Scholars LITERATURE

Neurological Sciences and Neurosurgery

Research Article

DOI: https://doi.org/10.47275/2692-093X-124
Volume 3 Issue 1

Cognitive Factors that Influence the Relationship between Sports Experience and Climbing Performance in Youth Romanian Climbers

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Abstract

Objective: Climbing performance can be divided into two types: on-sight climbing and red point climbing. There is a difference between motor climbing performance as a personal best route climbed by an athlete and competitive performance being a social comparison regime between athletes. The objective of the present study was to determine if and how some cognitive factors (spatial orientation and reaction time) can influence the predictive relationship between sports experience and sports performance at youth elite climbers.

Methods: The study was conducted on 17 youth climbers. The inclusion criteria were age, a minimum of three trainings per week, the minimum climbing grade 7a and active participation in internal and/or external competitions. We used the Cognitrom battery to apply the tests of measuring spatial skills and speed in reactions.

Results: As the sport experience and competitive experience increase, the spatial skills decrease. As climber's competitive performance increases, so do their spatial skills and ability to generate mental images. Reaction time in elections moderates the relationship between sports experience and on-sight climbing performance.

Conclusions: There are significant correlations between certain cognitive factors and experience, but also climbing performance. Cognitive variables differently influence the relationship between experience and on-sight performance versus red point performance.

Keywords: Sports Climbing; Elite Climbers; Cognition; Reaction Time; Spatial Orientation

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Citation: Ioana VA, Monica S, Florin P (2022) Cognitive Factors that Influence the Relationship between Sports Experience and Climbing Performance in Youth Romanian Climbers. Neurol Sci Neurosurg, Volume 3:1. 124. DOI: https://doi.org/10.47275/2692-093X-124

Received: September 17, 2022; **Accepted:** October 01, 2022; **Published:** October 05, 2022

Introduction

Climbing combines multiple forms of training, being a complex task for the motor system developing coordination, balance, body stabilization because it needs the simultaneous coordination of all four limbs. Every new route request different and new combinations of visual, spatial, kinaestetic and motor processing, being a completely acyclic physical activity [1]. The exact planning of moving sequences is crucial for a successful climb.

Sport climbing has three branches of climbing, depending on the style of ascent [2]: lead climbing, bouldering and speed climbing. The style of ascent depends on the safety protocol in case of a fall. In a bouldering setting a route is short enough in a matter of height so that the climber is protected by crash mats [3]. Longer routes which are classified for lead climbing need a rope and secure bolts, so that in the event of a fall the climber will be arrested by the trailing rope [4].

Giles D, et al. (2014) [5], highlight the importance of the prior knowledge of a route as being an important factor which impacts how the ascent is completed. Thus, climbing performance can be measured in three ways: on-sight, flash and red point climbing [6]. On sight means without any prior knowledge of the route and how to climb it. Flash means completing a route in the first try with some knowledge about how to climb it, but never actually tried it before the ascent. Red point performance means completing the route after repeated tries. The on-sight performance is considered the purest form of ascent, but it is also speculated that red point climbing will conclude a climber's absolute maximum climbing grade [5,7].

The performance in climbing is measured by the grade of the route climbed by the athlete. The climbs' difficulty is dictated by the size of the holds, the quality of the holds, by how many footholds are available, the spacing between holds, the length and the angle of the route. There is a standardized measure for route grades, using the UIAA scale, where routes are graded from 4a to 9c [8], but the climbers who can achieve the 7a grade of a route are considered elite climbers [9]. Studies have shown that on sight climbing is linked to more stress and anxiety in comparison to red point climb of the same route, indicated by greater climbing time, greater cognitive and somatic anxiety [10].

There is a difference between climbing performance (as a personal best route climbed by an athlete) and competitive performance (being a social comparison between climbers in the competition format). Also, studies have already shown that successful climbers are significantly more experienced in terms of years of participating in the sport and years of participating in lead climbing [8].

Climbing routes are a complex problem-solving task [5]. Climbing affordances are the link between the visual stimuli that come from the holds, the wall and the climbing environment and the motor action that the climber has to do [5,11]. It seems that the correct perception of affordances that the route offers is linked to success in achieving the top of the route [12]. The affordance is based on the stored information of a hold, thus the importance of memory training in climbing. Studies showed that there is a difference of the ability of recalling information between experienced and inexperienced climbers [13], thus the experienced climbers tend to recall more information about the route and the wall as clusters of information, in comparison with the inexperienced climbers who tend to recall just the holds themselves. When an anxious stimulus influences the climber, there is a reduction in information processing efficiency and regression to an earlier stage of motor learning which will negatively influence the climber's behavior [14]. Pijpers JR, et al. (2003) [15], suggested that trainings should be held under more anxious situations because will make the climber to inward his focus of attention and make him climb more conscious and control better the execution of his well-learnt motor skills.

