ASYMMETRIC LOADING DURING THE HANG POWER CLEAN - THE EFFECT THAT SIDE DOMINANCE HAS ON BARBELL POWER SYMMETRY

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The vertical ground reaction force (GRF) of both feet and bar end kinematics were recorded using force platforms and high speed video simultaneously during hang power clean (HPC) performance with typical training intensities, in order to determine whether perceived handedness and ground kinetic asymmetry influenced bar end kinematics. There were significant differences between the GRF when side dominance was determined from GRF asymmetries ($p \leq 0.05$), but not when determined by perceived handedness. Similarly, there were significant differences between bar end power outputs when they were determined according to bar end asymmetries but not when determined by perceived handedness or GRF asymmetry. These results suggest mechanisms other than ground kinetic asymmetries influence bar end power output symmetry.

KEY WORDS: side dominance, force, resistance exercise, weightlifting.

INTRODUCTION: Measures of resistance exercise power output (RPO) are routinely used to monitor the affects of resistance exercise training programs (Hori *et al.,* 2007). Recent research findings have shown that during controlled bilateral resistance exercise healthy individuals tend to favour a dominant side that may not necessarily correspond with the side they perceive to be dominant by as much as 10% (Flanagan & Salem, 2007; Newton *et al.,* 2006). However, little is known about how ground kinetic asymmetries affect barbell kinematics. This could have important implications to strength and conditioning practitioners because measures of RPO tend to be based on the movement kinematics of one end of the barbell. Lake *et al.* (2008) recently reported that barbell kinematic symmetry was not influenced by ground kinetic asymmetries during dynamic lower-body resistance exercise. However, the effect that ground kinetic asymmetries have on barbell kinematics during ballistic lower-body resistance exercise has not been studied. This could have important implications to the strength and conditioning practitioner because the most common method of estimating RPO relies on the position-time data of one barbell end. With the above in mind this study set out to investigate the effect that side dominance had on the symmetry of hang power clean bar power output.

METHODS: Participants: Following University of Chichester ethical approval and a thorough explanation of the experimental aims and procedures, nine healthy males with a minimum of one year's hang power clean (HPC) experience volunteered to participate in this investigation. Their mean (±SD) physical characteristics were age: 28.8 (±8.5) years, mass: 84.1 (±18.9) Kg, height: 1.79 (±0.04) m, HPC 1RM: 70.8 (±18) Kg.

Test Procedures: Participant maximum HPC strength (1 RM) was established during a visit to the laboratory that occurred at least 48 hours but no more than one week prior to the asymmetry testing session and which followed a procedure that was similar to that outlined and used by (Kawamori *et al.,* 2005).
During asymmetry testing each participant performed two single lifts with 80% of their 1RM (repetition maximum), with a minimum of one minute and a maximum of three minutes recovery between each lift (Reiser *et al.,* 1996). Of the two lifts, the lift with the greatest bar end power output was selected for later analysis (Kawamori *et al.,* 2005). Participants were instructed to lower the bar under control to above the knee and perform the positive phase as explosively as possible (Kawamori *et al.,* 2005). The 80% 1RM load was selected to represent typical training loads (Reiser *et al.,* 1996).

Measurements: The vertical GRF of HPC performance was recorded from both feet

individually by two 0.4 by 0.6m Kistler 9851 force platforms (Alton, UK) at a sampling frequency of 500 Hz. The analog GRF signals were amplified by two type 9865E 8-channel charge amplifiers before they were digitally converted.

Three cameras (Basler A602fc-2, Germany) were positioned on rigid tripods approximately 5m from the centre of the area of interest around the right hand side of the participant, with an inter-camera angle of ~120 degrees recorded HPC performance at 100 Hz. The HPC GRF and movement footage data collection was synchronised using an MX Ultranet control unit (Peak Performance Technologies Inc., Englewood, Colorado).

All successful trials were digitised at 100 Hz using Peak Motus 9.2 software. The digitisation of reflective markers on the bar ends enabled the calculation of three dimensional spatial coordinates using the direct linear transformation procedure. Raw co-ordinate data were smoothed using a low pass filter with a cut off frequency of 6 Hz. The positive phase of HPC performance was determined from the velocity-time curve, and bar end velocity and acceleration used to calculate bar end power output in accordance to the methods outlined by Hori *et al.* (2007). The positive phase barbell power and GRF data were then averaged for further analysis. This is an approach that was recently used by Flanagan & Salem (2007), who suggested that peak performance data may not accurately represent the behaviour of parameters of interest over a selected period of time. Side dominance was reported according to perceived handedness (LRSD or left right side dominance) (Flanagan & Salem, 2007; Newton *et al.,* 2006), and left and right foot positive phase GRF dominance (GRFSD or ground reaction force side dominance) (Flanagan & Salem, 2007; Newton *et al.,* 2006). The bar end power outputs and GRF were then grouped according to their dominant (D) and non-dominant (ND) sides for analysis.

