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Original research article

RELATIONS AND INFLUENCES OF BALANCE ON THE RESULT IN SPORTS CLIMBING

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Abstract. *The aim of the research was to determine the relations and influences of balance on the result in sports climbing in women. The research was conducted on a sample of 11 female participants, aged 16±1.55 years, participants of the Youth World Cup in Arco-Italy 2015. The research was conducted by the use of 3 variables for the estimation of balance (Flamingo test - FLAM, one leg standing along on a balance bench - OLSB and crosswise standing on a balance bench - CSBB) and 3 variables for the estimation of the result in sports climbing (bouldering - BOULDER, lead climbing – LEAD and speed climbing - SPEED). Based on the obtained results we can conclude the following: There are statistically significant relations between sets for the estimation of balance and the overall result in sports climbing, so it can be concluded that participants with greater balance will be more successful in sports climbing. There is a statistically significant influence of balance on the result in bouldering, both at the multivariate and univariate level of each variable individually. This means that the participants whose balance is at a higher level show better results in this discipline. However, the analysis of the influence of balance on the success in disciplines lead and speed climbing did not show a statistically significant influence at the multivariate level, even though the significance in discipline speed climbing was on the borderline. Within a framework of the individual influence on lead climbing the flamingo test was highly influential, whereas the crosswise standing on a balance bench test had a great influence on speed climbing. A general conclusion is that apart from strength as a dominant motor skill in sports climbing, balance represents another very relevant factor in this sport.*

Key words: *balance, bouldering, lead and speed climbing*.

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INTRODUCTION

According to the sports classification, a sport climbing belongs to a group of combined (complex) sports (Stanković, Joksimović,& Aleksandrović, 2011). They are characterized by a high variety of movements in compensated fatigue and changing intensity of work (Verhosanski, Sestakov, Novikov, & Nićin, 1992, 85). It has for many years been one of the fastest growing leisure activities, involving millions of people worldwide (Creasey, Shepherd, Banks, Gresham, & Wood, 1999, 6).

Performing in the vertical plane requires physical capabilities such as strength, power, and endurance. It also demands the development of technical skills such as balance and economic movement while gripping and stepping in an infinite variety of ways, positions, and angles. Most important, the inherent stress of climbing away from the safety of the ground requires acute control of your thoughts, focus, anxiety, and fears. In aggregate, the above factors dovetail into what may be one of the more complex sporting activities on this third rock from the sun (Horst, 2003, 1).

Some studies sought the prognosis of success in sports climbing through biomechanical analyses (Quaine, Martin, & Blanchi, 1997; Quaine & Martin, 1999; Binney & Cochrane, 2003a), whereas the majority of studies were involved in researching the influence of strength on success in sports climbing. The very nature of movement in sports climbing unequivocally indicates the increased strength and endurance of the upper extremity in such athletes. The researchers established that specific climbing endurance in the strength of forearm muscles is important for success in sports climbing (Binney & Cochrane, 2003b), that grip strength is one of the prerequisites for achieving good results in climbing (Grant, Hynes, Whittaker, & Aitchison, 1996; Grant et al., 2001; Watts, Joubert, Lish, Mast, & Wilkins, 2003), then the relative strength and concentric flexion of muscles of the hand and wrist (Schweizer & Furrer, 2007), general and specific strength of sports climbers (España-Romero et al., 2009; Stanković, 2009; Puletić, 2014) as well as specific static strength (Stanković et al., 2011). It was also proven that somatotype components, specific strength and specific flexibility influence the result in sports climbing (Grant et al., 1996; Grant et al., 2001; Puletić, 2014; Puletić & Stanković, 2014).

A very small number of researchers dealt with the issue of balance in sports climbers, as well as with their influence on the result in sports climbing. Only two researches dealt with the estimate of balance in sports climbers (Testa, Martin, & Debû, 1999; Quaine & Martin, 1999). Testa et al. (1999) came to the conclusion that the horizontal impulse participates in the control of balance, while the vertical impulse contributes to the initiation of movement, and Quaine and Martin (1999) devised a scheme for the establishment of static balance.

The aim of the work is to determine the relations and influences of balance on the result in sports climbing.

