KINETIC ANALYSIS OF A UNILATERAL SNATCH MOVEMENT

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The vertical ground reaction force (VGRF) of 7 weightlifters performing one-handed dumbbell power snatches with loads of 80%, 90% and 100% of 1RM were recorded at 500 Hz from 2 Kistler force platforms. There were no significant load or side effects for the pull phase peak VGRF or catch loading rates (P>0.05), although with the exception of the catch loading rate for the heaviest loads, non-lifting side values tended to be larger than those of the lifting side. In addition to this, lifting side pull phase duration was significantly longer than the non-lifting side (P<0.001). These results indicated that the dumbbell load distribution favoured one side affecting pull and catch symmetry and efficiency. This supports the suggestion that unilateral lifts may provide a different training stimulus that may be more specific for many sporting movements.

KEY WORDS: athlete, conditioning, force, power, snatch, strength.

INTRODUCTION: The one-handed dumbbell power snatch (DBPS) is a unilateral weightlifting variation that is increasingly included in athlete strength and conditioning (S&C) programs (Cross, 1993; Hedrick, 1998). Despite this little is known about its biomechanical characteristics.

Bar vertical displacement relies on the powerful extension of the lower limbs. This and an intervening period of knee flexion that enables the bar to be maneuvered around the lifter's knees is typically referred to as the "pull" and is associated with a double peak VGRF pattern (Enoka, 1979; Garhammer, 1998). Figure 1 shows typical DBPS vertical ground reaction force (VGRF) patterns and differences between the lifting and non-lifting sides (the lifting side corresponds with the hand holding the dumbbell) resulting from this study.

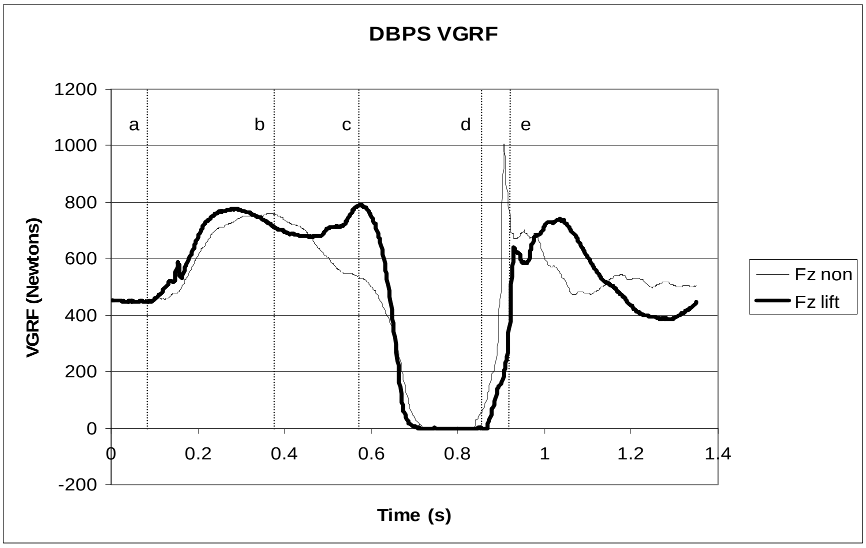

Figure 1. Typical 80% DBPS VGRF loading sequence and magnitude.

The DBPS VGRF deviates from the double peak pull pattern found in previous studies for the barbell power snatch (Hakkinen and Kauhanen, 1986). During the pull phase the non-lifting side demonstrated a single VGRF peak (Figure 1 a-b), which is caused by an uninterrupted lower limb extension, while the lifting side demonstrated a double peak (Figure 1 a-c). This is the result of knee extension (Fig 1 a-b) and delayed hip extension (b-c). Following a period of un-weighting (Figure 1 part of c-d) the non-lifting side experienced a greater catch VGRF over a shorter duration. This catch phase loading rate is greater than that experienced by the lifting side (Lauder and Lake, 2006). Lauder and Lake identified asymmetric movement patterns supporting the suggestion that unilateral weightlifting variations may provide a varied training stimulus. However, only loads corresponding to approximately 80% of the lifter's one repetition maximum (1RM) were examined. Using a similar methodology it was the aim of this study to determine the effects of heavier loads on the kinetic consequences of the DBPS.

