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ANTHROPOMETRIC AND STRENGTH CHARACTERISTICS IN YOUNG AND ADULT ELITE CLIMBERS

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SUMMARY

The aim of the study was to assess anthropometric and strength characteristics in young and adult elite climbers. Twenty two young (12 boys, 10 girls) and fifty nine adult (45 males, 14 females) climbers with the climbing ability ranging from 7+ to 10+ on the UIAA (Union Internationale des Associations d'Alpinisme) scale took part in the study. Despite no differences in climbing ability among male and female young and adult athletes (median: 8+ on UIAA scale in all four groups), young male and female climbers had higher ECM/BCM ratio (males 0.81, s = 0.08; females 0.92, s = 0.08), were stronger in finger-hang test (males 74.7, s = 22.0 s; females 81.6, s = 27.2), had less climbing experience (males 4.7, s = 2.4 years; females 4.7, s = 1.9 years) than adult climbers within the same sex (males ECM/BCM 0.72, s = 0.07; finger hang 60.2, s = 16.9 s; experience 9.0, s = 6.6 years; females ECM/BCM 0.82, s = 0.12; finger hang 57.2, s = 17.5 s; experience 6.9, s = 2.2 years). The enhanced finger endurance in youth is probably compensated by better technique and tactic of a climb in adult climbers. There were no significant differences in body fat percentage, bent-arm hang test results, grip strength and metres climbed per week.

Key words: sport climbing, youth, strength

INTRODUCTION

Sport climbing has become a very popular activity in recent years, especially among youth (Morrison & Schoeffl, 2007). Two main disciplines dominate sport climbing: lead climbing and bouldering. Lead climbing is climbing with the rope on natural or artificial terrain with preplaced "anchors" where the climber clips his or her rope through carabiners. Bouldering is climbing on rocks or artificial walls low over the ground without a rope. Climbers generally seek the most difficult sequences of moves, which are called "boulder problems". Assessment of climbing performance is, however, complicated. The route/boulder grading is subjective and is determined after discussions among the climbers and route/boulder setters. The UIAA scale is used in lead climbing in many European countries. It has 11 grades

with intergrades plus and minus. A higher number and plus mark is related to the higher climbing level.

The style of contemporary sport climbing has changed to steep, overhanging routes resulting in the need for high levels of 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). It is generally indicated that high scores in finger strength, finger and shoulder girdle endurance are associated with high levels of climbing performance (Grant et al., 2001; Grant, Hynes, Whittaker, & Aitchison, 1996; Macleod et al., 2007; Watts, Martin, & Durtschi, 1993).

Very little literature is devoted to the physiological aspects of climbing in children. Watts et al. (2003) characterise young competitive climbers as relatively small, with low body mass, low sums of skinfolds and high grip strength to body mass ratio, noting differences in body composition between climbers and non-climbing athletes despite similar BMI values.

Morrison and Schoeffl (2007) deal with the physiological response to rock climbing in young climbers. Their review study focused on prevention and gives notice about possible injuries in inappropriate climbing training.

To our knowledge, there are no data evaluating upper body strength and endurance in elite young climbers and very little is known about the relationship of the anthropometric and the strength/endurance characteristics in young and adult athletes.

The aim of the study was to assess anthropometric and strength characteristics in young and adult elite climbers.

PROCEDURES

Participants

Twenty two (12 boys with the mean age 15.2, s = 1.9 years, 10 girls 14.2, s = 1.8 years) young and fifty nine (45 males 27.5, s = 8.1 years, 14 females 25.5, s = 5.5 years) adult climbers with the climbing ability ranging from 7+ to 10+ on the UIAA scale took part in the study. The data were collected at a commercial climbing centre during autumn when the climbers move from outside to indoor walls. Climbers were contacted before testing through climbing instructors, trainers or climbing centre staff. All contacted climbers agreed to participate in the study.

Questionnaire & Body Composition

Every climber was asked to complete a questionnaire of actual performance RP (red point), climbing experience (in years), and volume of climbing training. RP performance is the style of sport climbing where the climber clips his/her rope in the preplaced anchors through quickdraws (two carabiners connected by a sling), and the route is achieved without a fall after previous training.

Body composition was evaluated using the multi-frequency device Nutriguard-M (Data Input GmbH, Germany), which measured 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 manufacturer's instructions. Participants were asked not to eat 2 hours and drink 1 hour before the measurement, and to avoid any strenuous physical 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 and adult 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).

After completing the questionnaire and anthropometric measurements each climber performed in order the grip strength, bent-arm hang and finger hang tests.

