FACTA UNIVERSITATIS
Series: **Physical Education and Sport** Vol. 7, Nº 2, 2009, pp. 161 - 169

Original empirical article

METRIC CHARACTERISTICS OF THE SPECIFIC STRENGTH SPORTS CLIMBERS TESTS

UDC 796.525

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Abstract. *The basic aim of this research was to determine the metric characteristics of the specific strength of sports climbers' tests. The research was conducted on a sample of 14 sports climbers at the national level, aged 18 to 27, those who can climb at least a VIII-route by means of 9 specific strength sports climbers' tests (three tests each for the estimation of specific explosive, specific repetitive and specific static strength). The obtained results point to the conclusion that homogeneity of the specific explosive strength tests in sports climbers is remarkably high, homogeneity of the specific repetitive strength tests is high and acceptable and of the tests of static strength is acceptable and barely acceptable. As for the distribution of data around the arithmetic means in all of the administered test there was normal symmetry and scattering. Also, all of the specific strength tests have very high reliability and belong to a hypothetical factor responsible for the estimation of the specific strength of sports climbers. The biggest coefficient of correlation with the first main component in tests for specific explosive strength shows a test of maximal left hand grab, in tests for the estimation of specific repetitive strength shows a test of pull-ups on two fingers phalanges and in tests for the estimation of specific static strength - block under 90˚ angle on left hand, so these tests could be used as a small battery of tests for the estimation of the specific strength of sports climbers.*

Key words: *Metric characteristics, specific strength, sports climbing*

Received August 27, 2009 / Accepted November 19, 2009
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INTRODUCTION

Sport climbing nowadays is a complex sport with its own terminology and equipment which evolved after years of experiments. Over the years it has been considered a most popular and most attractive sport of leisure time with the highest increase of membership worldwide (Creasey & al., 1999). For example, the USA can boast of over 8,8 million climbers (4,1% population) and in Great Britain the number of climbers increased in the period between 1989 and 1993 by 40% (Wright & al., 2001; Mihailov, 2008; Davis, 2004). All aspects of this sport require devotion on the part of participants and tend to induce admiration and inspiration. (Davis, 2004)

The immanent characteristics of complex sports include a changeable competition situation and a need to preserve a high level of working capacity in compensated fatigue conditions. These types of sports include features of organization of movement activities and energy provision mostly in the two previously mentioned sports (acyclic and cyclic). Having in mind the changing intensity of the competitions' activity, alteration of high movement activities and total rest, energy work of muscles has aerobic-anaerobic feature and specific weight of the glycolitic reaction. They are characterized by a high variety of movements in compensated fatigue and changing intensity of work. (Verhosanski, Sestakov, Novikov & Nicin, 1992).

All climbing disciplines demand strength, endurance and skills acquired during long systematic training. Physical preparation for sports climbing implies increased volume and specificity of the training which would lead to elite athletic sports form. Since the majority of sports climbers do not follow any expert plan of training (Twight & Martin, 1999) but utilize their ‘feelings' it is assumed that a more advanced climbing formula could be obtained by the administration of systematic and documented sports climbing's principles, these being frequencies, intensity, duration and types of trainings (Wilmore & Costill, 1999) which are to be selected based on the specific motor abilities of each single climber.

Strength is a basic physical ability most frequently researched and most valued in body exercise, especially in sport. "Strength, or muscular strength, is the ability to generate maximum maximorum external force" (Zatsiorski & Kraemer, 2006, 21). In the world of sports most disciplines require some degree of both strength and motor skill for the athlete to be successful (Jensen & al., 2005; Rahimi & Bephur, 2005).

Specific motor abilities are acquired in life and specifically in some sports and are the result of specific trainings, i.e. particular motor functioning. During the training process in specific sport, basic physical abilities are modified according to the demands of the given sport. These are basics used to build on specific physical abilities. Success in sport largely depends on numerous specific physical and other abilities. (Nicin, 2000, 128-129).

Rock climbing movement requires following a pattern that mostly exerts abundant pressure on the muscular – skeletal system of the upper limbs. Total body weight is placed on the hand and one finger or more, many times during the performance. Active limbs, such as the hand and finger in particular, act as support and connection points between a climber's body and the wall. (Shahram, Farzad, & Reza, 2007)

Many studies have been carried out on the metric characteristics of motor or physical tests (Abernethy, Wilson, & Logan, 1995; Veličković & Petković, 2005; Schaar, Simon, & Mattes, 2009). However, one of the most thoroughly conducted studies is the one carried out by Kurelić at al. (1975) which determined the metric characteristics of 18 tests for the estimation of anthropometric dimensions and 37 tests for the estimation of motor or physical abilities.

