Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

The Effect of Eight Weeks of National Academy of Sports Medicine and Kinetic Chain Training on Lordosis, Pelvic Tilt, and Hip Joint Range of Motion in Individuals with Lower Crossed Syndrome

Leila Ghadirian Marnani[1], MSc; Hooman Fatahi[1*], PhD; Mehrnoush Esmaeilian[2], PhD; Saeid Rostami[2], PhD

[1] Department of Physical Education and Sports Sciences, Isfahan (Khorasgan) branch, Islamic Azad University, Isfahan, Iran.

[2] Department of Physical Education and Sports Sciences, Faculty of Humanities, Ragheb Esfahani Institute of Higher Education, Isfahan, Iran.

ARTICLE INFO

Article History:

Received: 28/08/2023

Revised: 24/04/2024

Accepted: 09/06/2024

Keywords:

Hip Joint Range of Motion

Kinetic Chain

Lower Crossed Syndrome (LCS)

National Academy of Sports Medicine (NASM)

Please cite this article as:
Ghadirian Marnani L, Fatahi H, Esmaeilian M, Rostami S. The Effect of Eight Weeks of NASM and Kinetic Chain Training on Lordosis, Pelvic Tilt, and Hip Joint ROM in Individuals with Lower Crossed Syndrome. JRSR. 2025;12(3):25-31. doi:10.30476/jrsr.2024.100027.1415

ABSTRACT

Background: Lower Crossed Syndrome (LCS) is characterized by muscle imbalances and reduced flexibility, often leading to altered posture and movement dysfunctions. This semi-experimental pre-test/post-test study compared the effects of National Academy of Sports Medicine (NASM) exercises and kinetic chain training on lumbar lordosis, pelvic tilt, and hip joint range of motion (ROM) in individuals with LCS.

Methods: Thirty participants with LCS were purposefully and conveniently selected and randomly assigned to three groups: NASM, kinetic chain, and control. The NASM and kinetic chain groups completed an 8-week training program, with three sessions per week. Lumbar lordosis angle was measured using a flexible ruler, pelvic tilt angle was assessed via a tilt meter, and hip joint ROM was measured using a goniometer before and after the intervention. Data were analyzed using repeated measures ANOVA with significance set at $P < 0.05$. Analysis was performed with SPSS version 26.

Results: Both NASM and kinetic chain training significantly reduced lumbar lordosis ($P = 0.000$) and anterior pelvic tilt ($P = 0.000$), and increased considerably hip joint ROM in both flexion and extension ($P = 0.000$). Post-hoc analyses revealed that NASM exercises had a greater impact on reducing lumbar lordosis, anterior pelvic tilt, and increasing hip flexion ROM than kinetic chain exercises. Conversely, kinetic chain training was more effective in increasing hip extension ROM than NASM exercises.

Conclusion: Both NASM and kinetic chain exercises are practical corrective interventions for improving posture and mobility in individuals with LCS. NASM exercises are particularly beneficial for reducing lumbar lordosis and anterior pelvic tilt and enhancing hip flexion ROM, whereas kinetic chain exercises are more suitable for improving hip extension ROM.

Introduction

Lower Crossed Syndrome (LCS) is a postural abnormality characterized by anterior pelvic tilt (APT) and muscular imbalances in the lower body. Muscle balance around the pelvis is crucial in maintaining normal lumbar

* *Corresponding author:* Hooman Fatahi; Assistant Professor, Assistant Professor of corrective exercise and sport injry, Department of Physical Education and Sports Sciences, Isfahan (Khorasgan) branch, Islamic Azad University, Isfahan, Iran, **E-mail**: hoomanfatahi92@yahoo.com; **Tel**: 00989163188344.; **ORCID:** 0009-0005-9573-4270

lordosis [1]. LCS arises due to imbalances in the lumbopelvic region, where the force couple of the lumbar extensors and hip flexors, prone to tightness, overpowers the force couple of the hip extensors and abdominal muscles, prone to weakness. This imbalance leads to anterior pelvic tilt and an increase in lumbar lordosis [2]. Normal lumbar lordosis protects the spine against excessive mechanical stress and is a shock absorber during movement [3].

