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Specific physical test for higher elite speed climbers

Shunko Andrey
Academy of Physical Education and Mass Sports, Astana, Kazakhstan.
Email: chastmira@gmail.com

(+ Corresponding author)

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ABSTRACT

This study aims to identify significant physical tests for elite male speed climbers. By analyzing existing research and testing methods, we develop a reliable test battery to assess and monitor physical preparedness in competitive speed climbing. The study included 10 elite Russian national team climbers and a comparative group of 24 lower-level athletes. The test battery covered power, speed, coordination, and flexibility. Tests included the countermovement jump (JHT), Laffaye upper limb test, tapping test, and forward bend test. Statistical analysis using Pearson's correlation assessed the significance of each test in relation to climbing performance. Four key tests demonstrated strong correlations with speed climbing performance: JHT (r=0.933, p=0.012), Laffaye test (r=0.897, p=0.007), tapping test (r=0.821, p=0.009), and forward bend (r=0.967, p=0.001). These tests effectively differentiate elite climbers and provide a standardized method for assessing physical readiness. The identified tests can be used to monitor and enhance training programs for speed climbers. Express testing allows for rapid assessment, benefiting both elite and developing athletes. Coaches and athletes can use these tests to track performance, tailor training strategies, and identify talent. The results support structured physical preparation in speed climbing.

Contribution/Originality: This study is original in developing a validated test battery specifically for elite speed climbers, identifying four key physical tests strongly correlated with climbing performance. Unlike previous research, it integrates a comparative analysis of elite and youth climbers, providing a standardized framework for assessing and monitoring physical preparedness in speed climbing.

1. INTRODUCTION

Climbing is a promising "new wave" Olympic sport, represented at the Paris 2024 games by two disciplines: combined Lead & Boulder and speed climbing. Climbing has previously been featured at the Tokyo 2020 Olympics and has proved that there is a high interest in this sport. Speed climbing looks especially promising for several reasons: 1) speed climbing is traditionally a separate climbing discipline; 2) the most spectacular and dynamic type of climbing; 3) a chance to save a set of awards for future Olympic Games (Lutter, Tischer, & Schöffl, 2021).

Differences in the discipline of speed climbing have been repeatedly confirmed by many researchers. Physiologically, speed climbers differ not only in a set of strength indicators, but also in anthropometric data (Ryepko, 2013). The specific tests for climbers in the disciplines of difficulty and bouldering are very different from tests for speed climbers. This difference is justified by comparative tests of competing athletes in three disciplines on the power of the upper limbs (Levernier, Samozino, & Laffaye, 2020).

Most of the research in rock climbing concerns the strength and endurance of the finger flexor muscles, which are an important indicator for climbing in combined events (Maciejczyk et al., 2022; Michailov, Morrison, Ketenliev, & Pentcheva, 2015). The same applies to other qualities of an athlete. Modern research on climbing is becoming increasingly fragmented, describing biathlon or speed climbing separately (Michael, Witard, & Joubert, 2019). Abstracting from the division into disciplines, the importance and necessity of the physical development of elite level climbers has been unequivocally proved (Draper et al., 2021). Undoubtedly, physical strength and power of the whole body plays a major role for competitive climbers, especially the upper limbs (MacKenzie et al., 2020). However, one should not lose sight of the fact that rock climbing, being a complex coordination sport, places high demands on athletes in this aspect of training (Sterkowicz, Jaworski, & Rokowski, 2014). Also, regardless of discipline, there is a need to develop flexibility for climbers of any level of preparedness (Grant et al., 2001).

Speed climbing, being the youngest discipline, attracting the attention of researchers to the problem of technical and tactical training. Modern technologies, in accordance with the nature of competitive activity in speed climbing, allow the use of high-tech methods of training control (Pieprzycki et al., 2023). At this stage in the development of climbing technique, 3D modeling is the most promising technology (Iguma, Kawamura, & Kurazume, 2020; Reveret, Chapelle, Quaine, & Legreneur, 2020).

