Kinematics and Kinetics of Sumo versus Conventional Deadlift

by

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Submitted in partial fulfillment of the requirements for graduation as an Honors Scholar at Point Loma Nazarene University, San Diego, California on April 14, 2023.

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Date 4/14/2023

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Abstract

The two most common variations of the barbell deadlift are the conventional deadlift (CDL) and the sumo deadlift (SDL). Key differences between the SDL and CDL lie within the starting position, more specifically the grip placement, stance width, and foot angle of the starting position. The CDL involves starting with stance width and foot angles that are narrower than the SDL, and hands positioned on the bar just outside the knees. The SDL has a wider stance width and foot angle, with hands positioned on the inside of the knees. The additional factors that contribute to the variation in performance of the two lifts cannot be seen without the use of advanced technological tools. The purpose of this study is to analyze and compare the differences in kinematic and kinetic variables between the two deadlift styles. The study was conducted using twelve powerlifters with at least five years of experience in both deadlift types and no history of trunk or lower-extremity related pathologies. All willing participants were required to perform both lifts using the proper technique at their measured 6-RM intensity. Materials used for the data collection in this study include a standard 20.5 kg Olympic barbell, Olympic discs, a Vicon 3D motion capturing system, AMTI force platform (Model OR6-6-2000, Advanced Mechanical Technologies, Inc, MA, USA), and reflective markers. The results produced for the CDL indicate an increased lumbosacral, hip, and ankle moment as well as increased knee flexion at lift-off and trunk flexion at lift-off and knee passing. The SDL results indicate a decreased ankle dorsiflexion and increased foot orientation angle and stance width. The results of this study suggest that the CDL has increased joint moments and increased range of motion in comparison to the SDL.

Keywords: deadlift, conventional, sumo, joint moment, kinematics, kinetics, biomechanics

Introduction

The barbell deadlift is one of the three powerlifting competition exercises that is frequently used within athletic training and rehabilitation programs. Its primary use is to strengthen muscles found in the posterior aspect of the trunk and lower extremities. The two barbell deadlift variations that are most commonly used in powerlifting competitions are the conventional deadlift (CDL) and the sumo deadlift (SDL). The greatest known variation between these two lifts occurs within the placement of their starting positions. The CDL, which is slightly more common, is set up by having the lifter stand with their feet shoulder width apart, hips and knees slightly bent, hands gripping the bar just outside of the knees, arms straight, and shoulders directly above the bar. The SDL is quite similar, with the exception of a wider stance, greater foot angle, and a hand placement on the inside of the knees. Although they are similar, the slight differences in the set up of the two deadlift styles has been proven in previous studies to produce noticeable differences in performance and overall biomechanics of the exercise.

Summary of Literature

Biomechanical variables between the SDL and CDL have been previously analyzed within multiple studies, however many questions remain unanswered regarding the true relationships between the two lifts. Three primary focuses within existing literature for deadlifting include muscle recruitment, load-velocity profiling, and joint moment variation. This overview of the literature helps to identify specific aspects of the SDL and CDL that require further investigation as well as specific variables that have yet to be analyzed.

Load-Velocity Profiling

When examining the load-velocity relationships for the SDL and CDL, recent findings suggest that each lifter has their own unique load-velocity profile for each form of deadlift (Kasovic et al. 2019) that can be used to identify the ideal load by calculating the weight value for a specific % of their 1 repetition max (RM) (Benavides-Ubric, A., et al. 2020). Creating a known load-velocity profile for an athlete or for multiple subjects within a study is important for producing accurate results in performance and in data collection. If someone were to perform a powerlifting study without the use of load-velocity profiling, this could potentially create drastic variations in the results. The variation between the load-velocity profiles of different subjects is explained to be due to the variation of lower extremity biomechanics for all athletes (Kipp, et al. 2011). Previous research on load-velocity relationships for both SDL and CDL is important, because it explains why using load-velocity profiling, in order to calculate proper lifting intensity levels, is an important part of creating a more accurate method of data collection within powerlifting studies.

Electromyography Studies

Several studies that have used load-velocity relationships for data collection were able to detect significant variation in muscle recruitment between the SDL and the CDL, specifically in the lower extremities (Martín-Fuentes et al., 2020). Vecchio et al. (2018) reported that the SDL stimulates higher activation of the quadriceps and the anterior tibialis, while the CDL stimulates higher activation of the gastrocnemius and erector spinae, which could indicate that the SDL is an anterior dominant variation of the deadlift. The findings from the Vecchio study may also be supported by the results of a different study published in 2022, which concludes that most of the muscle recruitment variation was found to occur as a result of the different starting positions of the two deadlifts (Jo E et al., 2022). The variation in muscle recruitment between the SDL and the CDL may be the key to determining the strengths and weaknesses of each lift as well as how they can be utilized more efficiently.