Lower Crossed Syndrome (LCS) is characterized by an imbalance involving tight hip flexors and lower back muscles intersecting with weakened abdominal and gluteal muscles. Specifically, tightness is observed in the thoraco-lumbar extensors on the dorsal side, corresponding to tightness in the iliopsoas and rectus femoris. In contrast, the deep abdominal muscles exhibit weakness and reduced strength in the gluteus maximus and medius [2]. This distinct pattern of muscular tightness and weakness in LCS contributes to predictable joint dysfunctions, movement imbalances, and an increased risk of injury. Commonly affected joints include the subtalar, tibiofemoral, iliofemoral, sacroiliac, and lumbar facet joints. Furthermore, LCS individuals often demonstrate impaired lumbar spine stabilization during functional activities [4].

One method for correcting hyperlordosis is the corrective exercise protocol developed by the National Academy of Sports Medicine (NASM), presented in 2010. This protocol includes four stages: inhibition, stretching, activation, and integration techniques. In this protocol, restraint exercises should be performed first, followed by stretching using the myofascial release technique instead of simply stretching shortened or tightened muscles. Particularly for weakened muscles, it is advised to use integration exercises rather than merely strengthening them at the end [4].

According to Janda's approach, all body parts are interconnected, and defects in one part can lead to defects in other parts. Therefore, through neuromuscular chains, whole-body kinetic chain exercises can help correct this abnormality. Kinetic chain exercises involve a combination of corrective exercises targeting the knee joint, back, pelvic girdle, and chest area, with general exercises being used instead of localized corrective exercises. Numerous research studies have demonstrated the effectiveness of various exercises in improving abdominal muscle endurance. Dimitrijevic et al. concluded that corrective exercises significantly increased core stability, strength, and flexibility, as well as reduced the degree of lordosis in individuals with hyperlordosis [5].

Kamali et al., in their study titled *"The Relationship Between Selected Parameters of Lower Limb ROM and Biomechanical Parameters of 7–9-Year-Old Boys,"* found that it seems possible to identify the characteristics of children's lower limb range of motion (ROM) and the functional characteristics of sports fields used in different ways [6]. Hindle et al. investigated the mechanism and effect of proprioceptive neuromuscular facilitation (PNF) exercises on the ROM of the hip joint in individuals with lumbar hyperlordosis. After six weeks of PNF exercises, they found a significant increase in hip joint ROM. They concluded that PNF exercises can improve hip joint ROM in individuals with lumbar hyperlordosis [7].

The NASM corrective exercise protocol, myofascial release techniques, and kinetic chain exercise protocols are some of the methods that can be used to correct lumbar hyperlordosis. Corrective exercises can improve not only the lumbar lordosis angle but also the function of other parts of the body. This study seeks to determine whether eight weeks of kinetic chain training and NASM training affect lordosis, pelvic tilt, and ROM of the hip joint in individuals with Lower Crossed Syndrome.

Methods

This study was conducted both in the field and laboratory settings. It employed a pre-test and post-test semi-experimental design to investigate the effectiveness of NASM exercises and kinetic chain exercises in correcting lumbar hyperlordosis in first-grade female students with Lower Crossed Syndrome (LCS) in Isfahan.

The statistical population consisted of 50 first-grade primary school girls in Isfahan diagnosed with LCS. The current research utilized a semi-experimental pre-test and post-test design.

Participants were included in the study if they had a minimum lumbar lordosis angle of 51 degrees, a minimum anterior pelvic tilt (APT) of 9 degrees, a maximum hip flexion range of motion of 120 degrees, and a maximum hip extension range of motion of 30 degrees, all of which were criteria for the diagnosis of LCS.

The sample for the present study was randomly divided into three groups: NASM exercise group, kinetic chain exercise group, and control group, with 10 participants in each group. One week before implementing the intervention protocols, baseline evaluations were conducted. These included measuring lumbar lordosis angle using a flexible ruler, anterior pelvic tilt using a tilt meter, and hip joint range of motion (ROM) using a goniometer. After completing the designated exercises and interventions, all measurements were repeated. This study was conducted in a single-blind manner.

Based on previous studies, the sample size was determined using G*Power software version 1.3 at a significance level of 0.05, an effect size of 0.54, and a statistical power of 0.80. The required sample size was calculated to be 30 participants.