METHOD

The sample of participants

The sample of the participants was extracted from the population of female participants, aged 16±1.55 years, at the Youth World Cup in Sport Climbing in Arco-Italy held from August 28, 2015 to September 6, 2015. The research was conducted on 11 participants, and

the sample involved each participant, provided that they were healthy at the time of testing and voluntarily agreed to participate in the research.

Measuring instruments

In this study, the following tests were applied to estimate the balance of the sport climbers: the Flamingo test (FLAM) expressed as frequency, one leg standing along on a balance bench (OLSB) and crosswise standing on a balance bench (CSBB) expressed in seconds. The applied set of tests of general power was taken from the research of Kurelić et al. (1975). It has been used numerous times in basic experimental research and has an appropriate level of metric characteristics in explaining the tested motor dimensions. The result in sports climbing, and simultaneously the criterion variables were represented by the result in bouldering (BOULDER), lead climbing (LEAD) and speed climbing (SPEED) expressed in points, achieved at the Youth World Cup in Arco-Italy in 2015 in these three disciplines.

Statistical analysis

The statistical methods of analyses included:

Descriptive statistics that comprised number of participants (N), mean value (Mean), standard deviation (SD), minimum (Min) and maximum (Max) numerical results, range (Range) and standard error of the mean value (Error). Discriminative measurements were performed by two procedures: Skewness (Skew) pointing to the symmetry of substance layout around the arithmetic mean and Kurtosis (Kurt) designating peakedness or flatness of distribution.

The correlation of predictor and criterion variables (each with each) was shown in the matrix of intercorrelations and cross-correlations.

To determine the relations of balance to sports climbing success, a canonic correlation analysis was used. This analysis explains the relation structure for the two sets of variables. The followings were computed: size of the canonic correlation (Canonic R), Canonic power of determination (Canonic R^2), Bartlett Lambda test (Chi-sqr), Degree of freedom (df) and Degree of significance (p). In column (Root) a structure of isolated canonic factors was shown.

To determine the influence of the predicting variables (tests of the balance) on each criterion variable, a regression analysis was used. It contains the following parameters: coefficient of correlation (r), coefficient of the partial correlation (Part–r), standardized regression coefficient (Beta), vector of the standardized regression coefficient (t), significance of beta coefficient (p-level), coefficient of the multiple correlations (R) coefficient of the determination (R^2), and the level of the significance of regression connection on a multivariate level (p).

Raw data were processed by means of the Statistica 10.0 software package. Statistical significance was determined at the level of $p<0.05$.

RESULTS

Table 1 Descriptive Statistics for the estimation of balance in sports climbers and the results in sports climbing

Variables	N	Mean	Min	Max	Range	SD	Error	Skew	Kurt
FLAM (freq.)	11	3.49	2.11	6.20	4.09	1.007	0.304	2.0463	6.1247
OLSB (s)	11	18.44	11.25	20.00	8.75	2.726	0.822	-2.1851	4.9225
CSBB(s)	11	11.31	7.13	17.84	10.71	2.956	0.891	0.8129	1.3776
BOULDER (points)	11	43.64	0.00	100.00	100.00	33.494	10.099	0.6890	-0.3323
LEAD (points)	11	27.27	0.00	100.00	100.00	35.191	10.611	1.2052	0.4350
SPEED (points)	11	3.73	0.00	26.00	26.00	7.837	2.363	2.7367	7.8716

By analyzing the basic statistical parameters (Table 1) we can notice the good discrimination of the tests, as all the tests within the Range always contain 3 to 5 standard deviations (SD). By reviewing the data responsible for the symmetry of the distribution around the arithmetic mean (Skew) we can notice that the distribution is symmetric for the variables CSBB and BOULDER, slightly curved to the left in variable LEAD, strongly curved to the left in variables FLAM and SPEED and strongly curved to the right in variable OLSB. By analyzing the kurtosis we can notice that the results in variables FLAM, OLSB and SPEED are quite compressed, whereas they are lengthy in other variables (CSBB, BOULDER and LEAD).