There is a high degree of planning and spatial orientation needed in sport climbing [16]. Sport climbing is characterized by sensorial integration by involving multiple types of sensations. The multiple stimuli from multiple analyzers such as seeing the hold, feeling the shape and fabric of the hold, ensuring his own stability through shifting his body's center of gravity explain how climbing is about internalizing outer and inner perceptions [17]. Steimer J, et al. (2017) [16], suggest that because a climber needs to search for a viable way of ascending and preferably the least straining path, the climber is forced to rely on more than physical strength, but also coordinative and tactical skills. Studies indicate that a static climbing position requires a greater attention than standing in an upright position. In addition, the attention a climber needs when reaching for the next hold is approximated double compared to remaining static, even for expert climbers. Green AL, et al. (2011) [18], concludes that climbing demands a greater attention and control than many other physical activities. Research has shown that simultaneous cognitive task interferes with the act of walking. And walking is a cyclic activity [19]. If a simultaneous cognitive task can interfere with a cyclic activity like walking (also an automatic motor activity), Green AL, et al. (2011) [18], suggests and further demonstrated that a simultaneous cognitive task will significantly influence climbing (a physical activity which demands a greater level of attention and where the athlete is in a constant state of postural instability).

The objective of the present study was to determine if and how some cognitive factors (spatial orientation and reaction time) can influence the predictive relationship between sports experience and sports performance at youth elite climbers.

Methodology

Participants

The study was conducted on 17 climbers aged between 13 and 19 years (M = 16.59 years; DS = 2.00). All athletes live in big cities from Romania, where there are climbing gyms. We analyzed male climbers (58.82%), but also female climbers (41.18%). Among the inclusion criteria were: *age* - analyzing only athletes who participate in Youth competitions, in one of the 3 categories: youth B (13-14 years) - 4 athletes (23.52%), youth A (15-16 years old) - 4 athletes (23.52%) and juniors (17-19 years old) - 9 athletes (52.94%). The second inclusion criterion was *a training frequency* of at least three training sessions per week. The third inclusion criterion was a minimum climbing degree of *7a* (on sight or red point, bouldering or lead, artificial walls or rock climbing). The last inclusion criterion was *active participation* in national and international competitions and junior training camps organized by the federal team. The inclusion criteria were very drastic, trying to analyze almost all the athletes from the national youth team from Romania.

The group's on sight performance varies between 6c to 8b and red point performance varies between 7a to 9a. For measuring the competitive performance, we used a hierarchical scale of athletes, depending on the highest level reached in a competition. So, 6 (35.29%) of the athletes participated in a final of European or world competition; 2 (11.76%) are national champions; 2 (11.76%) participated in a European or world competition; 2 (11.76%) participated in a national final; 3 (17.64%) participated in a national semifinal; 2 (11.76%) never made it to the finals. The number of training sessions the athletes perform per week varies between 3 and 7 (M = 4.29, DS = 1,312), with a duration ranging from 2 to 4 hours (M = 2.85, DS = 0.52). Climbers have a sports experience ranging from 1 to 12 years (M = 6.94, DS = 3.01) and a competitive experience ranging from 0.5 to 11 years (M = 4.941, DS = 3.3).

Instruments and Variables

The variables that measured the factual data of the athletes were: age, sports experience (measured by the number of years the athlete practices climbing), competitive experience (measured by the number of years the athlete participates in internal and/or external climbing competitions), climbing performance (measured by the highest grade achieved in rock climbing or on climbing walls, at bouldering or lead, according to the UIAA rating) - which was divided into on sight performance and red point performance and then converted into a standard numerical scale taken from the literature [20], competitive performance (measured on a hierarchical scale on which athletes ranked themselves according to the highest level reached by them in a national / Balkan / European / world competition).

We used two scales for measuring spatial skills and speed in reactions from the Cognitrom battery. The spatial skills scale involves 3 subscales measured with 3 subtests: the mental imaging-transformation test, the spatial orientation test and the image generation test. The reaction speed measurement scale involves 3 subtests and measures: simple reaction time, election reaction time, and memory access reaction time.

Results

The means and standard deviations for all measured scales can be identified in Table 1.

We ran the Pearson analysis to demonstrate statistically significant correlations between competitive experience, on sight performance, red point performance, competitive performance, and cognitive

Table 1: Descriptive analysis of the measured cognitive scales.

