Correlation between the Endurance of Core Stability Muscles and Low Back Pain in Women Athletes with Lumbar Hyperlordosis

Neda Nematzadeh [a], Razieh Yousefian Molla [a*], Neda Boroushak [b]

a Department of Sports Biomechanics, Central Tehran Branch, Islamic Azad University, Tehran, Iran ; ***b*** Sport Science Research Institute of Iran (SSRII), Sports Biomechanics Department, Tehran, Iran

* ***Corresponding author***: Razieh Yousefian Molla, Department of Sports Biomechanics, Central Tehran Branch, Islamic Azad University, Tehran, Iran. ***E-mail***: razieh.yousefianmolla@iau.ac.ir

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Abstract

Introduction: Lumbar hyperlordosis is a common problem among athletes, characterized by an excessive increase in the lumbar arch which can lead to chronic Low Back Pain (LBP). The central stabilizing muscles of the trunk are crucial for maintaining proper stability and alignment of the spine. Weakness in these muscles can increase the lumbar arch's severity and associated pain. This study aimed to investigate the correlation between the endurance of different groups of core stability muscles and pain in women athletes with lumbar hyperlordosis. **Materials and Methods:** 36 female athletes with lumbar hyperlordosis were randomly selected and examined. The study assessed the endurance of the different central stability muscles, including trunk flexors, extensors, and lateral flexors, using McGill tests. Additionally, the athletes' level of LBP was measured using the Visual Analog Scale (VAS). Data analysis used multiple linear regression to assess the correlation between muscle endurance and pain. **Results:** None of the endurance variables of the four central stability muscles are significantly associated with the pain of subjects with hyperlordosis ($P \geq 0.05$). According to the reported beta values, the endurance of the muscles of the trunk extensor, left lateral flexor, right lateral flexor, and trunk flexor have the greatest association with LBP of athletes with lumbar hyperlordosis ($P \geq 0.05$). **Conclusion:** These findings suggest that increasing the endurance of the central stabilizing muscles, could not significantly reduce LBP in athletes with lumbar hyperlordosis, for this reason, there is no need to separate the strengthening of the core muscles to reduce LBP These results could be used to develop targeted exercise programs to correct posture and reduce pain in this population.

Keywords: Athlete; Core stability; Lordosis; Low Back Pain; Pain

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Introduction

Lumbar hyperlordosis is a common problem among women athletes that can lead to pain and discomfort in the lower back region (1). This condition occurs when there is an excessive increase in the natural arch of the lower back, negatively affecting an athlete's performance and quality of life(1). In these athlete LBP is often caused by pressure on the musculoskeletal structures of the lower back (2). Studies showed that hyperlordosis is more common in sports that require increased arching of the lower back and high flexibility, such as gymnastics and ballet (2). Increased mechanical load on the lower back and weakness of the core muscles can contribute to this condition (1). As core stability muscles play a vital role in maintaining proper stability and alignment of the spine many researchers are interested in assessing the relationship between core stability muscles and lumbar hyperlordosis, (2, 3). Muscle endurance is the ability of the muscles to contract repeatedly for a certain period until the muscles feel weak (3). The function of the core muscles as spinal stabilizers causes muscle weakness if endurance performance decreases. (14). Core muscle endurance (CME) indicates the capacity of core muscles to maintain their activity for long periods (7). It has been reported that core muscles are accountable for spinal stability; thus, lack of endurance may cause deterioration of functional mobility and spinal stabilization (7). Weakness or imbalance in these muscles can lead to undesirable changes in motor patterns and increased lumbar arch (3). It is well known that strengthening the muscles of core stability in lumbar problems, especially hyperlordosis, is crucial (4). These muscles include the abdominal muscles, lumbar muscles, and muscles around the pelvis that can help reduce pressure on the spine,

prevent pain, and create proper balance and stability. Strengthening these muscles can improve posture and reduce LBP in women athletes with hyperlordosis (4). Several studies have examined the effect of strengthening the core-stabilizing muscle on lumbar hyperlordosis (4, 5). Some of these studies have shown that exercise programs focused on strengthening these muscles can reduce lumbar arch and improve LBP (5). In a study by Chan *et. al.* (3), they found that athletes who worked to strengthen the muscles of central stability significantly are successful in reducing LBP and lumbar arch. In a survey conducted by Hodges *et al.* (6), the effect of central stability exercises on chronic LBP was examined. The results of this study showed that exercises focused on strengthening the transverse abdominal muscles and multifidus muscles significantly reduced pain and enhanced patients performance (6).

