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Electromyographic Examination of Hip and Knee Extension Hex Bar Exercises Varied by Starting Knee and Torso Angles

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ABSTRACT

International Journal of Exercise Science 15(1): 541-551, 2022. Variations of the deadlift can be executed using the hexagonal (hex) bar by altering, for instance, the knee and torso angles while maintaining a constant hip angle at the start position. PURPOSE: To examine muscle activation patterns of the biceps femoris, rectus femoris, and erector spinae during three deadlift variations using the hex bar. METHODS: Twenty resistance-trained male and female subjects performed hex bar deadlift variations in three different starting knee flexion positions: 128.4 ± 8.5°, 111.9 ± 8.7°, and 98.3 ± 6.5°. Subjects performed three repetitions at 75% of their three-repetition maximum. Electromyography sensors were placed on the dominant biceps femoris, rectus femoris, and lumbar erector spinae. A one-way repeated measures ANOVA was used to detect differences in mean and peak EMG values normalized to maximum voluntary isometric contraction (MVIC) ($p < 0.05$). RESULTS: As knee flexion increased at the starting position, mean activation of the rectus femoris increased (24.7 ± 21.5 → 35.5 ± 25.4 → 62.1 ± 31.3% MVIC, $p < 0.001$), while biceps femoris (40.6 ± 17.9 → 34.0 ± 16.4 → 28.1 ± 14.5% MVIC, $p = 0.003$) and erector spinae (73.0 ± 27.6 → 65.9 ± 34.4 → 54.9 ± 32.5% MVIC, $p = 0.009$) activation decreased. Peak activation of the rectus femoris increased (46.9 ± 33.0 → 60.9 ± 38.7 → 99.3 ± 41.6% MVIC, $p < 0.001$) while decreasing in the erector spinae (118.6 ± 47.1 → 105.9 ± 49.4 → 89.1 ± 40.1% MVIC, $p = 0.008$). The rectus femoris experienced the greatest mean differences of the three muscles. CONCLUSIONS: Practitioners should consider the muscular goals when adjusting the starting position of a hex bar deadlift as posterior chain recruitment diminished and quadriceps activation increased as knee flexion increased.

KEY WORDS: Resistance exercise, electromyography, neuromuscular

INTRODUCTION

The deadlift is a commonly utilized closed-chain exercise used in strength training programs to target posterior- and anterior-chain muscle development (22). Traditionally, the deadlift has been performed using a straight Olympic barbell, but more recently the hexagonal (hex) barbell has received more usage in strength and conditioning programs. While utilizing the hex bar, the lifter stands inside the hex shaped opening and the hand grip shifts to the lateral side of the body rather than being positioned in front of the body (17). By shifting the bar grips towards the lateral side of the body, the mechanics of the lifter may change. This shift in weight has been shown to allow for heavier loads to be lifted, lifts to be completed faster, accelerated for longer, produce larger forces, more mechanical work, and greater power development than the conventional bar deadlift (14). Part of the reasoning behind these changes is the altered body position when utilizing the hex bar. It has been suggested that the hex bar allows for a lower hip position than a conventional deadlift, which increases the amount of quadriceps activation (6, 16) and places the exercise somewhere between a deadlift and a squat in terms of mechanics. In other words, the hex bar allows the user to distribute the load closer to the body, i.e., hands directly below hips vs. hands in front of tibia like during the traditional DL.

As with any lift, it is possible to alter the starting position of the lift, which will in turn alter the mechanical output of the lifter. In comparison of the sumo deadlift to a traditional deadlift, the sumo elicits a more upright posture (reduced spinal flexion) which has been shown to increase biceps femoris activity while decreasing lumbar torque, as evidenced by decreased erector spinae activity (10, 18). A more upright trunk angle at the start of the deadlift reduced erector spinae activity while a more flexed knee increased quadriceps activity (21). The Romanian deadlift (RDL) position has been shown to elicit more lower back dependency and inefficient use of both the hamstring and glutes (8). This further illustrates that starting position of the exercise can change muscle recruitment and output patterns for the lifter. It has been suggested that no differences exist in joint angles with respect to hexagonal and conventional barbells in the ankle, knee, and hip (17), however the exact same starting knee position (135°) was utilized for both lifts.