The inclusion criteria consisted of girls aged 7 to 8 years with a minimum lumbar lordosis angle of 51 degrees, a minimum anterior pelvic tilt (APT) of 9 degrees, a maximum hip flexion ROM of 120 degrees, and a maximum hip extension ROM of 30 degrees. Participants were required to attend sessions regularly and to refrain from engaging in any other interventions or physical activities that could affect the condition of the lumbar spine and pelvis.

Exclusion Criteria:

- History of spinal trauma

- Joint dysfunction within the past three months or congenital deformities in the hip or lumbar region
- Recent fractures in related joints within the past six months
- History of abdominal, hip, or lumbar surgeries in the past three months
- Unwillingness to participate in the study

The initial evaluation was conducted one week before implementing the intervention protocols. The assessment included measurement of the lumbar lordosis angle using a flexible ruler (in a standing position), anterior pelvic tilt using a tilt meter (standing), and hip joint range of motion (ROM) using a goniometer (supine position on a bed). The ethical approval code for this study was IR.IAU.KHYISF.REC.1401.139. Before participation, the test and training protocols were explained to the participants, and informed consent was obtained from all subjects.

In this study, lumbar lordosis was measured in all participants using a flexible ruler. The measurement method involved placing the ruler along the spine's natural curvature, with the spinous process of the twelfth thoracic vertebra (T12) as the starting point and the second sacral vertebra (S2) as the arc's endpoint. The ruler was carefully positioned along these anatomical landmarks, marking the corresponding points.

The ruler was then transferred onto a sheet of paper without altering its shape, and the curve was traced using a pencil. After removing the ruler, a straight line connected the S2 and T12 points on the paper. This method enabled an accurate representation of the lumbar curvature for further analysis.

In this study, after determining the values of L (the horizontal distance between T12 and S2) and h (the height of the most concave part of the curve), these values were inserted into the formula for calculating the lumbar lordosis angle for all participants (Figure 1).

Pelvic tilt was measured unilaterally using a tilt meter applied to the right side, with an accuracy of one degree. The subject was positioned comfortably in a standing posture with feet shoulder-width apart. The tilt meter was aligned so that its two ends were placed on the ASIS (anterior superior iliac spine) and PSIS (posterior superior iliac spine), respectively (Figure 2).

To measure the hip joint's range of motion (ROM), both flexion and extension angles were assessed and recorded using a goniometer. For the measurement of hip flexion ROM, the participant was positioned in a supine position with the knees fully extended and the hip in a neutral position (0 degrees of abduction, adduction, and rotation) (Figure 3).

After the NASM and kinetic chain exercise interventions were completed (Table 1,2.3), all assessments were repeated to evaluate their effectiveness.

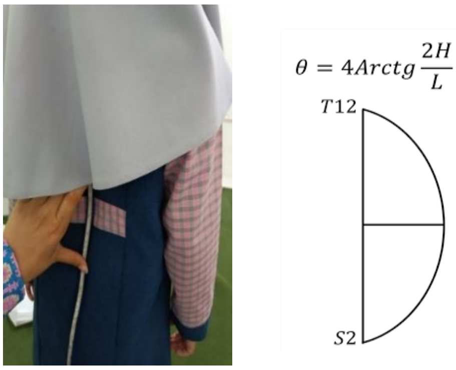

Figure 1: Measurement of Lumbar Lordosis

Figure 2: Measurement of Anterior Pelvic Tilt

Figure 3: Measurement of Range of motion (ROM)

Table 1: Kinetic Chain Exercises Protocol

Row	Exercises	Target muscle	First and second week	Third and fourth week	Fifth and sixth week	Seventh and eighth week
1.	Walking on heels	Stretching of the soleus, gastrocnemius, and hamstring muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
2.	Squat	Strengthening the quadriceps, gloteal, and hamstring muscles	10×3 S	15×3 S	20×3 S	**25×3 S**

Row	Exercises	Target muscle	First and second week	Third and fourth week	Fifth and sixth week	Seventh and eighth week
3.	Puling the leg back	Strengthening the gloteal and hamstring muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
4.	Lanch	Strengthening quadriceps, gloteal, and hamstring muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
5.	Lying with Legs up	Stretching the lumbar muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
6.	Half-seated strech	Stretching the quadriceps muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
7.	Crossed Arms and legs	Strengthening abdominal and chest muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
8.	Lying hip up	Strengthening pelvic girdle muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
9.	Prone head and hands back	Strengthening the trapezius, rhomboid, and the shoulder girdle muscles	10×3 S	15×3 S	20×3 S	**25×3 S**
10.	Prone head and hands up	Stretching the chest muscles	10×3 S	15×3 S	20×3 S	**25×3 S**