Table 2 Matrix of intercorrelations

Variables	FLAM	OLSB	CSBB	BOULDER	LEAD	SPEED
FLAM (freq.)	1.000					
OLSB (s)	0.117	1.000				
CSBB (s)	0.188	0.398	1.000			
BOULDER (points)	**0.666**	-0.106	0.580	1.000		
LEAD (points)	**0.741**	0.072	0.121	0.433	1.000	
SPEED (points)	0.401	0.147	**0.728**	**0.713**	0.229	1.000

Note: Marked correlations are significant at $p < .05$

By analyzing Table 2 which shows the intercorrelations of the applied variables for the estimate of the balance and results in sports climbing we can notice only 4 statistically significant coefficients. Statistically speaking, the most significant coefficient is between the variables LEAD and FLAM (0.741), then comes the coefficient between variables SPEED and BOULDER (0.731), then between variables SPEED and CSBB (0.728), and finally between variables BOULDER and FLAM (0.666). The other coefficients were not statistically significant.

Table 3 Canonic factors of balance and success in sports climbing and their significance

	Canonic - R	Canonic – R^2	Chi-sqr.	df	p
1	0.9314	0.8676	17.331	9	**0.0438**
2	0.6261	0.3920	4.190	4	0.3810

The canonic correlation analysis (table 3) showed the existence of only one statistically significant canonical factor, i.e. one significant correlation of the variable for the estimation of balance and results in sports climbing (the second factor is not statistically significant). That one significant function explains 87% (Canonic – R^2 = 0.8676) of the total variability of these two sets of variables which is considered a significant level of correlation. The significance of correlation is p = 0.0438.

Table 4 The factor structure of balance and success in sports climbing

Factor Structure, left set		Factor Structure, right set	
Variables	Root 1	Variables	Root 1
FLAM (freq.)	-0.817	BOULDER(points)	-0.960
OLSB (s)	0.028	LEAD(points)	-0.643
CSBB (s)	-0.616	SPEED(points)	-0.749

Table 4 depicts the coefficients of correlation of the manifest variables in both sets (balance and results in sports climbing) with the isolated canonic function. In the area of balance, function is mostly defined with the variables FLAM and CSBB, and in the other set of data, function is defined by all the variables for the estimation of results in sports climbing. The biggest projection on the canonic factor is provided by the variable BOULDER (-0.960).

Table 5 Regression analysis of the variable BOULDER by means of the system of variables of balance

Variables	r	Part-r	Beta	Std. Error of Beta	t(7)	p-value
FLAM (freq.)	0.666	0.805	19.847	5.524	3.5927	**0.0088**
OLSB (s)	-0.106	-0.675	-5.292	2.187	-2.4203	**0.0461**
CSBB (s)	0.580	0.802	7.242	2.038	3.5527	**0.0093**
R= 0.902	R^2= 0.814		F(3,7)= 10.207		**p<0.00598**	

Relatedness of the whole system for the estimation of balance and the results in BOULDER climbing (table 5), i.e. the coefficient of multiple correlation was 0.90 (R = 0.902), which explains the common variability between the system and criterion variable with about 81% (R^2 = 0.814). The remaining 19% when explaining the total variability of the BOULDER can be ascribed to other characteristics and abilities of the participants, but they were not taken into account (other motor abilities, morphological characteristics, etc.), and the testing conditions. These results give a statistically significant explanation of the criterion variable by means of the system for the estimation of balance (p < 0.00589), thus it can be concluded that system for the estimation of balance has a statistically significant influence on BOULDER climbing.

By analyzing single regression coefficients, it can be noted that all of the coefficients are statistically significantly related to the criterion variable BOULDER.

Table 6 Regression analysis of variable LEAD by means of the system of variables of balance

Variables	r	Part-r	Beta	Std. Error of Beta	t(7)	p-value
FLAM (freq.)	0.741	0.737	26.020	9.032	2.8808	**0.0236**
OLSB (s)	0.072	-0.012	-0.114	3.575	-0.0318	0.9755
CSBB (s)	0.121	-0.021	-0.185	3.333	-0.0555	0.9573
R= 0.741	R^2= 0.549		F(3,7)= 2.845		p< 0.11499	

By analyzing Table 5 which shows the results of relatedness of the system for the estimation of balance and the results in LEAD climbing, it can be said that there is no statistically significant correlation of the system on a multivariate level $p < 0.11499$. This explains the relatively high coefficient of multiple correlation $R = 0.741$, as well as the coefficient of determination $R^2 = 0.549$ which explains the correlation of the whole system of balance and criterion variable with about 55%. Consequently, it can be concluded that the system for the estimation of balance does not have a statistically significant influence on the LEAD climbing.

