THE SIGNIFICANCE OF SELECTED TESTS CHARACTERIZING MOTOR POTENTIAL IN ACHIEVING HIGH RESULTS IN SPEED CLIMBING

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Keywords: speed climbing, explosive strength, maximum non-lactic acid anaerobic power, reaction speed, countermovement jump

Abstract:

Study aim. The main aim of research was to verify which of the countermovement jumps (CMJ) provides the most accurate information on the possibility of obtaining the best result in a climbing run and to assess the coexistence (correlation) of the running result as well as the reaction time to an auditory signal.

Material and methods. The study was conducted among a group of male climbers at the average age of 20.5 years (n=6). At the time of the measurements, the competitors presented the highest sports level and were members of the Polish National Team in the speed climbing competition. Somatic measurements were carried out successively, followed by measurements of simple reaction time and various jumps.

Results. Correlations between the studied variables characteristic of somatic features as well as motor skills with climbing time were, in most cases, not significant. Statistically significant correlations at the level of $p<0.05$ were found between running time and the following trials: CMJb (cm) ($r_{xy}$: -0.88); $P_{\text{maxCMJb}}$ (W/kg) ($r_{xy}$: -0.88) and $P_{\text{maxCMJb}}$ (W/LBMkg) ($r_{xy}$: -0.86).

Conclusions. CMJ without arm swing is a valuable tool in assessing the motor potential of a sprinting climber and is a test of great informative value in the context of the possibility to obtain high results in a speed climbing competition.

The applied test to assess the level of response time to the auditory signal was a trial, which to a moderate extent, allows to diagnose the possibility of achieving high results in a speed climbing sprint.

Introduction

In sport climbing, we can distinguish 3 different competitions, among which we currently classify climbing according to lead, bouldering and speed climbing. Lead climbing is classified as endurance and strength sports, in which the main factors determining the results are, among others: relative force and special endurance of the fingers (1,2). In bouldering, the effectiveness of climbing is determined by relative force, the rate of strength increase over time and the maximal anaerobic power of the upper limbs (3,4). Compared to the
above-mentioned types of competition, speed climbing is a form in which other components of motor potential determine motor efficiency. It is a discipline that clearly distinguishes itself from climbing according to lead climbing and bouldering in its spatial and rhythmic structure. The result at championship level of a speed climbing on a technically easy route is usually 6-8 seconds or less. Therefore, it should be assumed that in this sports discipline, the high level of motor skill development characterise the climber will determine the effectiveness in sports competition. Shulga (5), examining competitors participating in the World Games in 2013, stated that climbing times of the best competitors were within the range of 5.96-6.4 seconds. Speed climbing is a competition in which – unlike other disciplines - the main driving function, enabling quick movement along the climbing route, is primarily played by the lower limbs. In this discipline, the upper limbs are mainly stabilisers (6). To date, research conducted among speed climbing competitors indicate that one of the significant factors determining sports level is the ability to perform above-average strength and speed efforts (6–10). Jump-based trials were the most common type used in these types of studies. The results of these tests were treated as indicators characterising power level of lower limb muscles. In the research by Ryepko (7), the average jump result among speed climbers was 53 cm and was significantly higher compared to other groups of climbers. Krawczyk and Ozimek (8), comparing the motor potential of team-representative runners with amateurs of speed climbing, used, inter alia, the standing long jump with arm swing trial, and found significantly better results among the sprinters. In research carried out earlier (6,9), it was also indicated that the results of long jump trials significantly coincided with the results achieved by climbers taking part in speed climbing competitions.

In the assessment of the explosive strength of the lower limbs and the maximum non-lactic anaerobic power generated by them, tests based on jumps are often used. A specific test used in recent years to assess motor potential is the countermovement jump (CMJ) with arm swing, which, as shown in previous studies (11,12), is a reliable test used to assess the level of lower limb explosive strength in physically active individuals. The results of these tests, based on jumps with arms swing, are significantly determined by the coordinative factor. The outcome of these trials primarily depend on the strength of the lower limb muscles, but also on the level of development of the ability to coordinate movements (13). Bearing in mind that in speed climbing, the lower limbs ensure the climber to achieve a high climbing velocity (7,14), and that the upper limbs play a stabilising role (6), it may be concluded that in the assessment of the lower limb explosive strength level among speed climbers, the vertical jump performed without arm swing will be are more valuable test than the standing long jump.