The problem of physiological characteristics and the body's response to a competitive load in speed climbing has attracted the attention of many researchers. Changes in blood lactate during speed climbing were determined, which correspond to power sports and increase the requirements for muscle hypertrophy (Guo, Wang, Liu, & Hanson, 2019). Electromyographic studies of the muscles of the whole-body during speed climbing showed the involvement of muscle structures responsible for 60-70% of the intensity of exercise (Voronov, Kvashuk, Voronova, & Krasnoperova, 2019). Heart rate variability measurements during speed climbing also showed that speed climbing is a sprint discipline. A delayed reaction of the body indicates an increased demand for muscle work on holding the breath and a gradual increase in heart rate to 180 beats / min (Fuss, Tan, Pichler, Niegl, & Weizman, 2020; Shunko & Kravchuk, 2020).

The conducted comprehensive study of the existing methods of testing in rock climbing does not answer the question about the control of physical fitness in climbing for speed (Stien, Saeterbakken, & Andersen, 2022). Numerous studies of the speed and power capabilities of the lower extremities show insufficient statistical relationships with the qualifications of athletes and the results of speed climbing (Draper et al., 2021; Fuss et al., 2020; Guo et al., 2019; Iguma et al., 2020; Krawczyk, Pociecha, Ozimek, & Draga, 2020; Levernier et al., 2020; Lutter et al., 2021; Pieprzycki et al., 2023; Reveret et al., 2020; Ryepko, 2013; Shulga, 2014; Shunko & Kravchuk, 2020; Voronov et al., 2019). Studies of the physical characteristics of climbers often face the problem of small sample size or low qualifications, as well as dependence on anthropometric indicators (Krawczyk et al., 2018; Shulga, 2014). The selection of tests to determine the physical fitness of athletes specializing in speed climbing remains relevant and important today.

2. METHOD

2.1. Subjects

Ten higher elite speed male climbers from Russian national team volunteered for this study. The study also presents a group of less qualified athletes from the youth national team of Russia in speed climbing as a comparative group of 24 men. We conducted similar tests as on the main group of climbers. The sample of the contingent was 100% of the general population, that is, the national men's team of Russia participated in the full team. The average climbing time of all the participants (34 male climbers) was 6.68 ± 0.25. All subjects took part in international competitions and each has prizes in championships, championships and world cups. Control tests and tests were carried out during the official training event of the Russian national team in speed climbing in Tyumen from February 12 to February 28, 2021. All investigations conform to the Code of Ethics of the World Medical Association (Declaration of Helsinki).

2.2. Study Design

The battery of tests included tests for the power of the muscles of the upper and lower extremities, coordination, speed and flexibility. The tests were carried out on the same day for 2 hours. The procedure for conducting physical tests was built in accordance with the recommendations of Platonov (2019): first of all, coordination is evaluated, then speed and maximum strength and power, after that endurance and flexibility (Platonov, 2019). Before the start of the testing, a standard warm-up for a training session in a competitive mode is carried out. Recovery between exercises lasted between 8-15 minutes, and between quality tests of the same limbs at least 30 minutes. Before the start of the whole experiment, a briefing was given on the general structure of the event. Also, before each individual exercise, a briefing was given on the technique of execution, conditions and safety precautions. Athletes were asked to refrain from intense competitive and general physical activity for 2 days before the experiment.

2.3. Methodology

We used a testing protocol using Myotest Pro for two tests: JHT and Laffaye test (Casartelli, Müller, & Maffiuletti, 2010; Laffaye, Collin, Levernier, & Padulo, 2014). The jump height test (JHT) was performed 3 times with a pause of 10 seconds at the designated area. The accelerometer was placed on the lower back. The jump area was on track and field rubber without excessive cushioning. During the jump, the subject's arms swing. The jump is performed in a single movement. In the Laffaye test, the accelerometer was also located on the lower back. The starting position was hanging on the most comfortable part of the comfortable jug holds with enough legroom underneath. We used a variant of the test with simultaneous repulsion with both hands. The subject had 3 attempts with a break of 10 seconds between them. The result in both tests was considered the height of the perfect movement in centimeters.

