

# Investigating the Effect of a Weightlifting Belt on the Electromyographic Activity of Core and Pelvic Muscles in Female Student-Athletes with Lumbar Hyperlordosis during Squat and Deadlift Movements: A Quasi-Experimental Study

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## Original Article

### Abstract

**Introduction:** Women exhibit the highest prevalence of spinal abnormalities. Due to musculoskeletal deficits, these anomalies lead to suboptimal lumbosacral posture in this demographic, particularly among female athletes. This study aimed to investigate the effects of using a weightlifting belt on the electromyographic (EMG) activity of selected muscles during squat and deadlift exercises in women with and without lumbar hyperlordosis.

**Materials and Methods:** Surface EMG was used to record the muscle activity of 34 female athletes (aged 18–25 years) from Allameh Tabataba'i University, Tehran, Iran. Participants were divided into two groups: those with lumbar hyperlordosis ( $n = 17$ ) and a healthy control group ( $n = 17$ ). EMG data were collected during squat and deadlift exercises, both with and without a belt. Intra-group and inter-group analyses were performed using the Wilcoxon and Mann–Whitney U tests, respectively.

**Results:** In the hyperlordosis group, the use of a belt during squat and deadlift movements resulted in significant differences in gluteus maximus ( $P \leq 0.001$ ) and external oblique ( $P = 0.009$ ) activity compared to the no-belt condition. However, no significant differences were observed in erector spinae activity between the belt and no-belt conditions for either movement ( $P = 0.156$  and  $P = 0.149$ , respectively). Notably, significant inter-group differences were found in erector spinae activity when using a belt during both the squat ( $P = 0.034$ ) and deadlift ( $P = 0.014$ ) exercises.

**Conclusion:** The findings suggest that using a belt may positively influence joint kinematics and muscle function, while reducing discomfort in both female student-athletes with hyperlordosis and healthy individuals.

**Keywords:** Weightlifting belt; Lumbar hyperlordosis; Deadlift; Squat

**Citation:** Bagheri S, Babakhani F, Balouchi R. Investigating the Effect of a Weightlifting Belt on the Electromyographic Activity of Core and Pelvic Muscles in Female Student-Athletes with Lumbar Hyperlordosis during Squat and Deadlift Movements: A Quasi-Experimental Study. *J Res Rehabil Sci* 2023; 19: 181-91.

Received date: 13.10.2023

Accept date: 03.11.2023

Published: 02.12.2023

### Introduction

Lordotic posture is one of the most prevalent non-structural anomalies in the sagittal plane. The primary etiology of hyperlordosis is muscular imbalance in the lumbopelvic region of the spine, which can lead to severe spinal injuries in this area (1). Hyperlordosis represents a maladaptive postural alignment that may be accompanied by pelvic anteversion (anterior pelvic tilt) and knee hyperextension (2). This condition is a

hallmark of Lower Crossed Syndrome (LCS), characterized by the shortening or hypertonicity of the erector spinae and hip flexors, concomitant with the weakness or lengthening (inhibition) of the abdominal muscles and hip extensors.

Physiological lumbar lordosis protects the spine from excessive stress and functions as a shock absorber. Any deviation in spinal alignment results in the loss of optimal posture and systemic imbalance

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throughout the body. Maintaining proper posture requires a precise equilibrium between strength and flexibility in both the anterior and posterior muscle groups (2). Muscle function can be analyzed in terms of strength and length; for instance, in hyperlordosis, the abdominal muscles are lengthened, while the gluteal muscles, hamstrings, hip flexors, and lumbar spinal muscles become shortened (2). Normal lordosis is a critical feature for maintaining somatic balance in the sagittal plane (3). Due to increased tension in the lower spine—which bears the maximum weight of the upper torso—hyperlordosis may predispose the individual to various musculoskeletal risks (3). Muscular imbalances and weakness lead to abnormal muscle shortening and lengthening, which can adversely affect overall equilibrium and gait (4). Furthermore, hyperlordosis may serve as a compensatory mechanism for gluteal weakness; this insufficiency creates tension in the pelvis, leading to pelvic instability and, frequently, anterior pelvic tilt (4).

Establishing and maintaining an optimal standing posture is a complex process that requires integrating sensory, visual, and proprioceptive information from throughout the body, as well as the brain's awareness of the body's position in space (5). Lumbar lordosis is a unique characteristic of the human spine, the magnitude of which is determined by muscular function and the integrity of the intervertebral discs (6). It has been established that trunk muscle activity consistently increases prior to any lower-limb movement; consequently, core weakness resulting from hyperlordosis can delay the activation of lower-limb muscles and disrupt overall balance (7, 8).

Among resistance training modalities, the free-weight squat is an exercise that, while strengthening the lower extremities, also imposes significant overloading on the spine (9). Back squats are highly popular due to the specific loading patterns of the lower limbs and the induction of the tension-stretch cycle, which is common in many athletic disciplines (10). The deadlift is a multi-joint compound exercise and a critical measure of overall systemic strength, engaging nearly every major and minor muscle group with large cross-sectional areas; it effectively enhances the strength of the knee and hip extensors and improves lumbopelvic stability (11). Both squats and deadlifts are foundational resistance exercises in athletic conditioning programs (12).