METHODS: Following a thorough explanation of the aims and experimental procedures, seven male weightlifters volunteered to participate in this investigation. Each volunteer had a minimum of one year's experience with the DBPS and each provided written informed consent to participation. The participant and load characteristics are displayed in Table 1.

Table 1. Participant physical and load characteristics.

	Physical characteristics			DB load (Kg)		
	Age (years)	**Height (m)**	**Mass Kg)**	**80%**	**90%**	**100%**
Mean	26.7	1.75	85.2	36.8	40.7	46.4
±SD	7.3	0.47	16.6	4.7	5.5	5.6

Following a thorough warm up each lifter performed progressively heavier single lift attempts with a spin-lock dumbbell bar loaded with 10Kg weight plates that had an outer circumference of 28cm. Participants rested as needed between lifts (Reiser et al., 1996), and continued until a maximum for that day was achieved. The weight lifted successfully before two failures with a given weight was assumed to be the 1 RM for the experiment (Hakkinen and Kauhanen, 1986).

Each lift was performed with the whole of each foot on one of two parallel 0.4m by 0.6m Kistler 9281 force platforms (Kistler,. Alton, UK). Two video cameras (Peak performance Technologies Inc, Englewood, Colorado,USA) which were positioned 5 meters from the centre of the force platforms with an inter camera angle of 90 degrees allowed recording of each lift at 200 Hz with a shutter speed of 1/1000s onto SVHS videotape using Panasonic high-speed AG-5700-E video recorder (Panasonic, UK). An Opus technologies personal computer running Kistler Bioware 3.21 software recorded the VGRF of both feet at a sampling frequency of 500Hz. Loads within ±5% of 80, 90 and 100% of the 1 RM were identified for analysis. Data was exported from Bioware software into Microsoft Excel, which was used to calculate peak pull and catch VGRF and catch loading rate (LR) (from the minimum catch phase un-weighting to the catch peak) relative to each subject's bodyweight (BW). Two-way repeated measures analysis of variance was used to determine between and within lift differences, with paired t tests (applying the Bonferonni correction) performed on significant results.

RESULTS AND DISCUSSION: Figure 1 provides a graphical representation of the typical VGRF patterns during the 80, 90 and 100% load conditions. The mean (±SD) pull phase peak VGRF values are presented in Figure 2. Statistical analysis showed that there was no significant difference between the different load conditions ($P>0.05$). This is contrary to the suggestion by Hakkinen et al. (1984) of a negative relationship between bar load increases and changes in VGRF. Statistical analysis also showed that there was no significant difference between the lifting and non-lifting sides pull phase peak VGRF. However, Figure 2 shows that the non-lifting side pull phase peak VGRF tended to be approximately 12% greater than that of the lifting side during all load conditions.

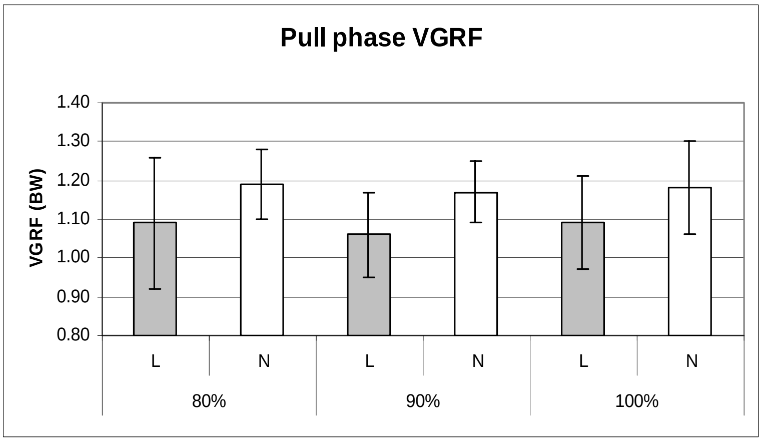

Figure 2. Mean (±SD) DBPS peak pull phase VGRF (BW) for lifting (L) and non-lifting (N) side.