To conduct the Margaria-Kalamen test, we used a modern testing protocol with a distance of 1 meter, which is overcome in 3 steps (Hetzler et al., 2010). To measure time, a laser timing system (EBSS.RU Electronic Systems) with an error of 0.001 seconds was used. The test was carried out twice with a break of 1 minute. The result was considered the time to overcome the distance in seconds.

The long jump was carried out from a standing position according to the traditional generally accepted method. For the jump, it was allowed to swing the arms. The subjects were given 3 attempts with a rest of 10-20 seconds. The result is the length of the jump in centimeters.

Sprint 30 meters was taken according to the traditional generally accepted methodology with a laser timing system. The subjects started with a 10-meter run, after which they covered a distance of 30 meters in the minimum time. The beginning and end of the control distance were measured by laser timing with an error of 0.001 seconds. The participant had only one attempt. The result is the time taken to cover the 30m distance in seconds. The flying start is used to measure speed capabilities in isolation without error in signal response speed.

The Romberg test was applied in the "Stork" position, which is used in the literature to determine vestibular stability in qualified athletes (Khasnis & Gokula, 2003). Starting position: supporting leg is straight with a full foot on the ground; the second leg is bent at an angle of 90 degrees, raised forward, the foot is pressed with the lateral part to the knee of the supporting leg; the body is straight; arms are straightened forward with palms open to each other at a distance of about 10 centimeters. The test begins when the subject closes his eyes, ends if one of the conditions of the initial position is violated.

Shuttle run was taken at a distance of 3 * 10 meters. The start was carried out from a standing position. The mark of the 10-meter distance was a strip on the floor, which had to be touched by hand. The finish was made by overcoming the finish line. The result was considered the time to overcome the distance in seconds. This test performed for 2 times. A digital stopwatch was used for measurements.

The tapping test was carried out for 1 minute using the TappingPro mobile application (Ashanin & Romanenko, 2015). The mobile test device was placed on the table so that the subject's hand rested completely on a hard surface. The result was the number of clicks. This test performed for 1 time.

Grant foot raise was performed using a modified Draper technique (Draper, Brent, Hodgson, & Blackwell, 2009). The starting position in this test is standing with your feet shoulder-width apart at a distance of 23 centimeters from the wall with your hands resting exactly in front of you. The task of the athlete is to hold the toe in a straight line from the starting position to the palm to the maximum height. The result is the height of the leg lift without losing balance in centimeters.

The forward bend and split were carried out according to the traditional generally accepted method. Particular attention in these tests was paid to straightening the joints of the legs and fixing the position. The result was measured in centimeters above the standing platform.

Standard speed climbing wall (competitive distance) is 15 meters height top rope route graded 6c. The standard route has an IFSC (International federation of sport climbing) -defined hold layout, which creates conditions for measuring record times and fixing results, regardless of the location of the competition and training sessions.

2.4. Statistical Analysis

All calculations were carried out using Microsoft Excel and the IBM Statistical Package for Social Sciences (SPSS) for Windows (Version 22, Chicago, IL). Data are reported as means and SDs (Standard Deviations). Pearson's correlation coefficients were calculated to estimate correlations between the mechanical parameters and climbing ability. Statistical significance was set at $p \leq 0.05$. The total strength of the Russian national team was chosen as the general population in determining the required sample. However, due to the small number of participants in the experiment, we identified a comparative group of 24 people of lesser qualifications.

3. RESULTS

The climbing time of the competitive distance for the test participants in main group of 10 higher elite climbers was 5.70 ± 0.16 seconds. All athletes successfully passed the test without gross violations.