However, by analyzing single regression coefficients, it can be noted that one variable has a statistically significant correlation with the criterion (FLAM = 0.0236).

Table 7 Regression analysis of the variable SPEED by means of the system of variables of balance

Variables	r	Part-r	Beta	Std. Error of Beta	t(7)	p-value
FLAM (freq.)	0.401	0.416	2.198	1.818	1.2092	0.2658
OLSB (s)	0.147	-0.269	-0.532	0.720	-0.7388	0.4841
CSBB (s)	0.728	0.746	1.986	0.671	2.9607	**0.0211**
R= 0.795	R^2= 0.632		F(3,7)= 4.007	p< 0.05940		

The correlation of the whole system for the estimation of balance and the results in SPEED climbing i.e. the coefficient of multiple correlation was 0.80 ($R = 0.795$), which explains the common variability between the system and criterion variable with about 63% ($R^2 = 0.632$). These results do not give a statistically significant explanation of the criterion variable by means of system for the estimation of balance ($p < 0.05940$), even though this coefficient is very close to statistical significance.

However, by analyzing single regression coefficients it can be noted that one variable has a statistically significant correlation with the criterion (CSBB = 0.0211).

DISCUSSION

By analyzing Table 1 we can notice a mild curvature of the distribution of data to the left in variable LEAD, a stronger curvature to the left in variables FLAM and SPEED and a stronger curvature of the distribution to the right in variable OLSB. This indicates that the OLSB test was easy for the selected sample (most of the participants achieved the maximum), while FLAM test proved to be difficult. Likewise, the results are quite poor for the variable SPEED, which can be noticed from the results where the majority of the participants scored 0 points. The reason for this is greater preference (specialty) of the participants for bouldering and lead climbing in comparison to speed climbing. The

analysis of the kurtosis showed that the results around the arithmetic mean in variables FLAM, OLSB and SPEED were very compressed, whereas in other variables (CSBB, BOULDER and LEAD) they were lengthy. The reason for such a distribution can be found in the difficulty-easiness of the applied tests, but also due to the present difference in the chronological age of the participants, experience in climbing, as well as their morpho-motor qualities.

As for the intercorrelation of the applied variables (Table 2) it can be noticed that only 4 coefficients are statistically significant. Of all the results only the FLAM test had statistically significant correlations with two variables for the estimate of the result in sports climbing (BOULDER and LEAD), while the result in speed climbing (SPEED) had a statistically significant correlation with the SPRK test most probably because of the very nature of the movement performance when speed climbing and performing the test.

An analysis of the corresponding canonic functions (tables 3 and 4) points to the assumption that result in sports climbing depends on balance. Since 2 of 3 measures of system for the estimation of balance are in direct proportion with the measures of success in sports climbing, it can be concluded that the participants with greater balance will be more successful in sports climbing. This indicates that the winner in the overall standings (collected results in all three disciplines) Staša Gejo was the best in CSBB and OLSB tests while in FLAM test she was second in terms of results. The biggest projection on the canonic factor was made by the variable BOULDER (0.960). What is interesting is that the overall champion won first place in bouldering, was tenth in lead and thirteenth in speed climbing.

The regression analysis of the connection of the system for the estimate of balance and each of the variables for the estimation of the result in sports climbing individually is shown in Tables 5, 6 and 7. Based on their analysis in can be concluded that there is a statistically significant influence of balance on the result in bouldering both at the multivariate and univariate level of each variable individually. This means that the participants whose balance was at a higher level achieve better results in this discipline. However, the analysis of the influence of balance on the success in disciplines lead and speed climbing did not show a significant influence at the multivariate level, although the significance in the discipline speed climbing discipline was on the borderline.

