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(3. Preisträger Kategorie Referate Studierende)

Body composition, strength and muscular endurance in sport climbers

Summary

The aim of this study was to evaluate the body composition, muscular strength and muscular endurance in sport climbers at different climbing levels. There were 150 climbers divided in 5 groups (3/5;5+/6+;7-/7+;8-/8+;9-/10+ UIAA scale) who undertook the body composition measurement and upper body strength tests. Climbers with higher performance were characterized by a lower body fat ($F_{4,140}$ = 7,18; p = 0,000; η^2 = 0,17), lower ECM/BCM ratio ($F_{4,140}$ = 3,29; p = 0,013; η^2 = 0,09), greater relative grip strength ($F_{4,140}$ = 18,95; p = 0,000; η^2 = 0,35), longer bent-arm hang ($F_{4,140}$ = 32,85; p = 0,000; η^2 = 0,48) and finger hang ($F_{4,72}$ = 20,29; p = 0,000; η^2 = 0,53). The tests used are good predictors of climbing performance and the article proposes reference values for climbers in various climbing levels.

1. Introduction

Sport climbing and especially indoor climbing has become a very popular activity during the last 20 years. The relatively safe environment permits to focus all climber‘s attention to the increase of climbing difficulty level. Assessment of climbing routes difficulty is subjective and comes from the propositions of route setter and discussions between climbers. The UIAA (Union Internationale des Association d’Alpinisme) scale is used in sport climbing in Germany and Middle Europe. It has 11 grades with intergrades plus and minus. Higher number and plus mark is related to higher climbing level.

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The style of contemporary sport climbing has changed to steep, overhanging routes soliciting the upper body and finger strength. The typical climber is characterised by small stature and low body fat (Giles, Rhodes & Taunton, 2006; Sheel, 2004; Watts, Martin & Durtschi, 1993). As we know, there are no data published evaluating the body composition with more then 2 components (body fat, lean body mass). More components models are accessible nowadays and especially the impedance analysis is quick, relatively cheap and procures reliable data (Bunc, 2007). It is generally indicated that finger strength, finger and shoulder girdle endurance are limiting factors of climbing performance (Grant et al., 2001; Grant, Hynes, Whittaker, & Aitchison, 1996; Macleod et al., 2007; Wall, Starek, Fleck, & Byrnes, 2004; Watts, Martin, & Durtschi, 1993). These studies were carried out with different tests and with small number of participants. Our question was, if there are simple tests to assess upper body strength in climbers.

The aim of this study was to evaluate the body composition, muscular strength and muscular endurance in sport climbers at different climbing levels.

2. Methods

2.1 Subjects

The testing was realised with 150 climbers on an artificial climbing wall. Climbers were divided according to their climbing performance into 5 groups (3/5;5+/6+;7-/7+;8-/8+;9-/10+ UIAA scale).

2.2 Testing

First, climbers were asked to fill in the questionnaire with actual RP (rot Punkt) and their volume of training. The multi-frequency device Nutriguard-M (Data Input GmbH, Germany) for evaluation of body composition was used, which measures the whole-body bio impedance on frequencies 1-5-50-100 kHz. Testing was undertaken in a lying position with the tetra polar configuration of electrodes according to the producer. Participants were asked not to eat 2 hours and drink 1 hour before the measurement and to avoid any strenuous motor activity in the previous 24 hours. Measurements with the transfer resistance lower than 250 Ω were used for calculation. From the measured data, assessment of body fat was undertaken from the prediction equation for a child population and the ratio of extra cellular and body cellular mass ECM/BCM, which is used for the assessment of conditions for muscle work. A small percentage of BCM (higher ECM/BCM ratio) is connected with insufficient movement load and unsuitable diet (Roche, Heymsfield, & Lohman, 1996).

