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Research Article

JOURNAL OF ORTHOPAEDICS AND SPORTS MEDICINE

ISSN: 2688-5115

Testing IRCRA Battery and Its Predictive Value on Red-Point Performance in Youth Advanced Climbers

Antonia Ioana Vasile* and Monica Stănescu

Abstract

Introduction: Various studies examined the factors that influence climbing performance measuring the contribution of anthropometric factors, physiological factors, physical factors, technical factors, psychological factors and mental factors. IRCRA developed a battery with 10 tests that evaluate key physiological parameters in climbing.

Hypothesis: We can predict climbing red-point performance based on the 5 factors: antropometric factor, upper body factor, flexibility factor, core factor and training factor.

Methods: The study was performed on 17 youth advanced climbers both male and female. The evaluating instrument was IRCRA performance-related test battery for climbers with 3 more added tests: push-ups, dips and hanging crunches.

Results: We composed five factors that influence red-point performance, which are, in order of their importance: training factors, upper body strength factors, anthropometric factors, core strength factor and flexibility factors. The model predicted 81.7% of the climbing performance variance. Power slap at Gullich rungs was the most predicting of the upper body strength.

Conclusions: The most important factor for performance in climbing is a trainable skill: strength of the upper body. Specific training on specific holds is more important than general physical preparation. Anthropometric characteristics influence performance more than core strength or flexibility in climbing.

Clinical relevance: We tested the efficiency of IRCRA battery in evaluating climbing performance and concluded that this battery can be used as a selection testing for competitions. This leads to better selection for competitions according to climbers' level of preparation and can lead to less frequent injuries.

Keywords: Sport climbing; Physical factors; Advanced climbers; Power; Strength

Introduction

Climbing has increased popularity worldwide both as a recreational activity as well as a competitive sport, with multiple studies that examined performance-related factors of the sport [1,2]. It has become increasingly popular since it was included in the 2020 Olympic Games [3,4]. It has three disciplines: traditional climbing, sport climbing and bouldering [5]. Traditional climbing can be performed only in outdoor areas [6]. Sport climbing has

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Citation: Antonia Ioana Vasile, Monica Stănescu. Testing IRCRA Battery and Its Predictive Value on Red-Point Performance in Youth Advanced Climbers. Journal of Orthopedics and Sports Medicine. 5 (2023): 249-259.

Received: May 09, 2023
Accepted: May 19, 2023
Published: May 22, 2023

Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

gained more popularity lately due to the emergence of indoor climbing gyms, making the sport more accessible to people [7]. Competitive sport climbing has three disciplines: lead, bouldering and speed.

Performance in rock climbing is measured by the perception of the route climbed and the route is given a specific grade expressed on a specific scale (such as UIAA (International Climbing and Mountaineering Federation), Yosemite decimal scale, French scale, Vermin, Font, IRCRA (International Rock Climbing Research Association), British, Watts) [8]. The grade should objectify the difficulty of the route which can depend on several factors such as: the technical difficulty, the power for every single move, the stamina needed for long passages, number of rest points [9]. All in all, grades are subjective [10] and are based on the comparison of the route with other routes previously climbed by that athlete. Depending on the number of attempts for succeeding the top, the route can be considered *on-sight* (from the first try, without any additional information about the climbing plan of ascending or about the holds), *flash* (from the first try, but with prior information about the route) or *red-point* (after multiple tries) [11]. The most valued and difficult style is considered on-sight climbing [9].

Various studies have examined the **factors that influence climbing performance**, measuring the contribution of physiological factors [12], psychological factors [13,14], mental factors [15] and the contribution of anthropometric factors [12,16]. Previous studies explained that climbing performance in correlated with endurance performance, flexibility and grip strength relative to body mass [17]. It is important to note that these physical and morphological characteristics of climbers are affected by environmental and genetic factors [3,4]. Watts [18] theorized the elite athlete profile for rock climbing: small stature and low body mass, with low percent of body fat, with high upper-body strength to body weight ratio, high dynamic and isometric muscular endurance, high upper body power and moderate to high aerobic power.

