

Effect of Bruegger's and Egoscue exercise on anterior pelvic tilt in lower crossed syndrome: a randomized clinical trial

Azka Batool ¹, Muhammad Affan Iqbal ¹

ABSTRACT

Objective: To investigate the comparative effects of Bruegger's exercise and Egoscue exercise on anterior pelvic tilt in individuals with lower crossed syndrome (LCS).

Methods: This single-center, parallel-group randomized clinical trial (NCT06303388) was conducted at Pakistan Railway General Hospital, Rawalpindi. A total of 34 participants (aged 20-50 years) with LCS were randomly allocated into two groups. Group A received Bruegger's exercise, while Group B received Egoscue exercise, alongside standardized conventional physiotherapy (hot packs and muscle stretching). The intervention comprised 12 sessions over four weeks. Anterior pelvic tilt was measured pre- and post-intervention using a pelvic inclinometer. Data were analyzed using the Wilcoxon signed-rank test for within-group comparisons and the Mann-Whitney U test for between-group differences.

Results: The mean age of participants was 26.45 ± 4.41 years, with 85.3% females. Both groups demonstrated significant reductions in anterior pelvic tilt after four weeks (Bruegger's: median 12 to 9, $p < 0.001$; Egoscue: median 12 to 9, $p < 0.001$). Within-group effect sizes were large (Bruegger's $r = 0.63$; Egoscue $r = 0.64$). However, no statistically significant difference was observed between groups at baseline ($p = 0.327$) or post-intervention ($p = 0.793$), with a negligible between-group effect size ($r = 0.04$).

Conclusion: Both Bruegger's and Egoscue exercises significantly improve anterior pelvic tilt in individuals with LCS, with no evidence of superiority of one intervention over the other. However, given its simplicity and ease of execution, Bruegger's exercise may offer a more practical and feasible option in clinical settings.

Clinical Trial Registration Number: NCT06303388

Keywords: Musculoskeletal Diseases (MeSH); Postural Balance (MeSH); Muscle Weakness (MeSH); Back Pain (MeSH); Low Back Pain (MeSH); Lower crossed syndrome (Non-MeSH); Pelvic cross syndrome (Non-MeSH); Anterior pelvic tilt (Non-MeSH); Exercise (MeSH); Lumbar Lordosis (Non-MeSH); Musculoskeletal Pain (MeSH); Warmup Exercise (MeSH).

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INTRODUCTION

Lower crossed syndrome (LCS), also referred to as pelvic crossed syndrome, results from muscular imbalance in the sagittal plane. It is characterized by tightness of the hip flexors and lumbar extensors, along with weakness of the abdominal and gluteal muscles. This imbalance leads to postural dysfunction, most notably anterior pelvic tilt and increased lumbar lordosis (sway back).¹⁻³

Anterior pelvic tilt is defined as a forward rotation of the pelvis and is considered excessive when the inclinometer reading exceeds 10° .¹ Both anterior pelvic tilt and LCS are common postural abnormalities associated with muscle imbalance and are linked to low back pain, altered movement patterns, and an increased risk of musculoskeletal disorders, particularly in individuals with prolonged sitting and repetitive occupational activities.¹⁻⁵ Multiple rehabilitation approaches have been

¹: Department of Physiotherapy, Faculty of Rehabilitation & Allied Health Sciences (FRAHS), Riphah International University, Islamabad, Pakistan

Email  : azkabatool09@gmail.com

Contact #: +92-335-8075871

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proposed for addressing LCS, including stretching, Multiple rehabilitation approaches have been proposed for the management of LCS, including stretching, core stabilization, Pilates, and manual therapy techniques.⁶⁻⁹ Manual interventions such as the Muscle Energy Technique (MET) have also been shown to improve pelvic alignment. For instance, Suresh A, et al., demonstrated that even two sessions of MET resulted in significant correction of posterior innominate tilt, along with reductions in pain and functional disability.⁹ These findings underscore the responsiveness of pelvic tilt as a measurable outcome in postural correction research.

