SINCLAIR TOTAL AND COUNTERMOVEMENT JUMP HEIGHT OF WEIGHTLIFTERS COMPETING AT 2018 USA YOUTH NATIONAL CHAMPIONSHIPS

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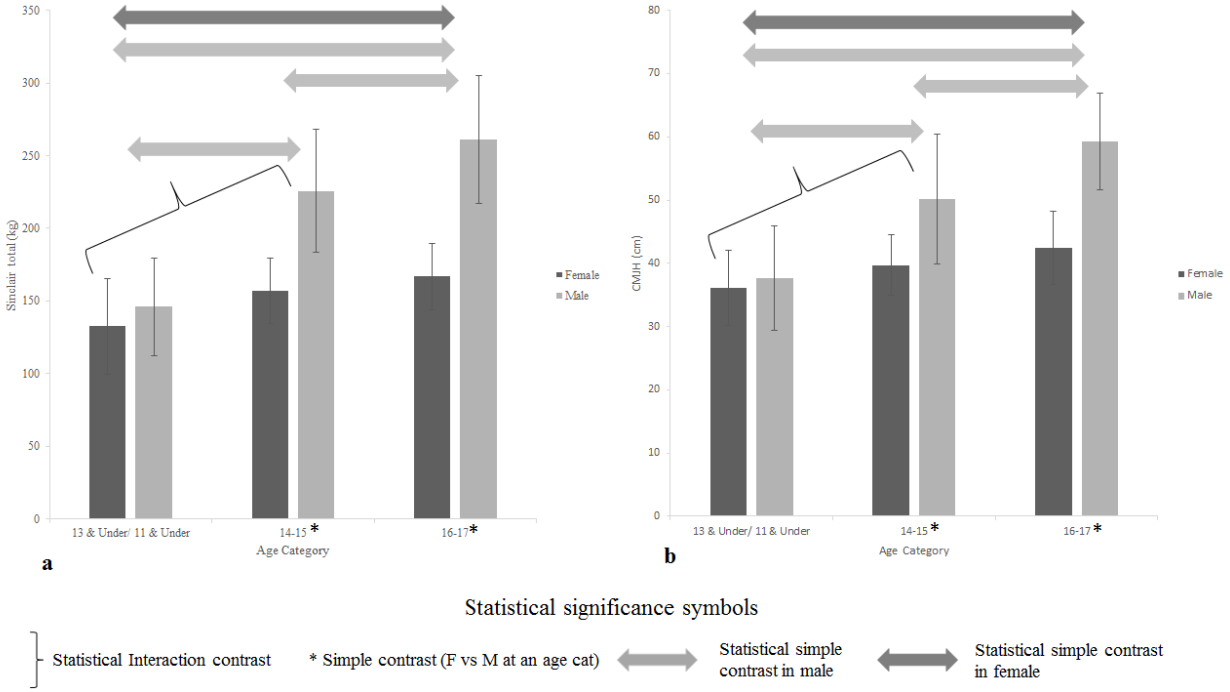
INTRODUCTION: It has been suggested that development of an elite athlete is a long process (Balyi, Way, & Higgs, 2013). While the debate on long-term development of an elite athlete continues, Gullich and Emrich (2014) reported senior athletes with success at the international level began specializing in their sports at an average age of 14.4. It is possible, if not likely, that development of an elite weightlifter should begin during an early stage of human development (e.g. adolescent) with possible specialization around the age of 12-14 (Pierce & Stone, 2017). Yet, the weightlifting community does not appear to have much knowledge of development of youth weightlifters. Thus, this study was designed with the purpose of providing insight into development of competition performance and pertinent fitness qualities of youth weightlifters. Specifically, the objective was to investigate relationships between competition performance and jumping performance and relationships of the two performances with sex and age category in youth weightlifters.

METHODS: This study used data provided by USA Weightlifting, which were determined to be publicly available by ETSU institutional review board (https://www.sportscienceed.com/blog/weightlifting-talent-identification). The data included 160 youth weightlifters who took part in countermovement jump (CMJ) testing at the competition venue of the 2018 Weightlifting Youth National Championships. Of the 160 weightlifters, 130 provided useable data for the study (65 females and 65 males). The CMJ testing was conducted with a jump mat (Probotics Inc., Huntsville, AL USA). Each weightlifter provided two trials with maximum effort while holding a PVC pipe on the back of the shoulders. Countermovement jump heights (CMJH) from the two trials were then averaged as a performance score for each weightlifter. Sinclair total at the competition, provided by USA Weightlifting, was also included with CMJH (https://drive.google.com/drive/folders/1_wFI5q350rrjeWe0sz6WYtO_ulgVO064). A Pearson's correlation coefficient was calculated between CMJH and Sinclair total for female and male weightlifters combined and separately. The correlations between the sexes were also statistically compared (Zou, 2007). Two 2x3 between-subject omnibus analyses of variance (ANOVA) were employed to examine relationships of two independent variables, age category (13&Under/11&Under, 14-15, and 16-17) and sex (female and male), with two dependent variables, Sinclair total and CMJH. The omnibus ANOVAs were then followed up with post hoc contrasts using Scheffe adjustment for family-wise error. The initial critical alpha was set at 0.05 for null hypothesis testing. Eta squared was calculated as an effect size measure for the ANOVAs. Eta squared is interpreted as a portion of the total variance occupied by the difference, similar to a coefficient of determination (Pearson's r^2).