While the optimal pelvic tilt angle during the squat remains undetermined, a slight posterior pelvic tilt is considered the most efficient lifting posture, as it mitigates hyperlordosis and reduces compressive loads on the intervertebral discs (13, 14). It is suggested that

a lordotic posture reduces the tension on the posterior elements of the lumbar spine, thereby decreasing the stress applied to them; additionally, abdominal activation may play a supportive role for the lumbar spine. While a slight posterior pelvic tilt and reduced lordosis during a squat minimize compressive loads on the intervertebral discs, maintaining a normal lumbosacral angle during the lift has been shown to minimize the risk of lower back pain (14).

Spinal injury, and activities of daily living (ADLs) often involve repetitive motions that can exacerbate these risks. Consequently, the use of supportive devices may help prevent spinal injuries (15). Lumbar braces facilitate proper postural alignment and provide support to vulnerable spinal segments. Furthermore, they may induce a placebo effect, serving as a psychological reminder to exercise caution during weightlifting; notably, this effect remains significant even when the belt is not optimally tightened (8). Another critical benefit of lumbar belts is the restriction of spinal mobility, thereby reducing axial trunk loads (16). One proposed primary mechanism is to enhance proprioception through tactile feedback, thereby increasing the user's perceived sense of security (15). Additionally, the abdominal compression exerted by the belt may prompt the individual to reduce lumbar lordosis when altering spinal positions (15).

Given that lumbar belts are designed based on diverse mechanical principles, their effects on spinal and pelvic mobility, lumbar muscle activity, and lumbar vertebral alignment may vary (17). Electromyography (EMG) analysis indicates that repetitive deadlifts performed with a belt do not significantly alter erector spinae activity (18). However, the use of lumbar belts may be contraindicated in overweight individuals with hyperlordosis, as it may paradoxically increase their tendency to exacerbate the lordotic angle (19) further.

While squats are frequently used to improve lower-limb strength and neuromuscular control, sex-based differences significantly influence muscular performance during these exercises. During deep squats, women exhibit greater activity within the posterior chain (20). Kinematic data from nine women indicated that females exhibit less trunk and pelvic flexion, potentially resulting in greater spinal loading (21). Furthermore, female athletes are at a higher risk of lower back pain (22).

Given these sex-based disparities, and to more accurately investigate the effect of an external support tool (such as a lumbar belt) on individuals with hyperlordosis versus those with normal lumbar lordosis, it was determined that sampling exclusively

female participants was necessary to control for the confounding variable of sex. Accordingly, the objective of this study was to identify an optimal method to mitigate deleterious muscle activity and excessive loading, thereby enhancing the performance of female athletes during squats and deadlifts—both fundamental compound resistance exercises. Female athletes with hyperlordosis were specifically selected for this research, as they may be more susceptible to the exacerbation of these spinal loads.

### Materials and Methods

Female physical education students from Allameh Tabataba'i University were recruited through a public call. Volunteers were screened against predefined eligibility criteria, specifically lumbar curvature and physical fitness. Following the screening process, informed consent was obtained, and demographic data were collected in the laboratory setting.

This study employed a longitudinal, quasi-experimental, and applied research design. The Ethics Committee of Allameh Tabataba'i University in Tehran approved the protocol. Data collection was conducted over approximately one month during morning and noon sessions at the Corrective Exercise Laboratory of the Faculty of Physical Education. Based on a sample size calculation (assuming  $\alpha = 0.05$  and  $\beta = 0.80$ ), 34 female students were selected via convenience sampling and assigned to two groups: those with lumbar hyperlordosis and those with normal lumbar lordosis. Written informed consent, approved by the university, was obtained from all participants prior to their involvement.

Inclusion criteria were determined based on participant reports and clinical assessments: a lumbar lordosis exceeding  $8^\circ$  (23) for the hyperlordosis group and a normal lumbar lordosis for the control group; optimal physical fitness based on athletic history; a normal Body Mass Index (BMI) between 18 and 25; and no history of acute spinal trauma.

Exclusion criteria included: a history of acute or chronic lower back pain within the last five years; pathological symptoms such as lumbar spasms or stiffness; and spondylolisthesis. These were identified through self-reporting and diagnostic assessments, including spinal flexion and extension tests, movement pattern analysis, range of motion (ROM) evaluations, and postural assessments. Other grounds for exclusion included any history of surgery, fractures, or musculoskeletal failure. Furthermore, participants were withdrawn from the study if they were unwilling to continue, failed to perform the movements correctly, were absent, or participated in high-intensity athletic

competitions during the study period.