Grip strength

A calibrated hand dynamometer was used for this test (Takei TKK 5401 Takei Scientific Instruments, Tokyo, Japan). In a sitting position, the climber grasped the hand dynamometer by the dominant hand with elbow in full extension, arm near the body and gradually applied maximal pressure for at least for 2 s. 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. The better score of two attempts for each hand was recorded with accuracy 0.1 kg. To eliminate right/left dominance, the mean of these scores was assessed. Subsequently, the relative strength was computed as the ratio of absolute grip (kg) to body mass (kg). Kilogram was chosen to enable comparison with results from other studies.

Bent-arm hang

Using an overhand grip, shoulder width apart the climber held onto a bar (2.5 cm wide) in a pull-up position. The chin was kept above the bar level and was not allowed to touch the bar during the test. The climber was verbally supported and the test was terminated when the chin dropped below the bar level. The result was measured with an accuracy of 0.1 s.

Finger hang

The climber held onto the 2.5 cm ledge with straight arms. The hold on the ledge was carried out with four fingers in open or crimp grip (Watts, 2004). The result was measured with an accuracy of 0.1 s.

Climbing volume

In bouldering, the intensity of climbing is often more important than in lead climbing, and the volume is counted in climbing movements. In lead climbing, the volume is frequently expressed as vertical metres climbed. To obtain one parameter, we took one bouldering movement as one vertical metre. Therefore, the volume of climbing was expressed in metres climbed per week.

Data analysis

Descriptive statistics (mean, standard deviation) were used to evaluate the anthropometric variables and climbing experience. The differences between young and adult climbers were analyzed by 2 × 2 ANOVA with factors sex and age. The limit age to include the

subject in the group "young climbers" was 18 years. To control for Type-I error, the significance level was set to 0.05. The coefficient η^2 was used to asses the effect size. Its value indicates the percentage of explained variance in the model. All analyses were carried out using the Statistical Package for the Social Sciences (SPSS) version 18.0.

RESULTS

The characteristics of body mass, height, ECM/BCM ratio, body fat, climbing experience for adult and young elite climbers are presented in Table 1. There were significant differences in body mass, height ECM/BCM ratio and climbing experience between adult and young climbers. There were also significant differences between sex in body mass, height, body fat and an interaction of body fat between sex and age. The climbers in all four groups were of similar climbing abilities (median 8+ UIAA).

Table 1. characteristics (mean ± standard deviation) of body mass, height, ECM/BCM ratio, body fat, climbing experience for adult and young elite climbers

	Sex	N	Body mass (kg)[1,2]	Height (cm)[1,2]	ECM/BCM [1,2]	Fat (%) [2,3]	Climbing experience (years)[4]
Adult climbers	Female	14	58.2 ± 5.8	167.9 ± 6.0	0.82 ± 0.12	13.3 ± 1.6	6.9 ± 2.2
	Male	45	72.0 ± 6.6	179.4 ± 7.0	0.72 ± 0.07	10.4 ± 2.0	9.0 ± 6.6
	Total	59	68.7 ± 8.7	176.7 ± 8.4	0.75 ± 0.10	11.1 ± 2.3	8.5 ± 6.0
Young climbers	Female	10	46.0 ± 11.1	159.0 ± 12.3	0.92 ± 0.08	13.2 ± 2.0	4.7 ± 1.9
	Male	12	53.2 ± 10.5	167.4 ± 10.5	0.81 ± 0.08	8.5 ± 1.8	4.7 ± 2.4
	Total	22	49.9 ± 11.1	163.5 ± 11.9	0.86 ± 0.09	10.6 ± 3.0	4.7 ± 2.2

[1] significant differences between adults and youth $\alpha < 0.001$; $\eta^2 > 0.18$
[2] significant differences between males and females $\alpha < 0.001$; $\eta^2 > 0.22$
[3] significant interaction between adults, youth and sex of climbers $\alpha < 0.05$; $\eta^2 > 0.05$
[4] significant differences between adults and youth $\alpha < 0.05$; $\eta^2 > 0.05$

The results of upper body strength/endurance tests and information about metres climbed per week are presented in Figures 1 and 2. We can document significantly better results in finger hang for young elite climbers but no differences in other two tests. There is either no difference in metres climbed per week between young and adult climbers.