Having in mind that success in sport depends on specific motor or physical abilities, the main aim of this research was to determine the metric characteristics of the specific strength of sports climbers' tests, so that they can later on serve as a battery of tests for the selection of sports climbers.

METHODS

The research was conducted on a sample of 14 sports climbers at the national level, aged 22,43±2,79, with an average body height of 177,21±5,69cm, body weight 69,29±5,80kg, body mass index 22,06±1,59 and experience in climbing 5,4±2,21years. The main prerequisite for the participation in the research was that the climbers had to have the ability to regularly climb at least a VIII-route (*Red point*) on natural rocks and to give their consent to be tested.

The following specific sports climbers' strength tests were applied:

Specific explosive strength

1. Maximal reach with the left hand MRLH
2. Maximal reach with the right hand MRRH
3. Maximal reach with both hands MRBH

Specific repetitive strength:

4. Pull-ups on two fingers phalanges PU2F
5. Horizontal pull-ups on the left hand HPLH
6. Horizontal pull-ups on the right hand HPRH

Specific static strength:

7. Block under 90˚ angle BL90
8. Block under 90˚ angle on left hand B90L
9. Block under 90˚ angle on right hand B90R

Conditions of measurement and description of tests

All of the tests were administered three times each. The plan of variable measurement was implemented by means of work stations in a circle so that bigger muscle groups and different functional mechanisms could be engaged alternatively in order to avoid the influence of one test on another. Apart from that, enough time to rest between the tests was provided, so as to diminish the effect of previous testing.

First of all, the tests of explosive strength were administered. Each test was repeated three times before the onset of the next test. Breaks between the repetitions of tests were 5 minutes long and following the next test administration this break was 10 minutes long. After the completion of the explosive strength tests and a 15 minute break, tests of static strength were administered. Due to higher consumption of energy, breaks between the repetitions of tests lasted 10 minutes each and between different tests lasted 15 minutes. In the end, after one more break of 15 minutes, the tests of repetitive strength with breaks between repetitions of tests and between the administration of different tests were 15 minutes long.

A more detailed description of the tests is to be found in unpublished doctoral dissertation of D. Stanković (2009).

Statistical Methods

In order to determine the metric characteristics of specific strength tests of sports climbers the following statistical procedures were applied:

(1)Discrimination: to determine discrimination, the following statistical parameters for each item and each test were calculated: arithmetic means (Mean), minimal and maximal numerical results (Min and Max), Range, standard deviation (Std.Dev.), coefficient of variation (CV), standard error of arithmetic means (Error), Skewness (Skew.) and Kurtosis (Kurt.).

(2)Reliability: in this research it was determined by means of: Cronbach's Alpha Coefficient, the Correlation between Forms, Spearman-Brown Coefficient and the Guttman Split-Half Coefficient.

(3)Factor validity was determined by means of factor analysis within which characteristic roots were calculated and parts of common variance and component matrix of extracted factors by means of main components method were calculated.

RESULTS AND INTERPRETATION

Table 1. Discrimination of specific explosive strength tests

Variables	Mean	Min	Max	Range	Std.Dev.	CV	Error	Skew.	Kurt.
MRLH1	82.57	78	89	11	3.78	4.57	1.009	0.4390	-1.2046
MRLH2	83.43	78	89	11	3.78	4.53	1.009	0.0508	-1.4139
MRLH3	83.29	77	89	12	4.23	5.08	1.131	-0.0828	-1.6364
MRRH1	80.21	75	87	12	3.19	3.98	0.853	0.6845	0.4282
MRRH2	81.14	75	88	13	3.68	4.53	0.983	0.5177	-0.2621
MRRH3	81.29	76	88	12	3.50	4.30	0.934	0.4528	-0.5727
MRBH1	60.00	54	64	10	2.75	4.58	0.734	-0.7024	0.4789
MRBH2	60.36	55	66	11	3.75	6.22	1.003	0.2036	-1.6419
MRBH3	59.64	52	70	18	4.40	7.37	1.175	0.6601	1.4501

Groups of measuring instruments which hypothetically in the best way represent the areas interpreted in this research, such as specific explosive strength, are the following: MRLH, MRRH and MRBH (maximal reach with the left, right and both hands). The results of these tests are expressed in centimeters (cm).