When analyzing **anthropometric factors**, the typical climber is short in height, low weight and has increased muscle mass in the upper body [19]. Espana-Romero et al. [20] reported that a low percentage of body fat is preferable, as excess body fat increases the muscular effort needed to maintain balance and climb to the top [18]. Billat et al. [21] demonstrated that a climber has an average height of 1.8m. An ape index of +2.5 cm has also been shown to be specific to performance climbers, but not different from the general population [12].

As for **strength factors**, when eliminating the influence that coordination, technical skills, tactical skills, anthropometric factors and mental factors have on performance, it appears that the intermittent endurance of the flexors of fingers is a key element that increases performance in climbing [22,23]. The flexors muscular fatigability is in association with success or failure in competitive climbing [24]. Grant et al. [25] explained that elite climbers, compared to recreational climbers and non-climbers, have a better upper body strength examined by number of pull-ups and maximum hanging. Birkett explained the important influence that upper limbs have on performance in climbing and Noe et al. [26] observed an increase in the upper limbs effort from 43% to 62% when the inclination angle of the wall increases by 10 degrees. High levels of maximal and explosive strength of the upper limbs (fingers, forearms, elbow flexors, shoulder muscles) and back muscles have been suggested to be significant attributes of the elite climbers [27-29].

It was postulated that **flexibility** is an important component of climbing fitness, being used in bridging or high stepping moves. Mermier et al. [12] confirmed that flexibility is an important factor that influenced climbing performance among elite climbers, but it does not directly influence the success. Another study explained that elite climbers compared to non-elite climbers and controls have a higher flexibility [30]. Saito et al. [3,4] reported that the frequency of a high flexibility gene (ACTN3 R577X polymorphism) [31] was higher in climbers compared to controls. Flexibility is an important skill for climbing performance [3,4]. Sit-and-reach tests were positively correlated with climbing performance and the results in this test are higher for elite climbers compared to recreational climbers [32]. Moreover, climbing-specific flexibility examined with foot raises in front of the wall is higher in elite climbers compared to recreational climbers and non-climbers [30].

Draper et al. [33] demonstrated that general **climbing experience** and number of years lead climbing significantly affected success on the route and appeared to provide successful climbers with a greater feeling of self-confidence before climbing. They explained that climbers with higher levels of self-confidence stayed fewer time in cruxes on the route and had a lower heart rate throughout the climb. Their findings explained that prior experience played a significant role in successful climbing performance in lead climbing or top roping.

IRCRA provided a battery of 10 climbing-specific tests for fitness for climbers that assess key physiological parameters[1].

Draper et al. [34] examined the validity and reliability of IRCRA battery on 132 rock climbers and demonstrated that flexibility and strength tests were partially successful in differentiating between climbers in accordance to their performance. In addition they demonstrated that the finger hang test and powerslap test are the most strongly correlated

[1] https://www.ircra.rocks/mct (last accessed: 12.04.2023, 18:12)

Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

with performance ability.

The aim of the sudy was to examine the validity of IRCRA battery (2015). The first objective of the study was to examine the efficiency of the IRCRA battery on evaluating red-point performance on youth advanced climbers. The second objective of the study was to evaluate the predictive value of the motor tests on red-point performance.

Methodology

Participants

The study was performed on 17 youth advanced climbers with ages between 13 and 20 years old (M=16.59; SD=2.00), including 10 male and 7 female with a climbing experience between 1 and 12 years (M=6.74, SD=2.00). All the climbers had at least 3 training sessions per week. The inclusion criteria was that the athlete had climbed at least one route measuring 7a grade in the last year before enrolling into the study, according to the French scale (lead red-point climbing). This meant that we analysed only advanced climbers, according to Draper et al. [8] classification. We included climbers who participated in at least one National competition in the last year before entering the study. Within the research group, 4 climbers participated at youth B competitions, 4 climbers participated in youth A competitions and 9 climbers participated in juniors competitions. The entire research group was part of the National youth climbing team.