Two of four power tests were significant with climbing time. The average jump height in JHT test was 70.7 ± 4.7 centimeters (r=0.933, P0=0.012). Result of Margaria-Kalamen test in average was 0.48 ± 0.06 seconds. Laffaye test is the second significant test for speed climbing with average 129 ± 23 centimeters (r=0.897, P0=0.007). The least reliable test of the power block is long jump with average result 272 ± 15 cm (Table 1).

Table 1. Result of exercise tests of higer elite speed climbers (Main group).

Test	Result (±SD)	Correlation with climbing time (6 ± 0.23 seconds) *
Power tests		
JHT, cm	70.7 ± 4.7	P_0=0.002*
Margaria-Kalamen test, sec	0.48 ± 0.06	P_0=0.223
Laffaye test, cm	129 ± 23	P_0=0.007*
Long jump, cm	272 ± 15	P_0=0.350
Speed tests		
30 meters sprint, sec	3.78 ± 0.18	P_0=0.544
Coordination tests		
Romberg test, sec	14.3 ± 2.6	P_0=0.105
Shuttle run, sec	3.43 ± 0.21	P_0=0.404
Tapping test, clicks	285 ± 49	P_0=0.009*
Flexibility tests		
Grant foot raise (Left), cm	102 ± 16	P_0=0.078
Grant foot raise (Right), cm	103 ± 17	P_0=0.112
Front split, cm	44 ± 9	P_0=0.719
Forward bend, cm	15.5 ± 6	P_0=0.001*

Note: *P_0<0.05 when t = from 2.78 to 4.6; * P_0<0.01 when t > 3.36.

The only speed test 30 meters sprint has no significant relationship with climbing time and the average result is 3.78 ± 0.18 seconds.

In the block of tests for coordination, the only test showed significant significance for climbing for speed - the tapping test. Average number of clicks in the tapping test is 285 ± 49 (r=0.821, P0=0.009).

The block of tests for flexibility was no exception. A significant test turned out to be a forward bend with a result of 15.5 ± 6 centimeters (r=0.967, P0=0.001).

An additional comparative test on the youth climbing team of Russia showed that all selected tests were confirmed at a lower level of climbing (Table 2).

Table 2. Test results on the comparative group.

Test	Result (±SD)	Correlation with climbing time (7.49 ± 0.6 seconds) *
Power tests		
JHT, cm	63 ± 4.6	P_0=0.006
Margaria-Kalamen test, sec	0.55 ± 0.08	P_0=0.223
Laffaye test, cm	120 ± 18	P_0=0.012
Long jump, cm	255 ± 18.5	P_0=0.041
Speed tests		
30 meters sprint, sec	4,05 ± 0.3	P_0=0.544
Coordination tests		

Model levels of development of general and special physical fitness of qualified climbers specializing in speed climbing are presented in Table 3.

Table 3. Scale for assessing the special physical fitness of speed climbers.

No	Test	Level of development, points						
		1	2	3	4	5	6	7
1	JHT, см*	61<	61 – 65	66 – 67	68 – 73	74 - 75	76 -80	>80
3	Forward lean, cm	<3	3 – 8	9 – 11	12 – 18	19 – 21	22 – 27	>27
5	Tapping test, clicks	<187	187 – 235	236 – 260	261 – 310	311 – 334	335 – 383	>383
6	Laffaye test, cm	<83	83 - 105	106 – 116	117 – 140	141 - 152	153 - 175	>175
9	Climbing time, sec	>6,58	6,57 – 6,35	6,34 – 6,12	6,11 – 5,88	5,87 – 5,65	5,64 – 5,42	<5.42

4. DICUSSION

According to the data obtained during the tests, first of all, I would like to note that in each test block, one significant test was identified: JHT test characterizes the power of the legs; the Laffaye test characterizes the power of the upper limbs; coordination is characterized by a tapping test; flexibility characterizes forward bend. Therefore, it is not possible to compare the selected tests with each other within the results of other researchers. All tests in one way or another have similar features with the daily exercises used in the training sessions of the national team, which means the lack of an individual approach to the physical preparation of athletes. Each athlete performed a single physical training program, which was based not on personal characteristics, but on the general principles of physical training for speed climbing. It should also be understood that we are discussing tests that are significant for performance in speed climbing, which reflect only special physical fitness.