Grip strength
The calibrated hand dynamometer Takei TKK 5401 (Takei Scientific Instruments, Tokyo, Japan) was used for this test. The tested person, in a standing position, grasped the hand dynamometer by the dominant hand and gradually

applied maximal pressure. The pressure was graduated for at least for two seconds. After recording the result, the non-dominant hand was measured. During the grasp the stretched hand was not allowed to touch any part of the body. The moveable part of the handle was adjusted to reach the first phalanx of the ring-finger. Two attempts were made and the best result for both hands was recorded with accuracy 0,1 kg. For the relative strength, the ratio of absolute grip in kg to body weight of the climber in kg was used. Kilogram was chosen to enable comparison with results from other studies.

Bent-arm hang
The tested person tried to hold onto the bar (2,5 cm) in the pull-up position, for as long as s/he could. The grip width matched that of the shoulders. The chin was kept above the bar level. The tested person was taken up to the required position and when s/he was ready to start the time started. The chin was not allowed to touch the bar during the test. The tested person was verbally supported. The test was finished the moment when the chin sank under the bar level. The result was measured with accuracy of 0,1 s.

3. Data analysis

Descriptive statistics (mean, standard deviation) was used to evaluate the anthropometric variables and volume of metres climbed during a week in the subgroups.

Test's results represented dependent variables in multivariate analysis of variance (MANOVA) with independent factors of sex and climbing performance. In addition to F-statistics, effect size was calculated using partial eta squared (η^2).

4. Results

The basic anthropometric data are presented in table 1. There were only 2 and 4 female climbers in the most performant groups and the following results can be affected by such a small number of participants. With the increasing difficulty, there was lower body mass in climbers but not statistically significant. There were no differences in height and age among the groups.

We have stated that climbers with higher performance were characterized by a lower body fat ($F_{4,140}$ = 7,18; p = 0,000; η^2 = 0,17), lower ECM/BCM ratio ($F_{4,140}$ = 3,29; p = 0,013; η^2 = 0,09), greater relative grip strength ($F_{4,140}$ = 18,95; p = 0,000; η^2 = 0,35), longer bent-arm hang ($F_{4,140}$ = 32,85; p = 0,000; η^2 = 0,48) and finger hang ($F_{4,72}$ = 20,29; p = 0,000; η^2 = 0,53) (table 1).

There was a significant relationship between the climbing performance and number of metres climbed per week (r = 0,507; using Kendall's coefficient of correlation).

Table 1. *Numbers of climbers in different groups. Means and standard deviations of age, weight, height and metres climbed per week*

	Climbing performance (UIAA scale)	N	Age (years)		Weight (kg)		Height (cm)		Metres climbed per week	
Men	3/5-	17	27,6	5,9	78,2	11,9	180,9	6,1	95,9	74,8
	5/6+	37	28,7	7,5	77,6	9,3	182,2	6,1	123,9	81,6
	7-/7+	23	27,3	6,8	70,5	7,8	178,3	5,4	180,6	90,5
	8-/8+	13	22,4	4,1	71,0	11,4	178,4	9,3	280,5	152,1
	9-/10+	14	27,1	4,9	70,8	4,8	179,5	5,7	397,1	148,9
Women	3/5-	19	28,0	5,6	63,1	8,0	168,8	6,4	81,6	42,8
	5/6+	16	26,3	7,4	60,2	5,7	168,1	5,0	131,9	67,9
	7-/7+	5	22,1	2,4	62,1	5,0	171,4	7,1	194,0	95,6
	8-/8+	2	25,4	9,7	64,2	5,9	169,5	9,2	525,0	35,4
	9-/10+	4	21,6	4,6	56,5	4,6	168,8	3,0	365,0	107,9

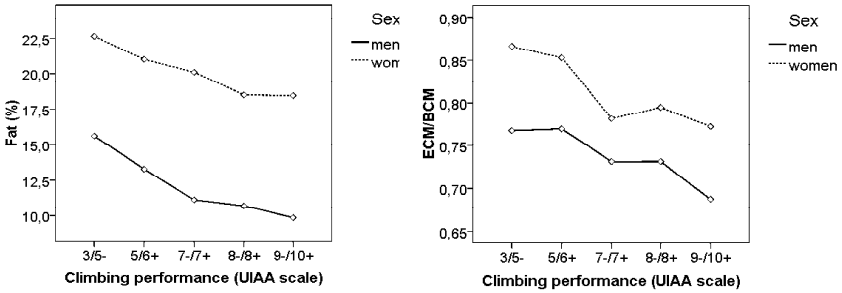

Fig. 1. The average percentages of body fat and the ratios of extra cellular to body cellular mass in different climbing groups