The studies involving human participants were reviewed and approved by the Ethical Committee of National Univerisity of Physical Education andSort, Bucharest, Romania (no. 120/25.01.2021). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Instrument

The evaluating instrument was adapted from the IRCRA performance-related test battery for climbers (2015) according to the existing equipment from the climbing gym. The adaptation was the following: the climbing specific foot-raise tests were measured at the espalier; the finger hang test was measured in three different grips (full crimp on small edge hold, half crimp on medium edge hold and open hand on the slopers) at the Metolius board; the pull-up shoulder endurance test was measured in three different grips (full crimp on small edge hold, half crimp on medium edge hold and open hand on the slopers) with a full pull-up at the Metolius board.

In addition, we evaluated the climbers with 3 more tests. The first one was for measuring the power of rectus abdominis with crunches from the starting position of hanging at the fixed bar, measuring the maximum number of reps. The second test was the power of triceps and pectoral muscles measuring the maximum number of push-ups. The third additional test measured the upper-body muscle power evaluating the maximum reps of dips. In total, the climber was evaluated with 16 tests.

Variables

The measured variables were classified in 5 categories. The **first** category included **anthropometric** data: *weight*, *height*, *BMI*, *ape index*, *forearms circumference* (right and left). The **second** category included **upper body** strenght data: maximum number of seconds *hanging* on three different holds (*small* edge, *medium* edge and *slopers*); power slap at *Gullich* (with left hand and right hand), maximum number of seconds *hanging in pull-up position* at the fixed bar in pronated position with both hands; with left hand only and with right hand only; maximum number of *pull-ups* on three different holds (*small* edge, *medium* edge and *slopers*); maximum *dips*; maximum *push-ups*. The **third** category included **core strength** data: alternative *crunches* from hanging position; *90 degree bent leg raise; plank* position test. The **fourth** category included **flexibility** data: *climbing specific foot-raise with rotation*; *climbing specific foot-raise without rotation*. The **fifth** category included **training components** such as: *number of trainings* per week and *climbing experience*. All these variables were considered **independent variables**. The last category included **factual data** such as: *age*, maximum *red point performance* in lead routes (which was measured in French scale and then converted according to Watts et al. scale [16]. The red-point performance was considered **dependent variable**.

Because of the large amount of variables, we decreased the number by doing the average for variables that were measured on the right and on the left hand/foot: for flexibility with rotation; flexibility without rotation and for power slap at Gullich. Similar, we did the same for variables that were measured on the three types of holds (small edge, medium edge and slopers): for hanging and pull-ups.

All the variables included in the statistical analysis can be seen in Table 1.

Research hypothesis

We can predict climbing red-point performance based on the 5 factors: **anthropometric factor**, **upper body factor**, **flexibility factor**, **core factor** and **training factor**.

Statistical analysis

For statistical analysis we used the structural equation modeling approach of partial least squares (PLS-SEM) that evaluates dependent variables (formative or reflective), including smaller data sets. PLS-SEM or path analysis should be used when the model is exceedingly complicated, the population size is relatively small and the model contains simultaneously formative and reflective variables [35].

Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

Prediction of relationships is its principal application [36]. Smart PLS is a reliable regression methodology because:

it diminishes the variance of the endogenous variables residuals;

1) it generates effective data despite small data sets;

2) it uses formative and reflective variables [36].

Forecasting and the explanation of complicated relationships are its principal applications [36].

Our model was formed by 6 factors: 4 reflective factors (Antrop, UpperBody, Core and Performance) and 2 formative factors (Flexibility and Training). The anthropometric characteristics of athletes formed the Antrop factor: age, BMI, arm span, ape index and circumference. The variables that measured strength of upper limbs were: hanging, gullich, hanging90dg, tractions, triceps, push-ups. The core strength of the body was measured by tests such as: core_bicycle, 90_bent_leg_raise and plank.