Similarly, Kudchadkar GS, et al., reported that Pilates, Egoscue, and lumbar stabilization exercises were all effective in reducing lumbar hyperlordosis and anterior pelvic tilt, further supporting the role of exercise-based interventions in the management of LCS.¹⁰ Among these, Bruegger's and Egoscue exercises have emerged as promising alternatives. Bruegger's exercise focuses on postural re-education by promoting an upright sitting posture, facilitating thoracic extension, and enhancing activation of spinal stabilizers through diaphragmatic breathing.¹¹ In contrast, Egoscue exercises comprise a structured sequence of corrective movements designed to restore musculoskeletal alignment through positional isometric holds and progressive neuromuscular re-training.^{10,12} Although corrective exercise interventions such as Bruegger's posture, Egoscue routines, Pilates, and stabilization programs have been investigated for postural

correction, the existing literature is limited by methodological shortcomings, including small sample sizes, lack of randomization, and heterogeneity in outcome measures. Moreover, while Egoscue and other exercise-based interventions have been relatively well studied, only a single published study to date has specifically evaluated the effects of Bruegger's exercise in individuals with LCS. Importantly, no randomized controlled trial has directly compared Bruegger's and Egoscue exercise protocols for the correction of anterior pelvic tilt. This gap in the evidence base limits informed clinical decision-making and underscores the need for well-designed trials to determine the comparative effectiveness and feasibility of these interventions in rehabilitation practice.

METHODS

Study design: A single-center, parallel-group, randomized clinical trial (registration number NCT06303388) was conducted to compare the effects of Bruegger's and Egoscue exercises on pain intensity and lumbar hyperlordosis in patients with LCS.

Participants and setting: The study

was conducted at the outpatient department of Pakistan Railway General Hospital, Rawalpindi, Pakistan. A total of 34 participants comprised females and males aged between 20 to 50 years presenting with low back pain, meeting the criteria for LCS, characterized by tight hip flexors (Modified Thomas test), tight erector spinae (visual assessment through toe touching), weak glutei (Prone Hip Extension Coordination/Strength Test) weak abdominals (Trunk Flexion Coordination / Strength Test), and thoracic kyphosis and angle of anterior pelvic tilt $>10^\circ$ were included. Exclusion criteria comprised spinal deformities, trauma, recent surgery, neurological conditions, and ongoing pharmacological pain management.

Randomization and allocation: Participants were recruited through convenience sampling and randomly allocated to two groups using a sealed-envelope method. Randomization codes were placed in sequentially numbered, opaque envelopes prepared by the principal investigator and opened in sequence after participant enrollment to ensure allocation concealment. Participants were blinded to group assignment, whereas the treating

therapist was not blinded due to the nature of the interventions.

Ethical consideration: Approval from the Institutional Review Board of Riphah International University was obtained before commencing a study (Reference #: Riphah/RCRAHS-ISB/REC/MS-PT-01721, dated: November 11, 2023). Each participant signed a written informed consent form before taking part in the research.

Outcome measure: A Pelvic Inclinator was used for pre- and post-assessment to measure the angle of an anterior pelvic tilt associated with LCS. The patient was instructed to stand with feet slightly apart. The inclinometer's arms were positioned evenly on the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS). Once the bubble was centered, the angle was measured in degrees. Anterior pelvic tilt was measured using a CHEK inclinometer, which has shown good to excellent reliability (ICC=0.87-0.98; SEM \approx 1-3.6 $^\circ$) and demonstrated validity through significant correlations with radiographic measures ($r = .51-.68, p < 0.001$).¹³

Sample size: The sample size was calculated using G*Power version 3.9.1.4, assuming an effect size (d) of 1.3 derived from previously published studies.¹⁴ The Type I error rate (α) was set at 0.05, and statistical power ($1-\beta$) at 0.95. Based on these parameters, the required sample size was estimated to be 34 participants, with 17 in each group. To account for potential attrition, the sample size was increased by 20%, resulting in a final target sample of 40 participants.