Each run in a speed climbing begins after a clear sound signal from the judge designated to give starting commands. After a clear command from the starting judge, the competitors assume their starting position against the wall, and then, the starting judge activates the device initiating the starting signal: these are 3 distinct sounds that the device emits at 1-second intervals. As soon as the 3rd starting signal is heard, time measurement begins. The competitor’s reaction to the auditory signal in this competition is very important. With the relatively short duration of the competition, a delay in the start by the competitor is most often associated with the inability to make up for the loss resulting from the delayed response to the signal and, consequently, results in a loss or an unfavourable result of the run.

In a review of the literature, it is indicated that until now, research on reaction speed in speed climbing is rare. The only time-related studies among climbers in which reaction time was measured (but to a visual signal — this type of signal does not occur during the competition) was carried out by Kozinha et al. (15), Ozimek et al. (16) and Krawczyk et al. (17). In their research, Kozinha et al. (15) used the “Psychodiagnostics” computer program to evaluate and compare the reaction time of competitors in groups of speed and Alpine and lead climbers. The results of their research showed that the speed climbing representatives, compared to other groups, had faster reaction time to the visual signal. Krawczyk et al. (17) used computer-based tests of coordination abilities, according to Klocek et al. (18), to assess the differences in the reaction time of speed and bouldering climbers. The level of simple reaction time did not significantly differ among the compared competitors, but, in their analyses, the authors found a significant correlation between the speed climber’s effectiveness and the level of reaction time. In the research by Ozimek et al. (16), which was carried out in a group of World Cup finalists, on the basis of video analysis examining a few runs, it was found that the fastest starting reaction time was 0.42 seconds and was correlated with total run time ($r_{xy} = 0.57$, $p >0.05$). Based on the above publications, it was considered advisable to develop a test allowing to assess reaction time to an auditory signal, which could be used in the diagnosis of speed climbers.

The informativeness of a test is usually determined by the correlation coefficient between the results of the sample (test) and the measurement results of the informational criterion (19). In connection with the above, it was assumed that the main objective of this study would be to verify which of the CMJ provides most accurate information about obtaining the best result in a climbing
run and to assess the coexistence (correlation) of the running result and the reaction time to an auditory signal. The indirect aim of the research was to assess the level of: explosive strength; maximal non-lactic acid anaerobic power of the lower limbs and response time to the auditory signal among speed climbers. The collected results may constitute reference values for coaches and sport climbing instructors, with particular emphasis on speed climbing competitions.

In connection with the objectives of this study, the following hypothesis was formulated:

H1: The CMJ test, performed without the involvement of the upper limbs, is a valuable trial allowing to predict the outcome of a run in a speed climbing.

In addition, in order to carry out the above-mentioned objectives of research, the following research questions were posed:

1. What is the correlation between reaction time to an auditory signal and the result of climbing?
2. Can the applied test used to assess reaction time to the auditory signal be recommended as a valuable diagnostic tool in speed climbing?
3. What is the relationship between basic features and body structure indices and the result of a climbing run?

Materials and methods

The study was conducted among a group of male climbers at the average age of 20.5 years (n=6). At the time of the measurements, the competitors presented the highest sports level and were members of the Polish National Team in the speed climbing competition. Furthermore, they had significant achievements in speed climbing in senior and junior categories during the World Championship and World Cup competitions. Measurements were carried out during the training camp of the national team in February 2016 at the facilities of the University of Applied Sciences in Tarnów.