Statistical analysis: The different dominant (D) and non-dominant (ND) side GRF and bar end power outputs were compared using paired t tests. All statistical calculations were performed using SPSS version 16.0 for Windows (SPSS, Inc., Chicago, IL) and an alpha value of $p \leq 0.05$ was used to determine statistical significance.
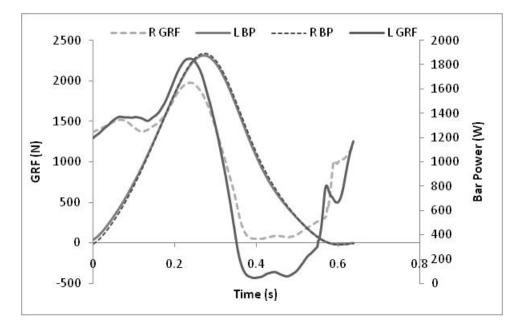
RESULTS AND DISCUSSION: The mean (±SD) and confidence intervals (CI) for D and ND side positive phase average GRF and bar end power outputs are presented in Table 1.
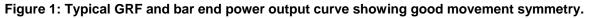
Table 1 Mean (±SD; CI) mean HPC positive phase GRF and bar end power output

	Mean GRF (N)				Mean Bar Power (W)			
	LRSD		GRFSD		LRSD		GRFSD	
	D	ND	D	ND	D	ND	D	ND
Mean	668.0	648.1	691.0	625.1	673.5	667.6	672.2	668.9
SD	110.5	145.4	128.4	121.0	152.1	151.1	156.4	146.7
CI	2.3	3.0	2.7	2.5	3.2	3.2	3.3	3.1

*Note: LRSD: left right side dominance; GRFSD: GRF side dominance; D: dominant side; ND: non-dominant side.

There was a non-significant difference of -5.2% (t(8)= 0.588, p=0.573) between the mean left and right side GRF. This can be seen graphically in Figure 1 and was in agreement with the results reported by Newton *et al.* (2006) for movement asymmetries during back squat performance. The high standard deviation (see Table 1) may offer explanation for the lack of significant difference. Further analysis highlighted that 6 of the 9 participants did not display side dominance that was consistent with their perceived handedness, with individual participant differences ranging from -49.2% to 11.7%. This finding was in good agreement with the results recently published by Flanagan & Salem (2007).

Figure 1: Typical GRF and bar end power output curve showing good movement symmetry.

A significant difference of 10.4% (t(8)=2.587, p=0.032) was established between the mean dominant and non-dominant side GRF. This is graphically presented in Figure 2. The mean difference was slightly greater than that recently reported for movement asymmetries during back squat performance (Flanagan & Salem, 2007; Newton et al., 2006). However, this may have been a consequence of the explosive nature of the HPC. It is worth noting that all 9 participants reported being right side dominant but that 6 of them demonstrated left mean GRF side dominance. This finding warrants further research as it suggests that there may be mechanisms other than ground kinetic side dominance that may underpin movement asymmetry.

There was a minimal and non-significant (0.8%; t(8)=0.834, p=0.428) mean difference between the mean left and right side bar end power outputs. There were no differences (t(8)=0.445, p=0.668) between the GRFSD mean dominant and non-dominant side bar end power outputs.
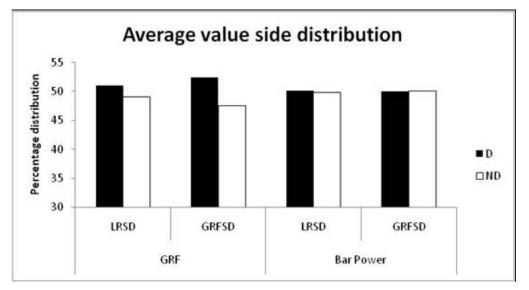

Figure 2: Mean LR and GRF side dominance D and ND GRF and bar end power distributions.

Further analysis of the bar end power output data showed that the side differences ranged from -5.9% to 6.1% for the left and right side bar end power output differences and -6.5% to 5.5% for the GRF dominant and non-dominant side bar end power output differences, indicating variability that was not a consequence of ground kinetic asymmetries. When side dominance was determined by bar end power output, that is the highest power output of the left and right bar end, power outputs became the dominant and the other side non-dominant, a mean difference of 2.8% was found, which was significant ($t(8)=4.383$, $p=0.002$). This finding supported the contention that mechanisms other than ground kinetics or perceived handedness underpin movement symmetry. This finding is a unique aspect of this study as these are the first asymmetry data to be determined by both ground kinetics and bar end kinematics.

CONCLUSION: It is apparent that any difference between the mean left and right side and GRF side dominant and non-dominant GRF does not necessarily influence the kinematics of the barbell. This is in good agreement with the findings recently presented by Lake *et al.* (2008) for asymmetric back squat performance but is the first time that ground kinetic and bar kinematic symmetry data from HPC performance have been presented. The results of this study support the integrity of methodologies that rely on the position-time data of one barbell end to estimate RPO. However, they also add to the growing body of research evidence that shows that healthy individuals tend to favour a dominant side may not necessarily correspond with the side they perceive to be dominant during controlled bilateral resistance exercise.

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