To quantify lumbar lordosis, the spinous processes of the T12 and S1 vertebrae were marked. The examiner used a flexicurve ruler to measure the curvature of the lumbar spine. The points of contact with the mid-spinous processes were marked with a marker; the ruler was then removed—maintaining its shape—and placed on white paper to trace the convex curvature and the marked points. A straight line was drawn between the two endpoints, and a perpendicular line was projected from the center of this line to the apex of the curve to calculate the curvature index. The normal range for lumbar lordosis in adults is typically  $8.7^\circ \pm 2.5^\circ$  (24); values exceeding this range were categorized as positive for lumbar hyperlordosis.

A specialized Iranian-made leather weightlifting belt, featuring an adjustable buckle to accommodate individual anatomical differences, was utilized. The belt was fastened around the lower spinal region (approximately from T7 to L1) with an appropriate level of stiffness to provide the necessary support during the exercise tasks (24-30).

Muscle activity of the gluteus maximus (GM), external oblique (EO), and erector spinae (ES) was recorded using a 16-channel electromyography system (Medboy, Iran). The calibrated device operated with a sampling frequency of 1000 Hz and a bandwidth of 20–500 Hz. Disposable silver-silver chloride (Ag/AgCl) surface electrodes (RG-F, Skintect, Germany) were utilized and aligned with the muscle fibers. The electrodes were applied to the skin using a conductive gel interface (containing silver chloride) to ensure optimal signal transmission. Each electrode had a contact surface area of  $1 \text{ cm}^2$  and was hypoallergenic. To apply an optimal and safe resistance level, a load equivalent to approximately 15% of each participant's body weight was used (31).

To minimize skin impedance, hair over the target muscles was shaved, and the skin was cleansed with alcohol swabs (32). Bipolar electrodes (1 cm diameter) were placed with an inter-electrode distance of 2 cm (center-to-center) over the muscle bellies (33). For the gluteus maximus, electrodes were positioned on the midline between the sacrum and the greater trochanter, corresponding to the maximum prominence of the gluteal region above the greater trochanter. For the erector spinae, electrodes were placed two fingers lateral to the L1 vertebra, and for the external oblique, they were positioned 15 cm lateral to the midline, passing through the navel. The reference electrode was placed over the C7 cervical vertebra. All electrodes were positioned according to the SENIAM (Surface Electromyography Appropriate Standardization in the

Interdisciplinary European Committee) protocol to ensure alignment with muscle fibers. Specialized adhesive tape was applied over the electrodes to ensure stability and measurement reliability.

To ensure participants' familiarity with the experimental conditions and the correct execution of the movements, comprehensive practical and visual training in squatting and deadlifting was provided. Following this, each participant performed trial repetitions to ensure technical proficiency; any biomechanical errors were corrected, and joint angles were standardized using a goniometer.

For the squat, participants assumed a shoulder-width stance with the barbell positioned slightly below the shoulders, resting on the upper trapezius and posterior deltoids. To minimize spinal loading, the torso was kept upright, and the feet were positioned at shoulder width or slightly wider, with slight external rotation. To stabilize the barbell, the trapezius muscles were slightly contracted (33). The barbell was aligned with the posterior deltoids, inferior to the C7 vertebra. The forearms remained parallel, and the hands were placed in a pronated grip adjacent to the shoulders. The wrists remained extended throughout the movement.

Participants performed the squat by flexing the knees until the thighs were parallel to the floor. During execution, strict control was maintained to prevent knee valgus (medial collapse) and to ensure linear alignment of the head and neck. By maintaining core stability and keeping the chest elevated ("up and out"), shearing forces on the intervertebral discs were minimized. Ultimately, a safe squat was executed while maintaining a neutral spinal position and optimal lumbar lordosis (34).

For the deadlift, the barbell was positioned on the floor in front of the participants, who assumed a shoulder-width stance. With arms fully extended and a grip wider than shoulder-width in a pronated position, the participants grasped the barbell by flexing the hip and knee joints. The spine was maintained in a neutral position with the thighs parallel to the ground. The shoulders were positioned directly above or slightly anterior to the barbell to prevent any excessive spinal curvature. The barbell was kept close to the body, ensuring no contact with the shins.

The trunk was maintained at an angle of approximately 30° to 45° relative to the floor, with a forward-facing gaze. The head, neck, spine, and pelvis were kept in linear alignment. By driving their feet into the ground, participants extended their hip and knee joints to bring their bodies upright. Exhalation occurred as the barbell passed the knees, while the chest remained elevated and open. During the ascent,

the scapulae were retracted, and through active hip extension, the barbell reached the thighs, completing the first phase of the movement in a neutral spinal position. The barbell was then lowered back to the starting position through controlled flexion of the hip, knee, and ankle joints (35). The deadlift load was set at 15% of each participant's body weight (36). The execution of both exercises is illustrated in Figure 1.

To normalize the EMG data and enable comparison of muscle activity across participants, the Maximum Voluntary Isometric Contraction (MVIC) was recorded using the EMG system and validated by standardized Manual Muscle Testing (MMT) (32). After an initial familiarization trial, two 5-second MVIC contractions were performed for each target muscle. A one-minute rest interval was provided between repetitions to prevent muscular fatigue (36).