Joint Moment Variation

Similar to the patterns of variation described for muscle recruitment, previous studies suggest that most joint moment variation is a result of the difference in starting position as well. A study focused on lumbar spine loads, that was published in 1991 (Cholewicki, 1991), found evidence that suggests the SDL has a reduced L4/L5 moment in comparison to the CDL. A slightly more recent deadlift study that was published in 1996 (McGuigan and Wilson, 1996) found similar findings. The common findings between these two studies provide good evidence that the SDL does have a lesser lower back moment than the CDL, however, the methods of data collection within these two studies were limited.

In another biomechanical comparison of SDL and CDL (Escamilla et al. 2000), it was suggested that both deadlift variations produce hip extensor and knee extensor moments, but only the SDL produces ankle dorsiflexor moments and only the CDL produces knee flexor and ankle plantar flexor moments. Essentially, the SDL and CDL have very different ankle and knee moments. These significant differences found between the joint moments of the SDL and CDL are important identifiers for key differences between the two lifts.

Lead-in

The evidence found in previous literature supports the idea that the variation in performance of the SDL and CDL may be dependent on variables other than pure athletic capability and training history. The differences in load-velocity relationships for the two deadlifting styles help to avoid guesswork during the data collection process and more accurately analyze the results of each deadlift style. It is important to take into account how each athlete has their own unique 1RM and load-velocity profile because it can help to improve the process of collecting, calculating, and analyzing data.

The variance in muscle recruiting is an important distinction to make between deadlift styles because it can greatly affect an athlete's training goals. Although many of the studies tend to have similar results as to which muscles are activated between the SDL and CDL, there is no consensus among the data to define a reliable relationship that could help predict the muscles targeted during a specific type of deadlift. Additionally, the use of untrained athletes in previous studies poses a risk for variance due to improper form that could create different combinations of muscle recruitment. Overall, the previous literature on muscle recruitment variation is useful for predicting relationships between the SDL and the CDL since it is a weak predictor of muscle activation variation.

Gaps in previous studies

Although there is sufficient evidence within pre-existing literature for predicting possible relationships between the CDL and SDL, there are still many gaps within the literature that provide opportunities to continue to expand the current understanding of the relationship between the CDL and the SDL. Limitations found in the literature include studies regarding the key differences between the SDL and CDL are limited to 2D (Cholewicki 1991) or a manually-digitized version of 3D motion capture (Escamilla, 2000, Escamilla, 2001, Escamilla, 2002, and Kasovic, 2019). Additionally, there are no known studies that directly compare the SDL and CDL with the use of ground reaction forces, because most of the previous studies used biomechanical models to estimate values such as joint moments.

Purpose and Hypothesis

Due to the limitations of these previous studies, further research is necessary to fill in the gaps in the literature concerning the biomechanical differences between the SDL and CDL. Although further research concerning muscle recruitment differences in the two deadlifts would be beneficial, this study will not be focusing on the collection and analysis of EMG data. The purpose of this study is to compare the sagittal plane trunk and lower body kinematics and kinetics between sumo and conventional deadlifts in competitive powerlifters. It was hypothesized that the SDL will exhibit different joint angles and moments at the ankle and lumbosacral joints compared to the CDL.

Methods

Participants

The kinetic and kinematic variables were recorded for the two DL styles using twelve experienced powerlifters; eleven male and one female. It is important to note that none of the participants had any prior history of lower extremity or trunk pathologies. The participants used in the study had an average mass of 89.9±9.3 kg, height of 181.0±4.7cm, and age of 26.0±7.8y. In order to participate, each subject was required to have at least 5 years of experience and proper technique at 6RM intensity for both deadlift styles. Each of the twelve participants provided written informed consent that was in agreement with the Institutional Review Board at Baptist Hospital in Gulf Breeze, Florida.

Pretest

One week prior to the data collection, the participants were given a pretest session that allowed each to practice both DL styles and review the experimental protocol. During this time, the weight for each subject's 6RM intensity was measured to be used during the actual data collection. The average (±SD) total mass used for the data collection of the sumo deadlift was 141.7±26.7 kg and 148.3±31.7 for the conventional deadlift. A standard Olympic barbell (20.5kg) and Olympic discs were used for the pretest performance and the data collection.

Materials

The kinetic and kinematic variables recorded in this study were collected with the use of the Vicon 3D motion capturing system (Vicon Corporation, Santa Rosa, CA), 10 video cameras, an AMTI force platform (Model OR6-6-2000, Advanced Mechanical Technologies, Inc, MA, USA), and 8 clusters of spherical reflective markers (19 mm in diameter) that are placed on the following areas of each subject: posterior trunk, posterior pelvis, lateral thigh, lateral shank, and lateral foot (see Figure 1). The reflectors that are placed on each subject project images that are captured by the 10 electronically synchronized high-speed charged couple device video cameras that are placed in specific parts of the room in order to capture every angle of the subject. The video data was captured by the cameras at 1200 Hz and directly transmitted into the Vicon motion capture software. The ground reaction forces and torques were recorded simultaneously with the video captures by using the AMTI force platform at 1200 Hz. A lifting belt was not used for any of the trials due to interference with the placement of the markers.

