

CLIMBING-SPECIFIC FITNESS PROFILES AND DETERMINANTS OF PERFORMANCE IN YOUTH ROCK CLIMBERS

⁽¹⁾ Nichols, J. ⁽¹⁾ Bates, R. ⁽²⁾ Wing, D. ⁽³⁾ Bellicini, Z. ⁽⁴⁾ McIntosh, I. ⁽⁵⁾ Kattus, M. ⁽⁶⁾ Hall, D. ⁽⁷⁾ Kain, R. ⁽⁸⁾

⁽¹⁾ DFMPH, University of California, San Diego, United States. dwing@ucsd.edu

⁽²⁾ Mesa Rim Climbing & Fitness Center, San Diego, CA, United States. rosie@mesarim.com

⁽³⁾ DFMPH, University of California, San Diego, United States. dwing@ucsd.edu

⁽⁴⁾ DFMPH, University of California, San Diego, United States. zbellicini@eng.ucsd.edu

⁽⁵⁾ Mesa Rim Climbing & Fitness Center, San Diego, CA, United States. ianmcintosh@mesarim.com

⁽⁶⁾ Mesa Rim Climbing & Fitness Center, San Diego, CA, United States. mark@mesarim.com

⁽⁷⁾ San Diego Sports Medicine Center, San Diego, CA, United States. dhall727@gmail.com

⁽⁸⁾ Mesa Rim Climbing & Fitness Center, San Diego, CA, United States. bob@mesarim.com

ABSTRACT

Introduction: With the recent decision by the International Olympic Committee to include rock climbing in the 2020 Olympic Games, climbers and coaches are seeking information to enhance training methods and improve performance. The purpose of this study was two-fold: 1) evaluate climbing-specific fitness and establish percentile rankings among youth climbers; and 2) determine the relationship between fitness and climbing performance.

Methods: Anthropometrics, fitness, and performance on three indoor bouldering problems ranging in difficulty from V0-V8 were assessed in 64 youth climbers (35 girls, 29 boys) aged 7-17 from the U.S. Data are reported by age groups (7-11; 12-17 yr) and sex. Percentile rankings of fitness scores were computed for girls and boys separately. Analysis of variance was used to compare fitness by age groups and by sex. Linear regression was used to evaluate the association between climbing performance and fitness. **Results:** As expected, fitness scores were generally higher among boys than girls. Multivariable linear regression revealed that, after adjusting for age, sex, and anthropometrics, fitness variables explained 48.2% of the variance in performance. **Conclusion:** Climbing-specific fitness measures are associated with bouldering performance in youth climbers, and therefore may be useful for monitoring progress in training.

Keywords: rock climbing; children; physiological characteristics; anthropometrics

Acknowledgement: We are grateful to the owners/directors of the Mesa Rim Climbing & Fitness Center for their financial support, to the staff, coaches, and the UCSD interns for their assistance with recruitment and measurement, and to our study participants and their parents for their enthusiastic support of this research.

PROFILS D'APTITUDE À L'ESCALADE ET DÉTERMINANTS DE LA PERFORMANCE CHEZ LES JEUNES GRIMPEURS

RÉSUMÉ

Contexte: Avec la décision récente du Comité International Olympique d'inclure l'escalade aux Jeux Olympiques de 2020, les grimpeurs et les entraîneurs cherchent des informations pour améliorer les méthodes d'entraînement et améliorer les performances. Le but de cette étude était double: 1) évaluer la condition physique spécifique à l'escalade et établir des classements centiles chez les jeunes grimpeurs; et 2) déterminer la relation entre la forme physique et la performance d'escalade. **Méthodes:** L'anthropométrie, la condition physique et la performance sur trois problèmes de bloc (sur Structure Artificielle d'Escalade) de difficulté 4+ à 7b ont été évalués chez 64 jeunes grimpeurs (35 filles, 29 garçons, âgés de 7 à 17 ans, citoyens américains) . Les données sont rapportées par groupes d'âge (7-11 ans, 12-17 ans) et par sexe. Les classements percentiles des scores de condition physique ont été calculés séparément pour les filles et les garçons. L'analyse de la variance a été utilisée pour comparer l'aptitude selon les groupes d'âge et selon le sexe. La régression linéaire a été utilisée pour évaluer l'association entre la performance d'escalade et la forme physique. **Résultats:** Comme prévu, les scores de condition physique étaient généralement plus élevés chez les garçons que chez les filles. La régression linéaire multivariée a révélé que, après ajustement pour l'âge, le sexe et l'anthropométrie, les variables de la condition physique expliquaient 48,2% de la variance de la performance. **Conclusion:** Les mesures de la condition physique spécifiques sont associées à la performance pour la discipline du bloc chez les jeunes grimpeurs et peuvent donc être utiles pour suivre les progrès de la formation.

