EVALUATION OF THE POWER CLEAN AS A SPRINT SPECIFIC EXERCISE

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The purpose of this study was to evaluate the contribution of the hips in the power clean as a sprint specific training exercise. Hip kinetics in the power clean were compared to those of accelerating sprints over 5 m and rolling sprints from a 15 m approach. Four male games players performed four series of the three exercises. Synchronised Kistler™ force plate and CODA™ 3D tracking data, combined with customised body segment inertia parameters were used as input for an inverse dynamic analysis to quantify the muscle moments, power and work at the hips. Peak hip kinetics were considerably greater in the power clean than in either of the sprinting exercises (moments and powers ≥40% and work 80%). When plotted against hip joint angle, the kinetic profiles revealed additional relationships with the power clean being more closely associated with the accelerating sprint than the rolling sprint.

KEY WORDS: kinetics, inverse dynamics, specificity

INTRODUCTION:

With athletes training near their physiological maxima it is desirable that training drills are effective and efficient in the development of the desired skill (Irwin and Kerwin, 2005). Previous literature has emphasised the importance of specificity of training in rowing (Elliott *et al*., 2002), swimming (Lauder and Payton, 1995) and gymnastics (Irwin and Kerwin, 2005; 2007; in press). In order for training drills to be most effective there should be good similarity between the drill and the final skill in terms of movement pattern and the musculoskeletal demand (Irwin and Kerwin, *in press*). The development of lower leg strength and power are key requirements for successful sprint running (Weyand *et al.,* 2000). Coaches, and strength and condition practitioners, use a variety of exercises that attempt to produce desirable changes in a performer's musculoskeletal and neuromuscular systems and consequently to improve performance (Siff, 1992). The power clean is well established as the "gold standard" exercise for the development of lower extremity propulsive forces (Garhammer, 1982). The power clean is a multi-joint, multi-muscle, lifting action incorporating extension at the ankles, knees and hips and includes a characteristic double knee bend (Stone et al., 2006; Garhammer, 1982). These co-ordinated actions have been empirically shown to produce similar ground reaction force profiles to vertical jumping (Burkhardt *et al*., 1990) and 10 m sprinting (Tricoli *et al*., 2005). Okanda *et al.* (2005) showed power clean power outputs that were highly correlated with the angular kinematics of the lower limb during sprinting. The power clean has become a sprint specific strength and conditioning exercise which is incorporated into periodised training programmes (Siff, 1992; Sheppard, 2003). Based on the dominant role of hip kinetics in successful sprinting, (Bezodis *et al*., 2007), the power clean should elicit similar kinematic and kinetic characteristics. Based on the training principles of specificity and overload, the purpose of this study was to determine the similarity in the musculoskeletal demand on the hips during the power clean compared with sprinting during acceleration and at speed. The overall aim was to evaluate the power clean as a sprint specific training exercise.

METHOD:

Data collection: Four male elite track and field athletes provided informed written consent and volunteered to take part in the investigation (Age 22.0 ± 0.8 yrs, Height 1.80 ± 0.04 m, Mass 93.7 ± 2.6 kg). All subjects were competent in the power clean movement utilising the double knee bend and had been employing this exercise as a part of their training programme for over at least two years. Each participant performed four series of the three different exercises namely, the power clean (PC); an accelerating sprint (AS) from a 5 m approach and a rolling sprint (RS) from a 15 m approach. Kinetic data were collected from a force plate (Kistler Instruments Ltd., 9287BA, Switzerland) at 1000Hz and synchronised to kinematic data from a 3D automatic tracking system (CODA CX1, Charnwood Dynamics Ltd., UK) at 200Hz. Winter's (2005) residual analysis was undertaken to determine the appropriate cut off frequency for the kinematic data. This was completed at each joint centre and a 6 Hz average used for the subsequent analyses to minimise random noise. Subject specific inertia characteristics were obtained using Yeadon's (1990) geometric model in combination with the kinematic data.