Data collection

On the day of the data collection, prior to recording, each subject performed 3-4 warmup sets for the SDL and CDL until they were near enough to the weight for their 6RM intensity. After warming up, each subject was recorded while performing 3 repetitions of both the SDL and CDL using the appropriate weight for a 6RM intensity. Each subject was instructed to pause for 1-2 seconds between each trial in order to clearly separate them. The order of the SDL and CDL were randomly assigned and recorded separately. Each subject was given an adequate amount of rest (3-4 minutes) between recordings to ensure complete recovery. Due to the low lifting intensity and low number of repetitions compared to the regular amount of training and level of fitness for all participants, it can be assumed that the amount of fatigue is negligible. Additionally, all participants recognized that there were no adverse effects on their performance for each exercise that was caused by fatigue.

At the end of each recording, the participants were asked to remain in their current position so that end stance measurements could be recorded by a tester. These measurements include their foot angle (with the midline of the foot defined as 0∞ and pointing in the direction the subject is facing), stance width (between the inside of the heels), and hand width (between the inside of the hands). The average measurements for the sample of participants during the SDL were a foot angle of 27.0±7.9°, a stance width of 65.4±12.8 cm, and a hand width of 26.2±6.9 cm. Meanwhile, the average measurements for this sample during the CDL were a foot angle of 8.1±3.9°, a stance width of 33.9±5.7 cm, and a hand width of 46.8±7.3 cm.

The video captures for all of the markers were instantly digitized in 3D space using a direct linear transformation method. The accuracy of the calibration system was tested and found less than a 1.0mm error when locating the reflective markers within the 3D space. A double-pass fourth-order Butterworth low-pass filter, with a cut-off frequency of 6 Hz, was used to smooth out the raw position data. The marker position data was then used to estimate locations of the lumbosacral (L5S1), hip, knee, and ankle joints as well as the poses of the trunk, pelvis, thighs, shanks, and feet using a 6-DOF inverse kinematics model. Sagittal hip and knee joint angles were calculated throughout each lift with joint angle extension defined as an angle of 0°. Likewise, ankle plantar-dorsiflexion and foot orientation with respect to the pelvis anterior-posterior axis were also calculated. Furthermore, kinetics (forces and torques) were estimated at the L5S1, hip, knee, and ankle joints using an iterative inverse dynamics model. All biomechanical model variables were calculated using Visual3D (C-Motion, Boyds, MD).

Data Analysis

All discrete biomechanical variables were compared between SDL and CDL conditions using paired t-tests at an *a priori* significance level of 0.05. In addition, the time-series signals of these variables were compared between conditions across the normalized time of the lift (LO to LC) using statistical parametric mapping (SPM) based on the paired t-test parametric statistical design. SPM uses random field theory to determine the critical threshold above which random data would produce the t-statistic (SPM{t}) in 5% of observed regions of continuous data (Pataky et al. 2013). All statistical analyses were performed in R Studio and Python.

Table 1: Participant Characteristics

Subject	**Gender**	**Age (years)**	**Weight (kg)**	**Height (cm)**
S01	Male	24	87.1	180.3
S02	Male	23	84.5	182.9
S03	Male	23	85.0	179.7
S04	Male	48	91.4	177.8
S05	Male	23	75.9	177.2

S06	Male	24	80.9	189.9
S07	Male	30	92.0	177.8
S08	Male	23	84.7	172.7
S09	Male	23	106.5	184.8
S10	Male	26	100.5	182.9
S11	Male	19	99.9	184.8
S12	Female	22	78.6	174.0

Figure 1. Marker placement a) front view; b) back view; c) side view

a b c

Figure 2. Conventional style deadlift. a) start position; b) end position

a

b

Figure 3: Sumo style deadlift. a) start position; b) end position

a

b

Results

In Table 1, twelve discrete variables for CDL and SDL are compared at three different points during the lift. The statistically significant discrete variables that produced greater SDL values include degrees of dorsiflexion at knee passing (-13.5±7.0°) and lift completion (-15.3±7.6°), and meters of stance width (0.9±0.1 m). The produced conventional deadlift values of those same variables were found to be (-6.0±5.1°, p <0.001), (-5.0±3.9°, p <0.001) and (0.4±0.1 m, p <0.001) respectively. The significant discrete variables with greater CDL values include trunk flexion at lift-off (77.2±10.9°) and knee passing (67.9±5.3°), knee flexion at lift-off (72.7±12.9°), and dorsiflexion at lift-off (10.8±6.7°), while the opposing sumo deadlift values are (69.7±14.0°, p = 0.002), (54.4±7.3°, p <0.001), (63.1±14.4°, p =0.02), and (-1.8±8.1°, p <0.001) respectively. The sumo deadlift maintained a greater angle of foot orientation at all three measurements: lift-off (-0.8±69.8°), knee passing (-1.1±69.8°), and lift completion (-1.7±69.8°) with the corresponding conventional deadlift foot orientation angles being (16.8±70.7°, p <0.001), (16.6±70.9°, p <0.001), and (15.7±71.0°, p <0.001). The three kinetic variables among the discrete variables that proved to be statistically significant are the average hip moment at knee passing, with a (-267.2±64.7 Nm) for CDL and (-213.5±88.4 Nm, p = 0.003) for SDL, the L5S1 moment at knee passing, with a (-41.9±-35.6 Nm) for CDL and (-35.6±46.0 Nm, p = 0.009) for SDL, and the average ankle moment at lift-off with (-107.6±26.9 Nm) for CDL and (-81.0±47.2 Nm, p = 0.039) for SDL. No measurable difference in average bar velocity between CDL and SDL was observed.

