PREDICTORS OF BOULDER CLIMBING PERFORMANCE IN YOUTH BOULDER CLIMBERS

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The purpose of this study was to determine if a simple measurement using hand dynamometer could be used as predictors of boulder climbing performance in youth climbers. The study cohort consisted of 12 competitive climbers (8 males, 4 females) who competed at European Bouldering Youth Championships (B) in Slany, Czech Republic in the year 2017. The hand grip force was measured at fingertips-thumbtip grip at three wrist positions and during free holding. The effect of hand dominance in grip strength was not observed except for free holding. It could be concluded that the elite young climbers has balanced grip strength between the left and the right hand. The performance in competitions was assessed by total number of number of achieved tops. The best predictor of number of top holds achieved in qualification round was the strength at free grip as it describes also upper body fitness level.

KEYWORDS: bouldering, grip strength, biomechanics

INTRODUCTION: Climbing is a versatile, physically demanding sport that can be done indoors or outdoors. The sport has shown remarkable growth in the past 10 years as numerous climbing walls have been constructed and the climbing was officially approved for 2020 Olympics.
There are three main types of climbing competition: lead, speed, and bouldering. The bouldering competition consists of climbing without belay ropes on short walls. Bouldering is a physically and mentally demanding sport, one that often tests a climber's strength, endurance, agility, and balance along with his or her mental control (Strejcov, 2015). Anthropometric, biomechanical, and psychological aspects of climbers has been evaluated in multiple studies. It was found that in addition to anthropometric similarities in elite climbers, physiological adaptation induced by training is the most important factor in rock climbing ability (Strejcov, 2015; Tomaszewski, Gajewski & Lewandowska, 2011).
However, most of the studies were performed in laboratory conditions that is not fully equivalent to the climber's competition. In addition, most of the studies are focused on senior experienced climbers, where factors others than physical endurance might affect the results (i.e. previous injuries, mental comfort, climbing tactics). The aim of the current study was to test the hypothesis, whether simple strength estimation using hand dynamometer measurement can be correlated with the performance during the bouldering competition. The participants of the study volunteered during the European Bouldering Youth Championship that looked place in Slaný, Czech Republic.

METHODS:
Participants: The participants consisted of 12 competitive climbers (8 males, 4 females) who competed at the European Bouldering Youth Championships (B) in Slaný, Czech Republic in the year 2017. They had been involved in the climbing for 3 – 10 years (mean ±SD 7.1 ±1.83 years). Participants competed in following categories: junior (17 – 18 years old, 1 female); youth A (15 – 16 years old, 3 male) and youth B (13 – 14 years old, 5 male and 3 female).

Grip strength measurement: The measurement was performed within the European Youth Championship by the authors of the study. In-field conditions required simple and portable method of measurement. The measurement device was KERN MAP 130K1 Hand grip dynamometer (Kern-Sohn, Germany). The device has been calibrated by an accredited laboratory for a 0 - 80 kg grip force range.

Figure 1: KERN MAP 130K1 Hand grip dynamometer

The device was adapted to measure finger and thumb grip, similar to wall hold grip, by adding non-slip strips to the holds. To ensure measurement reproducibility, all participants were seated with arm abducted and elbow flexed in order to hold the measurement device at the level of the head. Participants produced maximum force by squeezing the dynamometer by the fingertips at three wrist positions: neutral, fully flexed and fully extended (fingertips-thumbtip grip). In addition to these positions, the participants were asked to produce maximum force with free technique without restrictions on device holding style. The only restriction in free grip was to exclude contact between the hand and the body. Both hands were tested. The results of measurement are reported in kilograms based on internal device calibration.
The participants were allowed to practice becoming familiar with the measurement and taking rest period after each measurement. Data from three trials at each wrist position were averaged and used for further analysis.

Figure 2: Wrist position (1, 2, 3)

Qualification results: All participants competed in qualification round during the European Youth Championship in 2018. The scoring system is based on the rules of IFSC (International Federation of Sport Climbing). The performance at competition was estimated by the number of achieved top holds and bonus holds was evaluated along with the number of attempts. As each category has specific climbing routes, comparison of these results among categories is not applicable and further analysis is must be divided between subsequent categories.

Statistics: All variables were assessed for normality of distribution using the one-sample Kolomogorov-Smirnov goodness-of-fit test before any further statistical analysis. For non-normal distributed data, the Wilcox matched-pairs signed-rank nonparametric statistical test was used to compare inter-individual differences. Wilcoxon rank sum test was used to compare the groups. Correlation between parameters was tested by linear regression analysis and reported by Pearson correlation coefficient. The statistical significance level was

set to 0.05. Statistical analysis was performed using the open-source statistical software R (http://www. r-project.org).

Ethics statement: This study was performed in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board and Ethics Committee of the Faculty of Biomedical Engineering, Czech Technical University in Prague. Procedures were explained by a written document to the participants, who then gave their written informed consent to participate.

Table 1: Measured mean values and standard deviations during hand grip.

