effective and adaptable to different physiological profiles**, stimulating progress in athletes with a predominant strength orientation as well as in those with greater endurance capacities.

### **Indicators with the Strongest Effect**

The indicators showing the strongest effects include:

- Isometric holds on edges, spherical grips, and in neutral hanging positions—exhibiting the highest t-values and P(t) significance levels, with clear differences between the experimental and control groups.
- Number of pull-ups and weighted pull-ups—reflecting combined strength and endurance adaptations.
- Time required to complete climbing routes—indicating improved motor economy and technical efficiency.

### ***Questionnaire Survey – Interpretation in the Context of the Results -***

The questionnaire results, presented in Section 6, complement the objective test data by providing insight into **psychophysiological aspects**, including motivation, self-assessment, and perception of the training program.

***Perceived Progress*** - Participants from the experimental group reported clear improvements in strength, endurance, and psychological resilience, consistent with the outcomes of the functional and sport-specific tests. The control group reported more moderate improvements without a clearly defined dynamic.

***Motivation and Satisfaction*** - Intrinsic motivation dominated among experimental group participants, expressed through challenge, self-realization, and personal development. In contrast, social and recreational motives were more prevalent in the control group. These differences align with the structure of the training programs and help explain variations in engagement levels.

***Self-Assessment of Physical Fitness*** - Self-assessments related to strength, endurance, agility, and psychological resilience increased significantly in the experimental group, particularly among participants achieving the highest results in isometric endurance tests. The control group demonstrated more moderate increases without a clear correlation to objective test outcomes.



***Perceived Difficulty and Effectiveness of the Program*** - Participants from the experimental group evaluated the program as **useful and effective**, without experiencing excessive overload. Most expressed willingness to participate again, indicating high acceptance and strong intrinsic motivation.

***Consistency between Subjective and Objective Results*** - A high degree of consistency was observed between subjective self-assessments and objective performance outcomes in the experimental group, confirming the program's effectiveness on both physiological and psychological levels. In the control group, certain discrepancies were noted, suggesting the need for additional support and individualized feedback.

## 8. CONCLUSIONS

Based on the theoretical analysis, the methodologically sound training program, and the results of the experimental study, the validity of the research hypothesis is confirmed: **the original conditioning training program, comprising 124 specialized exercises, leads to statistically significant improvements in motor performance indicators among advanced sport climbers.**

The main conclusions of the study are as follows:

1. The experimental group (EG) demonstrated more pronounced positive changes across all major indicators compared to the control group (CG), which trained according to a standard methodology.
2. The most strongly affected indicators were those related to **isometric endurance** (edge hanging, spherical grip holding, neutral hanging position) and **isotonic strength** (weighted pull-ups and lat pull-down).
3. Tests related to route movement and route completion time showed improved motor coordination and performance stability, reflecting the effectiveness of the program under real climbing conditions.
4. Female participants exhibited a higher relative percentage of positive change, particularly in coordination and sport-specific endurance tests, indicating that the program is well suited to different levels of preparedness and individual characteristics.
5. Anthropometric indicators remained stable, with no significant changes in body mass or BMI, confirming that the program is physiologically balanced and does not lead to undesirable body composition changes.
6. The questionnaire survey revealed a high level of subjective satisfaction, motivation, and positive self-assessment among participants in the

experimental group, consistent with the objective test results. This indicates that the program is effective in both physical and psychological dimensions.

7. The methodological structure of the program—featuring clearly defined macrocycles, mesocycles, and microcycles—ensures progressive loading, adaptation, and sustainable development, in accordance with the principles of sports planning and training periodization.

## **9. CONTRIBUTIONS**

### **9.1. Scientific Contributions**

1. A systematic theoretical analysis of contemporary concepts and approaches to conditioning training in sport climbing was conducted, synthesizing and critically evaluating data from Bulgarian and international scientific literature on the development of sport-specific physical and psychological qualities in climbers.
2. A comprehensive research model for assessing conditioning preparedness in sport climbing was developed, incorporating anthropometric, functional, sport-specific motor, and psycho-subjective indicators, enabling holistic and objective evaluation of training effects.
3. Statistically significant changes were established in key physical qualities (strength, endurance, flexibility, agility, speed, and coordination), as well as in sport-specific performance indicators directly related to sport climbing, following the implementation of the developed training program.
4. The effectiveness of targeted conditioning training on psychological resilience, motivation, and subjective evaluation of the training process was demonstrated through comparative analysis between the experimental and control groups.
5. Relationships between the applied structure of the training process (macro-, meso-, and microcycles) and the dynamics of adaptive responses in climbers were identified, contributing to a deeper understanding of conditioning preparation in this sport.

