# TRAINING IMPLICATIONS OF PEAK BARBELL VELOCITY DIFFERENCES AMONG ELITE MEN AND WOMEN WEIGHTLIFTERS

[1]Aaron J. Cunanan, [2]W. Guy Hornsby, III, [1]Mark A. South, [1]Alec Perkins, [3]Kyle C. Pierce, [1]Kimitake Sato, & [1]Michael H. Stone

[1]Center of Excellence for Sport Science and Coach Education, Department of Sport, Exercise, Recreation, and Kinesiology, East Tennessee State University, Johnson City, TN;

[2]Department of Coaching and Teaching Studies, West Virginia University, Morgantown, WV;

[3]LSU Shreveport Center for Weightlifting High Performance and Development, Department of Kinesiology and Health Science, Louisiana State University Shreveport, Shreveport, LA.

**INTRODUCTION:** Weightlifting coaches can benefit from knowing kinematic and kinetic variables to provide feedback and instruction to lifters. These coaches should be particularly interested in peak barbell velocity during the weightlifting movements (snatch, clean, and jerk), as it is an important determinant of weightlifting performance (Bartonietz, 1996). Existing research has identified sex-based differences among several variables related to weightlifting performance, such as strength (Stone et al., 2005) and power (Garhammer, 1991; Gourgoulis et al., 2002; Harbili, 2012). To the authors' knowledge, Gourgoulis et al. (2002) and Harbili (2012) have performed two of the only sex-based comparisons of peak barbell velocity among elite men and women weightlifters and its relationship to the sex-based performance gap in weightlifting. Additional research on the current sex-based differences in peak barbell velocity may help coaches identify differential training needs of men and women to improve weightlifting performance at the elite level. Therefore, this study analyzed the performances of men and women weightlifters at the 2015 IWF World Championships to determine peak barbell velocities for each group.

While many factors contribute to sex-based performance differences in weightlifting (Storey & Smith, 2012), comparative analysis using a common weight class obviates the influence of body mass on such differences. Therefore, this study examined the performances of men and women in the 69 kg weight class, as it is the only weight class common to both sexes. The purpose of this study was to help practitioners identify training needs of elite men and women weightlifters to improve weightlifting performance based upon between-group differences in peak barbell velocity.

**METHODS:** This investigation utilized a cross-sectional design, examining the performances of elite men and women weightlifters at the 2015 IWF World Championships (Championships). This study included 11 male (age 24.45 ± 2.87 y; body mass = 68.78 ± 0.15 kg) and 10 female subjects (age 23.83 ± 3.94 y; body mass = 68.24 ± 0.81 kg). The institutional review board of East Tennessee State University approved this study.

Performances at the Championships were recorded using a GoPro HERO4 (San Mateo, CA) at an average sampling frequency of 240 frames·s$^{-1}$. The camera was arranged on a tripod with the lens facing perpendicular to the sagittal plane of the lifter in line with the geometric center of the competition platform. The camera was located approximately 15 m away from the near-edge of the platform and approximately 0.7 m above the lifting surface. This distance minimized image distortion and placed the camera's optical axis approximately level with the midpoint of barbell vertical displacement (Garhammer & Newton, 2013). The chosen height corresponds to the approximate height of the barbell at the end of the transition phase (Harbili, 2012). Barbell displacement of each successful attempt (N = 36) of the snatch lift from the A sessions of the men's and women's 69 kg categories at the Championships was measured using the automatic tracking feature of Kinovea (version 0.8.15) by placing a digitized marker over the center of the visible end of the barbell. According to Garhammer and Newton (2013), Kinovea provides values nearly equivalent, with a less than three percent difference, to those obtained from the gold standard Ariel Performance Analysis System.

Marker placement and tracking were performed after calibrating Kinovea's distance tool for each lift using the vertical diameter of the largest plate (45 cm) nearest to the camera with the barbell at the end of the transition phase as determined by the change in direction and magnitude of knee joint rotation (Akkuş, 2012; Gourgoulis et al., 2002). Barbell displacement data was smoothed using the five point moving arc method, and barbell velocity was calculated from the smoothed displacement values (Garhammer & Newton, 2013). An independent samples t-test was performed to assess the difference between group means of peak barbell velocity ($\alpha < 0.05$). A single investigator performed all analysis.

**RESULTS:** The average load of successful attempts for men was 148 ± 7.61 kg. Women successfully lifted an average load of 110 ± 5.39 kg. Mean peak velocity for men and women was 1.83 ± 0.15 $m \cdot s^{-1}$ and 1.95 ± 0.15 $m \cdot s^{-1}$, respectively. Levene's test indicated equal variances between groups ($F = 0.170$, $p = 0.683$), and t-test results indicated a significant difference of the mean peak velocity between men and women ($t[34] = -2.483$, $p = 0.018$).