To date, two studies have performed an electromyographical (EMG) analysis of the deadlift exercise using a hexagonal (hex) barbell in comparison to the standard straight Olympic style barbell (1, 6). Although data indicated a differential EMG pattern, particularly in the quadriceps, hamstrings, and lower back muscles, between the two apparatuses/variations, it cannot be ascertained whether these effects were influenced by technique, such as altered starting phase angles in related joints. This presents a limitation to these prior studies as it can be argued that altered EMG profiles during the deadlift could be explained by differences in starting phase joint angles, especially in the knee, and torso inclination, as opposed to the barbell type selected. The hex bar affords the capacity to manipulate the starting knee angle across a wider range of flexion while maintaining a constant hip angle in comparison to the straight bar. This would also allow for a greater range of torso angles relative to the ground such that with greater knee flexion at the starting phase, one would have a more upright/less parallel torso position and vice versa. Thus, multiple variations of the deadlift/hip hinge exercise can be executed using the hex bar with each variation differentiated, for instance, by starting knee and torso angles while maintaining a constant hip angle. These variations would plausibly accompany alterations to the overall EMG profile; however, no data exists to objectively substantiate these effects.

The purpose of this study was to examine and compare the EMG patterns of the biceps femoris, rectus femoris, and erector spinae during three deadlift/hip and knee extension exercise variations using the hexagonal/hex barbell. The primary objective was to determine, in collegeage, male and female, recreationally resistance-trained subjects, the degree by which starting knee and torso angle variations during hex bar hip+knee extension exercise alters the mean and peak activation of the biceps femoris, rectus femoris, and lumbar erector spinae while maintaining constant hip angle at starting position. We hypothesized that when hip angle remains constant, a hip extension hex bar exercise with greater knee flexion and more upright torso angle at the starting position would increase activation of the knee extensor (rectus femoris) and decrease activation of hip and back extensors (biceps femoris and erector spinae) compared to exercises with less knee flexion and more parallel torso angle at the starting position.

METHODS

Participants

Based on the assumption that a significant effect for normalized EMG amplitude is associated with $\rho = 0.85$, with 20 subjects, we would have 80% power to demonstrate a significant ($p < 0.05$) effect. Healthy college-aged, male ($n = 10$, age = 20.8 ± 1.5 y, bodyweight = 172.8 ± 19.9 kg, height = 173.2 ± 5.3 cm) and female ($n = 10$, age = 21.7 ± 1.8 y, bodyweight = 69.5 ± 16.8, height = 152.9 ± 37.0 cm), resistance trained subjects were recruited for this study ($N = 20$). Prior to participation, each subject completed a pre-participation exercise and health history questionnaire and signed a document of informed consent. Subjects met the following inclusion criteria: 1) age = 18 to 32 years and 2) resistance trained which was defined herein as a resistance training history of 3 days per week for the past 6 months and has performed the deadlift exercise at least 1 day per week for the past 6 months. Subjects were excluded from participation if they reported a medical or surgical history that would contraindicate the experimental protocol and/or confound the interpretation of results. These included, but were not limited to: 1) cardiovascular, pulmonary, metabolic, or renal diseases, 2) hypertension, 3) smoking, 4) use of any medication, including those with cardiovascular, pulmonary, hyperlipidemic, hypoglycemic, or hypertensive effects, and 5) musculoskeletal or orthopedic conditions. The Institutional Review Board at California State Polytechnic University, Pomona approved the protocol. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (19).