Figures 4-12 represent the continuous variables displayed via statistical parameter mapping. The continuous variable dorsi-plantar flexion (figure 8) has a difference between CDL and SDL that is uniquely statistically significant. All other SPMs show results that were not statistically significant (bar velocity, trunk flexion, hip flexion, knee flexion, L5S1 moment, hip moment, knee moment, and ankle moment).

Table 2: Kinematic and kinetic variables extracted at time points: Lift-Off (LO), Knee Passing (KP), Lift-Completion (LC)

Variable	**Conventional**	**Sumo**	**Difference (95% CI)**	***p***
Mean Bar Velocity (m/s), Mean (SD)	0.4 (0.1)	0.4 (0.1)	0.01 (-0.03 to 0.06)	0.57
Max Bar Velocity (m/s), Mean (SD)	0.7 (0.1)	0.7 (0.1)	0.04 (-0.03 to 0.10)	0.22
Trunk Flexion (°) @ LO, Mean (SD)	77.2 (10.9)	69.7 (14.0)	7.5 (3.4 to 12)	0.002
Trunk Flexion (°) @ KP, Mean (SD)	67.9 (5.3)	54.4 (7.3)	14 (9.2 to 18)	<0.001
Trunk Flexion (°) @ LC, Mean (SD)	-14.4 (13.5)	-4.9 (17.7)	-9.4 (-23 to 4.0)	0.15
Hip Flexion (°) @ LO, Mean (SD)	82.8 (13.6)	82.1 (16.0)	0.71 (-3.2 to 4.6)	0.7
Hip Flexion (°) @ KP, Mean (SD)	50.2 (14.3)	47.5 (18.0)	2.6 (-2.5 to 7.7)	0.28
Hip Flexion (°) @ LC, Mean (SD)	9.1 (5.4)	12.9 (9.0)	-3.8 (-8.9 to 1.3)	0.13
Knee Flexion (°) @ LO, Mean (SD)	72.7 (12.9)	63.1 (14.4)	9.6 (1.8 to 17)	0.02
Knee Flexion (°) @ KP, Mean (SD)	28.4 (6.8)	30.1 (10.3)	-1.6 (-6.7 to 3.5)	0.5
Knee Flexion (°) @ LC, Mean (SD)	11.8 (8.5)	15.3 (12.0)	-3.5 (-9.5 to 2.6)	0.23
Dorsi-Flexion (°) @ LO, Mean (SD)	10.8 (6.7)	-1.8 (8.1)	13 (8.1 to 17)	<0.001
Dorsi-Flexion (°) @ KP, Mean (SD)	-6.0 (5.1)	-13.5 (7.0)	7.5 (4.2 to 11)	<0.001
Dorsi-Flexion (°) @ LC, Mean (SD)	-5.0 (3.9)	-15.3 (7.6)	10 (6.1 to 14)	<0.001
Foot Orientation (°) @ LO, Mean (SD)	16.8 (70.7)	-0.8 (69.8)	18 (12 to 23)	<0.001
Foot Orientation (°) @ KP, Mean (SD)	16.6 (70.9)	-1.1 (69.8)	18 (12 to 23)	<0.001
Foot Orientation (°) @ LC, Mean (SD)	15.7 (71.0)	-1.7 (69.8)	17 (12 to 23)	<0.001
Stance Width (m) @ LC, Mean (SD)	0.4 (0.1)	0.9 (0.1)	-0.49 (-0.54 to -0.44)	<0.001
L5S1 Force (N) @ LO, Mean (SD)	328.1 (20.3)	314.8 (13.2)	13 (-3.8 to 30)	0.11
L5S1 Force (N) @ KP, Mean (SD)	301.0 (13.9)	304.5 (20.4)	-3.5 (-15 to 8.2)	0.53
L5S1 Force (N) @ LC, Mean (SD)	309.6 (16.2)	308.1 (24.2)	1.5 (-19 to 22)	0.87
L5S1 Moment (N) @ LO, Mean (SD)	-42.8 (57.3)	-39.6 (51.3)	-3.2 (-8.9 to 2.4)	0.24
L5S1 Moment (N) @ KP, Mean (SD)	-41.9 (49.7)	-35.6 (46.0)	-6.3 (-11 to -1.9)	0.009
L5S1 Moment (N) @ LC, Mean (SD)	19.2 (30.6)	9.4 (34.6)	9.8 (-8.3 to 28)	0.26