Table 2: National Academy of Sports Medicine (NASM) Exercise Protocol

Row	Myofascial release exercises	First week	Second week	Third week	Furth week	Lengthening exercises
1	Inhibition of the rectus femoris muscle with a medicine ball	3×20 S	3×30 S	3×20 S	3×30 S	**Stretching the latissimus dorsi muscle on the floor**
2	Inhibition of the rectus femoris muscle with a PVC pipe	3×20 S	3×30 S	3×20 S	3×30 S	**Stretching the latissimus dorsi muscle with a gym ball**
3	Inhibition of the latissimus dorsi muscle with a PVC pipe	3×20 S	3×30 S	3×20 S	3×30 S	**Stretching the thigh flexor muscle in the kneeling position**
4	Inhibition of the latissimus dorsi muscle with a medicine ball	3×20 S	3×30 S	3×20 S	3×30 S	**Stretching the thigh flexor muscle in a standing position**
5	Adductor muscle inhibition	3×20 S	3×30 S	3×20 S	3×30 S	**Adductor muscle stretch**
6	Paraspinal muscle inhibition	3×20 S	3×30 S	3×20 S	3×30 S	**Stretching of the paraspinal muscle**

PVC: Polyvinyl chloride

Table 3: National Academy of Sports Medicine (NASM) Exercise Protocol

Row	Activation exercises	Fifth week	Sixth week	Eighth week	Seventh week	Integration Exercises
1	Crunch on the ball	3×15	3×20	3×20	3×15	**Squat**
2	Crunches on the floor	3×15	3×20	3×20	3×15	**Squat with ball to overhead press**
3	Bouncing on the ball	3×15	3×20	3×20	3×15	**Squat with weight**
4	Bridge on the ground	3×15	3×20	3×20	3×15	**Squat with one leg to the overhead press**
5	Bringing hands and feet together	3×15	3×20	3×20	3×15	**Walking from the side**
6	Thigh extension	3×15	3×20	3×20	3×15	**Launch with overhead press**

Statistical Analysis

The data followed a normal distribution, as confirmed by the Kolmogorov-Smirnov test. Repeated measures ANOVA, along with the LSD post hoc test, was conducted to compare variables among groups. Statistical analysis was performed using SPSS software (Version 27), with a significance level set at $p < 0.05$.

Results

Table 3 presents the demographic characteristics of the participants, with no significant differences observed among the groups (Table 4).

NASM: National Academy of Sports Medicine

Examining intra-group changes in research variables.

Due to the normal distribution of the data and the quantitative nature of the variables, repeated measures analysis of variance (ANOVA) was used to analyze the pre-test and post-test data for the specified variables ($p < 0.05$). The Shapiro–Wilk test was used to assess the normality of the data(table 5).

The results of the repeated measures ANOVA indicated that, after eight weeks of exercise, the intra-group, inter-group, and interaction effects for pelvic tilt, lumbar lordosis, and hip joint ROM were statistically significant (table 6). This suggests that pelvic tilt, lumbar lordosis, and hip joint ROM changed significantly due to the exercise interventions .

Given the significance of the differences between groups, the LSD post hoc test was employed to conduct pairwise comparisons. After completing the training protocols, the results indicated significant intra-group differences between the pre-test and post-test ($p < 0.05$).

Table 4: Demographic Information (mean ±standard deviation)

Group	n	Age (year)	Height (cm)	Weight (kg)
NASM	10	7/2±0/05	4/3±2/143	3/3±0/40
Kinetic chain	10	0/2±8/7	3/2±1/146	4/1±2/42

Control	10	0/6±5/7	2/1±2/149	2/2±139

Table 5: Examining the Normality of Data with the Shapiro-Wilk Test

Test	Group	Significant (Pre-test)	Significant (Post-test)
Lumbar lordosis	NASM	0/25	0/037
	Kinetic chain	0/46	0/207
	Control	0/151	0/151
Anterior pelvic tilt	NASM	0/2	0/196
	Kinetic chain	0/33	0/86
	Control	0/002	0/32
Hip flexion range of motion	NASM	0/17	0/41
	Kinetic chain	0/1	0/151
	Control	0/54	0/11
Hip extension range of motion	NASM	0/41	0/300
	Kinetic chain	0/51	0/200
	Control	0/11	0/151