Within a framework of the individual influence on lead climbing, the FLAM test was highly influential, whereas speed climbing was individually influenced by the CSBB test. This is not surprising because the position of feet in speed climbing is mostly vertically directed towards the rock that ascends, and the crosswise standing on a balance bench is performed under the same conditions (the feet are at a 90º angle in relation to the bench).

It can be noticed that all the participants of the competition were physically strong and durable, their strength and durability being probably the consequence of intensive strength trainings. This corresponds to the researches which proved the influence of general and specific strength on the result in sports climbing (Grant et al., 1996; Grant et al., 2001; Binney & Cochrane, 2003b; Watts et al., 2003; Schweizer & Furrer, 2007; España-Romero et al., 2009; Stanković, 2009; Stanković et al., 2011; Puletić, 2014), which definitely has the greatest impact on the result in sports climbing. However, this may "cut both ways", because an early narrow specialization and the neglect of some motor skills may be a stumbling block to further progress in senior categories. Even back then Horst (2003, 5) claimed: "Rock climbing is unique among sports, however, in that it requires a near equal balance of mental, technical, and physical powers."

In top sport “a tiny detail” is enough to make a difference between the defeated and a medal winner. That “tiny detail” in this case, could, among other things, be balance.

CONCLUSION

Based on the obtained results one can conclude the following:

There are statistically significant relations between sets for the estimation of balance and the overall result in sport climbing so it can be concluded that participants with greater balance will be more successful in sports climbing.

There is a statistically significant influence of balance on the result in bouldering both at the multivariate and univariate level of each variable individually. This means that the participants whose balance is at a higher level show better results in this discipline. However, the analysis of the influence of balance on the success in disciplines of lead and speed climbing did not show a statistically significant influence at the multivariate level, even though the significance in discipline speed climbing was on the borderline. Within a framework of the individual influence on lead climbing the flamingo test was highly influential, whereas the crosswise standing on a balance bench test had a great influence on speed climbing. A general conclusion is that apart from strength as a dominant motor skill in sports climbing, balance represents another very relevant factor in this sport.

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RELACIJE I UTICAJ RAVNOTEŽE NA REZULTAT U SPORTSKOM PENJANJU

Cilj rada bio je da se utvrde relacije i uticaji ravnoteže na rezultat u sportskom penjanju kod žena. Istraživanje je sprovedeno na uzorku od 11 ispitanika ženskog pola, uzrasta 16±1.55 godina učesnica svetskog prvenstva za mlade u Arko-Italija 2015. godine. Istraživanje je sprovedeno korišćenjem 3 varijable za procenu ravnoteže (Flamingo test - FLAM, stajanje na jednoj nozi uzduž klupice za ravnotežu - OLSB i poprečno stajanje na klupici za ravnotežu - CSBB) i 3 varijable za procenu rezultata u sportskom penjanju (boldering - BOULDER, težinsko penjanje - LEAD i brzinsko penjanje - SPEED). Na osnovu dobijenih rezultata može se zaključiti sledeće: postoje statistički značajne relacije između seta za procenu ravnoteže i ukupnog plasmana u sportskom penjanju, tako da se može zaključiti da će ispitanici sa boljom ravnotežom biti uspešniji u sportskom penjanju. Postoji statistički značajan uticaj ravnoteže na rezultat u bolderingu, kako na multivarijantnom, tako i na univarijantnom nivou svake varijable pojedinačno. To znači da će oni ispitanici čija je ravnoteža na višem nivou postizati bolje rezultate u ovoj disciplini. Međutim, analiza uticaja ravnoteže na uspeh u disciplinama težinsko i brzinsko penjanje nisu pokazale statistički značajan uticaj na multivarijantnom nivou, mada je u disciplini brzinsko penjanje značajnost bila na samoj granici. U okviru uticaja na težinsko penjanje pojedinačno je značajno uticao flamingo test, a na brzinsko penjanje značajno je uticao test poprečno stajanje na klupici za ravnotežu. Generalni zaključak je da je pored snage, kao dominantne motoričke sposobnosti u sportskom penjanju, ravnoteža predstavlja još jedan bitan faktor za uspeh u ovom sportu.

Ključne reči: *ravnoteža, boldering, težinsko i brzinsko penjanje*