To increase the effectiveness of exercise programs, it is important to recognize individual differences between athletes and provide training programs tailored to the individual's needs. (7). Studies have shown a correlation between the endurance of different groups of muscles responsible for central trunk stability and pain in women athletes with lumbar hyperlordosis (7). However, it remains unclear which group of these muscles is more closely associated with the pain experienced by athletes with lumbar hyperlordosis. Lumbar hyperlordosis can result in chronic LBP and affect the endurance of various central stabilizing muscles of the trunk, including flexors, extensors, and lateral flexors to varying degrees (8). For instance, the core stabilizing muscles of the trunk, particularly the lumbar extensors, play a crucial role in maintaining the proper position of the spine and reducing the load on it (9). As greater endurance leads to a better ability to withstand mechanical and prolonged stress, strengthening these muscles can help improve endurance and reduce pain in women with hyperlordosis (10). Hence, focusing on strengthening different groups of central stability muscles can lead to more effective training plans and the development of appropriate treatment strategies to alleviate pain associated with hyperlordosis. This research aims to thoroughly examine the correlation between the endurance of various groups of core muscles and the pain felt by women athletes with lumbar hyperlordosis.

Materials and Methods

The current study was a cross-sectional study. The statistical population for this study comprised 40 women with hyperlordosis, who visited the local sports club. Out of this population, 36 subjects were selected based on a simple random sampling technique used for the selection and calculation of the sample size.

All subjects completed an individual consent form, and the research was conducted by the Kharazmi University's Institute of Kinesiology Research Center with the approved ethics code of: IR-KHU.KRC.1000.196.

This study included women athlete aged 30 to 45 with mild to moderate lumbar hyperlordosis and body-building sports history of 2 to 6 months. Exclusion criteria were skeletal-muscular injuries, previous surgeries, and unwillingness to participate in the research. The study was a single-blind study and the evaluation and testing procedures were conducted by an expert in corrective movements. After determining the lumbar lordosis degree in the participants, the endurance of the different flexors, extensors, right lateral flexors, and the left lateral flexor of the muscles of the central stability of their trunk were assessed by the McGill test (11). Their LBP were assessed by VAS too(12), and then the correlation of the endurance of the different muscle groups of the central stability of the trunk with the LBP of the subjects was estimated. The Flexi Curve Ruler was used to determine mild to moderate lumbar hyperlordosis and spinal curvature of the Flexi Curve Ruler, made in Taiwan, with a tenth-degree accuracy and a base coefficient of 97 percent(13). To perform the lumbar curvature test, the subject stood completely comfortably and naturally with bare feet on a pre-determined surface. The subject was asked to open his legs shoulder-width apart face the opposite direction and sit completely normally and comfortably. Then the researcher was placed behind the subject's head to find the reference points. These points are characteristic back and upper spines, which are evaluated using two indentations in the lower region of the back. By using anti-allergic magic, the skin of these points was marked. Then these points were connected by a straight line, which according to Gray's anatomy, the external appendage is level with S2. With the fingers on both sides of the person, the pressure was brought to the top of the crown of the person so that the soft tissues move aside and the two thumbs reach the person's back, parallel to the horizon, according to Gray's anatomy, the outer appendage of the fourth lumbar vertebra is on the same level. By counting the spines upwards, process found the first lumbar vertebra and was marked with magic. Then, the flexible ruler was placed on the specified points (S2, L1), and the same pressure was applied along the length of the ruler so that there was no space between the ruler and the subject's skin, and the ruler assumed the shape of the waist arch. Then the ruler was removed from the person's back and without changing the shape, the arc created on it was drawn on the paper. To draw the curve, the line should be drawn from the side where the line is tangent to the skin, then the marks are erased and after resting for a minute, the subject was asked to place it again on the specified

place with the condition that was explained and the measurement was done again in the same way. This procedure was performed three times for each subject and the average score obtained was recorded (13).

For assessing LBP, the VAS was used. The reliability of VAS was concluded by confirming a correlation coefficient of r=0.902 in Iran (12, 14). This scale uses a 10 cm ruler with "no pain" on the left end and "worst possible pain" on the right end. A score of 10 indicates the most severe pain, while a score of 0 indicates no pain. Mild pain falls within the range of 1-3, moderate pain from 4-7, and severe pain from 8-10. The subject determined their pain score by marking on the ruler (12).

The McGill assessment test is used to assess the endurance of different groups of central trunk stability muscles (15). The reliability of the test was concluded by confirming a correlation coefficient of r=0.88in Iran. The test involves assessing trunk flexors, trunk extensors, and right and left side flexors of the trunk. Each test will be performed once, with 3 minutes of rest taken between each test. The purpose of this endurance test is to measure the maximum time the body can remain in a static position. The tools required include a bed, a sloping surface with a 60-degree angle, and a timer. The recorded duration will be measured as seconds (15).