Protocol

A randomized, counterbalanced, crossover design was implemented for this study. Surface EMG of the biceps femoris, rectus femoris, and lumbar erector spinae was examined across three deadlift/hip + knee extension exercises performed on the hex bar each differentiated by starting phase knee, torso, and ankle angle with a constant hip angle (~60-70 degrees of flexion depending on subject's arm length): Variation A was similar in the general characteristics of an elevated Romanian Deadlift which involved a knee angle of 145-150 degrees at the starting position; Variation B was generally characteristic of a conventional elevated straight bar deadlift which involved a knee angle of 105-115 degrees at the starting position; and Variation C was representative of a conventional/typical hex bar deadlift which involved a knee angle 95-100 degrees at the starting position (Figure 1). Procedures for each variation and confirming that each variation had distinct starting knee, torso, and ankle angles are detailed below. Subjects were required to visit the laboratory on 2 separate occasions. During Visit 1, subjects first signed an informed consent and completed an exercise and health history questionnaire. Afterwards, subjects underwent anthropometric measures which included body height, weight in addition to femur, torso, and arm lengths followed by body composition assessment via multi-frequency bioelectrical impedance. Next, subjects performed a three-repetition maximum (3RM) assessment for the conventional hex bar deadlift. For Visit 2, wireless EMG sensors were placed on the subject's biceps femoris, rectus femoris, and lumbar erector spinae. Subjects then performed 3 repetitions of each exercise variation using a load equal to 75% of the pre-determined 3RM. Thus, a constant absolute load was employed for all three exercise variations (10). Afterwards, EMG data was obtained during a maximum isometric voluntary contraction for each muscle to obtain values for normalization of EMG data acquired during the trials. Data from all repetitions were used for subsequent analysis.

Hex Bar Exercise Variations and Analysis of Starting Position: The three deadlift/hip + knee extension exercises using the hex bar were differentiated by static knee, torso (relative to the ground), and ankle angles at the starting position which was determined using a goniometer and subsequent video/still frame analysis prior to execution (used for data analysis) (Figure 1). Variation A required a knee angle of 145-150 degrees at the starting position with arms straight and slightly in front of the shins. Variation B involved a knee angle of 105-115 degrees at the starting position with arms straight and slightly in front of the shins. Variation C incorporated a knee angle 95-100 degrees at the starting position with arms in line with the ankles. The subject maintained a straight arm for each variation. Starting hip angle remained constant between 60-70 degrees of flexion (depending on subject's arm length) across all three exercise variations. Thus, with a constant starting hip angle, manipulation of starting knee angle altered the starting torso angle (relative to the ground) such that the torso became less parallel to the ground and more upright from Variation A to C. Prior to each variation trial, subjects were positioned with the aid of a makeshift device/guide that allowed the subjects to match their knee and ankle angles to the guide set to the required angles. Subjects were provided multiple practice attempts to adjust themselves into the proper starting position before performing the trial. Video of each trial from starting position to the completion of the last repetition was taken with a video camera connected to video analysis software (Noraxon, USA, Inc., Scottsdale, AZ, USA). Knee, hip, torso, and ankle angles were measured on a still frame of the starting position immediately prior to first ascent (confirmed by a change in joint angles and EMG amplitude) using the analysis software program. The camera was kept in a fixed position relative to the subject for each recording. A single investigator conducted all analysis of joint angles with good intra-rater reliability (intraclass correlation = 0.92). Each repetition was performed using a 1- and 2- second concentric and eccentric tempo, respectively. A constant absolute load was administered across all three exercise variations which equated to 75% of the subject's 3RM for the conventional hex bar deadlift. A 1-second pause was required between each repetition, and a 2-minute rest was given between each exercise variation. The order in which the three variations/conditions were implemented was randomized and counterbalanced. Each trial was supervised by a Certified Strength and Conditioning Specialist who provided verbal cues and feedback to the participants.