Descriptive Statistics				
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Spatial skills	3	5	4.21	0.699
Mental imaging transformation	3	5	4.25	0.754
Spatial orientation	4	5	4.64	0.497
Image generation	2	5	3.67	0.985
Speed reaction	3	4	3.3	0.483
Simple reaction time	2	5	4	0.943
Election reaction time	1	4	2.3	1.16
Memory access reaction time	2	5	3.7	1.059

variables. The conclusions of the correlation analysis are the following. There is a significant negative correlation between sports experience and spatial skills (p=0.039, R=-0.557). There is a significant negative correlation between competitive experience and spatial skills (p=0.003, R=-0.737). There are significant negative correlations between on sight performance and spatial skills (p=0.009, R=-0.688), but also image generation (p=0.002, R=-0.789). There are significant correlations between red point performance and spatial skills (p=0.010, R=-0.659), but also image generation (p=0.03, R=-0.769). There were no statistically significant correlations with competitive performance. There were none significant correlations with the rapidity in reactions variables.

Since we demonstrated statistically significant correlations between experience and performance, we performed two simple regression analyzes to demonstrate how sports experience predicts climbing performance (on sight and red point) and how competitive experience predicts competitive performance (Tables 2-4). Sports experience explains a percentage of 46.3% of the variance of on sight performance (R=0.681; R^2=0.463; p=0.003). Sports experience explains a percentage of 52.7% of the variance of red point experience (R=0.726; R^2=0.527; p=0.001). Competitive experience explains a 50.5% percentage of the variance of competitive performance (R=0.711; R^2=0.505; p=0.001).

We want to test further whether any of the cognitive variables have a moderating or mediating influence on the relationship between experience and performance.

We tested if the variable *image generation* influences the relationship between *sports experience and red point performance.* We ran a mediation analysis (using model 4). The results can be identified in Table 5.

Regarding the effect of sports experience on image generation (the effect of the variable x on the mediating one), it seems that sports experience explains 12.1% of the image generation variance, and the regression coefficient is equal to -.0129, and the standardized value is -0.426. So, a = -0.129.

Sports experience and image generation explain almost 80% of the variance of on sight performance (R^2=0.799, p<0.05). Note that for path b the coefficient is -0.519, with a standardized value of -0.555. So, b=-0.519. The direct effect (c') is 0.142 with a standardized value of 0.503. So, c'=0.142.

For the total effect (path c), sports experience explains about 54.6% of the variance of on sight performance (R^2=0.546, p=0.006). The coefficient of the regression equation for the relationship between sports experience and on sight performance is 0.209, with a standardized value of 0.739.

Thus, we conclude that the variable image generation does not significantly mediate the relationship between sport experience and on sight performance (a*b=0,067, CI 95%= [-0.038-0.172]). The non-significant mediation effect can be explained through the small sample size which impacts the statistical power of the test (the probability that the test correctly rejects the null hypothesis). The mediating effect of image generation on the relationship can be viewed as a statistical diagram below (Figure 1):

We further wanted to test if the variable reaction time in the election influences the relationship between sports experience and on sight performance. We ran a moderation analysis (using model 1). The results can be identified in Table 6.

Since p=0.05, we conclude that reaction time in elections

Table 2: Predictive relationship between sport experience and red point performance.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	df
1	.726[a]	0.527	0.495	0.63586	16.68	1
a. Predictors: (Constant), exp_sp						
b. Dependent variable: red point performance						

Table 3: Predictive relationship between sport experience and on sight performance.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	df
1	0.681[a]	0.463	0.427	0.58300	12.944	1
a. Predictors: (Constant), exp_sp						
b. Dependent variable: on sight performance						

Table 4: Predictive relationship between competitive experience and competitive performance.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	F	df
1	0.711[a]	0.505	0.472	1.38300	15.32	1
a. Predictors: (Constant), competitive experience						
b. Dependent variable: competitive performance						

Table 5: Mediation analysis for the image generation variable.

	b	SE	t	p	CI 95%
Sport experience → image generation	-0.129	0.087	-1.489	0.167	[-0.322-0.064]
Image generation → red point performance	-0.519	0.154	-3.361	0.008	[-0.868- -0.169]
Sport experience → red point performance (c')	0.142	0.047	3.041	0.014	[0.036 - 0.024]
	Effect	**SE**	**CI 95%**		
Indirect effect	0.067	0.052	[-0.038-0.172]		
Direct effect	0.142	0.047	[0.075-0.343]		
Total effect	0.209	0.06	[0.075-0.343]		