Measurements were performed in the morning hours during training of the national team (between 10.00 a.m. and noon). Somatic measurements were carried out successively, followed by measurements of simple reaction time and various jumps. In the assessment of motor fitness, CMJs, with and without arm swing were implemented, which are a reliable, objective and accurate tool for measuring explosive force (12,20–22). The measurement of jump height began in a standing position, then the subject performed dynamic flexion in the hip and knee joints (the angle in the knee joints in maximal flexion was approximately 90 degrees), after which a maximal jump up was performed by extension in the hip, knee joints and ankle joints. The trial was conducted in a separate room to minimise possible distortion of the results by unforeseen factors. The subjects performed a 10-minute general warm-up, taking those parts of the body that were most involved during the test into account (hips, knee joints, ankles, arms). After the warm-up, the subjects proceeded to trials according to the protocol. Between successive CMJs, intervals of about 1 minute were applied (the intervals were used to prepare the next competitor).

In accordance with the standards of modern anthropometry (23), the following anthropometric measurements were taken: body height (BH), upper limb length (a-da), lower limb length (sy height). Body mass (BM), body fat percentage (FM%) and lean body mass (LBM) were determined using TANITA (model BC-730) in the mode for physically active individuals. Based on the measurements, the following body build indices were calculated: upper limb length index, lower limb length index, slenderness index and BMI (24).

In this study, the following tests were used to assess motor fitness:

1. Countermovement jump with arm swing (CMJ), as an indicator of the ability to connection movements and without arm swing to assess explosive force of the lower limbs (13). On this basis, the following were calculated: level of maximal anaerobic non-lactic acid power (P<sub>max</sub>CMJ and P<sub>max</sub>CMJb), which was expressed in absolute (W) and relative values - after conversion to body mass (W/kg) and lean body mass (W/kg LBM). To estimate power level, the equation proposed by Sayers et al. (25) was used: P<sub>max</sub> = 60.7 x jump height (cm) + 45.3 x body mass (kg) - 2055. The equation is similarly used for research in which muscle power is calculated on the basis of the CMJ (22,26–34). The implemented motor trials are not specific to speed climbing. A wall run resembles more like climbing a ladder (as a sum of the lower limbs' cyclic movements). Thus, testing motor fitness with the CMJ cannot be viewed as an attempt to describe special fitness in speed climbing. Despite this, similarities should be found, such as the way of shifting the body's centre of gravity, which is lifted upwards during a run. In addition, observation of the climbing run indicates that in some places on the route, climbers perform jump-like motor activities, but this is not a rule (rather depending on the method, the so-called "climbing style", which the climber uses to move along the wall). As pointed out by Shulga (5), the way of conquering the climbing route in this competition may be individual and determined by body height. Therefore, using the CMJ test among speed climbers, the levels of significant development and explosive strength, as well as maximal non-lactic acid anaerobic power were assessed.
2. Simple reaction time, understood as the period from the moment of stimulus presentation to the end of a strictly defined movement. The test was carried out
according to the protocol proposed by Apostolidis et al. (27), with author modifications. In the research by Apostolidis et al. (27), the athletes performed jumps at a visual signal, while in this study, bearing in mind that the start in speed climbing takes place at the sound emitted from a device, the attempt was modified by introducing auditory stimulus. The applied test consisted of performing 5 SJs (squat jump with arms folded over the hips) per auditory signal. The mean value of reaction times after removing the best and worst results was qualified for further analyses. The time interval between successive signals was set within the range of 3 to 5 seconds (the sound impulse was given automatically and randomly). The OptojumpNext measurement system (Microgate, Bolzano, Italy) was implemented to assess the explosive strength and response speed.

In statistical analysis of the collected data, the following were calculated:
1. basic descriptive statistics (arithmetic mean, standard deviation and coefficient of variation for each variable);
2. Kolmogorov-Smirnov test to assess the compliance of distribution regarding dependent variables with normal distribution;
3. Pearson’s linear correlation coefficient \( r_{xy} \) to estimate the strength and direction of the relationship

between the best climbing time achieved by the athletes during training and the variables describing somatic build, explosive strength, reaction speed and anaerobic power. The strength of the correlation was assessed on the basis of the following criteria: \( r < 0.1 \), weak; \( 0.1 \leq r < 0.3 \), low; \( 0.3 \leq r < 0.5 \), average; \( 0.5 \leq r < 0.7 \), strong; \( 0.7 \leq r < 0.9 \), very strong; \( r \geq 0.9 \), almost exact (35). The same criteria were adopted for negative correlations. In addition, a confidence interval (CI) was calculated for each correlation coefficient. If the 95% CI for the correlation was both within the range of positive and negative values, the correlation result was interpreted as ambiguous. A \( p \) value <0.05 was adopted as a statistically significant correlation value (35).