During the endurance test of the trunk flexor muscles, the athlete will sit on the bed at a 60-degree angle of flexion. The knees and thighs are placed at 90 degrees of flexion, the hands are crossed over the chest, and a strap is used to tighten the legs. The sloping surface of the bed is then placed horizontally, and the athlete is asked to maintain the trunk at the same angle. The duration of maintaining this position is recorded, and the test ends when athletes are unable to maintain the position. Next, the endurance of the trunk extensor muscles is assessed using the Sorensen test in the prone position. The higher parts of the pelvis are positioned off the upper edge of the bed, and the pelvis, thighs, and legs are secured to the bed using a strap. A chair of the same size as the bed is placed in front of the athlete to support his trunk and upper extremity. The chair is then pulled back, and the maximum duration the trunk remains in the horizontal position is considered as an indicator of the endurance of the trunk extensors. The test for the lateral flexor muscles of the trunk involves assuming the lateral bridging position. In this endurance test, the hip joint is kept flat with zero-degree flexion, and the knee is in flexion position. The upper leg is then placed in front of the lower leg, and the athlete lifts the pelvis from the bed, supporting its weight with the lower elbow and upper leg. The upper hand is placed on the opposite shoulder, and the duration of maintaining each of these conditions is recorded as the endurance score (15).

The statistical analysis for the study was done using the SPSS software Version 21. Descriptive statistics such as mean and standard deviation were used to summarize the research variables. The normal distribution of the data was assessed using the Kolmogorov-Smirnov test. Additionally, the Enter method of multiple linear regression was used to analyze the relationship between central stability muscles and LBP in athletes with lumbar hyperlordosis. To perform the statistical analysis process, partial correlation command was used in SPSS software from tolerance and VIF statistics of Venice, and variables such as physical fitness factors and elite level and skill of athletes were controlled and removed.

Results

Table 1 shows descriptive statistics on the characteristics of the athletes and the variables of the research.

The results of the Kolmogorov-Smirnov test indicated that, data were distributed normally ($P \geq 0.05$). Multiple linear regression analysis were used to estimate inferential statistics and analyze the correlation between different groups of central body stability muscles and LBP in women athletes with lumbar hyperlordosis. The results of the linear regression test can be seen in Table 2. Based on the reported coefficient, none of the endurance variables of the four central stability muscle groups are significantly associated with the LBP of athletes with hyperlordosis. According to the reported beta values, the endurance of the muscles of the trunk extensor, left lateral flexor, right lateral flexor, and trunk flexor have the greatest regression effect on the LBP of women athlete with lumbar hyperlordosis.

Based on the results in Table 2 of the correlation coefficient analysis section, it was found that the left lateral flexor muscle endurance, extensor muscle endurance, right lateral flexor muscle endurance, and flexor muscle endurance were the variables most correlated with the LBP.

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Discussion

In our study, we investigated the relationship between the endurance of different muscle groups in the central stability of the trunk and LBP in women athletes with lumbar hyperlordosis. The results of the present study indicated there is not a significant

Table 1. Mean and standard deviation of the demographic characteristics of the athletes

Variables	Mean (SD)
Pain (Number)	1.48 (6.15)
Flexor core stability muscles endurance (s)	38.19339 (435.78)
Extensor core stability muscles endurance (s)	22.59 (237.21)
Right Side Flexor core stability muscles endurance (s)	4.39 (80.57)
Left Side Flexor core stability muscles endurance (s)	4.91 (85.30)
BMI (kg/m^2)	0.87 (31.72)
Body-building Sports Background (month)	1.43 (3.06)
Age (yrs.)	5.10 (36.18)
LBP	Mild: 6 athletes ; Moderate: 30 athletes

Table 2. Results of the regression correlation analysis of various core muscle groups with LBP in women athlete with lumbar hyperlordosis

Coefficients [a]								
Unstandardized coefficients			Standardized coefficients			correlations		
Model	B	Std Error	Beta	t	sig	zero order	partial	part
1 Constant	-1.26	9.08		-0.13	0.89			
Stability of core flexors	-0.007	0.00	-0.16	-0.91	0.36	-0.17	-0.16	-0.15
Stability of core extensors	0.01	0.01	0.16	0.86	0.39	0.15	0.15	0.14
Stability of core right lateral flexor	0.04	0.06	0.12	0.63	0.53	0.07	0.11	0.10
Stability of core left lateral flexor	0.05	0.05	0.15	0.90	0.37	0.16	0.16	0.15

Dependents Variable: LBP

correlation between muscle endurance and the presence of LBP. Therefore, Strengthening these muscles separately cannot improve lumbar conditions and reduce pain, with these results are in line with previous studies (16). This study suggests that exercises aimed at increasing the endurance of these central stability muscles can lead to improved back conditions and reduced pain. These findings are consistent with previous studies that have shown the role of muscle weakness in the development of LBP in women athletes (5, 6, 17, 18).