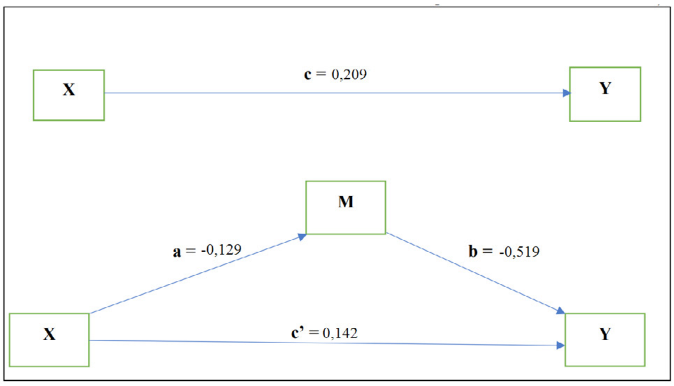

Figure 1: Statistical diagram of the mediating effect of image generation on the relationship between sports experience and on sight performance.

Table 6: Moderation analysis for the reaction time variable.

Model	**R**	**R^2**	**adjusted R^2**	**SE**		
1	0.905ª	0.819	-0.079	0.106		
a. Predictors: (Constant), sport experience, reaction time in elections						
Model				t	Sig.	
		B	ES			CI 95%
1	INT	-0.154	0.065	-2.387	0.050	[-0.313-0.004]
	reaction time in elections	-0.045	0.118	-0.381	0.716	[0.333-0.243]
	sport experience	0.068	0.041	-0.381	0.716	[-0.033-0.170]
a. Dependent variable: on sight performance						

moderates the relationship between sports experience and on sight performance. Because the R^2 is 0.819, the variance of the dependent variable is explained in 81.9% by the model which is composed by: sport experience, reaction time in election and the interaction between these two. This model explains more than the variance explained only by sport experience itself (46.3%). Moreover, adding the interaction variable to the model increases the variance of the on sight performance by 26% (ΔR^2=0.263, F(1.6)= 5.698; p=0.05).

The relationship can also be identified on the graph in Figure 2.

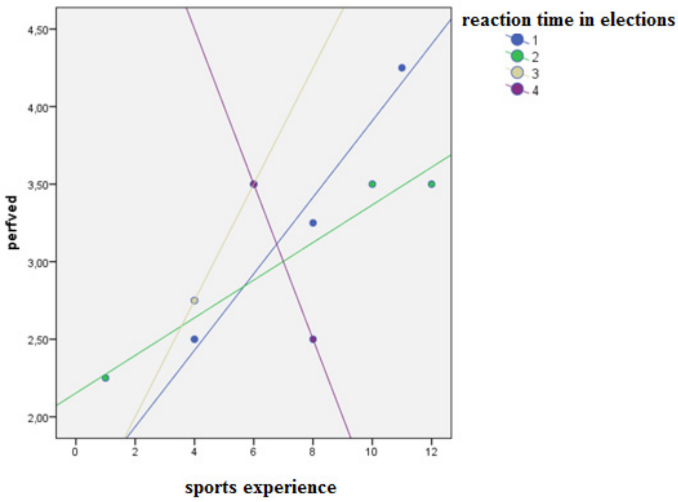

Figure 2: Moderation analysis for the variable reaction time in elections.

Figure 2 demonstrates how the moderator (reaction time in elections) influences the relationship between sports experience and on sight performance. Election reaction time is measured on a scale of 1 to 4, where 4 is a very short choice time. It seems that a faster reaction time (level 4), which corresponds to an athlete who makes the choices between solutions very quickly, will cancel the effect that the sports experience has on the on-sight performance. A good level reactivity (level 3) positively moderates the relationship between experience and performance. And for levels 1 and 2 of reactivity (the weak and very weak reaction time), it seems that the result differs depending of the number of climbing years. Thus, for a climber with an experience up to 6 years, a better reactivity brings him a better performance, but if he has an experience of more than 6 years, a weaker reactivity will bring him a better on sight climbing performance.