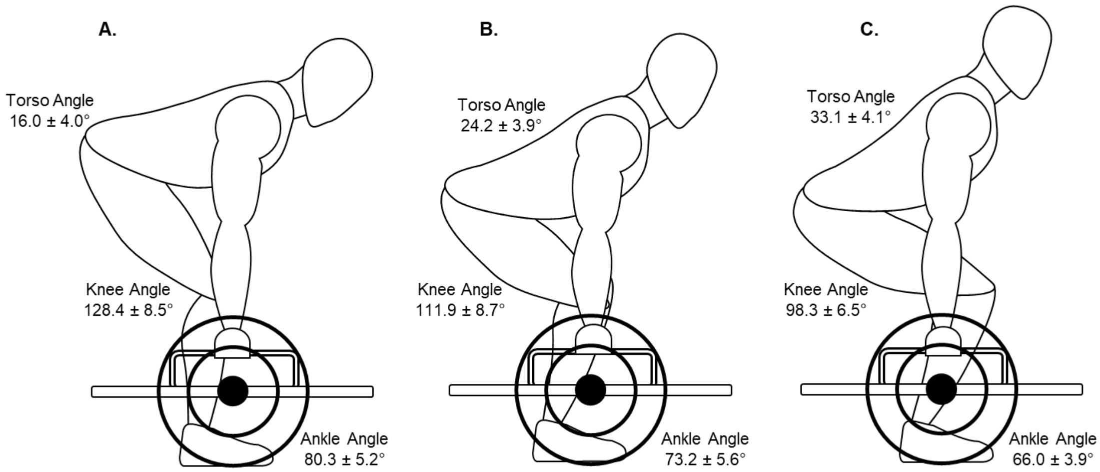

Figure 1. Variations A, B, and C and Mean Starting Torso, Knee, and Ankle Angles. Figures are intended as a general depiction of experimental hex bar exercise variations. Starting hip angle remained constant between 60-70 degrees of flexion (depending on subject's arm length) across all three exercise variations. Data presented as mean ± SD.

Surface Electromyography: The wireless Noraxon DTS EMG system (Noraxon USA Inc., Scottsdale, AZ, USA) was used to measure surface EMG activity during the three exercise variations. The Noraxon data acquisition and analysis software (myoResearch 3.10) was used to analyze EMG data. Bipolar adhesive surface electrodes (Noraxon Dual Electrodes, Ag-AGCL, spacing 2.0cm, Noraxon USA Inc., Scottsdale, AZ) were placed on the mid-belly of the following muscles on the dominant limb side: 1) biceps femoris, 2) rectus femoris, and 3) lumbar erector spinae (L3 paraspinalis) according to recommendations of SENIAM (11). The dominant limb was determined and self-reported to be the leg that participants kick a ball with. The test site was first shaven and then cleansed, abraded, and dried prior to electrode placement. Maximum voluntary isometric contraction (MVIC) for each muscle was determined using previously established manual tests (7). For the biceps femoris, the participants in a prone position performed maximum knee flexion at approximately 45 degrees of knee flexion against manual resistance applied to the distal leg just above the ankle (5). Two rectus femoris MVIC positions were used (7). The first had the subject sit and produce maximum knee extension against manual resistance applied to the distal leg just above the ankle at 90° hip and knee flexion while the second used a 90° hip flexion and 180° knee position. Peak EMG amplitude from either biceps femoris MVIC was used for normalization. For the erector spinae, a modified Sorensen MVIC test was implemented in which subjects were in a horizontal, prone position on a therapy table with feet and legs secured in position and upper trunk hanging off the edge of the table (4). Subjects performed a maximal extension against manual resistance applied to the upper back. The MVIC was determined as the peak EMG amplitude over a 3-second window across 2 MVIC attempts and subsequently used to normalize EMG data collected during the exercise variation trials. All EMG signals were acquired at 1000Hz with a bandwidth setting of 10 to 500Hz (fourth-order Butterworth filter). All raw EMG signals were rectified, integrated, and smoothed using the root mean square (RMS) with a 50-millisecond window. A linear-envelope technique for each muscle yielded the mean amplitude. The mean peak amplitude was derived by a linear envelope of 0.25 seconds surrounding the peak mV (0.125 above and below the peak mV) for each repetition. Peak EMG was the average of the mean peak activity values of all repetitions.