The collected data were processed using the STATISTICA 8 statistical package by StatSoft®. The computer applications of the Office 2007 Microsoft® suite were used for graphic preparation of the results.

**Results**

In Table 1, mean values, standard deviations and the coefficient of variation calculated for all analysed variables are shown. In Table 2, the results of the analyses used to determine the strength and direction of relation-

<table>
<thead>
<tr>
<th>variable</th>
<th>x</th>
<th>sd</th>
<th>v%</th>
</tr>
</thead>
<tbody>
<tr>
<td>run time (s)</td>
<td>7.78</td>
<td>1.32</td>
<td>17.00</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>177.57</td>
<td>6.24</td>
<td>3.51</td>
</tr>
<tr>
<td>MC (kg)</td>
<td>70.55</td>
<td>5.77</td>
<td>8.18</td>
</tr>
<tr>
<td>FM%</td>
<td>7.62</td>
<td>2.92</td>
<td>38.37</td>
</tr>
<tr>
<td>LBM(kg)</td>
<td>61.88</td>
<td>4.74</td>
<td>7.66</td>
</tr>
<tr>
<td>BMI</td>
<td>22.43</td>
<td>2.29</td>
<td>10.19</td>
</tr>
<tr>
<td>upper limb index</td>
<td>45.40</td>
<td>0.97</td>
<td>2.13</td>
</tr>
<tr>
<td>lower limb index</td>
<td>51.29</td>
<td>1.41</td>
<td>2.74</td>
</tr>
<tr>
<td>slenderness index</td>
<td>43.02</td>
<td>1.79</td>
<td>4.17</td>
</tr>
<tr>
<td>CMJ (cm)</td>
<td>49.87</td>
<td>7.71</td>
<td>15.46</td>
</tr>
<tr>
<td>CMJb(cm)</td>
<td>42.03</td>
<td>6.13</td>
<td>14.58</td>
</tr>
<tr>
<td>RESPONSE (s)</td>
<td>0.60</td>
<td>0.05</td>
<td>8.39</td>
</tr>
<tr>
<td>Pmax CMJ (W)</td>
<td>4167.82</td>
<td>633.39</td>
<td>15.20</td>
</tr>
<tr>
<td>PmaxCMJb(W)</td>
<td>3692.34</td>
<td>547.78</td>
<td>14.84</td>
</tr>
<tr>
<td>Pmax CMJ (W/kg)</td>
<td>58.94</td>
<td>6.27</td>
<td>10.64</td>
</tr>
<tr>
<td>PmaxCMJb(W/kg)</td>
<td>52.20</td>
<td>5.19</td>
<td>9.94</td>
</tr>
<tr>
<td>Pmax CMJ (W/kg LBM)</td>
<td>67.27</td>
<td>8.26</td>
<td>12.27</td>
</tr>
<tr>
<td>PmaxCMJb(W/kg LBM)</td>
<td>59.60</td>
<td>7.20</td>
<td>12.08</td>
</tr>
</tbody>
</table>
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Table 2. Values of Pearson’s correlation coefficient with 95% CI between the best running time with examined somatic variables and anaerobic power parameters.