Table 6: Descriptive Information and Analysis of Variance Test with Repeated Measures for Variables

Variable	Time	NASM (n=10)	Kinetic chain (n=10)	Control (n=10)	Intragroup changes	Intergroup changes	Interaction
Lumbar lordosis (degree)	Pre-test	60/53	80/53	80/52	50/139 =F 000/0=P	09/176 =F 000/0=P	**17/35 =F 000/0=P**
	Post-test	80/43	00/45	80/52			
Anterior pelvic tilt (degree)	Pre-test	00/18	40/16	60/13	500/253 =F 000/0=P	507/319 =F 000/0=P	**875/67 =F 000/0=P**
	Post-test	00/12	00/12	60/13			
Hip flexion range of motion (degree)	Pre-test	00/100	00/106	00/113	067/1581 =F 000/0=P	501/440 =F 000/0=	**267/31= F 0/000=P**
	Post-test	00/117	40/119	40/113			
Hip flexion range of motion (degree)	Pre-test	60/18	00/21	60/19	131/227 =F 000/0=P	073/328 =F 000/0=P	**F=57/69 P=0/000**
	Post-test	40/32	40/33	60/19			

Discussion

This research aimed to compare the effects of eight weeks of NASM and kinetic chain exercises on lordosis, pelvic tilt, and hip joint ROM. The findings of this research regarding the impact of NASM exercises in improving lordosis are consistent with those of MacDonald [10], Hindle [7], Okhli [8], and Jamali [9]. These findings indicate that strengthening and stretching exercises promote coordination between shortened and lengthened muscles, ultimately reducing APT. In individuals with lumbar lordosis, the abdominal muscles are weakened and lengthened.

Tightness and limited mobility in the trunk are key characteristics of LCS and require appropriate intervention. While numerous studies have examined the effects of training on ROM and pelvic tilt, limited research has specifically assessed the effectiveness of NASM and kinetic chain exercises [10]. Kage et al. reported that stretching and strengthening exercises based on Janda's approach effectively improve the flexibility of the erector spinae muscles [11]. Similarly, Chakraborty et al. (2019) compared motor control exercises with global core stabilization exercises, concluding that motor control exercises are more effective in enhancing ROM and function [12]. Other researchers have also suggested that flexibility exercises improve postural stability and muscle balance [13].

According to previous studies, stretching exercises based on Sahrmann's approach have been shown to increase flexibility. However, our findings indicate that the Janda-based group, despite not incorporating stretching exercises, experienced a greater increase in flexibility. Kinetic chain exercises focus on correcting muscle imbalances, enhancing proprioception and somatosensory input, and ensuring proper motor programming at the central nervous system level [14]. These exercises promote reflexive activation of the movement system, improve dynamic stability by enhancing motor control and minimizing undesired movements, support postural control, and optimize coordinated muscle function [15].

Kinetic chain exercises create beneficial changes by realigning the lower body's joints, particularly the trunk. By increasing the activation of key muscles involved in movement, reducing antagonist muscle coactivation, and improving synergistic muscle coordination, these exercises influence both facilitatory and inhibitory neural impulses [13]. Tightness in tissues often occurs when the nervous system limits joint motion to protect weak core structures from potential damage. A likely explanation for the observed improvements in mobility is that increased proprioceptive and kinesthetic awareness, linked to enhanced core stability, plays a critical role in movement efficiency [16]. The minor increase observed in the kinetic chain exercises group compared to the NASM group may be attributed to differences in pre-test values.

If there is increased abdominal pressure, it contributes to lumbar spinal stability, as anticipated by a buckling model analysis. However, contracting the transversus abdominis or oblique muscles did not significantly impact the level of spinal stability [17, 18]. Imagery exercises significantly altered the electromyographic (EMG) responses of the gluteus maximus and rectus femoris muscles, two lumbopelvic muscles. On the other hand, their impact on the degree and strength of lumbar lordosis was insignificant. When altering the EMG activity of the lumbopelvic muscles and the strength of the abdominal and gluteus maximus muscles, the combined exercise was just as successful as the active exercise [19].