Data Analysis: The ground reaction forces, kinematics and inertia data provided inputs into an inverse dynamics analysis used to quantify muscle moments (MM) at the hips. Muscle power (MP) was calculated as the product of MM and hip joint angular velocity (ω). MP was integrated over time to determine muscle work (MW). All MM, MP and MW results were normalised to body mass and the mean values were compared. The profile from the start of the double knee bend up to loss of ground contact (i.e. the second pull) of one hip was analyzed in each trial and normalised to 101 points to facilitate inter-subject comparisons. The corresponding eccentric-concentric phase, from touchdown to takeoff of the same hip for the two sprint exercises, was similarly interpolated. Root mean squared differences (RMSD) between the power clean and each of the sprint exercises were calculated across the selected variables and expressed in absolute units and as percentages of the respective ranges in the power clean movement.

RESULTS:

The hip joint extended continuously during all trials of the power clean and, after a short flexion phase, also in the sprints. Greater hip angular velocity was observed in the sprints than for the power clean (RS = 15.14; AS = 9.83; PC = 5.52 rad/s). Compared to the power clean, hip muscle moments were markedly lower during both sprints. Hip moments were almost totally extensor throughout the power clean, whereas flexor contributions were present in both sprint exercises (Figure 1).

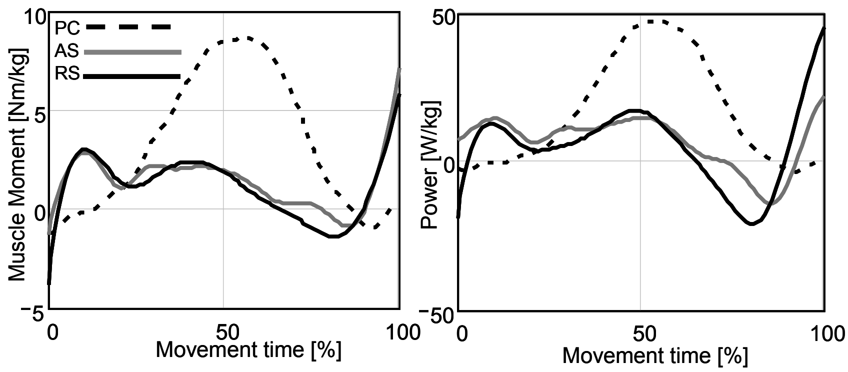

Figure 1 - Muscle Moment (left) and Muscle Power (right) at the hips during a power clean (PC), accelerating sprint (AS) and rolling sprint (RS)

Peak hip moments occurred earlier in the power clean (PC = 56%; AS & RS = 100%). In addition the power clean produced the greatest hip power (47.3 W/kg) over the greatest range of motion (46º) (Figure 2). The hip power was predominantly extensor. The rolling sprint produced the second largest peak concentric hip power (42.3 W/kg) and the largest eccentric power (-20.9 W/kg) over the smallest range of motion (30º), (Figure 2). During the accelerating sprint, the peak hip concentric power (22.0 W/kg) and eccentric power were smallest (-14.2 W/kg), but acted over a similar range (45º) to the power clean. The hip flexors were loaded eccentrically during both sprints (Figure 1). There were large percentage RMS differences in hip muscle power between the power clean and the accelerating sprint (47%) and the rolling sprint (42%). The power clean peak hip work of 5.1 J/kg was much greater than the equivalent for the accelerating sprint (1.1 J/kg) and the rolling sprint (0.60 J/kg). Table 1 contains a summary of the RMSD values for each of the sprints in comparison to the criterion values from the power clean.