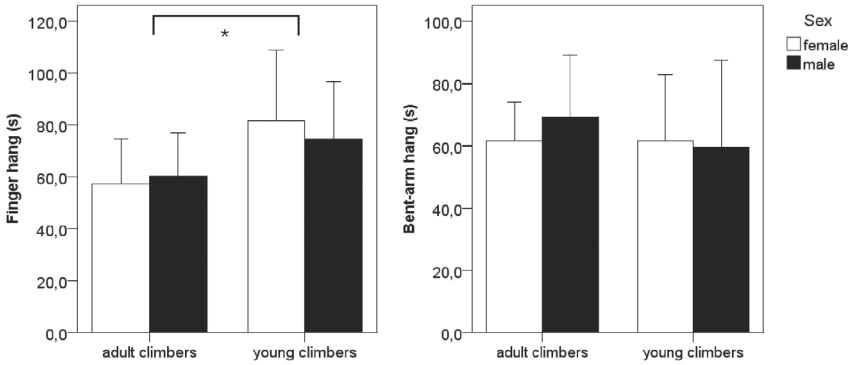

Figure 1. Results in finger hang and bent-arm hang for adult and young climbers, * denotes significant differences $p < 0.001$, $\eta^2 = 0.16$

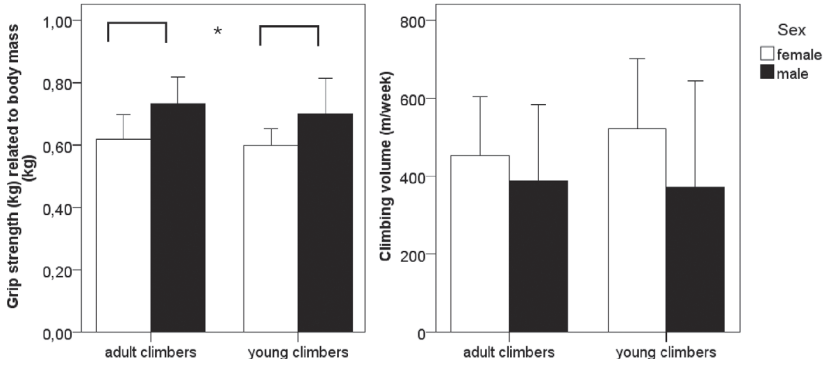

Figure 2. Results in grip strength and climbing volume for adult and young climbers, * denotes significant differences $p < 0.001$, $\eta^2 = 0.22$

DISCUSSION

The aim of the study was to assess anthropometric characteristic and upper body strength in elite young sport climbers. These characteristics were compared with adult elite climbers. The young and adult climbers regularly participated in sport climbing national competitions and represented top Czech athletes. There were an unequal number of participants due to insuficient number of Czech young elite climbers. To assure the similar climbing ability with adult climbers, only 10 girls and 12 boys were included in the study. The self reported actual best RP performance on the UIAA scale was used. Various studies have demonstrated that self reported RP is a valid evaluation of climbing ability (Mermier, Janot, Parker, & Swan, 2000; Wall, Starek, Fleck, & Byrnes, 2004).

The body composition analysis and three muscular strength/endurance tests were chosen to compare the youth and adults. It is documented that finger hang, bent-arm hang, grip strength and body fat are the strongest predictors of climbing performance (Baláš & Strejcová, 2010; Giles, Rhodes, & Taunton, 2006; Sheel, 2004; Watts, 2004).

The finger hang test was the only one strength/endurance test where significant differences between adults and youth were found despite similar climbing ability in both groups.

Young climbers had on average by 19 s longer hold on the 2.5 edge than adults. The result is surprising and we can only speculate about the causes. There can be an influence of technique and tactic of the ascent. Adults had longer climbing experience (8.5, $s = 6.0$ years) than youth (4.7, $s = 2.2$ years) and climbing experience is considered as significant predictor of climbing performance (Michailov, Mladenov, & Schoeffl, 2009). Lower finger endurance in adults is, therefore, compensated by better technique and tactic of the climb. The other explanation could be the lower body mass of youths. Although the finger hang is a test using the body mass of participants, the smaller and lighter climbers could benefit from their posture. Nevertheless, it was not confirmed in the second endurance test bent-arm hang.

The bent-arm hang assesses shoulder girdle muscle endurance and is a common test used with climbers (Grant et al., 2001; Grant, Hynes, Whittaker, & Aitchison, 1996; Mermier, Janot, Parker, & Swan, 2000). The mean performances 59.6, $s = 27.9$ s, for our male adult climbers corresponded to the findings of Grant et al. (1996) (53.1, $s = 13.2$ s) with male elite climbers. Female climbers, 62.5, $s = 22.3$ s, exceeded performances 31.4, $s = 9.0$ s, of female elite climbers in the study of Grant et al. (2001), which can be explained by higher performance ability of our female climbers.