The JHT test has been used in some studies in Czech competitions with international representation (Krawczyk et al., 2020). Comparing with the results obtained by Krawczyk, I would like to note the following remarks:

- In both cases, this test is significant for speed climbing. For comparison, in the results of Krawczyk's study (r=0.89, P0=0.001), in our study (r=0.933, P0=0.002).
- The differences in the result in this test are comparable to the differences in climbing time (8.19 ± 1.95 and 5.70 ± 0.16 seconds respectively).

JHT test also has sufficient justification from the point of view of the technical features of speed climbing (Voronov et al., 2019).

The Laffaye test has a strong rationale for experts in lead climbing and bouldering (Laffaye et al., 2014). However, until then there was no significant evidence of the effectiveness of the use of this test for speed climbers. In the work of the author of the testing methodology, only the results of elite climbers and below are given. From a technical point of view, the movement similar to the one in the test corresponds most closely to pushing off the holds with the hands while climbing. However, for an accurate conclusion, a deeper study of the individual characteristics of athletes is required.

The results of a block of tests for coordination create a unique fact about the independence of the result of climbing from agility. The repetition of movements in speed climbing is often erroneously identified as cyclical among climbing practitioners. From the point of view of variability and situational decision-making during competitions, this is justified, but from the point of view of complex coordination and agility, it is criticized. The tapping test characterizes the psychomotor ability to speed, as well as the development of fine motor skills (Fuss & Niegl, 2006). It is probably fine motor skills that play a greater role than agility in speed climbing, which is used in the study of many different movements in other disciplines.

According to the opinion of the athletes themselves, revealed during the conversation during testing, they devote little time to the development of flexibility, since they do not consider this part of physical training significant. However, our research has shown the opposite. Flexibility of the hamstring, spine, and shoulder joint that characterizes the forward bend test is a specific test for speed climbers. On the other hand, we see disappointing results in other flexibility tests, especially the splits. Results on the specific Grant Flexibility Test for Climbers are patchy, suggesting that there is no dependence on the climbing speed test. We recommend that coaches and athletes pay more attention to flexibility training in the preparation of athletes who specialize in speed climbing. However, the effect of training on flexibility needs to be studied separately and, in more detail, in order to design specific training programs.