**DISCUSSION:** The present study's findings are consistent with recent investigations that reported women to exhibit a higher peak velocity than men (Gourgoulis et al., 2002; Harbili, 2012). The current results may indicate a potential trend of increases in peak velocities of both men and women in the 69 kg weight class when compared to the results of Harbili (2012), who examined these groups at the 2010 IWF World Championships; however, differences in the analysis procedures between the current study and Harbili (2012) may limit such comparisons. Women from the present study had a greater average load at the highest successful snatch attempt compared to the group from 2010. However, further examination is necessary to determine if these increases in velocity and load are statistically significant and consistent over time. Nonetheless, women's performances (i.e. load lifted), as well as absolute and relative power outputs during the weightlifting movements, are less than those of men (Garhammer, 1991; Gourgoulis et al., 2002; Harbili, 2012; Storey & Smith, 2012).

The ability to lift heavier loads depends greatly upon peak power production (Kauhanen, Garhammer, & Häkkinen, 2000). Accordingly, training should elicit higher power outputs (Bartonietz, 1996). Given that power = force × velocity, coaches must determine whether training should emphasize increasing force (i.e. strength) or velocity (i.e. speed). With regard to velocity, coaches should consider the minimum barbell velocity required to successfully complete the lift, which is directly proportional to the lifter's height (Bartonietz, 1996). Bartonietz (1996) suggests ranges of critical velocity for the snatch lift from 1.50-1.60 $m \cdot s^{-1}$ for 52 kg men, up to 1.90-2.00 $m \cdot s^{-1}$ for men in the superheavyweight category. These values suggest that the women in the current study likely exceeded their critical barbell velocity because women in the 69 kg weight class are typically shorter than men in the same and heavier weight classes (Ford, Detterline, Ho, & Cao, 2000). In other words, peak velocity was not a limiting factor of these women's weightlifting performance. Thus, theoretically, these women could improve weightlifting performance by increasing strength.

Recent research also demonstrates that, while men and women display similar patterns of barbell and lower body kinematics, they exhibit differences in the magnitudes and rates of lower body angular kinematics due to strength differences (Gourgoulis et al., 2002; Harbili, 2012). In particular, women perform a shallower and slower double knee bend compared to men, which is attributed to women's relative inability to accommodate the eccentric forces during the stretch shortening cycle of this phase (Gourgoulis et al., 2002; Harbili, 2012). The results of Baumann (1988) suggest that despite differences in technique, weightlifting performance depends greatly upon hip extensor strength. In fact, the hip extensors have the greatest power demands during the snatch lift (Bartonietz, 1996). Furthermore, Baumann (1988) found strong positive correlations between barbell load and net hip joint moments, indicating that hip extensor strength is most critical during maximal (i.e. competition) attempts. Therefore, targeted strengthening of the hip extensors should be emphasized in training, particularly for elite women weightlifters.

## REFERENCES

Akkuş, H. (2012). Kinematic analysis of the snatch lift with elite female weightlifters during the 2010 World Weightlifting Championship. *The Journal of Strength & Conditioning Research, 26*(4), 897-905.

Bartonietz, K. E. (1996). Biomechanics of the Snatch: Toward a higher training efficiency. *Strength & Conditioning Journal, 18*(3), 24-31.

Baumann, W., Gross, V., Quade, K., Galbierz, P., & Schwirtz, A. (1988). The snatch technique of world class weightlifters at the 1985 world championships. *International Journal of Sport Biomechanics, 4*(1), 68-89.

Ford, L. E., Detterline, A. J., Ho, K. K., & Cao, W. (2000). Gender- and height-related limits of muscle strength in world weightlifting champions. *Journal of Applied Physiology, 89*(3), 1061-1064.

Garhammer, J. (1991). A comparison of maximal power outputs between elite male and female weightlifters in competition. *International Journal of Sport Biomechanics, 7*, 3-11.

Garhammer, J., & Newton, H. (2013). Applied video analysis for coaches: Weightlifting examples. *International journal of Sports Science & Coaching, 8*(3), 581-594.

Gourgoulis, V., Aggeloussis, N., Antoniou, P., Christoforidis, C., Mavromatis, G., & Garas, A. (2002). Comparative 3-dimensional kinematic analysis of the snatch technique in elite male and female Greek weightlifters. *The Journal of Strength & Conditioning Research, 16*(3), 359-366.

Harbili, E. (2012). A gender-based kinematic and kinetic analysis of the snatch lift in elite weightlifters in 69-kg category. *Journal of Sports Science and Medicine, 11*(1), 162-169.

Kauhanen, H., Garhammer, J., & Häkkinen, K. (2000). *Relationship between power output, body size and snatch performance in elite weightlifters*. Presented at the 5th Annual Congress of the European College of Sports Science, Jyvaskala, Finland.

Stone, M. H., Sands, W. A., Pierce, K. C., Carlock, J., Cardinale, M., & Newton, R. U. (2005). Relationship of maximum strength to weightlifting performance. *Medicine and Science in Sports and Exercise, 37*(6), 1037-1043.

Storey, A., & Smith, H. K. (2012). Unique aspects of competitive weightlifting. *Sports Medicine, 42*(9), 769-790.