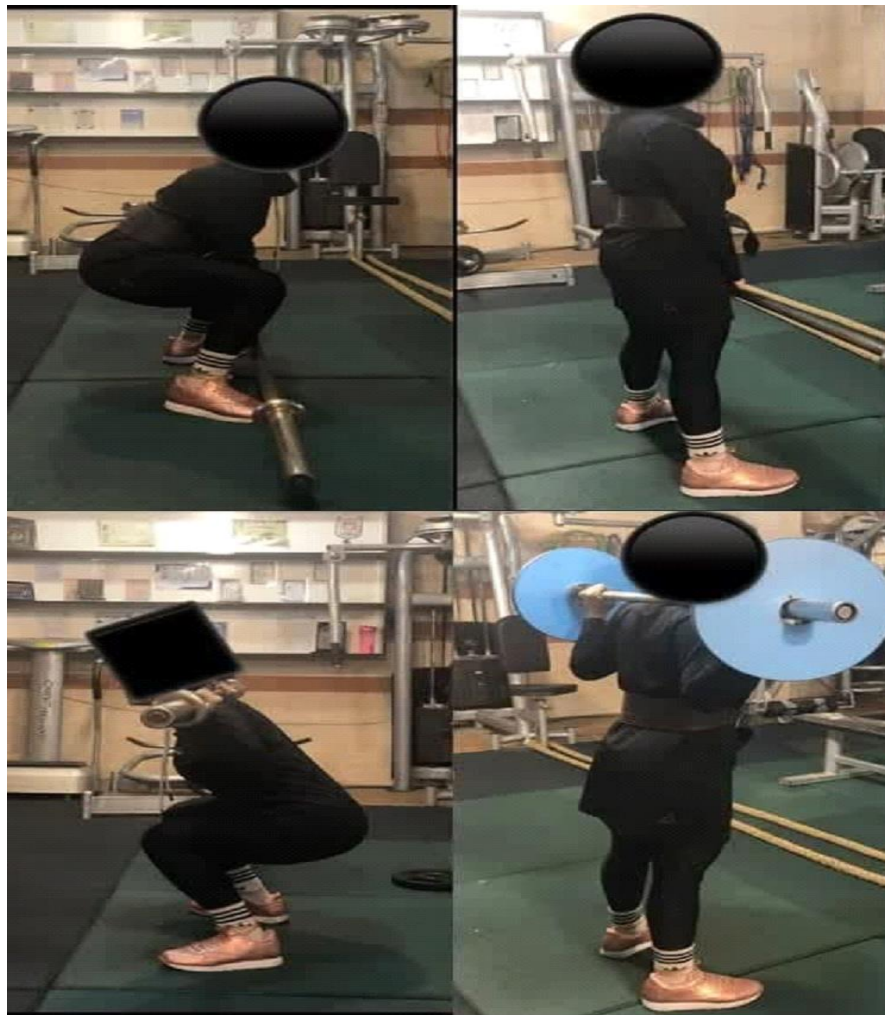
- External Oblique: MVIC was measured during trunk rotation. The participant was positioned in maximum flexion and rightward rotation, while the examiner applied opposing force toward leftward rotation (Babakhani & Hatefi).

- Gluteus Maximus: The participant was placed in a prone position with the hip in a neutral position within the frontal plane. To ensure stability, the participant gripped the edge of the examination table. The examiner stabilized the pelvis with one hand and applied manual resistance against hip extension with the other. The participant was instructed to lift the leg with maximum effort while maintaining 90 degrees of knee flexion (32).

- Erector Spinae: The participant lay prone with the upper torso extending beyond the edge of the table and the arms crossed over the chest. The lower extremities were secured using straps, and the participant was instructed to lift the torso until it was parallel to the floor (37). Electrodes for the erector spinae were positioned superior to the belt. Following the MVIC protocols, participants performed the designated exercises both with and without the supportive belt.

The EMG system calculated the Root Mean Square (RMS) of the isometric activity. For the analysis of the raw signals, the first and last 3 seconds of each recording were excluded, and the middle 4 seconds were used for the calculations. Data processing was performed using LabVIEW (National Instruments, Austin, TX), and statistical analysis was conducted using SPSS version 21. Muscle activity was expressed as a percentage of MVIC by dividing the RMS of the exercise by the recorded MVIC value (38-42).

Descriptive and inferential statistics were used to analyze the raw data. Demographic characteristics were described using mean and standard deviation.



**Figure 1.** Top left: Initial phase of deadlift with belt; top right: Terminal phase of deadlift; bottom left: Initial phase of squat; bottom right: Terminal phase of squat

The normality of the data distribution was assessed using the Shapiro-Wilk test. Since the results indicated a non-normal distribution, non-parametric tests were employed: the Wilcoxon signed-rank test for intra-group comparisons and the Mann-Whitney U test for inter-group comparisons. Effect sizes were interpreted based on Cohen's d, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively.

Data were compiled in Microsoft Excel (version 2311) and analyzed using SPSS version 21 (IBM Corp., Armonk, NY, USA), with a statistical significance level of  $p < 0.05$ .