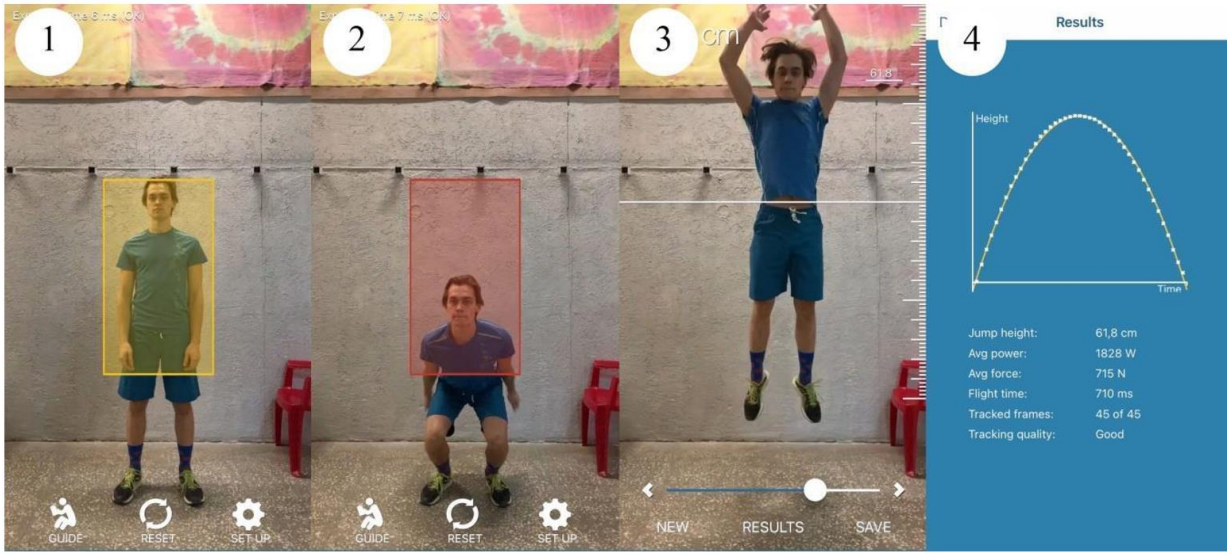

Figure 1. Step by step process of using the My jump app.

There is a possibility that the high correlations of physical testing are associated with poor technical preparedness of athletes and the formulation of tactical and technical actions with an emphasis on more powerful techniques. One way or another, the significant tests defined in the work have their theoretical and practical justification. Further justification of the battery of tests requires experimental justification using specific guidelines and training methods.

We assume that the research with the proposed system for assessing the physical fitness of athletes on athletes of various qualifications will give a broader understanding of the features in speed climbing.

The use of a myotest in a daily training routine can be complicated by the cost and availability of this device. In addition, not all practicing trainers have the financial ability to purchase an accelerometer. We propose the use of modern mobile applications like "MyJump" as an alternative way to measure leg strength. However, it is necessary to take into account the error of such measurement methods and focus on subjective values in longitudinal.

For JHT assessment, we suggest using the MyJump app (Gallardo-Fuentes et al., 2016). When testing with this application, it is necessary to take into account the possible error, however, by conducting and analyzing the data in the longitudinal direction, we will be able to obtain reliable data on changes in the physical fitness of athletes (Figure 1).

The Laffaye test is possible in several variations: using photo-fixation using the usual photo-video mode on a mobile device or using the Dartfish application. The advantage of Dartfish is the ability to accurately rewind and compare videos, which can be useful in analyzing multiple tests over the long term (Figure 2).