Hip Moment (N) @ LO, Mean (SD)	-301.6 (75.7)	-258.8 (114.9)	-43 (-94 to 8.1)	0.091
Hip Moment (N) @ KP, Mean (SD)	-267.2 (64.7)	-213.5 (88.4)	-54 (-85 to -23)	0.003
Hip Moment (N) @ LC, Mean (SD)	-86.3 (43.0)	-97.4 (59.4)	11 (-20 to 43)	0.46
Knee Moment (N) @ LO, Mean (SD)	-57.8 (30.5)	-53.3 (47.2)	-4.6 (-39 to 30)	0.78
Knee Moment (N) @ KP, Mean (SD)	49.9 (30.8)	28.0 (57.6)	22 (-1.9 to 46)	0.068
Knee Moment (N) @ LC, Mean (SD)	10.7 (24.0)	8.4 (46.8)	2.4 (-26 to 30)	0.86
Ankle Moment (N) @ LO, Mean (SD)	-107.6 (26.9)	-81.0 (47.2)	-27 (-52 to -1.6)	0.039
Ankle Moment (N) @ KP, Mean (SD)	-66.3 (42.1)	-66.3 (45.9)	0.00 (-26 to 26)	>0.99
Ankle Moment (N) @ LC, Mean (SD)	-48.4 (26.1)	-39.4 (35.8)	-9.1 (-28 to 10)	0.32

N = 12; LO = Lift-Off; KP = Knee Passing; LC = Lift Completion

Figure 4: Average bar velocity (left)throughout SDL and CDL and statistical difference (right).

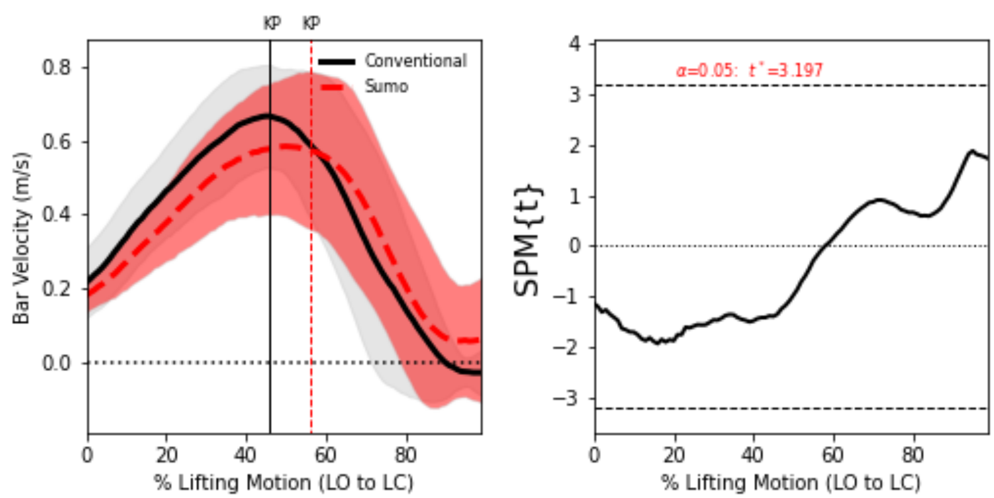


Figure 5: Average trunk flexion-extension (left) throughout SDL and CDL and statistical difference (right).

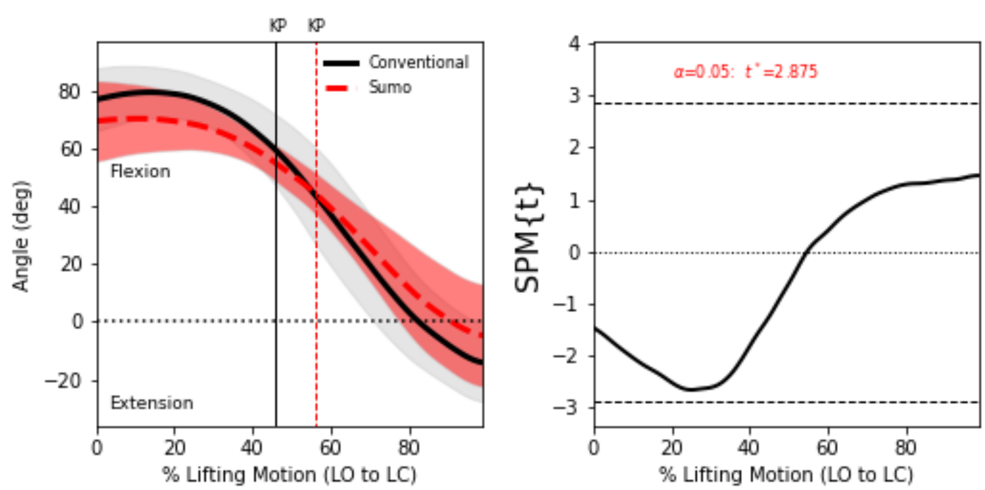


Figure 6: Average hip flexion-extension (left) throughout SDL and CDL and statistical difference (right).