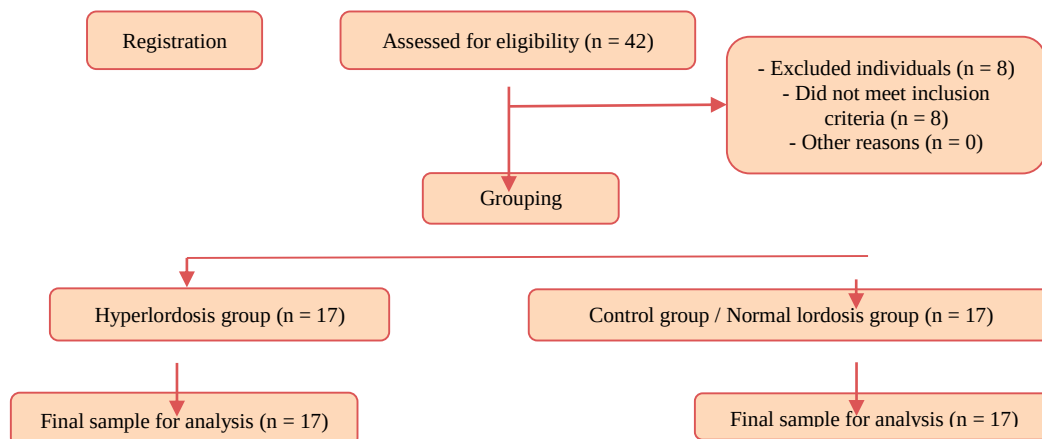
### Results

Of the 42 screened candidates, 34 met the inclusion criteria and were enrolled in the study. A 100% participation rate was maintained across both groups.

**Table 1.** Demographic characteristics of the two study groups (Mean  $\pm$  SD)

| Variable                             | Women without lumbar lordosis (n = 17) | Women with lumbar lordosis (n = 17) | p-value |
|--------------------------------------|----------------------------------------|-------------------------------------|---------|
| Age (years)                          | 63.23 $\pm$ 1.00                       | 49.01 $\pm$ 2.22                    | 0.390   |
| Weight (kg)                          | 43.34 $\pm$ 4.69                       | 91.83 $\pm$ 6.67                    | 0.613   |
| Height (cm)                          | 56.82 $\pm$ 3.17                       | 49.70 $\pm$ 5.17                    | 0.501   |
| Body mass index (kg/m <sup>2</sup> ) | 70.20 $\pm$ 1.21                       | 37.79 $\pm$ 0.22                    | 0.342   |

Statistical test: Independent-samples t-test. Differences were considered statistically significant at  $p < 0.05$ .



**Figure 2.** Consort flow diagram of the study protocol

Analysis of demographic characteristics revealed no statistically significant differences between the two groups regarding age, height, weight, and Body Mass Index (BMI) ( $p > 0.05$ ).

Based on the results of the Wilcoxon signed-rank test, no significant difference was observed in the mean activity of the investigated muscles. Therefore, the weightlifting belt had no significant effect on the electromyography (EMG) activity of the selected muscles in female student-athletes with normal lordosis during squat and deadlift tasks (Table 2).

However, the results of the Wilcoxon signed-rank test indicated a significant difference in the electrical activity of the gluteus maximus ( $p = 0.001$ ) and external oblique ( $p = 0.009$ , effect size = 0.61) during the deadlift exercise between the belt and no-belt conditions in female student-athletes with hyperlordosis. Regarding the squat exercise, the electrical activity of the gluteus maximus and external oblique muscles decreased in the no-belt condition compared to the belt condition; however, these results were not statistically significant. Furthermore, no significant differences were observed in erector spinae muscle activity during squat and deadlift exercises between the two conditions (Table 3).

The results of the Mann-Whitney U test indicated

that erector spinae muscle activity was significantly higher in individuals with hyperlordosis than in those without hyperlordosis during the squat exercise without the belt ( $p = 0.018$ ).

However, no statistically significant differences were observed in the activity of other muscles during the squat exercise between the two groups, regardless of the belt condition. Furthermore, during the deadlift exercise, the activity of the erector spinae ( $p = 0.045$ ) and gluteus maximus ( $p = 0.038$ ) was significantly higher in individuals with hyperlordosis than in those without hyperlordosis. No significant differences were found for the remaining muscles during the deadlift exercise between the two groups in either condition (Table 4).

Based on the calculated effect sizes, a moderate effect size was observed between the hyperlordosis and non-hyperlordosis groups in the no-belt condition for the activity of the erector spinae (effect size = 0.60) during the squat, and for the gluteus maximus (effect size = 0.56) and external oblique (effect size = 0.54) during the deadlift. Additionally, in the belt condition, moderate effect sizes were observed for erector spinae activity (effect size = 0.64) and gluteus maximus activity (effect size = 0.59) during the deadlift between the two study groups (Table 5).