Table 2 shows that the pull phase durations for the lifting side were much greater than those on the non-lifting side (P<0.002, Figure 1 b-c), though there were no significant differences between the total lift durations of the different load conditions.

Table 2. Mean (±SD) phase and total lift durations (s). (L= lifting and N= non-lifting side)

	80%		**90%**		**100%**	
	L	**N**	**L**	**N**	**L**	**N**
Pull phase	0.651 (0.179)	0.444 (0.203)	0.663 (0.172)	0.418 (0.239)	0.727 (0.149)	0.479 (0.221)
Catch Phase	0.139 (0.067)	0.107 (0.041)	0.099 (0.031)	0.120 (0.046)	0.097 (0.036)	0.121 (0.057)
Total lift (sides)	1.042 (0.206)	0.978 (0.190)	1.020 (0.184)	1.013 (0.184)	1.083 (0.146)	1.064 (0.185)
Total lift	1.044 (0.208)		1.045 (0.176)		1.105 (0.157)	

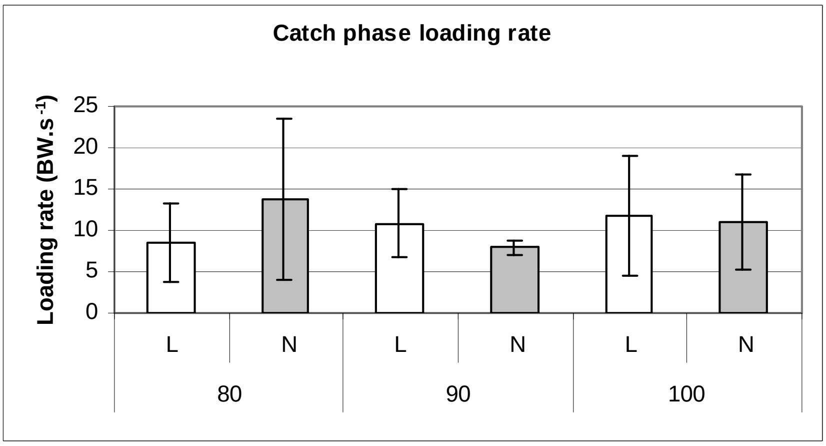

Figure 3. Mean (±SD) DBPS catch phase loading rate (BW.s-1).

When the catch phase loading rates were considered, as shown in figure 3, no significant differences were identified for either load or side. However, the 80% load non-lifting side mean loading rate of 13.8 was 62% greater than the lifting side value of 8.5 BW.s-1, while the 90% load non-lifting side value of 7.94 BW.s-1 was ~27% less than the lifting side value and there was only a difference of ~0.72 BW.s-1 between the lifting and non-lifting side values of the 100% load condition.

Table 3. Mean (±SD) catch VGRF values (N).

	80%	90%	100%
Lifting	792 (182.43)	882.86 (402.51)	891.32 (619.7)
Non-lifting	956 (212.29)	916.92 (288.92)	930.53 (199.4)

Table 3 indicated that as the dumbbell load increased, the non-lifting side VGRF values tend to decrease while catch phase duration increased in the case of the 80% and 90% load conditions. The 100% load condition lifting and non-lifting side loading rates of 11.8 and 11.1 BW.s-1 respectively indicate that as dumbbell load increased to the limiting value the movement became more symmetric as demonstrated by the symmetry of the dumbbell load distribution during the catch phase in figure 3.

CONCLUSION: This study found that the non-lifting side tended to generate a greater pull phase VGRF significantly faster ($P<0.001$) than the lifting side during the DBPS. In addition to this, non-lifting side catch loading rates were also greater during the 80% load condition, but decreased as dumbbell load increased. These results quantify the effects of a unilateral Olympic lift variation on movement patterns both during the concentric muscular contraction of load vertical displacement, and the loading implications of unilateral landing. The sporting implications of these results are important for strength and conditioning coaches. They support the suggestion of unilateral movements providing a different training stimulus (Hedrick, 1998), and their application to strength and conditioning for sports specific movements, including unilateral body movement and shock absorption (Bartonietz, 1996; Santana, 2001; Blackwood, 2004).

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