Mean EMG was determined as the average of the mean RMS EMG for each repetition. All EMG data was normalized to MVIC.

Body Composition: Body composition was analyzed for descriptive measures utilizing multi-frequency bioelectrical impedance via the InBody 770 system (Biospace Co. Ltd., South Korea). Before the measurement, subjects' palms and feet were cleansed of any residual electrolytes from bodily fluids. Subjects then stood on the InBody 770 platform with the soles of their feet in contact with the interfaced electrodes. The instrument derived the subjects' body mass, and their age, sex, and height were manually inputted. Subjects then grasped the handheld electrodes with arms fully extended and abducted about 20 degrees. Analysis was performed with the subject motionless. Prior test-retest reliability assessment indicated the following: fat mass (ICC = 0.998), fat free mass (ICC = 1.00) and body fat percentage (ICC = 0.995) (23).

Statistical Analysis

All data were assessed during the concentric phase of the lift. Mean values across the three repetitions were utilized for each subject in each of the three variations of the lift. A One-Way Repeated Measures Analysis of Variance (ANOVA) was used to detect any significant differences in normalized EMG values for each muscle among the three exercise variations. In the event of a main effect, a post hoc test with Bonferroni correction was administered for pairwise comparisons. All analyses were performed using Statistical Package for Social Sciences (SPSS) 23 (IBM, Armonk, NY, USA). Significance was set at $p < 0.05$.

RESULTS

Analyses confirmed that each variation was significantly distinct from one another in starting knee, torso, and ankle angles ($p < 0.0001$) (Figure 1, Table 1). From Variation A to C, 1) knee angle decreased (increased flexion), 2) the torso became more upright, and 3) the ankle became more dorsiflexed.

Table 1. Starting Knee, Torso, and Ankle Angles across Variations.

Variation	Knee (deg)	Torso (deg)	Ankle (deg)
A	128.4 ± 8.5	16.0 ± 4.0	80.3 ± 5.2
B	111.9 ± 8.7	24.2 ± 3.9	73.2 ± 5.6
C	98.3 ± 6.5	33.1 ± 4.1	66.0 ± 3.9

Starting knee, torso, and ankle angle was significantly different among the variations ($p < 0.0001$). Data presented as mean ± SD.

A significant main effect for exercise variation was detected for mean normalized EMG amplitude (% MVIC) for the biceps femoris ($p = 0.003$), rectus femoris ($p < 0.001$), and erector spinae ($p = 0.009$) (Table 2, Figure 2). For the biceps femoris, mean normalized EMG amplitude was significantly greater during Variation A (40.6 ± 17.9%) vs. Variation B (34.0 ± 16.4%, $p = 0.01$) and C (28.1 ± 14.5%, $p = 0.03$) while Variation A and B did not differ significantly ($p = 0.31$). For the rectus femoris, mean normalized EMG amplitude was significantly lower during Variation A (24.7 ± 21.5%) vs. Variation B (35.5 ± 25.4%, $p = 0.003$) and Variation C (62.1 ± 31.3%, $p < 0.001$), and Variations B and C differed significantly ($p < 0.001$). Mean normalized erector spinae activation was significantly greater during Variation A (73.0 ± 27.6%) compared to Variation C (54.9 ± 32.5%, $p = 0.02$) while Variation A vs. B (65.9 ± 34.4%) and B vs. C were not significantly different ($p = 0.55$ and $p = 0.18$, respectively).