<table>
<thead>
<tr>
<th>variable</th>
<th>r(x,y)</th>
<th>p-value</th>
<th>95%CI dla r(x,y)</th>
<th>correlation strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>run time (s)</td>
<td>1.00</td>
<td>p= ---</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>0.42</td>
<td>p=.403</td>
<td>-0.99. 0.92</td>
<td>ambiguous</td>
</tr>
<tr>
<td>MC (kg)</td>
<td>-0.38</td>
<td>p=.459</td>
<td>-0.91. 0.62</td>
<td>ambiguous</td>
</tr>
<tr>
<td>FM%</td>
<td>-0.49</td>
<td>p=.326</td>
<td>-0.93. 0.54</td>
<td>ambiguous</td>
</tr>
<tr>
<td>LBM(kg)</td>
<td>-0.22</td>
<td>p=.672</td>
<td>-0.88. 0.72</td>
<td>ambiguous</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.60</td>
<td>p=.211</td>
<td>-0.95. 0.42</td>
<td>ambiguous</td>
</tr>
<tr>
<td>upper limb index</td>
<td>-0.56</td>
<td>p=.250</td>
<td>-0.94. 0.46</td>
<td>ambiguous</td>
</tr>
<tr>
<td>lower limb index</td>
<td>0.68</td>
<td>p=.137</td>
<td>-0.29. 0.96</td>
<td>ambiguous</td>
</tr>
<tr>
<td>slenderness index</td>
<td>0.62</td>
<td>p=.186</td>
<td>-0.38. 0.95</td>
<td>ambiguous</td>
</tr>
<tr>
<td>CMJ (cm)</td>
<td>-0.75</td>
<td>p=.089</td>
<td>-0.97. 0.17</td>
<td>ambiguous</td>
</tr>
<tr>
<td>CMJb(cm)</td>
<td>-0.88</td>
<td>p=.022</td>
<td>-0.99. -0.22</td>
<td>very strong</td>
</tr>
<tr>
<td>RESPONSE (s)</td>
<td>0.37</td>
<td>p=.470</td>
<td>-0.63. 0.91</td>
<td>ambiguous</td>
</tr>
<tr>
<td>Pmax CMJ (W)</td>
<td>-0.71</td>
<td>p=.116</td>
<td>-0.96. 0.25</td>
<td>ambiguous</td>
</tr>
<tr>
<td>PmaxCMJb(W)</td>
<td>-0.78</td>
<td>p=.070</td>
<td>-0.97. 0.1</td>
<td>ambiguous</td>
</tr>
<tr>
<td>Pmax CMJ (W/kg)</td>
<td>-0.74</td>
<td>p=.090</td>
<td>-0.97. 0.17</td>
<td>ambiguous</td>
</tr>
<tr>
<td>PmaxCMJb(W/kg)</td>
<td>-0.88</td>
<td>p=.020</td>
<td>-0.99. -0.25</td>
<td>very strong</td>
</tr>
<tr>
<td>Pmax CMJ (W/kg LBM)</td>
<td>-0.77</td>
<td>p=.070</td>
<td>-0.97. 0.1</td>
<td>ambiguous</td>
</tr>
<tr>
<td>PmaxCMJb(W/kg LBM)</td>
<td>-0.86</td>
<td>p=.029</td>
<td>-0.98. -0.15</td>
<td>very strong</td>
</tr>
</tbody>
</table>

Explanation: bold font indicates statistically significant correlations.

Discussion

Analysis of literature concerning climbing sports allows to clearly shows that small body dimensions (i.e. height and mass as well as low fat content) are characteristic of climbers representing a high sports level (1,3). Rokowski et al. (36) conducted an analysis of somatic build among competitors of all climbing competitions presenting the highest level of sport (occupying the first 10 places in the World Cup ranking in speed climbing, bouldering and lead climbing). In their research, Rokowski et al. (36) indicate that the athletes competing in speed climbing differed from athletes of other competitions. The speed climbers had more athletic body build. The average height and mass of the climbers participat-}

ships among studied variables with the climbing run time are presented. The correlations between the studied variables describing somatic features as well as motor skills and climbing time were not significant in the majority of cases. Statistical significance at the level of $p<0.05$ was noted for the correlation between running time and: CMJb (cm) ($r_{xy} = -0.88$); PmaxCMJb (W/kg) ($r_{xy} = -0.88$) and PmaxCMJb (W/LBMkg) ($r_{xy} = -0.86$).