Kinetic chain and NASM exercises are treatment options for managing lower crossed syndrome-related persistent low back pain, in terms of pain and disability, reduced lumbar ROM, and some degree of lumbar lordosis. The internal oblique muscle was substantially more active when sitting compared to the supine position. Standing resulted in significantly more activity in the external and internal oblique abdominals than sitting. The ideal crossing of the legs when seated substantially reduces the activity of the oblique abdominals [1].

When muscles are stretched, tension is reduced, and muscle spindle fibres are stretched, increasing their length [20]. Therefore, this may explain the normalization of tightened muscle length. A previous study concluded that stretching tight muscles and strengthening weak ones is beneficial for normalizing the strength of the abdominals and gluteals and increasing the flexibility of hip flexors and thoracolumbar extensors [11].

Janda’s approach hypothesized that restoring the muscle length of a tight muscle would spontaneously facilitate a weak antagonist. The normalization of muscle length should be followed by specific strengthening, movement re-education, and endurance training. Once peripheral structures are normalized, muscle balance is restored [2]. Therefore, restoring normal muscle length must first be addressed before attempting to strengthen a weakened muscle in the presence of tight antagonistic muscles.

The muscles at the front of the hip joint and the lumbar region are shortened, which can reduce lordosis by strengthening the stretched and weakened muscles and stretching the shortened muscles. The findings of this research are consistent with those of Lee et al. [21] and Sullivan et al. [22] regarding pelvic tilt. The present study showed that the NASM exercise protocol had a more significant effect on pelvic tilt than the kinetic chain exercise protocol, leading to a decrease in APT in this group of subjects. The local kinetic chain exercises were ineffective and wasted time on distal and proximal exercises.

The findings of this research are consistent with those of MacDonald [23, 10], Kila [9], and Zarei et al. [15] regarding the effects of NASM and kinetic chain exercises on the hip joint's ROM. In this study, the NASM exercise protocol had a positive and significant effect on increasing hip flexion ROM. In contrast, the kinetic chain exercise protocol had a positive and significant impact on increasing thigh extension ROM in the subjects.

This study highlights the importance of choosing the appropriate exercise protocol based on the targeted muscle groups and the individual's specific needs. Based on these results, therapists, corrective exercise specialists, and trainers are encouraged to implement these exercise protocols to address lumbar lordosis, APT, and thigh ROM limitations in individuals with LCS. Future research should explore the effects of NASM and kinetic chain exercises on pelvic kinematics using motion analysis systems for a more precise understanding of their biomechanical impact.

Conclusion

The results of this study indicate that both the kinetic chain exercise and NASM protocols are effective in reducing lumbar lordosis and anterior pelvic tilt (APT) while also improving hip joint range of motion (ROM) in individuals with lower crossed syndrome (LCS). Notably, the NASM protocol demonstrated a greater impact on reducing lumbar lordosis and APT and enhancing hip flexion ROM. In contrast, the kinetic chain exercise protocol was more effective in increasing thigh extension ROM.

Acknowledgment

We sincerely thank all the students, experts, and colleagues who contributed to this research.

Conflict of interest: The authors declare no conflicts of interest related to this article.

References

1. Burile G, Phansopkar P, Deshmukh NS, Burile GC, Deshmukh Jr NS. Prevalence of Lower Cross Syndrome in Housemaids. Cureus. 2024 1;16(4).
2. Janda V. Muscles and motor control in low back pain: assessment and management. Physical therapy of the low back. 1987.
3. Jafari Amirkhiz S, Shahbazi B. The Effect of Extra Functional Exercises with and without Functional Muscle Stimulation on the Lumbar Lordosis in Women Aged 20-30 Years in Tabriz. Journal of Sport Biomechanics. 2023 10;9(3):192-202.
4. Clark M, Lucett S, editors. NASM essentials of corrective exercise training. Lippincott Williams & Wilkins; 2010 21.
5. Dimitrijević V, Šćepanović T, Milankov V, Milankov M, Drid P. Effects of corrective exercises on lumbar Lordotic angle correction: a systematic review and meta-analysis. International journal of environmental research and public health. 2022 18;19(8):4906.
6. Kamali M, Ghasemi B, Moradi MR, Bagherian-Dehkordi S. Comparing the effect of two kinds of the traditional and the NASM corrcetive exercises training protocols on the correction of hyperlordosis in female students. Journal of research in rehabilitation sciences. 2015 1;11(2):155-63.
7. Hindle KB, Whitcomb TJ, Briggs WO, Hong J. Proprioceptive neuromuscular facilitation (PNF): Its mechanisms and effects on range of motion and muscular function. Journal of human kinetics. 2012 3;31:105.
8. Okhli H, Hojjati H, Akhoundzadeh G. Comparing the effect of the corrective exercises of America’s National academy of sports medicine and Pilates on the correction of lordosis among female high school students in Golestan Province in 2018. International Journal of School Health. 2019 1;6(4):1-6.
9. Jamali Brayjani S, Alizadeh MH, Amini M. A Review of Corrective