Intervention: Hot Packs were applied to the lower back for 10 minutes in each group. Additionally, muscle stretching for the hamstrings, iliopsoas, rectus femoris, and tendo-achilles muscles was performed bilaterally for both groups. Three stretches were given with each stretch held for 30 Seconds. Group A followed a protocol of Bruegger's exercise, and Group B followed a protocol of Egoscue exercise. The protocol consisted of 12 sessions in total, with 3 sessions a week for 4 weeks. Group A received the protocol of Bruegger's exercise as mentioned.

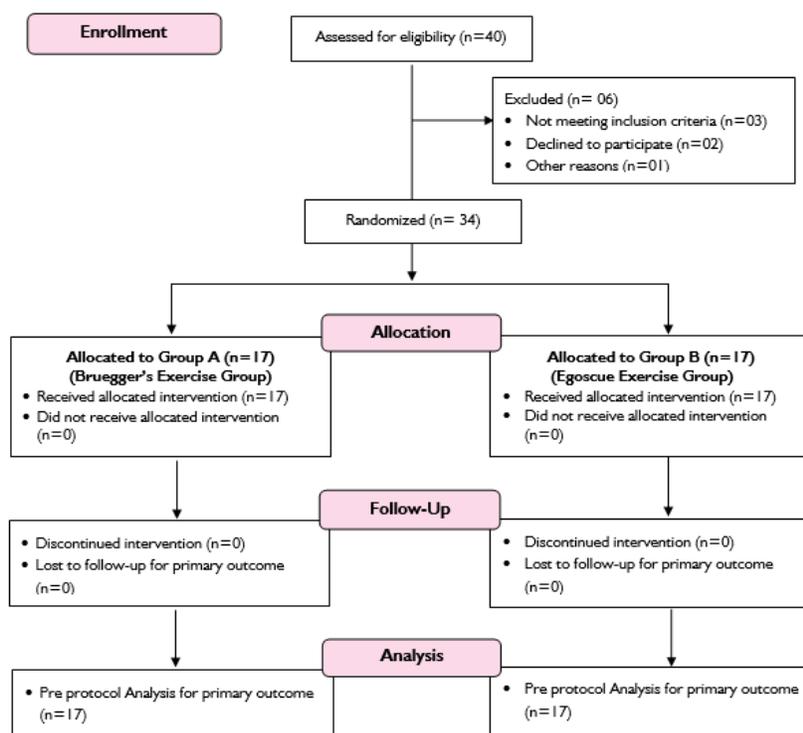


Figure 1: Consort flow diagram of the study

The patient contracts their gluteal muscles and stabilizes their core muscles before sitting. The patient was instructed to sit on the edge of a chair and perform Bruegger's exercise by turning their feet outward, sitting upright with their shoulders retracted and head elevated, and rotating the forearms and wrists upward. The patient then slowly exhaled through pursed lips while actively externally rotating the arms and spreading the fingers. The exercise was to be performed once or twice every 20-30 minutes during prolonged sitting, maintaining the position for 30-60 seconds.¹¹ To enhance compliance, the patient was also asked to perform five repetitions of an exercise with a five-second rest after each repetition during each clinical session.

The Egoscue group received a total of 10 exercises, which included static back alone and with breathing, abdominal contraction while in the static back position, abductor press, overhead extension, elbow curls on the wall, static wall, upper spinal twist, pelvic tilts, supine groin progressive, and air bench exercises. The Exercise frequency progressed as follows: three repetitions in week 1, five repetitions in week 2, fifteen repetitions in week 3, and twenty repetitions in week 4. Each exercise was performed with a 10-second hold per repetition. Session duration increased from approximately 25 minutes in week 1 to 45 minutes in week 4. A 5-10 second rest was allowed between repetitions.¹⁰ Hot packs and standardized stretching were administered as part of conventional physiotherapy care to uphold ethical standards and establish a uniform baseline for evaluating the specific effects of Bruegger's and Egoscue exercises. All intervention sessions were given and supervised by the principal investigator as per predefined protocol and session checklist to ensure treatment fidelity. Adherence was tracked using attendance logs maintained by the therapists and through verbal input from participants, with encouragement provided for home practice when relevant. Before each supervised session, participants were asked about their home exercise performance.