Results

The descriptive statistics for the factual data is presented in Table 2.

The descriptive statistics for the motor variables is presented in Table 3.

Construct reliability and validity: In order to evaluate consistency using Construct Reliability, we used SmartPLS [37] as indicated in Table 4. The variance of Performance variable is explained by the other factors Core, Training, Antrop, Flexibility and Upper Body variance in 73,4% (R^2 adjusted= 0.734). We can see the analysis in Table 4 and Figure 1.

Correlation between variables: The correlation analysis revealed a very strong positive correlation between Performance and Training (0.792). We also demonstrated a very strong positive correlation between Performance and Upper Body (0.703). The Path coefficient for the relationship between Training and Performance is 0.513 and for the relationship between UpperBody and Performance is 0.302 (Figure 1). The Performance is also influenced by the anthropometric factor with a correlation coefficient of 0.658 and a Path Coefficient is 0.246. The flexibility and core strength have a very small influence on Performance. A very small correlation was found between Flexibility and Performance (0.305) and between Core and Performance (0.265). The path coefficient is very low (less than 0.1). A

Table 1: Name, code, and significance of variables analyzed.

Variables	Items	Description significance
Antropometric factor (Antrop)	Age	The respondent age
	BMI	Body mass index
	Arm span	Arm spam
	Ape	Ape index (= difference between arm spam and height)
	Circumference	Forearm circumference (as a mean between left and right forearms)
Red-point performance (Performance)	workWatts	Climber's red-point performance in the last year before enrolling into the study
Upper body strength factor (Upper body)	Hanging	Maximum number of seconds hanging on three different holds (small edge, medium edge and slopers) as a mean
	Gullich	Power slap at Gullich
	hanging90dg	Maximum number of seconds hanging in pull-up position at the fixed bar in pronated position
	Tractions	Maximum number of pull-ups on three different holds (small edge, medium edge and slopers) as a mean
	Triceps	Maximum number of dips
	Push-ups	Maximum number of push-ups
Core strength factor (Core)	core_bicycle	Maximum number of alternative crunches (left foot and then right foot) starting from hanging position at the fixed bar
	90_bent_leg_raise	Maximum number of seconds standing in the position: 90-degree flexed elbows with the knees and hips both flexed at 90 degrees
	Plank	Maximum number of seconds standing in plank position
Flexibility factor (Flexibility)	Rotation	Maximum external rotation and abduction of the hip with internal rotation of the supporting leg
	Norotation	Maximum external rotation and abduction of the hip with external rotation of the supporting leg
Training factor (Training)	sports_exp	Sport experience
	Workouts	Number of workouts per week

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Tabel 2: Descriptive statistics for the factual data.

Descriptive Statistics						
	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis
Age (years)	13	20	16.65	2.09	-0.02	-1.06
Weight (cm)	41	72	58.02	8.29	-0.25	-0.06
Height (cm)	150	184	170.53	8.28	-0.47	1.14
BMI	17.5	23.24	19.75	1.58	0.6	0.15
Arm span (cm)	160	191	173.84	9.74	0.44	-1.04
Ape index	-7	12	2.92	5.29	-0.03	0
Right arm circumference (cm)	22	29.5	26	2.18	-0.02	-0.96
Left arm circumference (cm)	22	30	25.85	2.31	0.23	-0.93
Climbing experience (years)	1	12	6.94	3.01	-0.32	-0.21
On-sight performance	2.25	4.75	3.25	0.8	0.41	-0.93
Red-point performance	2.75	5.75	4.02	0.9	0.13	-0.92
Number of trainings per week	2	7	4.24	1.39	0.31	-0.79
Number of hours per training	2	4	2.85	0.52	0.22	0.19

Tabel 3: Descriptive statistics for the motor variables.