A significant main effect for exercise variation was detected for peak normalized EMG amplitude for the rectus femoris ($p < 0.001$) and erector spinae ($p = 0.008$) (Table 3, Figure 3). For the rectus femoris, peak normalized EMG amplitude was significantly lower during Variation A (46.9 ± 33.0%) vs. Variation B (60.9 ± 38.7%, $p = 0.02$) and Variation C (99.3 ± 41.6%, $p < 0.001$) while Variation B and C also significantly differed ($p < 0.001$). Peak normalized erector spinae activation was significantly greater during Variation A (118.6 ± 47.1%) compared to Variation C (89.1 ± 40.1%, $p = 0.01$) while Variation A vs. B and B vs. C did not differ significantly ($p = 0.66$ and $p = 0.14$, respectively).

Table 2. Comparison of Mean Normalized EMG Amplitudes across Variations

	Variations				Mean Difference		
Muscle	A	B	C	Main Effect	A – B (95% CI)	A – C (95% CI)	B – C (95% CI)
Biceps Femoris (%)	40.6 ± 17.9	34.0 ± 16.4	28.1 ± 14.5	$p = 0.003$	6.7 ± 9.3* (1.2, 12.1)	12.5 ± 18.9* (1.4, 23.6)	5.8 ± 15.2 (-3.1,14.7)
Rectus Femoris (%)	24.7 ± 21.5	35.5 ± 25.4	62.1 ± 31.3	$p < 0.001$	-10.8 ± 12.6* (-18.2, -3.4)	-37.4 ± 19.8* (-49.0, -25.8)	-26.6 ± 13.2* (-34.3, -18.9)
Erector Spinae (%)	73.0 ± 27.6	65.9 ± 34.4	54.9 ± 32.5	$p = 0.009$	7.1 ± 22.9 (-6.4, 20.6)	18.1 ± 27.4* (2.1, 34.2)	11.1 ± 24.7 (-3.4, 25.5)

*$p < 0.05$. Data presented as mean ± standard deviation. CI = Confidence Interval

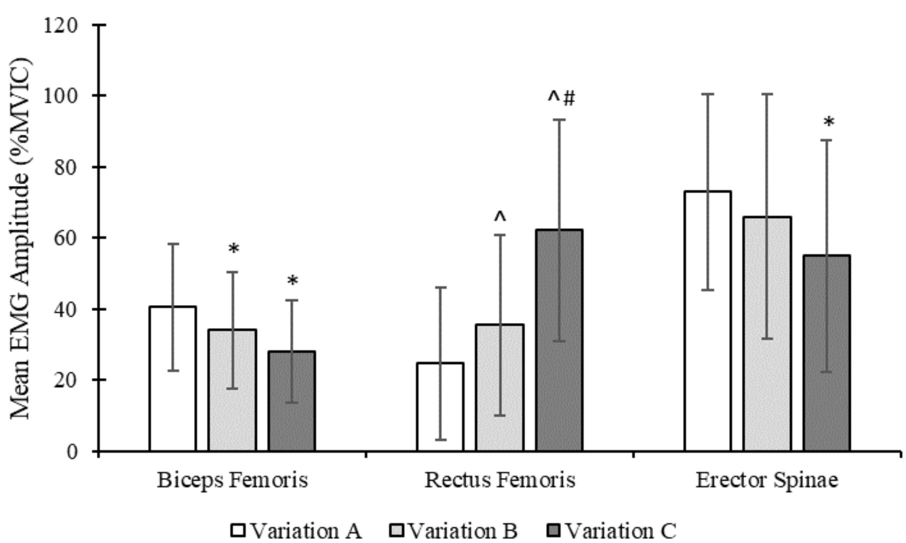

Figure 2. Comparison of Mean Normalized EMG Amplitude across Variations. Data presented as mean± standard deviation. * Different vs. Variation A ($p < 0.05$), ^ Different vs. Variation A ($p < 0.005$), # Different vs. Variation B ($p < 0.001$)