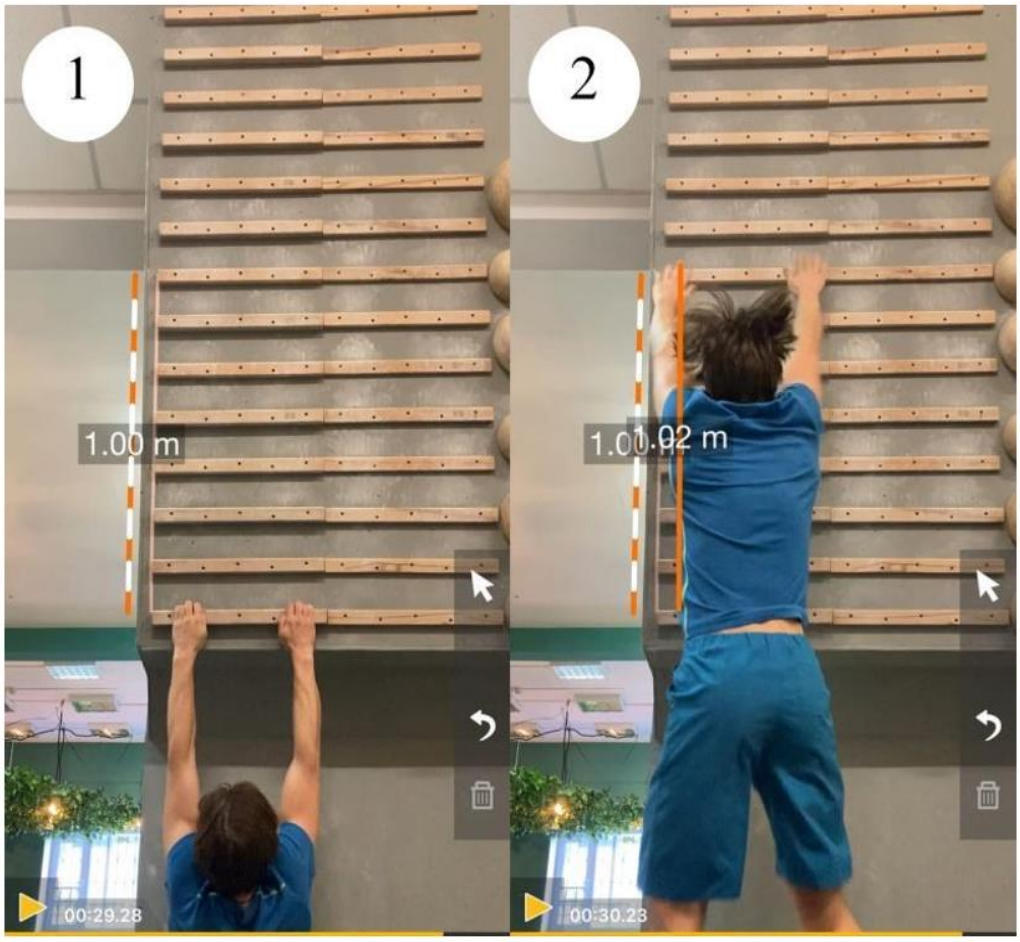

Figure 2. Step by step process of using the Dartfish app.

The tapping test is the easiest test to use on a mobile device. As in our main test, we suggest using the TappingPro application in express testing. In addition to the number of clicks, the application will show the state of the athlete's nervous system and save all past results in a convenient format with the ability to export to Excel (Figure 3).

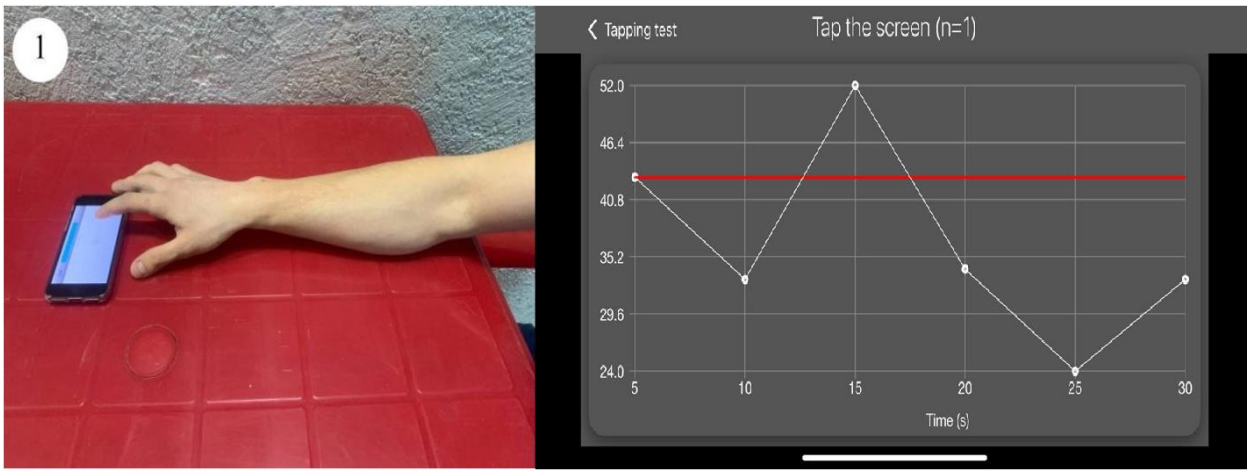

Figure 3. Process of using the Tapping Pro app.

The forward bend test does not require a mobile application and is performed using a podium and a drawn ruler. The result is taken into account in the lowest position of both hands in a static position (Figure 4).