Mots-clés: Escalade; les enfants; caractéristiques physiologiques; anthropométrie

Introduction. The sport of rock climbing has markedly grown in popularity over the past 20-25 years as both a recreational activity and competitive international sport. Climbing walls in gyms, fitness centers and other recreational facilities have made indoor climbing a safe and enjoyable sport for adults and children alike. While the number of research publications on rock climbing has increased over the past decade, few published studies exist on youth climbers (Morrison & Schoffl, 2007; P. B. Watts, Joubert, Lish, Mast, & Wilkins, 2003; P. Watts & Ostrowski, 2014), yet, it is from this group that future Olympians will be selected. The purpose of this study was twofold: 1) to evaluate climbing-specific fitness and establish percentile rankings among youth climbers using the 2015 Test Battery developed by IRCRA (Draper, Giles, Balas, Panackova, & Espana-Romero, 2015); and 2) determine the association between fitness and climbing performance.

Methods. *Study Design and Timeline:* The present study was designed as a single sample observational study. Participants were boys (n=29) and girls (n=35) between 7-17 years of age (mean \pm SD girls:11.3 \pm 2.6; boys:13.7 \pm 2.7 yr.); members of the Mesa Rim Climbing & Fitness Center (San Diego, CA, U.S.A) enrolled in the youth climbing program. Participants trained in bouldering and sport climbing 2-6 d/wk (mean 2.5) for an average of 6 hr/wk, and competed in local (90% of sample), regional (45%), divisional (15%), and/or national (5%) competitions. The study was approved by the University of California, San Diego Institutional Review Board. Anthropometric and sport-specific fitness measures were conducted on two non-training days separated by 1-2 weeks. Climbing performance was assessed 2-3 weeks following fitness assessments.

Anthropometric measures included, height, body mass, arm and leg length, and arm-span. Body mass index (BMI) was calculated as $\text{wt}(\text{kg})/\text{ht}(\text{m}^2)$. Arm length was measured on the dominant arm as the distance from the acromion process to the tip of the middle finger, with the arm extended by the side, fingers extended and palms of hand facing the torso. Leg length was measured on the dominant leg, in the standing position, as the distance from the level of the greater trochanter down the midline of the thigh to the middle of the lateral malleolus at the ankle. Arm-span was measured as the distance between the tips of each middle finger as the participant stood with feet together facing a wall with arms and hands fully extended horizontally and touching the wall.

Climbing-specific fitness was assessed using selected measures from the International Rock Climbing Research Association (IRCRA) Performance-Related Test Battery for Climbers (version 1.6) (Draper et al., 2015). These included bent arm hang (right, left, both arms), pull-ups, finger hang (right and left), and power slap test (right and left). We also included a vertical jump for leg power, dead/straight arm hang, and the Y-Balance Test (YBT) (Chimera, Smith, & Warren, 2015), which consists of upper and lower body movements performed from the plank (upper body) or single-leg standing position (lower body). It assesses a combination of core strength, dynamic balance and agility of the upper and lower body independently, as well as single leg strength in the lower body test. The YBT measures were conducted by a licensed physical therapist familiar with the sport of rock climbing.

Climbing Performance was determined on an indoor bouldering wall at the climbing center. Participants were assessed twice over a 2-week period in which they attempted three different bouldering problems of increasing difficulty, ranging from V0-V8. They were scored from 0 to 7 on the basis of highest grade completed. The three routes were designed to challenge a wide range of climbing ability as well as age and body size. For the present study, the bouldering routes restricted the climber to a maximum height of 10-12 feet (3.0-3.6 m) from the landing surface. The

courses were set by the director of the climbing center, who is a nationally recognized course setter. Climbers began with the least difficult course and proceeded until they were unable to negotiate a hand or foot hold resulting in a fall. The score used for data analysis was the best/highest score achieved.

Statistical Analyses: Descriptive statistics, including means, standard deviations (SD), and range of scores were computed for girls and boys separately and for age groups (7-11 and 12-17 years). Analysis of variance (ANOVA) was used to compare fitness and anthropometrics by age group and by sex. The size of the sample was too small to further divide age groups by sex. Percentiles in 10 percentage point increments were computed for girls and boys separately. Bivariate correlations were computed on variables of interest. Multivariable regression was used to determine the contribution of fitness, anthropometric, and demographic measures to climbing performance. To reduce the number of fitness variables for this analysis, measures on right and left arms/hands and legs were averaged. Similarly, the three directions of movement assessed on the YBT were averaged for each of the upper and lower body measures. The final number of fitness variables used in regression analysis was thereby reduced from 14 to 9. Age, sex, and anthropometrics were evaluated as possible covariates in the regression. Analyses were conducted with SPSS (version 24.0). The alpha level was set a priori at 0.05 for all analyses.

Results (Results are summarized in text but not shown in tables due to space limitations, but will be displayed on a poster or slides if accepted for presentation).

Anthropometrics: Boys were approximately 2 years older than girls, and were taller and heavier and had longer limbs and arm span (all P values < 0.01), but had similar BMI (P=0.13). Age group comparisons indicated that, as expected, the older climbers had greater values for all anthropometric variables compared to younger climbers.

