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Comparison of Electromyographic Activity of Selected Muscles on One Repetitione Maximum in the Sumo and Conventional Deadlifts in National Power-Lifting Athletes: A Cross-Sectional Study

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Original Article

Abstract

Introduction: Deadlift is an effective exercise to increase the strength of knee and hip extensors. The aim of the present study is to compare the electromyographic activity record during one repetitione maximum (1RM) movement in the sumo and conventional deadlifts in national power-lifting athletes.

Materials and Methods: Eight elite male powerlifters were selected from the Iran' national team. The selected subjects performed Sumo and conventional deadlift motions with an intensity of 80% of 1RM. While performing each exercise, surface electromyographic activity of Gluteus maximus, Vastus medialis and lateralis, and Erector spinae muscles were recorded using wireless electromyography (EMG). For intra-group comparison of muscle activity in two states, paired t-test was administered at a significance level of 0.05.

Results: The results of the present study showed that the muscle activity was not significantly different between muscle co-contraction pattern in the dominant and non-dominant lower exterimities in the Sumo and conventional deadlifts ($P > 0.05$). There was a significant difference between the muscle contraction pattern in 1RM in the Sumo and conventional movements for vastus medialis (dominant leg $P \leq 0.038$, non-dominant leg $P \leq 0.047$) and erector spine muscles (dominant leg $P \leq 0.032$, non-dominant leg $P \leq 0.037$), in contracst to that of vastus lateralis and gluteus maximus ($P > 0.05$).

Conclusion: According to the results, both vastus medialis and erector spi e muscles can be specifically strengthened in the Sumo and conventional deadlift movements. To design a training protocol for corrective and rehabilitation purposes in the deadlift movement, trainers and therapists must pay attention to these changes in the electromyographic activity of the muscles.

Keywords: Power-lifting; Electromyography; Sumo deadlift; Conventional deadlift

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Introduction

Many people are physically active for health reasons, but some of them want to compete in a certain type of sport at the elite level. Endurance training is well used for people who are active at all levels of sports (1). Endurance training is a form of training and requires overcoming external forces to increase muscle volume and strength (2). The goal of powerlifting is to become stronger. Therefore, in the nature of exercise, the body muscles should be in demand for adaptation to greater resistance (3). Barbell lifting is a common type of strength training, and powerlifting is one of the most popular methods of performing this exercise. In deadlift, the athlete is supposed to lift the barbell off the floor so that he stands upright (1). Undoubtedly, the deadlift is the ultimate test of the overall strength of the body,

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covering every muscle large and small in the body (3). Exercises such as deadlifts use muscle groups with the largest cross-sectional area and should be used to increase lower limb strength (2). Deadlift is a multi-joint exercise that is performed in different exercises (4). Deadlift is an effective exercise to increase the strength of the knee and pelvic extensors and improves lumbar-pelvic stability (5).

There are two common deadlift styles, including Sumo and traditional. In the sumo deadlift, the legs are positioned with a relatively wide distance and the muscles are inclined to the inner side of the knees, however in the traditional deadlifts, the legs are positioned with a relatively lower distance and the muscles are inclined outside the knees (6). The results of a study by Escamilla et al. in relation to sumo deadlift and traditional deadlift with and without lift belt on soccer players showed that in sumo deadlift, the electromyographic activity increased in the external vastus, internal vastus, and anterior tibialis muscles, but it decreased in internal gastrocnemius (7). Carbe and Land reported in their study that there was a strong and significant correlation between knee angle and electromyographic activity of the gluteus maximus and trapezius muscles when the barbell was lifted off the ground, with a larger effect on the activity of the vastus medialis, biceps femoris, and erector spinae muscles when the barbell was crossing the knee (8).

In their study, Bezerra et al. examined the electromyographic activity of the lower torso muscles during deadlift and stiff-legged deadlift and concluded that there was a significant difference between the estimation of external vastus and internal gastrocnemius muscle activation in deadlift and stiff-legged deadlift. However, no differences were found in the muscles of the biceps femoris, lumbar multifidus, and tibialis anterior (9).