In a heterogeneous study conducted by Jones *et al.* (19), it was found that strengthening the muscles of central stability has little effect on reducing LBP in women athletes with hyperlordosis. The researchers suggested that other factors such as the flexibility of the thigh and trunk muscles could be causing LBP in these individuals. Similarly, another heterogeneous study by Smith *et al.* (20) showed that lumbar-pelvic muscle strengthening exercises, which are part of the deep muscles, have a limited effect on improving LBP in these individuals. The researchers believed that factors such as anatomy of spine in each women and movement patterns also played a significant role in the incidence of LBP in hyperlordosis.

The results of this study are in line with the findings of Williams *et al.* (21), indicating that increased muscle endurance and core stability have a significant effect on reducing LBP in athletes women with hyperlordosis. The researchers also noted that factors such as previous injuries, weakness in thigh and trunk muscles, and improper movement patterns may also contribute to the development of LBP in these individuals. Additionally, a study by Nadler *et al.* (22) discovered a significant correlation between central stability endurance and lumbar pain in athletes women with lumbar hyperlordosis. Discrepancies in these findings may be attributed to variations in the methods used to assess central stability endurance and LBP, as well as differences in sample populations. Therefore, careful selection of methods for assessing central stability endurance and LBP in women athletes with lumbar hyperlordosis is crucial for obtaining more accurate results. Also, a study conducted by Chen *et al.* (23) demonstrated a significant correlation between the strength of thigh and trunk muscles and LBP in individuals with hyperlordosis. The researchers emphasized that factors such as previous injuries and improper movement patterns may have a more pronounced impact on these individuals. In all of these similar studies, the methods of assessing the endurance of core muscles were similar and were based on McGill.

The study by Leetun *et al.* (24) and Hibbs *et al.* (25) found that there is no significant correlation between the endurance of the muscles of the central stability of the trunk and the presence of LBP in women athletes. These results are in contrast to the findings of our present study. The possible reason for this lack of correlation could be attributed to the differences in the level of exercise activity and severity of LBP among women athletes,

as these factors could influence the pattern of core stability muscle endurance and the pattern of LBP. It should also be noted that this study assessed core muscle endurance with a different method with the modified pain tolerance test, which is completely different from the McGill test. Additionally, the study by Hides *et al.* (26) showed that clinical trials of central stability muscles such as transverse abdominal and multifidus were not associated with chronic LBP in patients. This finding is consistent with the results of our studies, which reported a lack of correlation between the endurance of the central stability trunk muscles and the presence of LB P in women athletes. This suggests that factors other than simply the endurance of these muscles may affect LBP. Moreover, the results of the study by Brumitt *et al.* (27) indicated that, although exercises to strengthen the muscles of central stability of the trunk are useful for improving athletic performance, there is insufficient evidence to link them for reducing LBP. The absence of meaningful evidence may be due to the complexity of LBP, which is often multifaceted and influenced by various factors. Therefore, a more holistic approach that takes into account these additional factors may be necessary to fully understand the relationship between exercises to strengthen the muscles of central stability of the trunk and LBP.

Due to the limitations of the present study, such as the small sample size and the lack of access to men who inherently have higher muscle endurance, it is recommended to conduct further studies with larger sample sizes and more appropriate designs to confirm and complete the results of the study. These further studies should also examine the role of other influencing factors, such as strength, flexibility, and muscle coordination, in the development and progression of lumbar hyperlordosis. Additionally, it is important to develop targeted rehabilitation programs to strengthen and coordinate the muscles of central stability and improve the performance of athletes with LBP.

Conclusion

The results of the present study indicate that there is no significant correlation between the endurance of the central stability muscle groups and the presence of pain. These findings suggest that increasing the endurance of the central stabilizing muscles, could not significantly reduce low back pain in athletes with lumbar hyperlordosis, for this reason, there is no need to separate the strengthening of the core muscles to reduce back pain. This, in turn, can lead to the development of more effective rehabilitation and prevention programs. Furthermore, a better understanding of the link between central stability muscle endurance and pain in lumbar hyperlordosis can help identify risk factors and possible predictors of the disorder.

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Ethical consideration

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Conflict of interest

None.

Authors' contributions

NN and NB: Supervision, data duration, formal analysis, investigation, and methodology, writing, original draft. NN and RYM: supervision, resources, and writing, original draft. All authors read and approved the final manuscript.

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