**Table 2.** Comparison of the effect of the weightlifting belt on the electrical activity of selected muscles in female student-athletes without hyperlordosis during squat and deadlift tasks

| Muscle           | Exercise | Without a Weightlifting Belt (%MVIC) | With a Weightlifting Belt (%MVIC) | Z      | p-value | Effect Size |
|------------------|----------|--------------------------------------|-----------------------------------|--------|---------|-------------|
| Erector spinae   | Squat    | 71.37 ± 22.24                        | 05.68 ± 25.24                     | -0.118 | 0.906   | 0.04        |
|                  | Deadlift | 77.83 ± 22.22                        | 44.34 ± 16.16                     | -1.160 | 0.246   | 0.31        |
| Gluteus maximus  | Squat    | 70.77 ± 28.34                        | 24.06 ± 27.32                     | -1.112 | 0.266   | 0.07        |
|                  | Deadlift | 93.38 ± 18.24                        | 51.45 ± 12.20                     | -1.160 | 0.246   | 0.26        |
| External oblique | Squat    | 27.54 ± 26.36                        | 67.02 ± 28.40                     | -0.592 | 0.554   | 0.14        |
|                  | Deadlift | 68.00 ± 29.39                        | 02.67 ± 28.39                     | -0.213 | 0.831   | 0.01        |

MVIC, maximum voluntary isometric contraction

**Table 3.** Comparison of the effect of wearing a weightlifting belt on the electromyographic activity of selected muscles in female student-athletes with lumbar hyperlordosis during squat and deadlift tasks

| Muscle           | Exercise | Without a Weightlifting Belt (%MVIC) | With a Weightlifting Belt (%MVIC) | Z      | p-value | Effect Size       |
|------------------|----------|--------------------------------------|-----------------------------------|--------|---------|-------------------|
| Erector spinae   | Squat    | 21.43 ± 37.19                        | 34.43 ± 35.17                     | -1.420 | 0.156   | 0.11              |
|                  | Deadlift | 24.54 ± 26.15                        | 61.37 ± 26.15                     | -1.445 | 0.149   | 0.02              |
| Gluteus maximus  | Squat    | 58.10 ± 43.26                        | 98.69 ± 36.23                     | -1.728 | 0.084   | 0.25              |
|                  | Deadlift | 23.78 ± 36.22                        | 95.03 ± 28.16                     | -3.338 | 0.001*  | 0.41              |
| External oblique | Squat    | 72.86 ± 46.17                        | 15.19 ± 41.13                     | -1.917 | 0.055   | 0.35              |
|                  | Deadlift | 13.27 ± 54.26                        | 71.85 ± 39.23                     | -2.627 | 0.009*  | 0.61 <sup>‡</sup> |

Values are expressed as mean ± standard deviation.

\*Statistically significant at  $p < 0.05$ .

<sup>‡</sup>Medium effect size according to Cohen's criteria ( $d \geq 0.50$ ).

MVIC, maximum voluntary isometric contraction.

### Discussion

The present study aimed to investigate and compare the effect of a weightlifting belt on the electromyographic (EMG) activity of selected muscles during squat and deadlift exercises in female student-athletes with and without hyperlordosis. In the non-hyperlordosis group, belt use had no significant effect on EMG activity in the investigated muscles during either the squat or deadlift tasks. However, in the hyperlordosis group, the belt significantly reduced the activity of the gluteus maximus and external oblique muscles only during the deadlift task. Furthermore, no significant differences were observed in erector spinae muscle activity between groups across exercises and conditions. Nevertheless, during the squat without the belt, the activity of the erector spinae was significantly

higher in the hyperlordosis group compared to the non-hyperlordosis group. Similarly, during the deadlift, the activity of the erector spinae and gluteus maximus was significantly greater in the hyperlordosis group than in the non-hyperlordosis group.

Therefore, it appears that for female athletes without hyperlordosis, using a weightlifting belt during squats and deadlifts may not provide additional benefit in reducing the activity of the muscles investigated in this study. Conversely, for female athletes with hyperlordosis, the changes recorded in the present study suggest that the use of such belts could be beneficial in reducing the activity of certain muscles. Previous research on the impact of lumbar belts on core muscle activity has yielded contradictory results (27).

**Table 4.** Comparison of the electromyographic activity of selected muscles between female student-athletes with and without lumbar hyperlordosis during squat and deadlift tasks performed with and without a weightlifting belt