Evaluation of the measuring instruments and their sensitivity was performed on the basis of the variability of the measuring results, i.e. by standard deviation. Since standard deviation is significantly smaller than 1/3 of arithmetic means it can be said that the homogeneity of results is high, which confirms the very low coefficient of variation for all of the applied variables. As for the deviation from normal distribution in asymmetrics – skewness (Skew.), there is normal symmetry of distribution since skewness values in all variables are in the range +1 and -1. This also points to the adaptability of the task difficulty to a studied sample of subjects. However, kurtosis values (Kurt.) are much smaller than 2.75 in all the variables, which supports the fact that distribution of the results is scattered, i.e. platykurtic. This does not come as a surprise, since we did not use a sample selected according to age or a climber's experience.

Table 2. Discrimination of specific repetitive strength tests

Variables	Mean	Min	Max	Range	Std.Dev.	CV	Error	Skew.	Kurt.
PU2F1	12.36	9	16	7	2.24	18.13	0.599	0.0039	-1.0196
PU2F2	11.93	8	15	7	2.02	16.92	0.539	-0.4113	-0.3517
PU2F3	11.29	8	14	6	2.02	17.87	0.539	-0.3244	-0.8956
HPLH1	13.57	8	18	10	3.32	24.47	0.888	-0.0747	-1.3605
HPLH2	13.50	8	17	9	3.01	22.27	0.803	-0.3071	-1.2555
HPLH3	12.86	8	17	9	3.13	24.38	0.838	-0.0910	-1.5604
HPRH1	14.29	9	19	10	3.47	24.32	0.928	0.1568	-1.3214
HPRH2	13.93	9	19	10	3.25	23.30	0.867	0.1532	-1.2802
HPRH3	13.36	8	18	10	3.52	26.36	0.941	0.1102	-1.4355

Groups of measuring instruments whose intention was to measure the hypothetic dimension of specific repetitive strength are PU2F, HPLH and HPRH tests (Pull-ups on two fingers, phalanges, Horizontal pull-ups on the left hand, Horizontal pull-ups on the right hand). The test results are expressed numerically.

As in the previous Table, the evaluation of the measuring instruments and their sensitivity is performed on the basis of the variability of the measuring results, i.e. by standard deviation. Since the standard deviation is significantly smaller than 1/3 of arithmetic means, it can be said that the homogeneity of the results is high and because the coefficient of variation of the variable PU2F is slightly below, and for the variables HPLH and HPRH is slightly above 20%. As for the deviation from normal distribution in asymmetrics – skewness (Skew.), there is normal symmetry of distribution, since skewness values in all the variables are in the range +1 and -1. This also points to the adaptability of the task difficulty to the studied sample of subjects. However, kurtosis values (Kurt.) are much smaller than 2.75 in all of the variables, which supports the fact that the distribution of results is scattered, i.e. platykurtic. This does not come as a surprise, since we did not use sample selected according to age or a climber's experience.

Table 3. Discrimination of specific static strength tests

Variables	Mean	Min	Max	Range	Std.Dev.	CV	Error	Skew.	Kurt.
BL901	49.87	25.2	73.1	47.9	13.64	27.35	3.645	-0.2513	-0.5230
BL902	49.61	25.0	70.8	45.8	13.37	26.94	3.572	-0.3073	-0.6908
BL903	48.79	22.7	70.5	47.8	13.93	28.56	3.723	-0.3656	-0.6686
B90L1	7.20	2.1	14.3	12.2	3.89	54.05	1.040	0.4572	-0.8135
B90L2	7.16	2.2	14.4	12.2	3.95	55.14	1.056	0.5264	-0.7157
B90L3	6.96	1.8	13.9	12.1	3.89	55.92	1.041	0.5166	-0.7223
B90R1	8.63	3.3	17.4	14.1	4.43	51.36	1.184	0.6110	-0.4362
B90R2	8.52	3.1	17.1	14.0	4.36	51.21	1.166	0.5824	-0.5092
B90R3	8.28	2.8	16.9	14.1	4.37	52.77	1.168	0.5726	-0.5177

Table 3 shows the results of the central and dispersive parameters of the hypothetic dimension of specific static strength of sports climbers. These are BL90, B90L and B90R tests (Block under 90˚ angle, Block under 90˚ angle on the left hand, Block under 90˚ angle on the right hand).