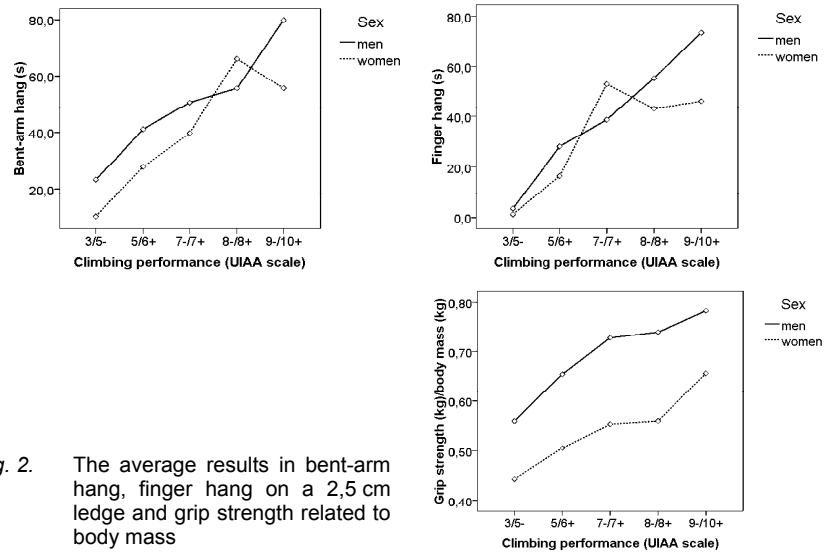

Fig. 2. The average results in bent-arm hang, finger hang on a 2,5 cm ledge and grip strength related to body mass

5. Discussion and conclusion

From the current data and especially from the η^2 we could state that our strength and endurance tests are good predictors of the climbing performance. The tests are simple and can be easily performed in sport practice. The percentage of body fat and the ECM/BCM ratio explained the lower percentage of climbing performance but still with a significant portion. We propose the reference values of upper body strength for men and women in various climbing levels. There were little participants in female most performant groups and the results may be influenced by this fact.

We confirmed that low percentage of body fat is closely related to the climbing performance (Giles, Rhodes, & Taunton, 2006; Sheel, 2004; Watts, 2004). As far as we know, this is the first study where the body cellular mass was monitored in climbers. Climbers with higher performance showed smaller ratio of extra cellular mass to body cellular mass. It appears that the relative amount of body cellular mass can be a useful parameter to evaluate body composition of climbers, next to the body fat.

We agree with the stated literature that finger flexors endurance and grip strength related to body mass are very good predictors of climbing performance (Giles, Rhodes, & Taunton, 2006; Macleod et al., 2007; Schweizer & Furrer, 2007; Wall, Starek, Fleck, & Byrnes, 2004; Watts, 2004). The influence of the shoulder girdle muscle endurance is not so emphasized (Grant et al., 2001; Wall, Starek, Fleck, & Byrnes, 2004). We have stated that around 50 % of climbing performance can be explained by the endurance of finger flexors and shoulder girdle muscles. Only 35 % of performance was explained by the grip strength related to the body mass. Therefore, we assume that the specific endurance is more important then the specific maximal strength.

It was also discussed in the literature that the simply hand dynamometry is not a suitable test for sport climbers because of different muscles groups activation (Watts et al., 2008). Despite this fact, we found better climbers with significantly greater grip strength and the test seems very useful to us.

We have found a strong relationship between the climbing performance and number of metres climbed per week ($r = 0{,}507$). We assume, therefore, that regular climbing on an artificial wall leads to the increase of upper limb's muscular endurance, grip strength and changes in body composition. The upper body strength and body composition are important components of health oriented fitness and are closely related to health.

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