Accordingly, there was no study measuring the effect of one maximum repetition (1RM) of sumo deadlift and traditional deadlift on electromyographic activity of selected muscles in powerlifters. Such information may play an important role in designing and prescribing exercises for different purposes and understanding patterns of lower limb muscle activation patterns between different postures in the squat movement. In addition, with a proper understanding of the activation pattern of the muscles in the squat movement, the corrective movement therapists can design exercises with goals of reinforcement, performance enhancement, injury prevention, and rehabilitation techniques. Therefore, the aim of the present study is to compare the electromyographic activity of selected muscles of 1RM of sumo deadlift and traditional deadlift movements in powerlifting athletes of the Iranian national team. In the present study, it was assumed that the state of muscle activation could be different between the two movements. As a result, it will provide useful information to educators and health professionals active in the field.

Materials and Methods

This study was cross-sectional in terms of time and semi-experimental in terms of method. The participants were invited to the study through the Board of the Bodybuilding Federation and attended the record club of Amin Police Academy, Tehran, Iran according to the schedule. After selecting the subjects, a written consent form to participate in the study was received from them and a full explanation was given to them about the objective of the study and its implementation process. Finally, the subjects who wished to remain in the study, entered the study by completing the details and signing the written consent form. The subjects consisted of 8 male athletes of the national powerlifting team who were selected according to the inclusion criteria (age range 25 to 35 years and being a professional athlete) and exclusion criteria (history of surgery, fracture, spine, shoulder girdle, pelvis, and knee joint disease, back pain) through a questionnaire as well as evaluation by a corrective exercises specialist. After being selected, the participation consent form was completed voluntarily by the participants. The powerlifters performed deadlifts in two separate days with an interval of 48 hours in the record club of Amin Police Academy. The study protocol was approved by the ethics committee of Allameh Tabataba'i University of Tehran with the code IR.ATU.REC.1398.006.

To warm up, the muscles were stretched by holding the stretch for 30 seconds and 3 repetitions of the stretch for each muscle (10). Thus, individuals performed one to 10 repetitions of deadlifts with sub-maximal selected weights in order to prepare for 1RM. Based on the study by Carbe and Land, the initial warm-up sets were performed with optional rest until the subjects reached approximately 80% of their 1RM, then they tried for 1RM (8). Prior to the main study, it was necessary to calculate the maximum voluntary isometric contraction (MVIC) as a standard source (11) to compare the change in the electromyographic activity between different subjects and muscles so that the study data is normalized as a percentage of MVIC.

The electrical activity of the selected knee, thigh, and lumbar-pelvic muscles of the national powerlifters was recorded while the athletes performed deadlifts in both traditional and sumo modes. Due to the limitation in the number of muscles selected due to noise and crosstalk, the electromyographic signals and previous studies, these muscles were selected in the present study (Figure 1).

Figure 1. Sumo deadlift (a) and traditional deadlift (b)

All athletes performed the movement three times with 30-second rest intervals (12) to eliminate the potential fatigue effect (13). Between one deadlift procedure and the next procedure, the athlete was given a 4-minute break (14).

To evaluate the activity of vastus medialis, vastus lateralis, Gluteus maximus, and erector spinae muscles and the activation ratio of the vastus medialis and vastus lateralis muscles, a 16-channel electromyographic device (Baya Med, Iran) was used and the device was calibrated, with a sampling frequency of 1000 Hz and bandwidth of 20 to 500 Hz. In the electrode placement stage, disposable silver-chloride surface electrodes (INTCO, Negin Nama Negar Company, Iran) were used. To reduce skin resistance, surface electrodes were positioned on the gluteus maximus muscle, one-third of the distance between the spinous process of the second sacral vertebra to the greater trochanter of the femur, after skin preparation (muscle surface hair was shaved off and the skin was cleansed with a cotton swab dipped in medical alcohol).