Descriptive Statistics						
	Minimum	**Maximum**	**Mean**	**Std. Deviation**	**Skewness**	**Kurtosis**
Flexibility with rotation on the right leg (cm)	134	191	168.88	17.58	-0.81	-0.41
Flexibility with rotation on the left leg (cm)	138	193	171.53	16.32	-0.83	-0.48
Flexibility without rotation on the right leg (cm)	113	208	148.76	26.32	0.73	0.01
Flexibility without rotation on the left leg (cm)	117	210	153.47	26.17	0.55	-0.19
Finger hang on open hand hold (sec)	51	133	84.71	25.52	0.81	-0.38
Finger hang on half crimp hold (sec)	35	77	54.41	15.42	0.12	-1.61
Finger hang on full crimp hold (sec)	18	67	41.71	16.57	0.19	-1.47
Power slap on the right arm (cm)	61	115	93.12	18.71	-0.28	-1.08
Power slap on the left arm (cm)	61	118	93.12	18.86	-0.24	-1.14
Bent arm hang (sec)	24	70	45.59	13.45	-0.21	-0.59
Bent arm hang on the left hand (sec)	0	21	5.56	7.39	1.22	0.06
Bent arm hang on the right hand (sec)	0	20	4.44	6.36	1.72	2.27
Pull-ups on open hand hold (number)	7	26	16	6.62	0.11	-1.29
Pull-ups on half crimp hold (number)	4	21	11.59	5.32	0.28	-1.08
Pull-ups on full crimp hold (number)	3	15	7.82	3.81	0.23	-1.3
Plank (sec)	76	601	178.82	125.03	2.68	840
90_bent_leg_raise (sec)	19	75	48.18	18.23	-0.17	-1.2
Push-ups (number)	10	50	31.29	11.05	0.05	-0.12
Dips (number)	0	23	7.88	6.57	0.75	-0.1
Core_bycicle (number)	52	140	89.29	23.77	0.3	-0.36

Table 4: Validation Steps.

Formative/ Reflective constructs	Composite Reliability	Cronbach's Alpha	AVE	rho_A	R^2	R^2 Adjusted
Normal value	(>0.7)	(>0.7)	(>0.5)	(>0.5)	(>0.5)	(>0.5)
Core	1.209	0.637	0.331	0.35	-	-
Training	-	-	-	1	-	-
Antrop	0.685	0.752	0.366	0.831	-	-
Flexibility	-	-	-	1	-	-
Upper body	0.883	0.896	0.593	0.969	-	-
Performance	1	1	1	1	0.817	0.734