| Test         | Muscle           | Group                 | Squat (%MVIC) | U   | Z      | p-value | Deadlift (%MVIC) | U   | Z      | p-value |
|--------------|------------------|-----------------------|---------------|-----|--------|---------|------------------|-----|--------|---------|
| Without belt | Erector spinae   | Without hyperlordosis | 37.71 ± 24.22 | 76  | -2.359 | 0.018*  | 83.77 ± 22.22    | 76  | -2.185 | 0.414   |
|              |                  | Hyperlordosis         | 21.43 ± 37.19 | 103 | -1.429 | —       | 24.54 ± 26.15    | 103 | -1.320 | —       |
|              | Gluteus maximus  | Without hyperlordosis | 77.70 ± 34.28 | 109 | -1.223 | 0.221   | 38.93 ± 24.18    | 109 | -1.751 | 0.380   |
|              |                  | Hyperlordosis         | 58.10 ± 43.26 | 96  | -1.671 | —       | 23.78 ± 36.22    | 96  | -1.587 | —       |
|              | External oblique | Without hyperlordosis | 54.27 ± 36.26 | 102 | -1.464 | 0.143   | 0.68 ± 39.29     | 102 | -1.802 | 0.344   |
|              |                  | Hyperlordosis         | 72.86 ± 46.17 | 104 | -1.395 | —       | 13.27 ± 54.26    | 104 | -1.415 | —       |
| With belt    | Erector spinae   | Without hyperlordosis | 68.05 ± 24.25 | 69  | -2.284 | 0.105   | 34.44 ± 16.16    | 69  | -2.347 | 0.045*  |
|              |                  | Hyperlordosis         | 34.43 ± 35.17 | 80  | -1.137 | —       | 61.37 ± 26.15    | 80  | -1.489 | —       |
|              | Gluteus maximus  | Without hyperlordosis | 6.24 ± 32.27  | 102 | -1.185 | 0.305   | 45.51 ± 20.12    | 102 | -1.443 | 0.038*  |
|              |                  | Hyperlordosis         | 98.69 ± 36.23 | 89  | -2.018 | —       | 95.03 ± 28.16    | 89  | -1.570 | —       |
|              | External oblique | Without hyperlordosis | 2.67 ± 40.28  | 101 | -2.142 | 0.425   | 67.02 ± 39.28    | 101 | -2.284 | 0.689   |
|              |                  | Hyperlordosis         | 15.19 ± 41.13 | 94  | -1.728 | —       | 71.85 ± 39.23    | 94  | -1.302 | —       |

Values are expressed as mean ± standard deviation.

\*Statistically significant at  $p < 0.05$ .

MVIC, maximum voluntary isometric contraction.

**Table 5.** Effect sizes for muscle activity levels between the hyperlordosis and non-hyperlordosis groups during squat and deadlift tasks performed with and without a weightlifting belt

| Test condition | Muscle           | Squat effect size | Deadlift effect size |
|----------------|------------------|-------------------|----------------------|
| Without belt   | Erector spinae   | 0.60 <sup>‡</sup> | 0.17                 |
|                | Gluteus maximus  | 0.32              | 0.56 <sup>‡</sup>    |
|                | External oblique | 0.45              | 0.54 <sup>‡</sup>    |
| With belt      | Erector spinae   | 0.49              | 0.64 <sup>‡</sup>    |
|                | Gluteus maximus  | 0.19              | 0.59 <sup>‡</sup>    |
|                | External oblique | 0.04              | 0.01                 |

<sup>‡</sup>Medium effect size according to Cohen's criterion ( $d \geq 0.50$ ).

Mechanical considerations of the lumbar spine are of particular importance, as the lumbar vertebrae and intervertebral discs experience the highest mechanical loads in the spinal column; furthermore, muscle strength, weakness, or atrophy can be influenced by changes in lumbar lordosis (6). In contrast, some studies reported that using a protective belt during deadlifts and similar simulated load-lifting tasks—repeated for approximately 5 minutes—reduced erector spinae activity in healthy individuals (42). These studies found that the belt reduced the angle between the vertebrae (L1 and S1), thereby decreasing pressure on the spine, as the pelvic belt supports the upper lumbar joints and limits pelvic motion. In hyperlordosis, the hip flexors and lumbar extensors become shortened (43, 44). Under these conditions, due to increased muscle tension—particularly in the lumbar erector spinae—using a belt may be an effective strategy to prevent overstretching these muscles (45).

The increased activity of the gluteus maximus and external oblique muscles in individuals with hyperlordosis can be justified from two perspectives. First, the length-tension relationship suggests that the external oblique remains in a shortened position for a longer duration during the deadlift compared to the squat. Second, based on the theories of Kendall et al., weakness in the abdominal muscles and hip extensors leads to anterior pelvic tilt, which subsequently exacerbates lumbar lordosis (16, 46). Regarding dynamic electromyography, it has been suggested that the biomechanical changes induced by a specialized weightlifting belt can reduce the activity of certain muscle fibers. Ultimately, this prevents the generation of excessive shear and compressive forces in individuals with hyperlordosis, who are typically more susceptible to such structural injuries. However, in the present study, erector spinae activity in individuals with hyperlordosis showed no significant difference between the two exercises without a belt.