The measurement was performed from the spinous process of the second sacral vertebra. The position of the electrodes was 10 cm above and 7 cm outside the upper patellar line at an angle of 10° outward to the vertical line for the external vastus muscle (15), about 4 cm above and 3 cm inward to the upper inner line of the patella and at an angle of 55° to the vertical line (16) for the medial vastus muscle, and the surface of the fourth cervical vertebra at a distance of 1.5 cm outside relative to the spinous process of this segment. The reference electrode was preferably placed on the bony area close to the target muscles. The disposable electrodes with a center-to-center distance of 20 mm were placed in the direction of the muscle fiber according to the guidelines of the Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) protocol (11).

In order to record MVIC, the following was performed:

Erector spinae muscle: The person was lying on the bed in the supine position. With the torso out of the bed, the arms were crossed on the chest and the legs were fixed to the bed by straps. The person was then asked to keep their trunk parallel to the ground.

Gluteus maximus muscle: The person was lying on the bed in the supine position with his hips in a normal abduction-reduction position. He was asked to hold the edge of the bed with his hands to maintain his stability during the test. The examiner fixed his pelvis with one hand and resisted his hip extension with the other. During the test, the individual was asked to lift his foot strongly with his knee at a 90-degree angle of flexion against the tester's resistance.

Internal vastus and external vastus muscles: The person was sitting on a chair with the knee of the dominant leg bent 70 to 90 degrees. The person tried to open the knee against the resistance exerted by the examiner on his leg (15). This test was held for 5 seconds for each muscle and was recorded three times in total (17).

The Shapiro-Wilk test was employed to determine the normal distribution of the data. Data were analyzed using paired t-test in SPSS software (version 22, IBM Corporation, Armonk, NY, USA). $P < 0.05$ was considered as the significant level.

Results

8 subjects with a mean age of 28.62 ± 3.50 years, mean height of 180.60 ± 7.86 cm, mean weight of 91.75 ± 25.61 kg, and mean body mass index (BMI) of 23.8 ± 1.20 kg/m^2 participated in the present study.

Based on the results of the paired t-test, there was no significant difference in the activity of vastus medialis, vastus lateralis, gluteus maximus, and erector spinae muscles in the sumo deadlift technique between the dominant and non-dominant legs (Table 1).

The results of the paired t-test showed that the activity of Vastus medialis, Vastus lateralis, Gluteus maximus, and Erector spinae muscles in the traditional deadlift technique was not significantly different between the dominant and non-dominant legs (Table 2).

Table 1. Mean and ratio of muscles' electromyographic activity in sumo deadlift technique between dominant and non-dominant legs

Muscle electromyographic activity (MVIC) (%)	Dominant leg	Non-dominant leg	P
Vastus medialis	5.22 ± 2.25	5.15 ± 2.50	0.25
Vastus lateralis	5.09 ± 2.10	5.12 ± 2.44	0.27
Vastus medialis/Vastus lateralis	1.40 ± 0.33	1.02 ± 0.42	0.57
Gluteus maximus	3.18 ± 0.92	2.79 ± 0.25	0.41
Erector spinae	0.90 ± 0.75	0.70 ± 0.44	0.54

MVIC: Maximum voluntary isometric contraction
Data are reported as mean ± standard deviation (SD).

Given the results of the paired t-test, no significant difference was observed between the activity of the Vastus lateralis and Gluteus maximus muscles in the dominant and non-dominant legs in the sumo and traditional deadlift movements (Table 3), however the difference in Vastus medialis muscle activity between the dominant leg (P = 0.038) and non-dominant leg (P = 0.047) as well as the erector spinae muscle activity between the dominant leg (P = 0.032) and non-dominant leg (P = 0.038) were significant in the sumo and traditional deadlift movements.