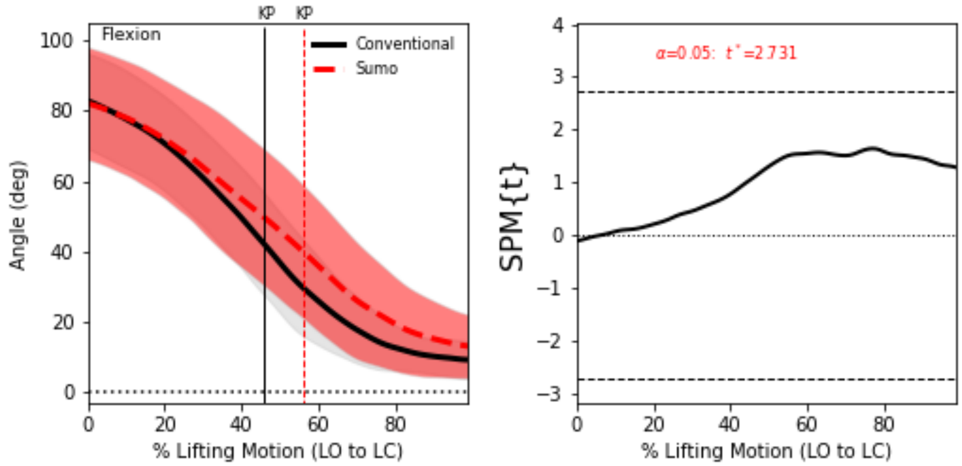


Figure 7: Average knee flexion-extension (left) throughout SDL and CDL and statistical difference (right).

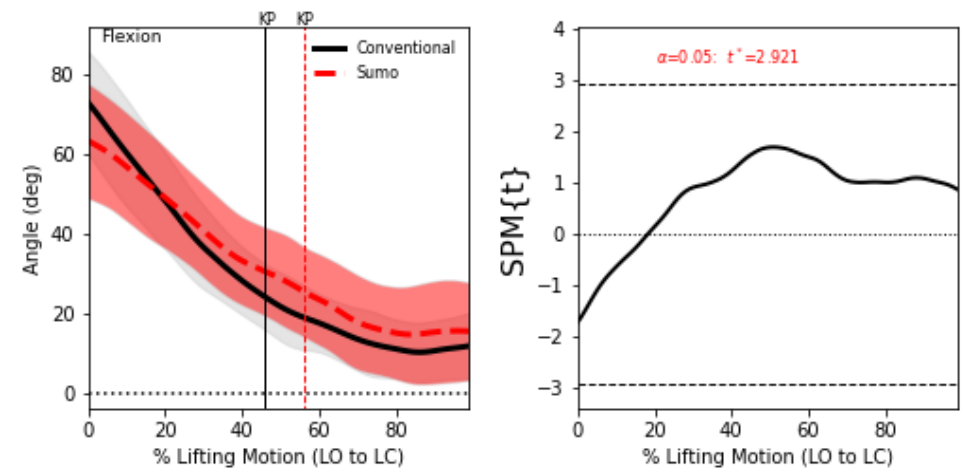


Figure 8: Average dorsi-plantar flexion (left) throughout SDL and CDL and statistical difference (right).

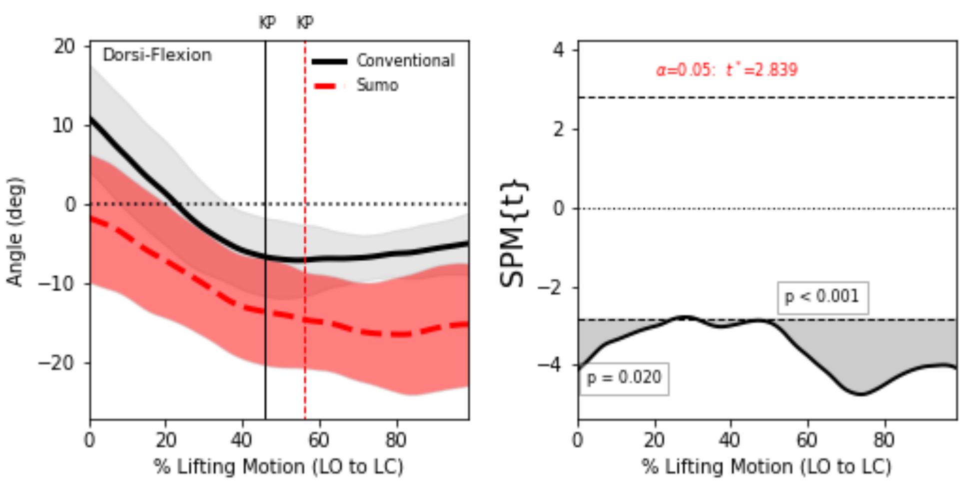


Figure 9: Average L5S1 Moment (left) throughout SDL and CDL and statistical difference (right).