Conclusions

The first conclusion of the study lies in the correlation analysis. Significant correlations symbolize that reaction speed is not a cognitive variable that is associated with performance in youth climbers. This result is in concordance with previous studies [1], which suggest that while in some sports like wrestling the success is dependent on a fast reaction response, in sport climbing the athlete needs to plan and imagine the exact temporal and spatial movement of his limbs before going to the next hold. We emphasize the important association with spatial skills and the ability to generate mental images, but, surprisingly, we identified a negative correlation. In other words, as the experience increases, the spatial skills decrease. As a climber's performance increases, his or her spatial skills and ability to generate mental images decrease. This result can be explained by the fact that we analyzed a research group with elite climbers (high performance athletes) for which many of the climbing moves have become motor automatisms [9]. This elite group has a highly developed motor memory so, regardless of difficulty of a route, they may associate a move with something they have experienced before. This leads to a smaller need for spatial orientation, further supporting the theory that this research group has a highly developed proprioception and can orient their body on the wall much better. Draper N, et al. (2011) [21], have studied expert climbers and demonstrated that they chose to climb slower and more carefully so that they can control their body, their equilibrium. The same authors support the idea that successful climbers are significantly more experienced, in terms of years participating in the sport and years participating in lead climbing. The authors highlight that more experienced climbers had reached an autonomous stare of learning, which has a stress-proofing effect, thereby increasing the likelihood of a successful ascent. Climbing is considered an acyclic sport, consisting of a series of movements using intermittent isometric contractions of the forearms along with dynamic movements of the whole body [22]. However, it is considered that the number of technical procedures is finite, the way of their implementation being different from the characteristics of the route (grips, inclination, length of the route, difficulty of the route) [5]. The advanced motor memory of an advanced climber helps and makes it possible to associate a motor task with something they have experienced before. This reduces the need for spatial orientation.

The second important conclusion comes from the mediation analysis which showed that image generation is a not a mediator on the relationship between sports experience and red point performance. This conclusion must be explained by the small sample group because it impacts the statistical power of the test (the probability that the test correctly rejects the null hypothesis). We cannot be sure that what influences the relationship between a climber's experience and his performance after multiple tries is his ability to generate images. Further studies on perhaps multiple athletes must test this hypothesis. Red point climbing involves an unlimited number of attempts to complete the route, the ultimate goal being to conquer a high grade. Thus, he has to search for various solutions to approach the route in order to succeed. This is correlated with a good creativity which makes the climber able to generate more ascent variants that can bring him success. This explains the importance of the tactical training and what tactics means in climbing, with creativity and imagery being two absolutely necessary skills for high-performance climbing [23]. Sanchez X, et al. (2009) [24], have already demonstrated that using techniques such as imagery and video-modeling can influence positively climbing performance. Other studies [25,26], also explained how external imagery can be highly beneficial in climbing. The third important conclusion of the study was the moderating effect of reaction time in choices on the relationship between sports experience and on sight performance. First of all, out of all the measured reaction times (simple reaction time, election reaction time, and memory access reaction time), it seems that the time that counts in an on sight climb is the reaction time between choices. We imagine a climber is on his first attempt on a route that he has never seen or climbed before. When he is in a crux, he has to identify several strategies for crossing it, but at the actual moment of the climb he needs a quick reaction time in the elections, in order to choose the best approach that will bring him success. This finding is also sustained by the results of previous research [27], which has shown that reaction time performance in climbing is influence by the location in the route, but also by the outside factors. A good reaction time in elections is related to a good decision-making capacity, the ability to choose the optimal solution which brings success. We are talking about a sport in which any hesitation can lead to falling and, implicitly, to failure, through the rapid accumulation of lactic acid in the forearms [28,29].

Moreover, our study shows that there is an optimal reaction time in the election. On the one hand, too short a reaction time (level 4) cancels out the effect that sports experience has on on-sight performance. A quick reaction time (level 3) positively influences the relationship. For poor or very poor reactivity, the level of experience becomes important: an athlete with up to 6 years of experience will perform better if he has better reactivity (level 2), but an athlete with more than 6 years of experience needs a weaker reactivity (level 1). This result can be linked to another study conducted in speed climbing which has shown that shortening of reaction time may have a significant effect on the final result in the climbing race [30], but conclusions should be drawn carefully, because it can also lead to failing.

The last two conclusions are particularly important because they demonstrate how climbing experience is related to climbing performance. The decisive factors that influence the relationship, comparing between on sight performance and red point performance, might be different: when we talk about an ascent on sight, speed in reactions matters and when we talk about a red point ascent, image generation can be decisive. It is interesting to note that both factors are cognitive, which explains why cognitive variables influence climbing performance (personal best in sport climbing). In addition to the branches of training already known as important in climbing, similar to other sports (theoretical, physical, technical, tactical, psychological) [23], we now highlight the importance of cognitive training where we increase memory, attention, spatial orientation, decision-making ability, reaction time [31,32].

The study has some limitations. On one hand, the design was cross-sectional which block us from identifying causal relationships between variables. On the other hand, the research group was relatively small due to inclusion criteria, but we wanted to analyze the cognitive skills of elite youth climbers from Romania. Lastly, the test battery that we use is not measuring specific cognitive climbing skills and are not measured in a climbing setting; future studies should focus on analyzing cognitive aptitudes on more specific instruments.

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