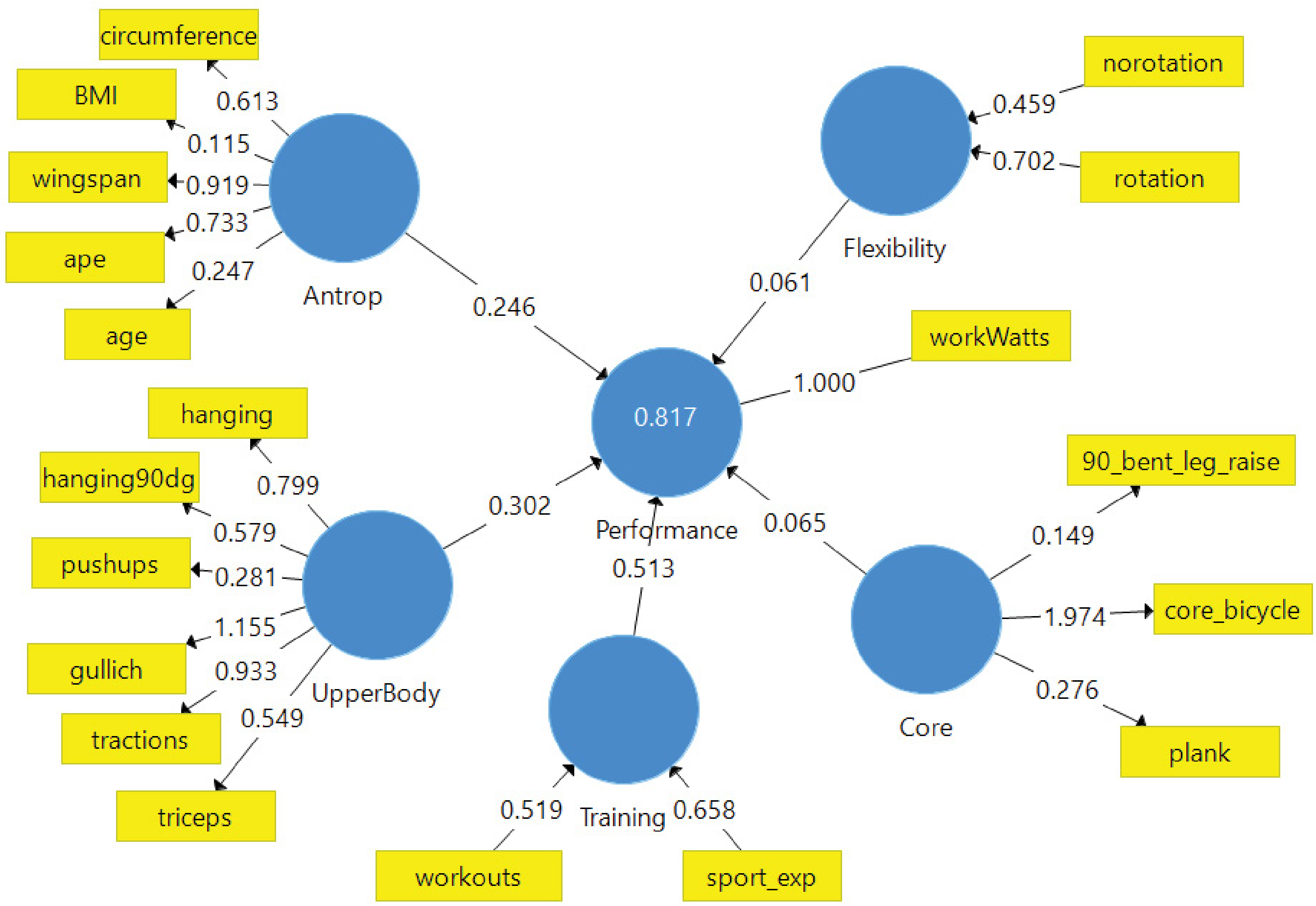

Figure 1: Cronbach's Alpha Analysis and Path Coefficients.

Table 5: Correlation Coefficients.

Latent constructs	Antrop	Core	Flexibility	Performance	Training	Upper body
Antrop	1					
Core	0.067	1				
Flexibility	0.268	0.249	1			
Performance	0.658	0.265	0.305	1		
Training	0.461	0.125	0.228	0.792	1	
Upper body	0.512	0.343	0.15	0.703	0.475	1

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Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

Table 6: Discriminant Validity.

	Fornell-Larcker					
Latent constructs	Antrop	Core	Flexibility	Performance	Training	Upper body
Antrop	0.605					
Core	0.067	1				
Flexibility	0.268	0.249				
Performance	0.658	0.265	0.05	1		
Training	0.461	0.125	0.228	0.792		
Upper body	0.512	0.343	0.15	0.703	0.475	0.77

Table 7: Collinearity Analysis.

Variable	VIF	Variable	VIF	Variable	VIF
Age	2.172	Hanging	3.83	Plank	1.17
BMI	2.699	Gullich	4.71	sports_exp	1.23
wingspan	5.14	hanging90dg	2.48	workouts	1.23
Ape	2.418	Tractions	9.31		
circumference	6.554	Triceps	2.74		
workWatts	1	Pushups	2.48		
Rotation	1.268	core_bicycle	2.08		
norotation	1.268	90_bent_leg_raise	1.86		

small positive correlation was found between Antrop and Training (0.461) and between Upper Body and Training (0.475). The table explaining the correlation analysis is Table 5.