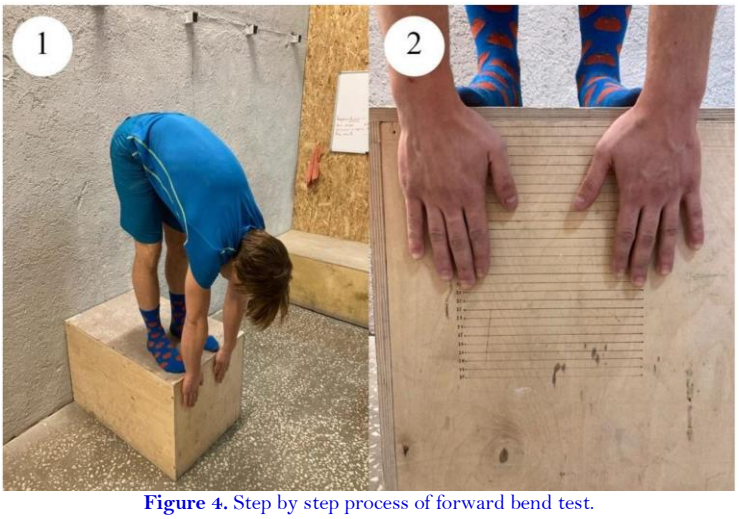

Figure 4. Step by step process of forward bend test.

Based on the data obtained, we propose the use of reliable tests using mobile devices in the format of express testing. Using applications on a mobile device will shorten the time of testing and provide an opportunity for operational control of the athlete's physical fitness. We calculated the model levels for the selected tests. We used a seven-point scale according to the method of Zatsiorsky and Kraemer (2006).

In this method 1 point is very low level of development. Then 2 points - low level of development and 3 points - characterized by development below the average level. For the average level in individual tests, 4 points were taken. 5 points characterizes the development above the average level. 6 points - a high level of development. 7 points - a very high level of development.

Accordingly, the maximum level of development of the complex of physical qualities of qualified climbers is 36 points. Further, the result from 27 to 35 points will be slightly inconsistent with the model level. The result, which is in the range from 18 to 26 points, is the average degree of mismatch with the model level. And a result of less than 17 points is a strong mismatch with the model level.

In our opinion, the total number of points will be the most indicative in assessing the readiness of a climber for speed climbing competitions.

5. CONCLUSIONS

The proposed tests can be the basis for building a training process for climbers specializing in speed climbing. Timely control at various stages of training will provide an opportunity to understand the strengths and weaknesses of the athlete. These data, in turn, allow not only to adjust the training program with a focus on the leading and remaining indicators, but also to form a climbing tactics decision based on them. The use of the test once a month during the period of enhanced physical training will allow you to more accurately determine the direction and nature of physical training.

The total duration of the entire express assessment is 8 minutes, taking into account the briefing and transitions to the next tests. The exercises included in the express assessment complex do not take much time, are intuitive and have the specifics of rock climbing. Also, the exercises are characterized by low intensity, do not carry large energy losses and can be used at any stage of the training of qualified athletes. Rating scales can be both a guide for elite speed climbers and as a way to identifying talents for already qualified climbers.

Evaluation scales open up a new control functionality in the training of speed climbers. Express assessment gives an understanding of the correctness of the decisions made about the preparation of both the coach and the athlete, which indirectly affects the psychological stability of the athlete during the competition. An objective understanding of one's condition gives confidence in one's strength and acceptance of the result.

The tests defined in our work, which demonstrate the special physical fitness of speed athletes, can be successfully used both in full according to the methodology indicated by us, and in an abbreviated form of an express test. Many of the issues raised in the discussion require further work and an experimental part to substantiate the assessment methodology. Evaluation scales can be used to control the preparedness of an athlete for training and competition.

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Transparency: The author declares that the manuscript is honest, truthful and transparent, that no important aspects of the study have been omitted and that all deviations from the planned study have been made clear. This study followed all rules of writing ethics.
Competing Interests: The authors declare that they have no competing interests.

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