	Left hand [kg]	Right hand [kg]
Position 1	7.50±1.20	7.04±2.31
Position 2	10.66±4.09	11.40±2.43
Position 3	9.59±3.17	10.58±2.62
Free position	39.64±9.26	37.18±8.95
Male (free position)	42.43±9.95	40.26±9.36
Female (free position)	34.08±4.58	31.02±3.63

RESULTS:

Sex: There was no obvious difference between male and female climbers in hand grip strength at fingertips-thumbtip grip for all wrist positions (Wilcoxon rank sum test p-values are 0.37, 0.46, and 0.27 for neutral, extension, and flexion position, respectively, Table 1 and Figure 3). Although the statistical difference is low for free grip (Wilcoxon rank sum test p-value 0.11), it might be attributed to low number of participants and we observe a moderate trend toward significance (Figure 3).

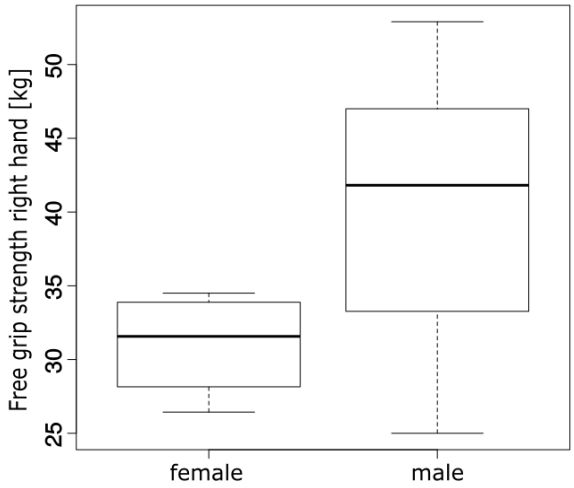

Figure 3: Difference in the free grip strength for dominant hand between the male and female participants. Female participants have weaker free grip.

Hand dominance

All participants were right handed. However, there is no obvious difference between the grip strength between the left and the right hand in neutral position, wrist flexion and wrist extension (Wilcoxon signed rank test p-value = 0.17, p-value = 0.47, p-value = 0.06, respectively). Surprisingly, the dominant hand is weaker in free grip in the majority of participants (9 participants) and the difference is statistically significant within the whole study cohort (Wilcoxon signed rank test, p-value < 0.05). The difference between the right and the left hand is relatively low in free grip (mean 2.46 kg, standard deviation 3.03 kg, Fig. 4).

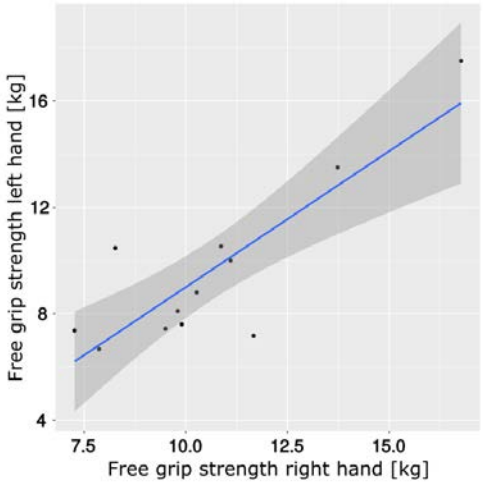

Figure 4: Comparison of free grip strength between dominant (right) and non-dominant (left) hand.

Wrist position and grip type: The finger and grip strength is the highest in neutral position and in the wrist extension of the dominant hand (Table1). The free grip produces almost four times higher force as the upper body muscles are involved.

Qualification score: Due to the limited size of the studied groups and differences in climbing routes among the groups, the further analysis was performed only for youth B group consisting of five male climbers. No correlation was found between the number of achieved tops and the body weight or body height in the group youth B (Pearson correlation coefficient 0.74, p-value = 0.15, 95% confidence interval -0.40 - 0.98 and Pearson correlation coefficient, 0.69, p-value = 0.20, 95% confidence interval -0.49 - 0.98). The fingertips-thumbtip grip strength shows limited application as predictor of sports performance (Pearson correlation coefficient 0.22, p-value = 0.50, 95% confidence interval -0.70 – 0.41 for neutral position). Considering the small size of the group, the free grip strength shows a certain trend toward significance (Pearson correlation coefficient 0.47, p-value = 0.12 95% confidence interval -0.14 – 0.82).

CONCLUSION: The study indicates that the free grip strength might serve as predictor of overall climbing performance in boulder competition. In free grip, the climber actively involves whole upper body and therefore it might be considered as a measure for overall upper body strength. An interesting observed phenomena is, that the elite youth climbers achieved balance in grip strength magnitude for both hands with slightly stronger non-dominant hand. These results are in contradiction with results from non-trained population where so called 10% rule is observed. The 10% rule states that the dominant hand possesses a 10% greater grip strength than the nondominant hand (Petersen, Petrick, Connor & Conklin, 1989). However, the results of the study have limited applicability due to the small sample size and further research is warranted on larger cohort size to confirm study conclusions.

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