RESULTS: Countermovement jump height and Sinclair total produced $r = 0.791$ for the sexes together, $r = 0.546$ for female weightlifters, and $r = 0.806$ for male weightlifters (all $p < 0.0001$). The coefficients were statistically different between the sexes ($p = 0.0051$, 95% confidence

interval: -0.470 to -0.075). The two ANOVAs both indicated presence of statistical differences for all effects (all $p < 0.0001$) (eta squared for CMJH – age category = 0.327, sex = 0.197, age category by sex = 0.097; eta squared for Sinclair total – age category = 0.360, sex = 0.270, age category by sex = 0.104). The two models accounted for 54.7% and 64.4% of the variance of CMJH and Sinclair total, respectively. Post hoc contrasts indicated that CMJH and Sinclair total both showed identical patterns with respect to statistical differences (Figures 1a&b). Male weightlifters showed a greater difference than female weightlifters between 13&Under/11&Under and 14-15 categories (statistical interaction contrasts). There was no statistical difference observed between the sexes in the 13&Under/11&Under category. The only statistical difference observed between the age categories for female weightlifters was between 13&Under/11&Under and 16-17 categories while each category was statistically different from each other for male weightlifters. Based on eta squared, the difference between 13&Under/11&Under and 16-17 categories in male weightlifters accounted for the largest portion of the model variance (i.e. 0.384/0.644 and 0.371/0.547 for Sinclair total and CMJH, respectively). The difference between male and female weightlifters in the 16-17 category accounted for the second largest portion (0.227 and 0.198 for Sinclair total and CMJH, respectively). The difference between 13&Under/11&Under and 14-15 categories in male weightlifters accounted for the third largest portion (0.171 and 0.116 for Sinclair total and CMJH, respectively). All other statistical differences accounted for less than 0.1 including 0.027 (Sinclair total) and 0.048 (CMJH) for the difference between 14-15 and 16-17 categories in male weightlifters and 0.036 (Sinclair) and 0.034 (CMJH) for the difference between 13&Under/11&Under and 16-17 categories in female weightlifters.

FIGURE 1. Sex by age category comparisons of Sinclair total and countermovement jump height.



Notes: 1a corresponds to Sinclair total (kg) and 1b corresponds to countermovement jump height (CMJH) (cm).

DISCUSSION: This study aimed to provide an overview of development of youth weightlifters in hopes to facilitate the sport at the youth level. Three primary findings are that 1) there is little difference between female and male weightlifters in the 13&Under/11&Under category, 2)

CMJH can be a practical measure for tracking a youth weightlifter's progress through the age categories, and 3) female weightlifters are likely to develop at a slower rate than male weightlifters.

Similar to what has been reported in the literature (Barber-Westin, Noyes, & Galloway, 2006; Dore, Bedu, & Van Praagh, 2008; Tonnessen, Svendsen, Olsen, Guttormsen, & Haugen, 2015), female and male youth weightlifters do not appear to differ in their weightlifting performance as well as jumping ability at an early age. In our study, the female and male weightlifters did not differ in the 13&Under/11&Under category perhaps owing partially to a lack of sex hormone differences (Crewther, Obminski, & Cook, 2016). Furthermore, our results suggest that the transition from 13&Under/11&Under to 14-15 categories is likely to be when male weightlifters experience the largest rate of performance development. Interestingly, previous studies also reported the age of 14 to be when the sexes begin to differ in measures of strength and explosiveness (Barber-Westin et al., 2006; Dore et al., 2008). Practically, the lack of sex difference may suggest similar training goals between the sexes in the 13&Under/11&Under category. On the other hand, coaches should expect a sex difference in the two older categories. Moreover, the sex difference is expected to increase as a youth lifter progresses through the age categories.

CMJH appears to be a useful monitoring tool to track development of a youth weightlifter. The suggested usefulness is supported by the correlation coefficients between CMJH and Sinclair total and the identical patterns of statistical differences in Sinclair total and CMJH. However, it should be noted that CMJH is a better indicator of a Sinclair total for male weightlifters than female weightlifters although the confidence interval suggests the difference in the indicative ability of CMJH may be practically negligible between the sexes. Overall, the observed positive correlation coefficient still suggests that coaches should expect a greater likelihood of an increase in a youth lifter's total as CMJH improves.

In conclusion, our results suggest sex by age category differences in the development of Sinclair total and CMJH. While at an early age (e.g. until age of 13), coaches may implement similar programs between the sexes, it may be important to design programs with different goals and emphases above the age of 13. In particular, coaches may be advised to emphasize physical development (e.g. strength) in female youth weightlifters at an earlier age than male youth weightlifters. At the same time, it is important to acknowledge that the primary findings of the study are based on an average trend of development for youth female and male lifters. Use of chronological age to gauge the stage of development for an athlete is not the best recommended practice (Balyi et al., 2013). Thus, coaches are encouraged to regularly track changes in simple anthropometry such as standing and seated height and wing span for biological age and consequently a developmental stage (Balyi et al., 2013) along with a practical measure of fitness qualities pertinent to weightlifting such as CMJH.

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