Fitness Variables: Fitness scores were generally higher among boys than girls (P<0.05). The largest differences between girls and boys were noted for the tests requiring upper and lower body power, namely, power slap and vertical jump, respectively, and for the bent arm hang, dead arm hang, and pull-ups. However, there were no statistically significant differences between girls and boys on the YBT of the upper body (P=0.74 and 0.70 for left and right arm, respectively), or on the finger hang test, which was expressed as a percentage of body weight (P=0.28 and 0.42 for left and right hand, respectively). The age group comparisons yielded somewhat similar findings as gender comparisons; the older climbers had greater values for the same tests as noted above for boys compared to girls, with the exception of single bent arm and dead arm hang. To determine the association between climbing-specific fitness and performance in bouldering, three regression models were examined. First, all fitness variables, age and sex, and anthropometric variables that correlated significantly with performance, namely arm span, leg length and BMI, were tested in the same model. This model explained 87.3% of the variance in performance (P<0.001). The second model tested the combined fitness variables with age and sex as covariates. Fitness explained 50.5% of the variance (P<0.01). The third model added anthropometric variables as covariates; this model explained an additional 1.7% of the variance (P=0.02); thus, fitness alone explained 48.2% of the variance in performance.

Discussion. To our knowledge, this is the first study to report percentile scores on climbing-specific fitness in youth rock climbers. Given that measurement procedures strictly adhered to IRCRA's standardized procedures (Draper et al., 2015), additional data could be added to our existing database with confidence on its fidelity, assuming the same procedures were followed. While the sample size limits generalizability, we believe the data provide a framework for

coaches of youth climbers to detect strengths and weaknesses of individual climbers, and thereby tailor their training to achieve optimal results.

The regression analysis indicated that climbing-specific fitness measures accounted for nearly half of the variance in climbing performance. Similar findings were reported in a previous study on young adult climbers, in which climbing specific training variables explained 46% of the variance in self-reported climbing ability, while less than 4% of the variance was explained by anthropometric variables (Laffaye, Levernier, & Collin, 2015). Our findings support the notion that the IRCRA test battery initially developed on adult climbers (Draper et al., 2015), may also serve as a useful benchmark to monitor training and improvement among young climbers as they grow and develop.

To our knowledge, no studies have evaluated youth climbers' core stability and opposing limb strength and flexibility, and how these relate to performance. We included the YBT in our measures as it has been widely used by physical therapists and athletic trainers to evaluate core stability and opposing limb strength and flexibility (Plisky, Rauh, Kaminski, & Underwood, 2006), elements we considered to be relevant to rock climbing. Interestingly, scores on the YBT were not significantly different between girls and boys, and were almost identical for the younger vs. older climbers in the upper body. Given that the Y-balance upper body test requires a high level of core stability as well as opposing shoulder stability and flexibility, this finding suggests that these factors may be similar among male and female youth climbers, even though the boys were approximately two years older than the girls. While the Y-balance lower body was not significantly different between age groups or boys vs. girls, the mean values were approximately 3-4 cm greater among the older climbers, and in boys vs. girls. We speculate that these climbers had greater leg strength and/or were more proficient at performing a single-leg ("pistol") squat, which could largely account for their higher scores. We believe this is an important area of research to further explore, as the YBT has been associated with sports injury (Plisky et al., 2006).

Conclusion. Our findings suggest that climbing-specific fitness measures are associated with bouldering performance in youth climbers, and therefore may be useful for determining strengths and weaknesses, and to monitor progress in training.

References

- Chimera, N. J., Smith, C. A., & Warren, M. (2015). Injury history, sex, and performance on the functional movement screen and Y balance test. *J Athl Train*, *50*(5), 475-485. doi: 10.4085/1062-6050-49.6.02
- Draper, N., Giles, D., Balas, J., Panackova, M., & Espana-Romero, V. (2015). The IRCRA Performance-Related Test Battery (Vol. 1.6, pp. 1-39).
- Laffaye, G., Levernier, G., & Collin, J. M. (2015). Determinant factors in climbing ability: Influence of strength, anthropometry, and neuromuscular fatigue. *Scand J Med Sci Sports*. doi: 10.1111/sms.12558
- Morrison, A. B., & Schoffl, V. R. (2007). Physiological responses to rock climbing in young climbers. *Br J Sports Med*, *41*(12), 852-861; discussion 861. doi: 10.1136/bjism.2007.034827
- Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *J Orthop Sports Phys Ther*, *36*(12), 911-919. doi: 10.2519/jospt.2006.2244
- Watts, P. B., Joubert, L. M., Lish, A. K., Mast, J. D., & Wilkins, B. (2003). Anthropometry of young competitive sport rock climbers. *Br J Sports Med*, *37*(5), 420-424.
- Watts, P., & Ostrowski, M. L. (2014). Oxygen uptake and energy expenditure for children during rock climbing activity. *Pediatric Exercise Science*, *26*(1), 49-55. doi: 10.1123/pes.2013-0035