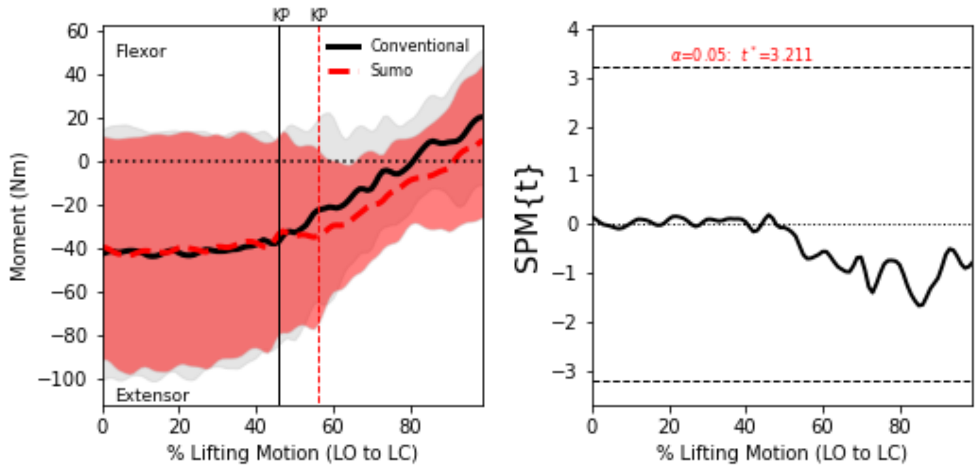


Figure 10: Average hip moment (left) throughout SDL and CDL and statistical difference (right).

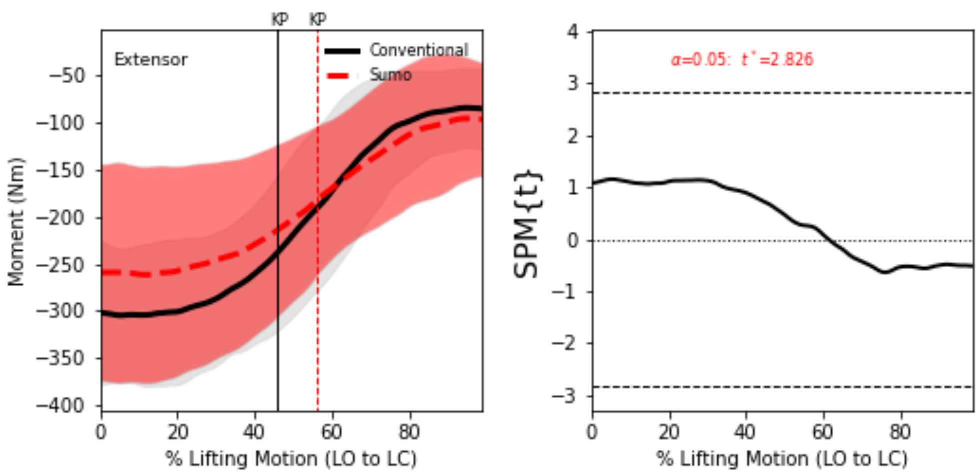


Figure 11: Average knee moment (left) throughout SDL and CDL and statistical difference (right).

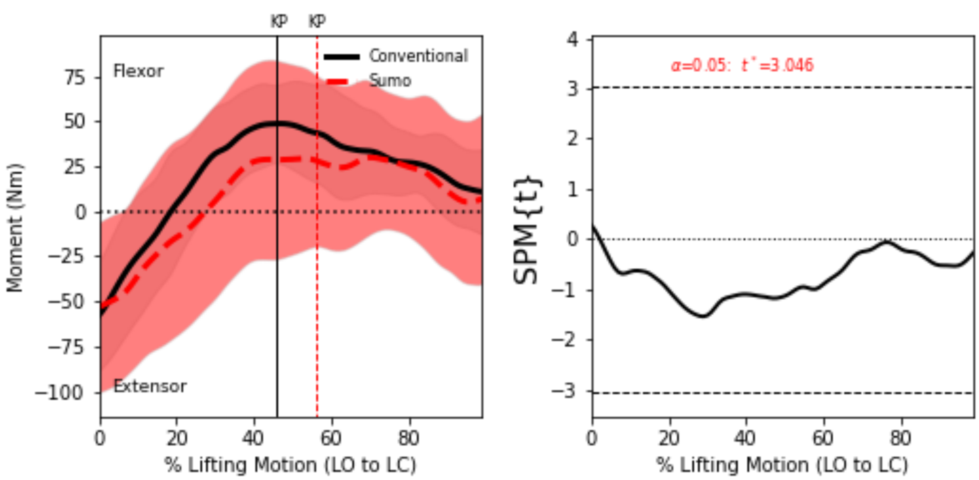
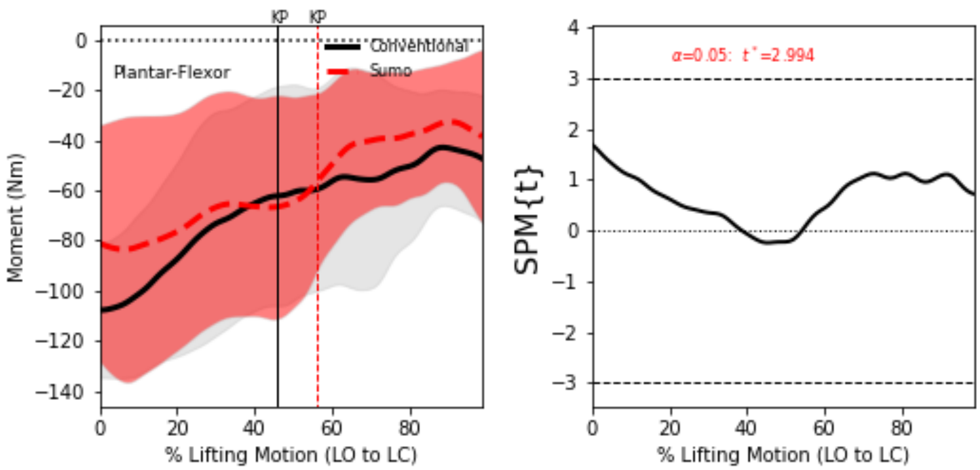