Exercise Protocols in People with Lumbar Lordosis Disorders. Pars Journal of Medical Sciences. 2022 25;18(2):9-18.

10. Niroomand T, Rabiei M, Mohammadi B. Investigating the Effects Janda's and Sahrmann's Correcting Exercise Approaches on Trunk Muscles Function in Young Girls with Lower Crossed Syndrome. Journal of Advanced Sport Technology. 2023 1;7(3):48-58.
11. Kage V, Putti BB. Effectiveness of stretching and strengthening exercises (Janda's approach) in subjects with postural backache: A randomized controlled trial. Int J Physiother Res. 2015;3(6):1301-6.
12. Chakraborty J, Kumar P, Sarkar B. Comparative study of motor control exercises and global core stabilization exercises on pain, rom and function in subjects with chronic nonspecific low back pain-A randomized clinical trial. International Journal of Health Sciences & Research. 2019;9:116-23.
13. Sitges C, Velasco-Roldán O, Crespí J, García-Dopico N, Segur-Ferrer J, González-Roldán AM, Montoya P. Acute effects of a brief physical exercise intervention on somatosensory perception, lumbar strength, and flexibility in patients with nonspecific chronic low-back pain. Journal of pain research. 2021 18:487-500.
14. Ahmad I, Noohu MM, Verma S, Singla D, Hussain ME. Effect of sensorimotor training on balance measures and proprioception among middle and older age adults with diabetic peripheral neuropathy. Gait & posture. 2019 1;74:114-20.
15. Gheitasi M, Khaledi A, Daneshjoo A. The effect of combined core stability and sensory-motor exercises on Pain, Performance and movement fear in retired male athletes with non-specific chronic low back pain. Anesthesiology and Pain. 2020 Apr 10;11(1):38-48.
16. Junker D, Stöggl T. The training effects of foam rolling on core strength endurance, balance, muscle performance and range of motion: a randomized controlled trial. Journal of sports science & medicine. 2019 1;18(2):229.
17. Stokes IA, Gardner-Morse MG, Henry SM. Abdominal muscle activation increases lumbar spinal stability: analysis of contributions of different muscle groups. Clinical biomechanics. 2011 1;26(8):797-803.
18. Waddell G, Burton AK. Occupational health guidelines for the management of low back pain at work: evidence review. Occupational medicine. 2001 1;51(2):124-35.
19. Ghorbani M, Alizadeh MH, Shahbazi M, Minoonejad H. The effect of three methods of kinesthetic imagery, active, and combined exercises on electromyographic pattern of hip hyperextension and the muscle strength of gluteus maximus and abdominal in women with lumbar hyperlordosis. Physical Treatments-Specific Physical Therapy Journal. 2021 10;11(3):145-56.
20. Page P. Current concepts in muscle stretching for exercise and rehabilitation. International journal of sports physical therapy. 2012;7(1):109.
21. Lee SK, Jung JM, Lee SY. Gluteus medius muscle activation on stance phase according to various vertical load. Journal of Back and Musculoskeletal Rehabilitation. 2013 May;26(2):159-61.
22. Sullivan MK, Dejulia JJ, Worrell TW. Effect of pelvic position and stretching method on hamstring muscle flexibility. Medicine and science in sports and exercise. 1992 1;24(12):1383-9.
23. MacDonald GZ, Penney MD, Mullaley ME, Cuconato AL, Drake CD, Behm DG , et al. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. The Journal of Strength & Conditioning Research. 2013 1;27(3):812-21.