Discriminant validity: The model is statistically robust because it fulfills the Fornell–Larcker criterion requirements. Most of the values obtained for Fornell-Larcker were less than 0.70, implying that all constructs were statistically different one from another when taken two by two (Table 6).

Multicollinearity analysis: SmartPLS's software generated the Variance Inflation Factor (VIF) per each component to measure the relevance of variables (Table 7).

Discussion

The main conclusion of our study was that the most important factor for performance was about the training, with emphasis on the trainable skills needed in climbing: **stregth of the upper body**, with emphasis on the **shoulder muscles**. Secondly, the arm muscles are important, with emphasis on *specific training, rather than general physical preparation*: pull-ups on specific and different holds, hanging on specific holds. Our study highlighted again the widely accepted idea that strength and endurance of the upper-body is the primary predictor for climbing performance [38-40]. Other studies have explained that elite climbers compared to non-elite climbers and controls have higher grip strength relative to their body mass [25] Rate of force development of the finger flexors is believed to be a key factor in determining climbing performance and can discriminate between skilled and international performance climbers [41]. Although it is considered that the fingers are responsible only for maintaining the contact with the holds, while the propulsive force for advancing is produced by the upper body muscles (elbow flexors and shoulder extensors) [41].

When evaluating anthropometric variables, our results are in line with previous research which explain the importance of **arm span** in climbing [17]. During a climbing route, the load on the fingers, elbow and shoulders is shown to be substantial [42]. A lower BMI will lead to lower load for the climber and will reduce the odds for an injury [43]. Although, the studies are inconsistent about the influence that BMI has on performance. When climbing, the load is on upper body muscles and a climber relies on relative strength (power-to-ratio) to progress up a wall. But Grønhaug [43] demonstrated that a light climber and a heavy climber are both training with their own body weight. Their tendons and muscles are adapted according to the stress they get: so, no matter what weight does the climber have, it results to the same adaptation in the strength-to-weight ratio.

Our result that **power slap measured on Gullich board** is the most predicting for climbing performance is another evidence that demonstrates the importance of campus board training. Campus board training is a method frequently used by highly accomplished climbers and involves multiple upper-body moves on shallow rungs, without assistance from the feet [1,2]. This training method challenges finger flexors and involves highly-specific movements of the upper body that increase explosive strength.

Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

Our study is in line with other studies that tried to analyze the determining factors of performance in climbing. Laffaye et al. [44] conducted a study that analyzed the determinant factors for performance in climbing. They combined their variables into three components labeled as training, muscle and anthropometry components, which together explained 64.22% of the performance variance. Their finding was that trainable variables explained 46% of the total variance of climbing skill, whereas anthropometry and muscle factors explained fewer than 4%. Mermier et al. [12] conducted a similar study with a multiple regression analysis that demonstrated a 58.9% variance of climbing performance, where anthropometric characteristic explained 0.3% of the variance and flexibility explained 1.8% of the variance. Their study explained that the trainable skills influence better climbing performance compared to native anthropometric factors. The trainable skills that predicted climbing performance were: upper body strength, lower body strength, shoulder strength, grip strength and hanging time.

Nichols et al. [45] tested the IRCRA battery on youth climbers and demonstrated that fitness scores were generally higher for boys compared to girls and older climbers compared to younger. They explained that fitness variables explained 49% of the variance in climbing performance.

Most of the studies validate the idea that climbing involves a combination of mental factors, upper limb strength and power, technical skills and anthropometric characteristics [46]. The identified determinants which correlated with climbing performance are trainable skills and should receive attention in training sessions, like previous studies explained [17]. Our study demonstrated **the small importance that the non-trainable factors** (like anthropometric factors) have on climbing performance, as previously noted [12,16,32,44]. This concludes that **climbing is a sport that is not restricted by specific body types or somatotypes**, so that body weight or body dimensions do not stop progress in climbing.