Table 3. Comparison of Peak Normalized EMG Amplitudes across Variations

Muscle	Variations A	Variations B	Variations C	Main Effect	Mean Difference A – B (95% CI)	Mean Difference A – C (95% CI)	Mean Difference B – C (95% CI)
Biceps Femoris (%)	69.5 ± 31.4	63.3 ± 26.8	57.9 ± 14.5	$p = 0.13$	6.1 ± 22.7 (-7.2, 19.5)	11.6 ± 29.8 (-5.9, 29.0)	5.5 ± 21.1 (--6.9, 17.9)
Rectus Femoris (%)	46.9 ± 33.0	60.9 ± 38.7	99.3 ± 41.6	$p < 0.001$	-13.9 ± 20.5* (-26.0, -1.9)	-52.4 ± 28.2* (-69.0, -35.9)	-38.5 ± 23.6* (-52.3, -24.6)
Erector Spinae (%)	118.6 ± 47.1	105.9 ± 49.4	89.1 ± 40.1	$p = 0.008$	12.7 ± 44.8 (-13.6, 39.0)	29.5 ± 38.9* (6.7, 52.3)	16.8 ± 35.0 (-3.7, 37.4)

* $p < 0.05$. Data presented as mean ± standard deviation. CI = Confidence Interval

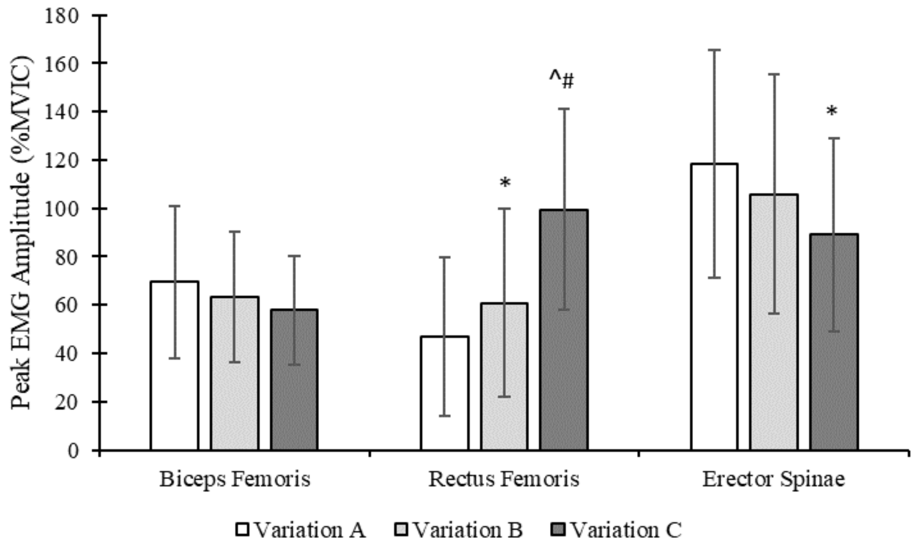

Figure 3. Comparison of Peak Normalized EMG Amplitude across Variations. Data presented as mean± standard deviation. * Different vs. Variation A ($p < 0.05$), ^ Different vs. Variation A ($p < 0.001$), # Different vs. Variation B ($p < 0.001$)

DISCUSSION

The purpose of this study was to examine the effects of different starting positions on the EMG patterns of lifters while using the hexagonal barbell. It was hypothesized that increased knee flexion and a more upright torso would elicit increased rectus femoris activation and decreased erector spinae and biceps femoris activation. Our hypotheses were partially confirmed by this study as increased rectus femoris activation (mean and peak) was evident with increased knee flexion and a more upright torso. Peak and mean erector spinae activation decreased in Variation C compared to Variation A (no differences to Variation B) while mean biceps femoris activation was decreased in Variation C compared to Variations A and B (no differences in peak activations of the biceps femoris).