Discussion

The purpose in the present study was to compare the electromyographic activity of selected muscles of 1RM in the sumo and traditional deadlift movements of the national powerlifting team. The findings suggested that there was no significant difference in the electromyographic activity of Vastus medialis and Vastus lateralis muscles between the dominant and non-dominant legs in both sumo and traditional deadlift techniques. This finding can be justified according to the length-stress relationship (12). Since these muscles are one-joint muscles and pass only through the knee joint, changing the position of the thighs during the deadlift technique cannot affect the length of these muscles. Because the speed of movement, moments, and forces applied to the joints and the angle of tension of the muscle fibers affect the amount of muscle activity (7), one should not expect the activity of these muscles to change in the traditional sumo deadlift technique. In the study by Sykes and Wong, the electromyographic activity of the Vastus medialis muscle in the straight-leg raising (SLR) movement at different angles of the hip joint (internal, normal, and external rotation) was examined, with the results suggesting that the activity of this muscle increased with external hip rotation (18). In another study, Nicholas et al. investigated the effect of leg position on the electrical activity of the quadriceps muscles during hug squat movement in three modes of internal, external, and normal rotation and concluded that the tibia rotation did not make a difference in the activity of these muscles. Although the increase in the Vastus medialis muscle activity in the external angle of the shank was not significant, they reported an increase in the activity of this muscle in the external angle of the leg (19). In a study, Troubridge investigated the effect of foot position on the electromyographic activity of quadriceps and hamstring muscles during bodyweight squats in both wide stance and close stance positions and showed that there was no significant difference in the activity of these muscles (20); this was consistent with the findings of the present study.

The results of comparing the electromyographic activity in the sumo and traditional deadlift techniques rvealed a significant difference between the dominant and non-dominant legs in 1RM of Vastus medialis muscle, but Vastus lateralis muscle activity was not significant. In their study, Carbe and Land reported the greatest effect on Vastus medialis muscle activity when the barbell was lifted off the ground and as the barbell crossed the knee (8). Although muscle activation levels at different stages were not studied in the present study, in general, in terms of the increase in muscle activity, it was consistent with the results of the present study. In the present study, the electromyographic activity of the Vastus medialis muscle in the sumo deadlift was higher than that in the traditional deadlift.

Table 2. Mean and ratio of muscles' electromyographic activity in traditional deadlift technique between the dominant and non-dominant legs

Muscle electromyographic activity (MVIC) (%)	Dominant leg	Non-dominant leg	P
Vastus medialis	4.13 ± 2.30	4.10 ± 1.93	0.64
Vastus lateralis	4.97 ± 2.10	4.82 ± 2.34	0.31
Vastus medialis/Vastus lateralis	0.88 ± 0.82	0.86 ± 0.30	0.44
Gluteus maximus	2.89 ±0.49	2.86 ±0.75	0.37
Erector spinae	1.20 ±0.75	1.15 ±0.44	0.49

MVIC: Maximum voluntary isometric contraction
Data are reported as mean ± standard deviation (SD).

Table 3. Comparison of mean and ratio of muscle electromyographic activity in sumo and traditional deadlift movements between the dominant and non-dominant legs

Muscle electromyographic activity (MVIC) (%)	Organ examined	Traditional deadlift	Sumo deadlift	P
Vastus medialis	Dominant leg	4.13 ± 2.30	5.22 ± 2.25	0.037*
	Non-dominant leg	4.10 ± 1.93	5.15 ± 2.05	0.047*
Vastus lateralis	Dominant leg	4.79 ± 2.10	5.09 ± 2.10	0.710
	Non-dominant leg	4.82 ± 2.34	5.12 ± 2.44	0.620
Vastus medialis/Vastus lateralis	Dominant leg	0.88 ± 0.28	1.04 ± 0.33	0.038*
	Non-dominant leg	0.86 ± 0.30	1.02 ±0.24	0.046*
Gluteus maximus	Dominant leg	2.98 ± 0.94	3.18 ±0.92	0.780
	Non-dominant leg	2.86 ± 0.75	2.97 ± 0.85	0.590
Erector spinae	Dominant leg	1.20 ± 0.75	0.90 ± 0.75	0.032*
	Non-dominant leg	1.15 ± 0.44	0.70 ± 0.44	0.038*

*Significant difference at the level of P < 0.050
Data are reported as mean ± standard deviation (SD).