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ing skeletal muscle mass - especially with a predominance of fast twitch fibres, has a significant effect on the level of strength and anaerobic power (38,39), which significantly affects an athlete’s locomotive speed. In this trial, it was noted that the nature of the correlation between the LBM index values and the running time was “ambiguous” ($r_{xy} = -0.22$, 95% CI: -0.88 - 0.72). The result allows to suggest that in this competition, the most important factor in achieving good athletic results may be the morphological structure of the muscles, including a high percentage of fast twitch fibres relative to muscle mass, rather than the absolute level of muscle tissue development. This conclusion is further confirmed by the strong correlation of the running result with the index of maximal non-lactic acid anaerobic power expressed in relation to the lean body mass ($P_{LBM-CM}W(LBM \ in \ kg)$), which can be treated as an indicator concerning the percentage of fast twitch fibres in the skeletal muscles (40). Therefore, it can be assumed that the main and most important somatic predisposition in this competition may be the quality of muscle fibres, i.e. the ratio of fast twitch to slow twitch fibres, and not their number, i.e. the overall size of the muscle tissue.

The number of studies on the significance of body proportions in sport climbing is still small, and the results of these studies indicate the direction that seems to be followed when conducting somatic measurements among climbers. The research by Tomaszewski et al. (41) should be distinguished here, who indicated that in the lead climbers, to achieving the best results is favoured by a high level of limb length indices (e.g. ape index). Magiera et al. (42) also pointed to the potentially high importance of the ape index in lead climbing. In the research by Ozimek et al. (43), conducted among bouldering competitors, it was found that a high level of arm length and the upper limb length index correlate with sports results achieved in competitions. In this study, the correlations between climbing time and length indices were calculated: upper limb index ($r_{xy} = -0.56$), lower limb index ($r_{xy} = 0.68$) and slenderness index ($r_{xy} = 0.62$). These results allow to suggest that in speed climbing, the result of a run may be related to length proportions of body build. This corresponds with the results obtained in previous studies on body proportions and their potential significance in sport climbing (41–43). It should be emphasized, however, that the correlations of the above-mentioned indices were irrelevant. In addition, the correlation results, based on the 95% CI for individual $r_{xy}$ were interpreted as “ambiguous” (Tab. 2). Shulga (5) demonstrated that speed climbers, depending on their body height, i.e. length features, use a different way of overcoming the climbing route, expressed by the difference in the number of limb movements. The differences found by them between “short and tall” climbers indicated that tall athletes made less movements in total. Shulga (5) also observed differences between the climbers studied in terms of climbing time, and found that the fastest climbers were “short” or “tall”. The quite strong but insignificant correlations between the studied length indices and climbing time observed in the this trial, as well as the results of Shulga’s research (5), lead to the conclusion that in speed climbing, the proportions of body build may be a factor determining the way of overcoming the route, significantly affecting the result of the run. However, this should be treated as a hypothesis requiring future scientific verification.

Sozatski et al. (44) distinguish 3 basic manifestations of speed: reaction time, straight movement duration and frequency of movements. They define the reaction time as the that from the activation of the stimulus to the initiation of the movement. On the other hand, Starosta (45) provides a slightly different definition, claiming that it is the time between the signal and the completion of a strictly defined movement in which the whole body participates (global reaction) or its part (local reaction). Raczek et al. (13) report that the ability to react quickly allows for quick initiation and execution of a deliberate, short-term motor action focused on a specific signal, in which the whole body or its parts may be involved. Raczek et al. (13), similarly to Starosta (45), claim that the level of reaction speed is indicated by the time that passes from the moment the signal is triggered to the end of a specific movement. All of the above-mentioned authors agree that response speed is the sum of the latent reaction time as a sensory component and the action time of the muscles involved as a motor component (13,44,45). In practice, 2 types of response times are most often distinguished: simple and complex (13,44,45). Research on the reaction time of climbers was conducted by Sterkowicz et al. (46) and Magiera et al. (42), who, in their research, evaluated climbers specialising in the lead climbing. Based on a review of literature on the reaction time of speed climbers, the research by Kozinha et al. (15), Ozimek et al. (16) and Krawczyk et al. (17) should be mentioned. The results of these studies indicate that the high level of response time may be a factor conducive to achieving successful sports results in this climbing competition. In speed climbing, the measurement of the running result begins with a clear, standardised, familiar acoustic signal that is known to the athletes, after which the climbing run is initiated. This means that the start of a run in a timed climb is based on the mechanisms characteristic of a simple reaction. In the research by Kozinha et al. (15) and Krawczyk et al. (17), response time was measured using computer programs implementing a visual signal, and thus, the
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One of the main objectives of this study was to evaluate the maximal level of non-lactic acid anaerobic power in speed climbers. Muscle power is determined by maximal muscle strength and the speed of muscle contraction. Power, i.e., developing high strength of muscle contractions in a relatively short time, largely determines the speed of performing motor activities (39).