The ratio of grip strength to body mass was used to assess the grip strength for two reasons. First the relative strength was found to be greater in competitive and performance sport climbers than absolute values of strength (Schweizer & Furrer, 2007; Wall, Starek, Fleck, & Byrnes, 2004; Watts, Joubert, Lish, Mast, & Wilkins, 2003). The other reason was that the low body weight in youth could influence the absolute grip strength.

Watts et al. (2003) found in 13.5, $s = 3.0$ years old competitive climbers a grip strength/body mass ratio 0.62, $s = 0.08$ for girls, 0.70, $s = 0.13$ for boys. The female young climbers in the current study had the ratio 0.60, $s = 0.06$ and male young climbers 0.70, $s = 0.11$. These values correspond to the previously cited study of competitive climbers. The male adult climbers had slightly elevated performances in grip strength than youth. The mean values of grip strength/body mass ratio 0.73, $s = 0.09$, of our elite male climbers (7+/10 + UIAA) correspond to the findings of Watts et al. (2000) (0.77, $s = 0.07$) in climbers with ability 9/10 + UIAA.

To assess body composition, bio impedance analysis was used, which provides three components (body fat, lean body mass, and body water) and estimates extra cellular and cellular mass. Our findings confirm that low percentage of body fat is closely related to climbing performance and are in agreement with other findings (Giles, Rhodes, & Taunton, 2006; Sheel, 2004; Watts, 2004). We have not found differences between young and adult climbers in body fat percentage and we are in agreement with the study of Watts et al. (2003) that young competitive climbers have similar general anthropometric characteristics to elite adult climbers. The question of the impact of the activity on the body fat amount is still unanswered. We do not know if the climbing causes the changes in body composition or the athletes choose the climbing because they are lean. Probably both propositions are partially true as suggested Glenmark et al. (1994).

There were, however, significant differences in ECM/BCM ratio between youth and adults and males and females which is not surprising because the ECM/BCM ratio is

normally lower in children and females (Bunc, 2007). The ratio is used as an indicator of muscular predispositions (Bunc, 2009) but its effect on the climbing performance is still hypothetical. Our measurement (not published) did not show any relationship between the ECM/BCM ratio and the climbing performance.

CONCLUSION

The young elite climbers have similar anthropometric and strength characteristics as adult elite climbers. These include low body fat, high performances in bent-arm hang, grip strength related to body mass and metres climbed per week. There was, however, found nearly 20 s difference in finger hang time. The finger hang belongs to the strongest predictors of climbing performance and the enhanced finger endurance in youth is probably compensated by better technique and tactic in adult climbers. The higher ECM/BCM ratio in young climbers corresponds to physiological maturing of the musculosceletal system.

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ANTROPOMETRICKÉ A SILOVÉ CHARAKTERISTIKY MLADÝCH DOSPĚLÝCH VRCHOLOVÝCH HOROLEZCŮ

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SOUHRN

Cílem této studie bylo posoudit antropometrické a silové charakteristiky mladých a dospělých vrcholových lezců. Studie se zúčastnilo 22 mladých (12 chlapců, 10 dívek) a 59 dospělých (45 mužů, 14 žen) lezců s lezeckým výkonem 7+ až 10+ na UIAA (Union Internationale des Associations d'Alpinisme) stupnici. Ačkoli měli mladí i dospělí lezci a lezkyně stejnou lezeckou výkonnost (medián 8+ UIAA pro všechny skupiny), chlapci i dívky měli vyšší poměr ECM/BCM (chlapci 0.81, s = 0.08; dívky 0.92, s = 0.08), delší čas výdrže ve visu na liště (chlapci 74.7, s = 22.0 s; dívky 81.6, s = 27.2), kratší lezeckou zkušenost (chlapci 4.7, s = 2.4 let; dívky 4.7, s = 1.9 let) než dospělí lezci stejného pohlaví (muži ECM/BCM 0.72, s = 0.07; vis na liště 60.2, s = 16.9 s; zkušenost 9.0, s = 6.6 let; ženy ECM/BCM 0.82, s = 0.12; vis na liště 57.2, s = 17.5 s; zkušenost 6.9, s = 2.2 let). Zvýšená úroveň svalové vytrvalosti u mladých lezců je pravděpodobně kompenzována lepší lezeckou technikou a taktikou u dospělých. Neshledali jsme významné rozdíly v podílu tělesného tuku, výsledcích výdrže ve shybu, síly stisku ruky a počtu nalezených metrů týdně.

Klíčová slova: sportovní lezení, mládež, silové schopnosti

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