In contrast to the previous Tables, standard deviation in the first test is about 3,5 times smaller than the arithmetic means, with a coefficient of variation around 27%, and in the second and the third test, the standard deviation is about ½ of the arithmetic means with a coefficient of variation slightly above 50%. It can be said that the homogeneity of the results in the first test is acceptable and barely acceptable or not acceptable in the second and third. As for the deviation from normal distribution in asymmetrics – skewniss (Skew.), there is normal symmetry of the distribution since the skewness values in all the variables are in the range +1 and -1. This also points to the adaptability of the task difficulty to the studied sample of subjects. However, the kurtosis values (Kurt.) are much smaller than 2.75 in all variables, which supports the fact that the distribution of results is scattered, i.e. platykurtic. This does not come as a surprise, since we did not use sample selected according to age or a climber's experience.

Table 4. Reliability of the specific explosive strength tests

Variables	Cronbach's Alpha	Correlation Between Forms	Spearman-Brown Coefficient	Guttman Split-Half Coefficient
MRLH	0.961	0.954	0.976	0.902
MRRH	0.979	0.939	0.968	0.865
MRBH	0.887	0.912	0.954	0.924

Table 4 shows the reliability of the specific explosive strength tests. On closer analysis, one can notice that the coefficients (Cronbach's Alpha, the Correlation between Forms, Spearman-Brown Coefficient and the Guttman Split-Half Coefficient) of most variables are bigger than 0.90, which supports the high reliability of the specific explosive strength of sports climbers' tests. Only the Guttman Split-Half coefficient in maximal reach with the right hand and Cronbach's Alpha coefficient in Maximal reach with both hands is somewhat smaller than 0.90. Essentially all three tests for the estimation of specific explosive strength are highly reliable.

Table 5. Reliability of the specific repetitive strength tests

Variables	Cronbach's Alpha	Correlation Between Forms	Spearman-Brown Coefficient	Guttman Split-Half Coefficient
PU2F	0.976	0.976	0.988	0.864
HPLH	0.990	0.993	0.996	0.884
HPRH	0.994	0.997	0.998	0.901

Table 5 shows the reliability of the specific repetitive strength tests. On closer analysis, one can notice that the coefficients (Cronbach's Alpha, the Correlation between Forms, Spearman-Brown Coefficient and the Guttman Split-Half Coefficient) of most variables are bigger than 0.90, which supports the high reliability of the specific explosive strength of sports climbers' tests. Only the Guttman Split-Half coefficient in the Pull-ups on two fingers, phalanges and the Horizontal pull-ups on the left hand is somewhat smaller than 0.90. Essentially all three tests for the estimation of specific repetitive strength are highly reliable.

Table 6. Reliability of the specific static strength tests

Variables	Cronbach's Alpha	Correlation Between Forms	Spearman-Brown Coefficient	Guttman Split-Half Coefficient
BL90	0.996	0.996	0.998	0.897
B90L	0.999	0.997	0.999	0.886
B90R	0.999	0.999	1.000	0.887

Table 6 shows the reliability of the specific static strength tests. On closer analysis, one can notice that the coefficients (Cronbach's Alpha, the Correlation between Forms, Spearman-Brown Coefficient and the Guttman Split-Half Coefficient) of most variables are bigger than 0.90, while only the Gutman Split-Half coefficient is somewhat smaller than 0.90. It supports the high reliability of the specific static strength tests. As for tests for the estimation of specific explosive and static strength of sports climbers, all three tests for the estimation of specific static strength are highly reliable.

Table 7. Isolated factors

	Eigenvalue	% Total variance	Cumulative %
1	**7.843**	**87.140**	**87.140**
2	.595	6.615	93.754