Our study is one of three studies (1, 6) to examine the EMG profiles of the hexagonal barbell to our knowledge. Camera et al (6) displayed increased quadriceps activity (vastus lateralis) and decreased erector spinae and biceps femoris activity in the hex bar compared to the straight bar

(6). Andersen et al (1) displayed similar results with decreased biceps femoris activity in the hex bar, but no differences in erector spinae or gluteus maximus activity (1). Variation C (the more traditional hex bar style deadlift) showed reduced biceps femoris and erector spinae activity and increased rectus femoris activity compared to Variations A and B, which are more akin to a hex-bar version of an RDL style lift and a traditional straight bar deadlift, respectively, specifically in terms of starting positions. These results are in partial agreement with Camara et al (6) and Andersen et al (1) with respect to muscle activation patterns comparing the straight bar (similar to Variation B) and the hex bar (similar to Variation C). It should be noted that either of these studies controlled for starting position. In examining research comparing a traditional RDL exercise or a stiff-leg deadlift, erector spinae activity has been shown to be increased when utilizing a stiff-leg approach (12). This research agrees with Iversen et al (12) as increased erector spinae activity was present when comparing the stiff-leg approach (Variation A) to the more traditional hex bar approach (Variation C). In comparing an RDL style lift and a traditional deadlift, increased ankle and knee flexion angles have been shown in the traditional lift (15). These increased angles also led to increased ankle and knee torques, which in turn increased rectus femoris and gluteus maximus activity (15) and increased vastus lateralis but reduced gastrocnemius activity (3). We observed similar results when utilizing these positions on a hex bar, as the increased ankle and knee flexion (going from Variation A to B) led to increased rectus femoris (mean and peak) and biceps femoris (mean) activity. There were, however, no changes in erector spinae activity between the two styles.

This study agrees with other studies which have shown altered muscle activation patterns based on different body positions (15, 20, 21). Part of the alteration in this study is not simply the starting angular changes but also the bar position. Variation C has a hand position closest to the ankle joint while Variations A and B are slightly more anterior to the body. The location of the weight can change the angular requirements of the body during the movement. During a traditional deadlift, as the bar moves closer to the ankle, the knee flexion tends to be reduced while the torso and pelvic angles tend to increase, leading to decreased quadriceps (vastus lateralis) activity and increased biceps femoris and lumbar erector spinae activity (9). In the hex bar deadlift, this phenomenon is the opposite. As the weight moved closer to the ankle, quadriceps (rectus femoris) activity increased while biceps femoris and erector spinae decreased. With the traditional bar, the bar moving closer to the ankle prevents increased flexion of the tibia, thereby changing the available patterns for completing the lift. Due to the shape of the hex barbell, there is more flexibility in terms of starting positions of the lift. As the knee flexion angle increases (similar to Variation C), there is an increased knee joint moment (13), which can result in the need for increased muscle activation to overcome the external load.

There are a few limitations to consider within this study. First, this data only concerns the concentric phase of the lift with a controlled tempo. Many lifting programs do not control tempo so it may be tougher to generalize the results considering this factor. As starting angle was a main part of the research conducted, it was important to return the weight back to the same position between repetitions. This created large inter-subject variability in the eccentric data, and it was subsequently not examined. Lastly, fat distribution could be a factor that influences surface EMG measurements due to its impact of signal impedance. Therefore, between-group analyses, such as between sexes, could not be performed for EMG data; data were limited to within-group/crossover analyses.

The findings of the current study indicate that the starting position of a deadlift exercise while using a hexagonal barbell has a significant impact on the muscle recruitment patterns. Using a more flexed knee and ankle with a more upright torso increases the recruitment of the rectus femoris while decreasing the recruitment of the biceps femoris and erector spinae. This is an important factor for coaches, athletes, physical therapists, and athletic trainers to consider when designing programs, based on the desired goal of the exercise as muscle patterns are changed. Posterior chain recruitment decreases as the flexion angles of the knee and ankle increase. Utilizing a more stiff-legged posture may help to better target the erector spinae and biceps femoris when using a hexagonal barbell.

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