A THREE DIMENSIONAL KINETIC ANALYSIS OF SUMO AND CONVENTIONAL STYLE DEADLIFTS

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INTRODUCTION

Strength athletes and rehabilitation patients often employ the deadlift in their training and rehabilitation regimens. The deadlift is performed using either a conventional (narrow stance, feet slightly turned out) or sumo (wide stance, feet turned out ≈45°) style. In the only previous kinetic analysis between sumo and conventional deadlifts [Cholewicki, 1991], lumbar spinal forces & moments and knee & hip moments were quantified using a one camera two-dimensional (2-D) analysis. Unlike trunk movements, ankle and knee movements during the deadlift occur in three-dimensions when the feet are turned out. Therefore, erroneous ankle and knee moments and moment arms may result with a 2-D analysis, especially during the sumo deadlift. Hence, it was the purpose of this study to conduct a three-dimensional (3-D) analysis of the sumo and conventional deadlifts, and compare ankle, knee, and hip moments and moment arms between these two lifting styles. Mechanical work was also compared.

MATERIALS AND METHODS

Twenty-four male powerlifters served as subjects (12 sumo and 12 conventional) during a national powerlifting championship. Two synchronized video cameras were used to collect 60 Hz video data. Three events were noted during the deadlift:1) liftoff (LO); 2) knee passing (KP); and 3) lift completion (LC). A 3-D video system was used to manually digitize joint and segmental centers of the toes, ankles, knees, hips, shoulders, hands, and bar. A 4^{th} order, zero lag Butterworth digital filter was used to smooth the raw data with a cutoff frequency of 5 Hz . A 2 x 1.5 x 1 m volume calibration frame was positioned in the volume occupied by the lifter-barbell system. A 3-D orthogonal axes system was translated and rotated appropriately in order to calculate ankle, knee, and hip moments and moment arms. Joint moments were calculated using a quasi-static model. Body segment center of masses and weights were estimated by using appropriate anthropometric data and each lifter's known mass. Unpaired t-tests ($p < 0.01$) were used to used to compare kinetic parameters between sumo and conventional deadlift groups.

RESULTS AND DISCUSSION

When normalized by body height, the conventional group had 20-25% greater vertical bar displacements from LO to LC compared to the sumo group. This is not surprising since the sumo group had a stance width approximately three times greater than the conventional group. The lower vertical displacement by the sumo group resulted in 25-30% less mechanical work performed compared to the conventional group. Joint moments and moment arms are shown in Table 1. Since ankle and knee movements occur in the direction the feet are pointing, ankle and knee moments and moment arms calculated from a 2-D analysis were significantly different from a 3-D analysis, especially for the sumo group. Ankle and knee moment arms for the conventional deadlift were generally only a few centimeters different between a 2-D and 3-D analysis. In contrast, ankle and knee moment arms for the sumo deadlift were generally 20-25 cm different between a 2-D and 3-D analysis. Similar to data from Cholewicki et al. [Cholewicki, 1991], there were no significant differences in hip moments and moment arms between sumo and conventional deadlifts. This was not surprising since hip flexion and extension during the deadlift occurs primarily in the sagittal plane. Hence, a 2-D analysis is adequate in calculating hip moments and moment arms. Unlike knee moments in the current study (Table 1), knee moments from Cholewicki et al. [Cholewicki, 1991] were not significantly different between sumo (18 N·m) and conventional (18 N·m) deadlifts. In addition, 2-D knee moments for the sumo (106±55 N·m) and conventional (-7±66 N·m) deadlifts were relatively similar to the 2-D knee moments from Cholewicki et al. [Cholewicki, 1991], but quite different than 3-D knee moments (Table 1).

SUMMARY

Mechanical work is greater in the conventional deadlift, which suggest a higher energy expenditure. Moderate to high hip extensor, knee extensor, and ankle dorsiflexor moments are generated during the sumo deadlift, which implies moderate to high muscle activity is needed from the hip extensors, knee extensors, and ankle dorsi flexors. In contrast, moderate to high hip extensor moments and low knee flexor, knee extensor, and ankle plantar flexor moments are generated during the conventional deadlift. This implies moderate to high muscle activity from the hip extensors, and lower activity from the knee flexors & extensors and ankle plantar flexors. These kinetic differences result from technique differences. Hence, a electromyographic analysis should now be conducted to confirm muscle activity patterns. This would help trainers and therapists in prescribing the appropriate deadlift technique.

REFERENCES

Cholewicki, J. et al. (1991). Med. Sci. Sports Exerc., 23(10), 1179-86.

Table 1. Moments and moment arms relative to barbell load center of mass.

	Sumo	Conventional
Moment Arms at LO		
Ankle (cm)	-17.2±6.8*	5.1±2.5*
Knee (cm)	-17.8±5.0*	-3.9±3.6*
Hip (cm)	19.0±4.0	20.7±6.7
Moments at LO		
Ankle (N·m)	-359±159+*	109±50*
Knee (N·m)	-370±11*	-95±91*
Hip (N·m)	403±121	461±164
Moment Arms at KP		
Ankle (cm)	-18.6±6.1*	1.4±3.5*
Knee (cm)	-12.8±5.1*	2.2±2.7*
Hip (cm)	17.4±4	16.2±4.5
Moments at KP		
Ankle (N·m)	-389±145*	23±80*
Knee (N·m)	-266±109*	46±66*
Hip (N·m)	366±102	351±78
Moment Arms at LC		
Ankle (cm)	-17.6±6.9*	2.9±3.4*
Knee (cm)	-9.8±4.2*	2.4±3.5*
Hip (cm)	8.7±2.9	6.0±2.0
Moments at LC		
Ankle (N·m)	-369±167*	55±75*
Knee (N·m)	-204±93*	46±75*
Hip (N·m)	190±92	132±45

*$p < 0.01$

Note. Hip extensor, knee flexor, and ankle plantar flexor moments are positive