In another investigation, Escamilla et al. performed electromyographic analysis of sumo deadlift and traditional deadlift and found that the electromyographic activity of the Vastus medialis muscle in the sumo deadlift was significantly higher than traditional deadlift (7) which is in line with the results of the present study. Since the vastus medialis and vastus lateralis muscles are one-joint muscles, and taking into account their traction line, it can be claimed that these muscles are an external dynamic stabilizer. Therefore, the results obtained for this muscle stating that there was no significant difference between muscle activity in the sumo and traditional deadlift movements can be accepted.

The electromyographic activity of the gluteus maximus muscle between the dominant and non-dominant legs in both sumo and traditional deadlift techniques, as well as the comparison between them was not significant. Activation of motor units per unit time in different muscles of the body when lifting loads is different (3). The lower activity of the motor units in the gluteus maximus muscle in the traditional and sumo deadlifts can be justified by this argument, which contradicted the results of the study of Lee et al. (5).

There was no significant difference in the electromyographic activity of the erector spinae muscle between the dominant and non-dominant legs in both sumo and traditional deadlift techniques. This finding is justifiable due to the synergistic nature of the erector spinae muscle with the gluteus maximus in sumo deadlift and the lack of significant reduction in the activity of the erector spinae muscle. During the deadlift, because the hip moves backwards, the lower limb is such that the center of mass of the body tends to move off the support surface, which is a factor for instability in controlling the body's balance (21). Normally, the upper body bends forward with a compensatory mechanism to overcome this imbalance, which naturally results in more activity of the thigh extensor relative to the traditional deadlift position in motion (22). With this argument, the increase in the erector spinae muscle activity compared to the traditional deadlift position can be justified. The difference in the electromyographic activity in the sumo and traditional deadlift techniques between the dominant and non-dominant legs in 1RM was significant in the erector spinae muscle, which was in agreement with the results of the study by Carbe and Land (8). The results of the present study suggested that performing deadlift movement in sumo (wide stance) and traditional (close stance) did not make a difference in the activity of Vastus lateralis and gluteus maximus muscles, however performing sumo and traditional deadlift movements increased the electromyographic activity of vastus medialis and erector spinae muscles. Due to the limited studies in this field, it was not possible to compare the results. Therefore, the results can be used as part of the design of exercises with different goals and new research with training and therapeutic approaches.

Limitations

The present study was accompanied by some limitations needed to be considered. First, due to the cross-sectional nature of the study, the long-term effect of these exercises could not be determined. Second, crosstalk may have occurred between the muscles due to the use of surface electrodes, which is a known limitation of this widely used method. Finally, given that the present study was conducted only on healthy men, it is not generalizable to all individuals.

Recommendations

It is suggested that the effect of different hip joint positions on the electromyographic activity of selected muscles before and after the fatigue protocol be investigated. Additionally, similar studies are necessary to be performed on women. It is better to conduct a study to compare the delay of muscle activity time between these two movements. It is recommended that a similar study be performed in individuals with musculoskeletal problems.

Conclusion

Given the obtained results, it seems that the vastus medialis and erector spinae muscles can be strengthened in the deadlift movement specifically in the sumo technique. For corrective movement and rehabilitation purposes in deadlift movement and in order to design a training protocol, coaches and therapists should consider these changes in muscle electromyographic activity to progressively increase muscle activity.

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Authors' Contribution

Keyvan Salehi, Study design and ideation, attracting financial resources for the study, study support, executive, and scientific services, data collection, analysis and interpretation of results, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, responsibility for maintaining the integrity of the study from the beginning to publication, and responding to the referees' comments; Farideh Babakhani, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistics services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, responsibility for maintaining the integrity of the study from the beginning to publication, and responding to the referees' comments; Ramin Baluchi: providing study equipment and samples, analysis and interpretation of results, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, responsibility for maintaining the integrity of the study from the beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest. Keyvan Salehi, a former member of the national team and national champion, conducted basic studies related to this article in the national team camp. Dr. Babakhani is an assistant professor and Dr. Baluchi is an associate professor and faculty member of Allameh Tabataba'i University.

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