The results of the conducted statistical analyses indicate that a high level of maximal non-lactic acid anaerobic power and explosive strength of the lower limbs are significant factors affecting the result of the run (high values of \( r_{xy} \)) for the CMJ, \( P_{max} \), CMJb (W/kg) and \( P_{max} \) CMJb (W/kg LBM) indices. The obtained results are confirmation of those achieved in previous research (6–8, 16, 50), in which a high level of lower limb explosive strength significantly determines the sports result in the given competition. On this basis, it can be concluded that during activities related to recruitment for speed climbing, diagnosis of the maximal level of non-lactic acid anaerobic power should be one of the basic elements assessed, because it is a strongly genetically determined predisposition (51, 52).

Attention should also be paid to some limitations of this study: there were only 6 competitors representing high sports level, meaning that the practical conclusions can only be limited to a specific category of athletes. They were seniors who presented a level of explosive strength and the ability to coordinate movements (13), thus, it should not be treated as a measure of only explosive strength.

This study was also aimed at verifying which of the used versions of the jump test has higher value. The conducted analyses led to the conclusion that the CMJ test without arm swing and the maximal; non-lactic acid anaerobic power calculated on its basis provides information about the potential possibilities of the subject to a greater extent than the CMJ test with arm swing. It should be noted that the \( p \)-value of the correlation between the result of the run and the results of the CMJ test with arm swing, as well as power indices calculated on the basis of the CMJ with arm swing, were for the CMJ: \( P_{max} \) CMJ (W/kg) and \( P_{max} \) CMJb (W/kg LBM), respectively: \( p = 0.099, \ p = 0.090 \) and \( p = 0.70 \), as well as \( r_{xy} \), respectively: -0.75; -0.71 and -0.77. These results indicate that the CMJ arm swing test can also be used in tests and measurements among speed climbers. It should be borne in mind, however, that the result of the CMJ test with arm swing is conditioned by explosive strength and the ability to coordinate movements (13), thus, it should not be treated as a measure of only explosive strength.

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Attention should also be paid to some limitations of this study: there were only 6 competitors representing high sports level, meaning that the practical conclusions can only be limited to a specific category of athletes. They were seniors who presented a level qualifying them for the national team in the course of selection. Based on the results of the current research, it can only be assumed that the level of explosive strength and muscle power will be a significant factor in determining the results of runs in other age categories. Nonetheless, this seems very probable. The CMJ tests, as previously demonstrated, are not specific for speed climbing, despite the vertical direction regarding movement of the climber’s body identical in sprint climbs. This indicates the need for creating a special test to assess the level of motor fitness in this competition. It also seems that it would be reasonable to develop, based on the CMJ jump test without arm swing, standards of fitness preparation in terms of anaerobic power expressed in terms of body and lean body mass. This type of research should be carried out among competitors taking part in competitions of international rank and cover, if possible, a large sample.
Conclusions

The results of this study, as well as a review of the literature on the discussed subject, allow to formulate the following conclusions:

1. The CMJ test without arm swing is a valuable tool in assessing the motor potential of a speed climber and is a test of great informative value regarding the possibility of obtaining high results in a speed climbing competition.

2. The test used to assess the level of response time to an auditory signal was a trial that allowed to diagnose the possibility of achieving high results in a speed climbing run with moderate strength. This points to the need for further research concerning tests with high informative value that would allow to measure the reaction time of a sports climber in a speed climbing competition.

3. In the recruitment and selection for speed climbing, explosive strength of the lower limbs and maximal non-lactic acid anaerobic power should be diagnosed on time.

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Sci Sports. 2020 Mar;

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