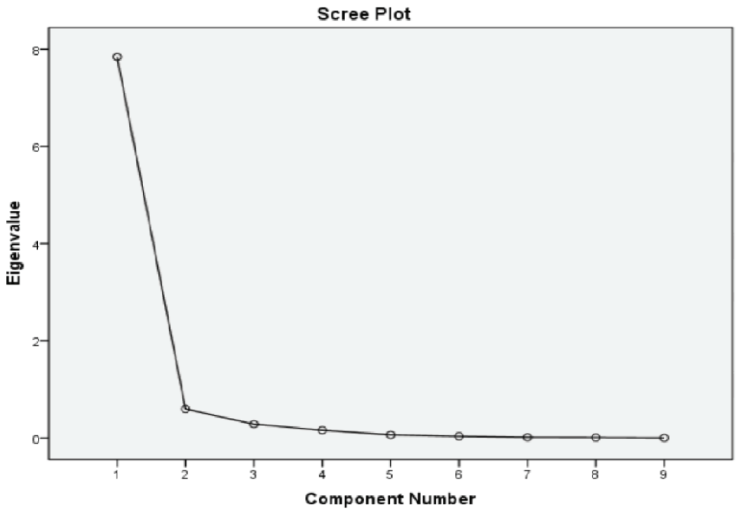

Table 7 and the graph show the isolated factors of specific strength of sports climbers. Only one significant factor was isolated that explained 87,14% of the common variance of the whole system.

These tests belong to the hypothetic factor responsible for the estimation of the specific strength of sports climbers. The mutual manifest feature of these tests is that, by muscle efforts, external resistance is overcome. The most appropriate thing would be to

identify this latent dimension with the hypothetic dimension of the specific strength of sports climbers.

Having in mind that only one characteristic root was obtained whose value is bigger than 1 and only one main component was extracted, the procedure of orthogonal and parallel transformations is redundant.

Table 8. Component matrix of extracted factors using principal components method

	Component 1
MRLHF	0.985
MRRHF	0.906
MRBHF	0.790
PU2FF	0.968
HPLHF	0.916
HPRHF	0.960
BL90F	0.935
B90LF	0.972
B90RF	0.954

All extracted factors have high correlation with the first main component, and almost all are over 0.9 (except MRBHF which is about 0.8). The biggest coefficient of correlation with the first main component of the tests for the estimation of specific explosive strength can be found for the test - maximal reach with the left hand (MRLHF = 0.985), of the specific repetitive strength tests - Pull-ups on two fingers, phalanges (PU2FF = 0.968) and of the specific static strength tests - Block under 90˚ angle on left hand (B90LF = 0.972). Because of s high correlation with the first main component, all these tests could be used as a battery of tests for the estimation of the specific strength of sports climbers, and as a small battery of tests these three tests, MRLH, PU2F and B90L, could be used.

CONCLUSION

In the light of everything we have previously mentioned, one can conclude that the homogeneity of the specific explosive strength tests in sports climbers is remarkably high, the homogeneity of the specific repetitive strength tests is high and acceptable and of the tests of static strength, it is acceptable and barely acceptable. As for the distribution of data around the arithmetic means in all administered tests, there was normal symmetry and scattering. Also, all specific strength tests have very high reliability and belong to a hypothetical factor responsible for the estimation of the specific strength of sports climbers. The biggest coefficient of correlation with the first main component for the tests of specific explosive strength can be found for the test of the maximal left hand grab, in the tests for the estimation of specific repetitive strength can be found for the test of pull-ups on two fingers, phalanges and in the tests for the estimation of specific static strength – the block under 90˚ angle on the left hand, so these tests could be used as a small battery of tests for the estimation of the specific strength of sports climbers.

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METRIJSKE KARAKTERISTIKE TESTOVA SPECIFIČNE SNAGE SPORTSKIH PENJAČA

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Osnovni cilj ovog istraživanja bio je da se odrede metrijske karakteristike testova specifične snage sportskih penjača. Istraživanje je sporvedeno na 14 sportskih penjača saveznog ranga, uzrasta od 18 do 27 godina koji mogu da popnu smer minimalne težine VIII-, uz pomoć 9 testova za procenu specifične snage sportskih penjača (po tri testa za procenu specifične eksplozivne, specifične repetitivne i specifične statičke snage). Dobijeni rezultati upućuju na zaključak da testovi za procenu specifične snage sportskih penjača imaju solidnu diskriminativnost, veoma visoku pouzdanost i pripadaju hipotetskom faktoru odgovornom za procenu specifične snage sportskih penjača. Testovi: maksimalni dohvat levom rukom, zgibovi na falangama dva prsta i blok pod uglom od 90° na levoj ruci, preporučuju se kao manja baterija testova za procenu specifične snage sportskih penjača.

Ključne reči: *metrijske karakteristike, specifična snaga, sportsko penjanje*