Figure 12: Average ankle moment (left) throughout SDL and CDL and statistical difference (right).



Discussion

The comparison of kinematic and kinetic variables of the SDL and CDL within this study successfully produced findings that support the previously stated hypothesis, which proposed that the SDL would have different joint angles and joint moments for the ankle and lumbosacral joints in comparison to the CDL. Based on the results of the study, there is evidence that supports not only variation in the joint angles for the ankle and lumbosacral joints but also joint angle variation found at the knee joint as well. Significant joint moment variability was also found at the lumbosacral, hip, and ankle joints.

Joint Angles

Many of the significant variables found in this study are congruent with findings in previous deadlift studies. A study by McGuigan and Wilson in 1996 found a greater average knee flexion at lift-off for the CDL in comparison to the SDL (McGuigan and Wilson, 1996). Although the actual degrees of knee flexion for both lifts vary greatly between the previous study and the current study, both indicate that the lift-off is the only point of significant difference.

In agreement with the results in the Escamilla study that was published in 2000, the CDL presented with greater trunk flexion angles at the lift-off and during knee passing (Escamilla et al., 2000). This difference in trunk angle primarily emphasizes the difference in the range of motion for the CDL vs the SDL. Additionally, the knee flexion for the CDL in the current study was found to be greater than the SDL, which is an unexpected area for the CDL to have a greater range of motion. This difference may be due to deadlift technique preferences among the participants in the current study.

One of the most significant findings from this study is the variation of dorsi-plantar flexion between the CDL and SDL. The CDL was consistently measured to have a greater dorsiflexion angle for each point of measurement for the discrete variables. In addition to the discrete measurements, the results of the time series analysis using statistical parametric mapping are in full agreement with a statistically significant difference measured for nearly the entire lift (figure 8). Although previous SDL vs CDL studies (Escamilla, 2000, Escamilla, 2001, and McGuigan, 1996) examined the variation for the shank angles rather than the dorsi-plantar flexion angle, the resulting shank angles found in these studies still support the findings of the present study assuming that the participants' feet remain on the floor throughout the entire lift. This is because the shank angle is measured from the ground and while the dorsi-plantar flexion angles are measured from the foot.

Both the foot orientation and stance width were calculated to be significantly greater for the SDL than the CDL. These findings are expected due to the natural difference in starting position and they help indicate the correct use of deadlift form within this study.

Joint Moments

The joint moments which produced significant findings in this study are the lumbosacral extension and hip flexion moments at knee passing and the ankle dorsiflexion moment at lift-off. Within these three joint moments, all produced significantly greater values for conventional CDL than the SDL. There is some agreement found between the findings of this study and previous deadlift studies. The study carried out by Escamilla in 2000 resulted in higher levels of ankle plantar-flexion moment for the entire lift, while this study only contains one point of high ankle plantar flexion moment for the CDL (Escamilla et al., 2000). The variation between these two studies may possibly be due to variation in athletic performance between the two samples used in the two studies, variation in data collection methods, or due to other unknown variations within the two deadlifts.

The study performed by Cholewicki in 1991 presented data that indicated a significantly high lumbosacral moment and a high hip flexion moment for the CDL (Cholewicki et al., 1991). The agreement between the Cholewicki study and the present study suggests that the CDL may be more hip-flexion dominant than the SDL.

Clinical and Athletic Applications

The significant findings produced in this study, with the support of findings from previous studies, suggest that the CDL is more hip dominant than the SDL. This is due to the increased joint moments located at the lumbosacral joint and the hip joint, which are both significant points of hip movement. These findings are helpful for determining how to use each variation more effectively within athletic and clinical settings.

The increased joint moments surrounding the hips in the CDL indicate a higher amount of stress being applied to the hips during the movement. This means that the CDL is not an ideal choice for patients or athletes who are at high risk of hip injury, and therefore may benefit from using the SDL variation instead. Alternatively, the increased stress on the hips in a CDL can be useful for patients and athletes with an interest in targeting their hips.

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