The study had **limitations**. The cross-sectional design of the study did not help in drawing conclusions about the causal relationships between variables. Firstly, from a physiological point of view, the two genders may not share the same characteristics and this may have influenced the results [32]. Future studies should analyze physical determinants for climbing performance gender specialized. Another limitation of the study came from the typical evaluation of physical strength of a climber with static, both-handed or single-handed exercises. Because of the increase of media attention and human progress in competitive climbing, the competition routes shifted from focusing on physical strength and stamina to coordination and technique. So studies have explained the need for new methods of evaluation with force senzors for example [47]. Secondly, another limitation comes from the homogeneity of the group in terms of sub-discipline practiced: we included only sport climbers, excluding traditional climbers. On the other hand, we did not analyze differences between lead climbers and bouldering climbers, where the determinant factors may differ. A lot of climbers have on their training program bouldering and lead sessions and have as goals both bouldering and lead competitions and routes to conquer. Moreover, Stien et al. [1,2] did a study that analyzed the influence of a bouldering specific training versus a lead specific training on performance and concluded that a longer bouldering training period can improve performance in both disciplines. Thirdly, another limitation comes from the red-point performance definition based on their personal best in the last year before enrolling into the study, but it was recorded as a self-reported performance and on different routed that they conquered. Future studies should analyze the physical factors that influence performance on the same route, at the same moment of evaluation. According to the majority of previous studies, we did not examine the influence of lower body strength. Lastly, the study analyzed the physical preparation of an advanced youth climber, so we did not evaluate the influence of factors about mental preparation [48], technical factors [49], tactical skills [50], recovery [15] or resistance to fatigue [22,23], all of these may be contributing to climbing performance.

Perspectives and practical application

This is one of the first studies that tested the efficiency of IRCRA battery in evaluating climbing performance among young advanced climbers. We concluded that this battery can be used as a selection testing for competitions according to climbers' level of preparation [51-54]. We explained how selected physiological variables can influence red-point performance. Our study emphasized the importance of upper body factors for climbing performance: the most predicting factor being powerslap at the Gullich rung which demonstrates the importance of campus board training. In addition, the emphasis for hanging time, number of push-ups and pull-ups on Metolius board demonstrated the importance of specific training rather than general physical preparation for climbing performance. Between anthropometric factors, we highlighted the important influence of arm span in predicting performance, validating previous hypotheses of previous studies. Anthropometric characteristics influence performance more than core strength or flexibility in climbing. Future research should search also for the influence of lower body factors and should specialaze between genders, sub-disciplines and competitive performance in a specific competitive setting.

Conclusions

The present study assessed the efficiency of the tests from the IRCRA battery in evaluating climbing performance in advanced climbers. We composed five main factors and

fortune Journals

Vasile AI and Stănescu M., J Ortho Sports Med 2023
DOI:10.26502/josm.511500108

analyzed their influence on climbing performance. Our study demonstrated that the most important factors for climbing performance were, in order of their importance: ***the training factors*** (0.5213), ***the upper body strength factors*** (0.302) and ***the anthropometric characteristics*** (0.246). Then, the factors with less importance were core strength factor and flexibility factors. Our model predicted **81.7%** of the climbing performance variance.

Between the *training variables*, climbing experience has a better influence than number of training sessions per week in predicting performance.

When analyzing *the upper body variables* that explained a good percentage of red-point performance, **power slap on Gullich** was the most predicting (1.155), then number of pull-ups (0.933), then number of seconds hanging on the different holds (0.799), followed by number of seconds hanging in pull-up position (0.579), followed by dips (0.549), then, lastly, push-ups (0.281).

Between *anthropometric factors*, with important influence were: **arm span** (0.919), **ape index** (0.733) and **forearm circumference** (0.613). With a small influence was age (0.247).

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Vasile AI and Stănescu M., J Ortho Sports Med 2023
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