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# Biomechanical analysis of conventional and sumo deadlifts

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## 1. Introduction

Different deadlift techniques are used in strength training and rehabilitation to develop hips, thighs, and back muscle strength (Escamilla et al., 2000).

There are notably two deadlift variations commonly used in competition: the conventional deadlift (CDL) and the sumo deadlift (SDL). The main differences between these two techniques are the placement of the hands and the feet. During SDL, the knee moment is approximately three times higher than for CDL when the bar leaves the ground. SDL induces also a higher electromyographic (EMG) recruitment of vastus lateralis (VL) and vastus medialis (VM) compared to CDL (Escamilla, Francisco, Kayes, Speer, & Moorman, 2002; Jovanovi c et al., 2021).

During CDL, data from Cholewicki et al. (1991), particularly regarding lumbar flexion moments, indicate approximately a 10% greater demand for spinal extension due to the increased anterior inclination of the torso at the starting position. A stronger contraction of the ES muscles is necessary to maintain back extension when the bar is taking off from the ground (Salehi, Babakhani, & Baluchi, 2020). However, some studies did not support this finding. Indeed, no significant difference in ES or VL recruitment was found between CDL and SDL (Escamilla et al., 2002; Salehi et al., 2020).

Furthermore, most studies comparing these techniques using kinematics or inverse dynamics have been conducted using low frequency cameras (Cholewicki, McGill, & Norman, 1991; Escamilla et al., 2000). Today, we have tools that allow us to gain precision.

The purpose of the present study was to compare the biomechanics of CDL and SDL in order to adapt training protocols. It was hypothesized that (1) the CDL would show significantly greater EMG activities

of the biceps femoris (BF), gluteus maximus (GM) and ES muscles than the SDL and that (2) the SDL would show significantly greater knee and ankle moments with greater EMG activity of the VL than the CDL.

## 2. Methods

### 2.1 Participants

Eight males ( $26.0 \pm 2.3$  years,  $179.1 \pm 2.3$  cm, and body mass  $81.02 \pm 10.0$  kg) took part in this study. They were all familiarized with deadlift techniques and trained until achieving a stable technique. Thirty powerlifters will be included in this study.

### 2.2 Trial condition

In a randomized order, subjects performed 3 repetitions of each deadlift technique at 85% of their one repetition maximum (1RM), estimated from the load-velocity relationship as the load associated with reference mean velocity (Mor an-Navarro, Mart inez-Cava, Escribano-Pe nas, & Courel-Ib a nez, 2021).

### 2.3 Equipment setup and data collection

Neuromuscular recruitment of the anterior tibialis (AT), gastrocnemius (GA), VL, BF, GM, adductor (AD), erector spinae thoracic (EST) and lumbar (ESL) were measured at 2000Hz using surface EMG (Delsys).

Kinematics and kinetics from ankle, knee, hip and trunk were obtained at sampling rates of 200Hz and 1000Hz, respectively, using a 14-camera motion analysis system (QUALISYS) and two triaxial force platforms (AMTI). A full-body marker model was utilized (Schmid, Connolly, Moschini, Meier, & Senteler, 2022).

### 2.4 Statistical analysis

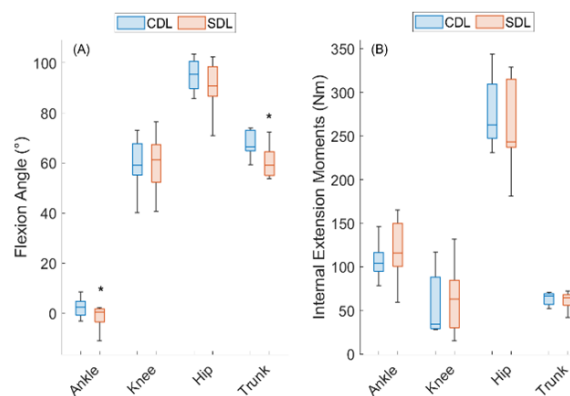
The maximum flexion angles and internal extension moments were calculated for each joint and trial. The variables were then averaged across the three repetitions according to the adopted technique. Root mean square (RMS) were calculated for each muscle group during the ascending phase to compare intra-subject muscle activity. Wilcoxon Signed-Rank test were used to compare kinematics, joint moments and EMG between CDL and SDL. All analyses were conducted using MATLAB (R2023b). The significance level was set at 0.05 for all statistical tests.

## 3. Results and discussion

During the ascending phase, the trunk was more inclined during the CDL execution ( $p < 0.05$ ), and the ankles exhibited greater dorsiflexion ( $p < 0.05$ ), while the maximum flexion of the knee and hips was not significantly different (Figure 1 A).

These kinematic differences did not reveal differences in joint moments. In fact, all joint moments remained

consistent across techniques (Figure 1 B). Furthermore, there were no differences in maximum knee flexion angles and moments. However, the median value of the knee moment is nearly twice larger in the SDL condition (Med = 34.22Nm, IQR = 46.20Nm; Med = 63.00Nm, IQR = 46.69Nm), yet no significant difference was found ( $p=0.21$ ). Similar to Escamilla et al. (2000), the difference in the VL muscle activity between the two techniques was significant, with greater activation during SDL (Table 1,  $p<0.05$ ). Contrary to the findings of Salehi et al. (2021), which found that the EMG activity of the ES muscles in CDL was significantly higher than in the SDL, our results, revealed no significant difference in the activity of the ES, GM, BF, AD, GA, and AT muscles.



**Figure 1.** Comparison of kinematics (A) and kinetics (B) between CDL and SDL. (\*  $p<0.05$ )

**Table 1.** EMG RMS (mV) activations in CDL and SDL.

	CDL		SDL		p
	Med	IQR	Med	IQR	
AT	0,108	0,090	0,134	0,046	0.813
GA	0.127	0.080	0.112	0.090	0.813
VL	<b>0.177</b>	<b>0.125</b>	<b>0.204*</b>	<b>0.116</b>	<b>0.016</b>
BF	0.181	0.104	0.175	0.114	0.938
GM	0.105	0.053	0.097	0.053	0.375
AD	0.074	0.022	0.064	0.024	0.813
ESL	0.207	0.074	0.215	0.074	0.688
EST	0.127	0.083	0.119	0.072	0.938

\*  $p<0.05$ ; Anterior Tibialis (AT), Gastrocnemius (GA), Vastus Lateralis (VL), Biceps Femoris (BF), Gluteus Maximus (GM), Adductor (AD), Erector Spinae Lumbar (ESL) and Thoracic (EST)

#### 4. Conclusions

The activity of only the vastus lateralis, ankle and trunk angles were influenced by technique, while joint moments remained similar throughout the entire ascending phase. It would be interesting to decompose the ascending phase and conduct a temporal analysis. This could enhance the understanding of the movement and the inherent differences between

techniques. To target larger quadriceps activation during training, SDL should be preferred to CDL.

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#### Conflict of Interest Statement

The authors have no conflicts of interest relevant to this study.

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