### **9.2. Scientific and Applied Contributions**

1. A specialized long-term conditioning training program for sport climbing was developed and experimentally validated, tailored to the specific demands of the discipline and aimed at the comprehensive development of climbers' physical and psychological qualities.
2. A structured system of macrocycles, mesocycles, and microcycles was created, which can be applied and adapted in the training practice of climbing clubs, sports schools, and sport climbing centers.

3. A practical set of specialized exercises, training stations, and climbing tasks was proposed, targeting the development of strength, endurance, agility, coordination, reaction speed, and psychological resilience under real climbing conditions.
4. A set of instruments for baseline and final questionnaire surveys was developed, enabling monitoring of motivational attitudes, self-assessment, and subjective perceptions of training, complementing objective performance indicators.
5. The obtained results can serve as a methodological basis for planning and optimizing conditioning training in sport climbing, for both beginner and advanced athletes.

### 9.3. Practical significance of the study

The results of the dissertation have direct practical applicability and can be utilized by coaches, instructors, and specialists working in the field of sport climbing. The developed training program provides a concrete model for targeted development of conditioning qualities in accordance with contemporary demands of the sport.

The applied methodology for evaluating training effects allows effective monitoring and individualization of training loads by combining objective measurements with subjective assessments. This creates conditions for more sustainable performance development and reduces the risk of overtraining and injury.

## 10. RECOMMENDATIONS

### For Coaches and Sports Educators

- The inclusion of **isometric endurance exercises** (hanging and holding on various grips) is strongly recommended in the conditioning preparation of advanced climbers.
- Training programs should be **individualized**, taking into account the athlete's physical preparedness, sex, and accumulated training experience.
- Combining strength exercises with technical climbing tasks leads to improved coordination, stability, and movement efficiency.
- Maintaining a **training diary** and encouraging self-monitoring support motivation, self-regulation, and conscious engagement in the training process.

## For Application in Training Programs

- Periodization of training loads is recommended, alternating blocks focused on strength, endurance, and sport-specific technique, in accordance with the stage of preparation and individual goals.
- The inclusion of **psychophysiological components** (e.g., visualization, tension control, meditative practices) may further enhance program effectiveness.
- The program is suitable for both individual and group training and can be adapted to different age groups and performance levels.

## For Future Research

- Future studies may expand the program by incorporating coordination and cognitive tasks, particularly in preparation for competitive performance.

## 11.FINAL CONCLUSION

The present dissertation is devoted to the study of conditioning training in sport climbing and to exploring opportunities for its improvement through the application of a scientifically grounded and systematized training approach. The research analyzed the theoretical foundations of conditioning training, the specific characteristics of motor activity in sport climbing, and contemporary trends in climber preparation.

The developed and experimentally validated specialized conditioning training program demonstrated its effectiveness in developing both general and sport-specific physical qualities essential for successful sport climbing. The results confirm that systematic and targeted development of strength, strength endurance, coordination, flexibility, and psychological resilience leads to significant improvements in climbers' overall preparedness.

Analysis of the experimental data, including questionnaire results, shows that structured conditioning training has a positive impact not only on objective physical indicators but also on athletes' motivation, confidence, and subjective evaluation of the training process. This highlights the importance of a comprehensive approach integrating physical and psychological components.

The achieved results confirm the validity of the working hypothesis and demonstrate that the application of a scientifically grounded conditioning training program leads to higher training effectiveness compared to standard practice. The study contributes to the enrichment of scientific knowledge in the field of sport climbing and provides a basis for improving training methodologies.

In conclusion, the findings of the dissertation have both theoretical and practical value and can be applied in the work of coaches, educators, and specialists in sport climbing. The conclusions also open avenues for future research aimed at further optimization of conditioning training and its adaptation to different age groups and levels of sport qualification.

### **Publications related to the topic of the dissertation.**

1. Radkov, Kr, G. Krachanov (2018) Study of interest in physical education and sports classes in 10th and 11th grades of secondary schools, Sport and Science, issue 6, pp. 127-135

2. Krachanov G. (2020) Genotypic prerequisites for sports achievement in sport climbers, Sport and Science, issue 1,2, pp. 93-99