In contrast, another study reported an increase in intramuscular pressure of the erector spinae during use of a belt across 8 sets of 20 repetitions of deadlifts; this finding appears inconsistent with our results, as we

observed no significant effect on paraspinal muscle activity under similar conditions (47). Furthermore, a study involving seven men with low back pain and increased lordosis found that isometric activity of the transverse abdominis, obliques, and rectus abdominis significantly increased when wearing a belt, leading to enhanced intra-abdominal and intra-lumbar pressure and spinal stabilization (48). Discrepancies between the results of the present study and previous research may stem from various factors, including gender differences, anthropometric variations, physical fitness levels, and the quality of the instrumentation used. For instance, a study conducted on 11 male subjects during squats with 10 and 20 kg loads (49) indicated that while the use of a belt combined with proper breathing control significantly reduced back muscle activity during repetitive lifting, the activity of abdominal muscles, including the rectus abdominis and erector spinae, actually increased.

Therefore, the claims regarding the advantages of belt usage remain controversial, as the thoracic cage configuration and the specific pressure exerted by the belt may lead to varying effects (50). One study examined the effect of a pelvic support belt in individuals with sacroiliac joint pain—a condition responsible for 15% to 20% of low back pain cases. The findings indicated that the belt induced compression of the sacroiliac joint and reduced the loading forces on the interosseous, posterior, sacrospinous, and sacrotuberous ligaments. Furthermore, it was noted that pelvic belts cause irregular bony structures to rotate outward, ultimately resulting in joint compression and reduced mobility of the sacroiliac joint. However, the therapeutic mechanisms depend heavily on the belt's positioning. As is well known, chronic or acute mechanical defects in bony structures compromise spinal stability. To maintain a normal level of stability, the core muscles must compensate for these impairments. This raises the long-standing question of whether an abdominal belt or increased intra-abdominal pressure can provide the necessary stability (51). In this regard, a study investigating the squat exercise at 90% of one-

repetition maximum (1RM), with and without a belt, reported no significant differences in gluteus maximus and erector spinae muscle activity, which aligns with the present study's results (52). However, movement velocity was significantly higher with the belt. This suggests that the belt may reduce compressive forces on the spinal discs, thereby enhancing upper-body stability and reducing the risk of flexion. However, it might lead to atrophy or weakness of the abdominal muscles.

### Limitations

Several limitations of the present study should be acknowledged. First, the findings are generalizable only to non-pregnant female athletes without musculoskeletal disorders; therefore, results might differ if the study were conducted on non-athletic women. Second, the scope of this research was limited to traditional squat and deadlift exercises performed at a specific load, meaning the results may not generalize to other bodybuilding exercises or varying load intensities. The selection of female students with higher physical fitness was intended to ensure the participants' ability to handle barbell loads, maintain correct technique, and prevent injuries during the study.

Additionally, this study included only women with BMI within the normal range. Including participants with higher BMI could have compromised the accuracy of EMG recordings for the external oblique muscle due to increased subcutaneous adipose tissue in the abdominal region. Furthermore, only a select group of muscles accessible via surface EMG was investigated; the activity of other core muscles, such as the multifidus, quadratus lumborum, rectus abdominis, and internal oblique, was not assessed. Finally, the use of a standardized weight rather than individual-specific loads, along with anthropometric variations and the impact of abdominal fat on the signal quality of the external oblique muscle in some participants, constitutes further limitations of this study.

### Recommendations

Future research would benefit from a larger, more diverse sample, including both genders and various age groups, while also incorporating the activity of other core muscles. Additionally, investigating the impact of different belt types on lower-limb muscle activity and coordination patterns under heavier loads in individuals with other postural abnormalities is warranted. It is also suggested that the effects of various belts be evaluated across endurance, strength, and concurrent training protocols to determine their efficacy in preventing muscle injuries during fatigue or during low-resistance,

high-repetition exercises. Finally, conducting similar studies on non-athletic populations exposed to heavy or repetitive lifting in daily life—such as homemakers or office workers—could provide valuable insights into the mechanisms of core muscle injury and the onset of mechanical low back pain.

### Conclusion

The present study demonstrated that the use of a weightlifting belt reduced activity of the external oblique and gluteus maximus muscles in women with hyperlordosis. While a decrease in erector spinae activity was observed in both groups during squats and deadlifts, this change was not statistically significant. It appears that for female athletes with hyperlordosis, weightlifting belts may positively affect EMG activity in the gluteus maximus, erector spinae, and external oblique during these exercises. In contrast, no such advantage was observed in women without hyperlordosis. Given the lack of significant differences between the two groups when using a belt, it seems more logical to emphasize proper movement technique and implement corrective protocols prior to heavy lifting rather than rely on bodybuilding belts. In other words, prioritizing proper postural alignment and preventing hyperlordosis may be the most critical factor in regulating the activity of the paravertebral, gluteus maximus, and external oblique muscles during squats and deadlifts.

### Acknowledgments

The authors express their gratitude to Mr. Dr. Mohammadreza Hatfi and all the people who provided materials in the implementation of this research project, and they also express their gratitude to the officials of the educational group and laboratory for achieving the related goal.

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sports pathology and corrective movements of Saleha Bagheri (registration code 2913600, code of ethics: IR.ATU.REC.1401.053). It was organized without financial support.

### Funding

This study is based on the secondary analysis of part of the information extracted from the master's thesis of

### Conflict of Interest

The authors did not have a conflict of interest.

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