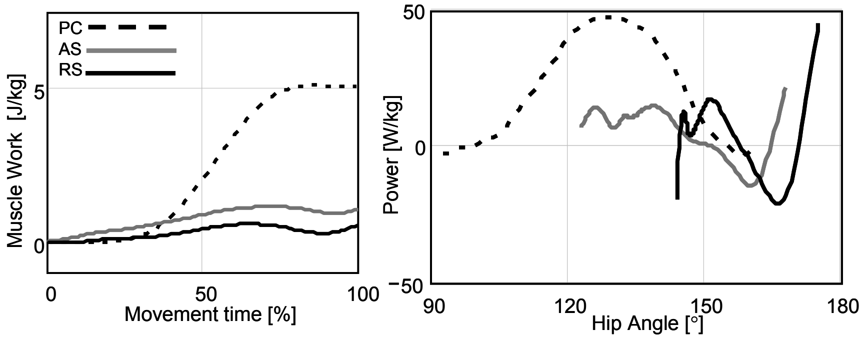

Figure 2 - Left = Hip muscle work during the power clean (PC), accelerating sprint (AS) and rolling sprint (RS). Right = hip muscle power plotted against hip angle for the three exercises.

Table 1 - RMSD and (%RMSD) between (i) the power clean (PC) and the accelerating sprint (AS), and (ii) the power clean and the rolling sprint (RS).

PC versus:	ω [rad/s]	MM [Nm/kg]	MP [W/kg]	MW [J/kg]
(i) AS (RMSD)	3.1 (64%)	4.2 (46%)	20.4 (47%)	2.5 (78%)
(ii) RS (RMSD)	6.2 (80%)	4.4 (46%)	23.9 (42%)	2.9 (99%)

DISCUSSION:

The overall aim of this study was to evaluate the power clean as a sprint specific exercise. Hip extension was seen to dominate the initial 60-70% of the sprints. In the later stages of the movement, the hips underwent eccentric loading which has been suggested to be beneficial for hip flexion in the subsequent recovery phase of sprinting (Johnson and Buckley, 2001). The hips produced greatest work during the power clean (Figure 2), with the differences between the power clean and the two sprint exercises being at least 78% of the PC range. Between the two sprints, the hip produced more work in the rolling sprint than in the accelerating sprint. This was explained by Bezodis *et al.* (2007), who reported a lower contribution from the hip and a higher contribution from the knee during the accelerating phase of sprinting as the athlete attempted to increase horizontal impulse. The hips provided the vertical propulsive forces (along a closed rigid link kinetic chain (Garhammer, 1980) to pull the barbell into the air. Based on the training principle of over load (Dick, 2004), the larger musculoskeletal work at the hips during the power clean may produce specific muscular and neurological adaptations that will facilitate an improvement in sprint performance. The power clean may be particularly effective in improving running near maximum velocity when the hip is more dominant (Bezodis *et al*., 2007). However, during the clean, the hip flexors were not eccentrically loaded which appears to be an important variable to improve power for the recovery phase of sprinting (Johnson and Buckley, 2001). The power clean appears to be able to provide the necessary specific overload to develop hip extension power for sprinting. However, the fact that the power clean involves both legs means that there would be no overload for developing gluteal and adductor synergy (Ae *et al.,* 1988). Very little eccentric loading of the hip flexors was reported in the power clean which is necessary to propel the leg forward during the swing phase in sprinting (Johnson and Buckley, 2001). Peak power in the power clean and the rolling sprint occurred at similar hip angles (120-130º) but this was not the case in the accelerating sprint exercise, where the peak occurred when the hip angle was extended by a further 30º (Figure 2).

CONCLUSION:

The power clean was identified as an effective exercise for loading the hips, and may elicit musculoskeletal and neurological adaptations that improve concentric hip extension power, which could be beneficial in the general preparation phase of training for a sprinter. However large differences in the hip kinetics and variations in the power-angle profiles suggest that not all sprint activities match closely with those of the power clean. This study has provided a platform for future research to explain other contributing biomechanical variables associated with the performance of the power clean. Furthermore this study has highlighted wider issues in terms of enhancing the interface between biomechanics and strength and conditioning in order to develop the concept of exercise specificity and provide coaches with ecologically valid information regarding the most effective training drills.

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