Statistical analysis: Pelvic Inclinator readings were found to demonstrate a non-normal distribution ($p < 0.05$) using the Shapiro-Wilk test. The mean, standard deviation, and frequency were calculated for the patient's physical characteristics, i.e., age and gender. Wilcoxon Rank sum test was used for pre-and post-treatment, and for between-group analysis, the Mann-Whitney U test was used for pelvic inclinometer readings. IBM SPSS 27 version was used for the whole statistical analysis.

RESULTS

The overall mean age of the participants was 26.45 ± 4.41 years, with the Bruegger's group averaging 28.0 ± 7.63 years and the Egoscue group averaging 24.9 ± 1.19 years. The majority of the participants were female (85.3%), while males accounted for 14.7% of the total sample. Both groups showed a similar gender distribution, with females making up more than four-fifths of each group. Groups were demographically comparable (Table I).

The findings of within-group analysis demonstrate that both Bruegger's and Egoscue exercises significantly reduced the angle of anterior pelvic tilt in individuals with LCS following four weeks of exercise for both groups (Table II). The Bruegger's group experienced a decrease in pelvic inclinometer scores from a median of 12 to 9 ($p < 0.001$) in both groups.

The within-group effect sizes for pelvic

inclinometer readings were large (Bruegger's: $r = 0.63$, 95% CI [0.32-0.78]; Egoscue: $r = 0.64$, 95% CI [0.34-0.79]), indicating strong improvements within both groups.

Between-group analysis of pelvic inclinometer readings showed no statistically significant difference at baseline ($U = 117.0$, $p = 0.327$) and post-intervention ($U = 137.5$, $p = 0.793$). Both Bruegger's and the Egoscue group demonstrated comparable improvements in anterior pelvic tilt following the intervention (Table IV).

DISCUSSION

The present study compared the effects of Bruegger's and Egoscue exercises on anterior pelvic tilt in individuals with LCS. Both interventions are designed to address core muscle imbalance and sagittal plane dysfunction. Still, limited research exists evaluating Bruegger's and Egoscue's effects on pelvic alignment, making this study a valuable addition to rehabilitation evidence. To date, there is only one study that has specifically involved Egoscue exercises and directly compared their effects on anterior pelvic tilt, which underscores the novelty and importance of the present investigation in addressing this gap.

In this trial, anterior pelvic tilt measured with a pelvic inclinometer showed significant reductions within both groups ($p < 0.001$), demonstrating that both exercises approach effectively corrected lumbopelvic imbalance.

Table I: Gender distribution of participants across study groups

Variables	Categories	Bruegger's Exercise	Egoscue Exercise	Total (n=34)
Gender, n (%)	Male	2 (11.8)	3 (17.6)	5 (14.7%)
	Female	15 (88.2)	14 (82.4)	29 (85.3%)

Table II: Within-group comparison of pre- and post-intervention pelvic inclinometer measurements

Groups	Assessment	Median (IQR)	z-value	p-value
Bruegger's Group	Pre-Intervention	12 (8)	-3.677	< 0.001
	Post-Intervention	9 (4)		
Egoscue Group	Pre-Intervention	12 (8)	-3.716	< 0.001
	Post-Intervention	9 (4)		

Table III: Between-group comparison of pelvic inclinometer measurements at baseline and post-intervention

Variable	Assessment	Median (IQR)	Mean Rank Bruegger's	Mean Rank Egoscue	U-value*	p-value
Pelvic Inclinometer	Baseline (Pre-intervention)	12 (8.5)	15.88 (270.0)	19.12 (325.0)	117.0	0.327
	Post-intervention	9 (4.25)	17.09 (290.5)	17.91 (304.5)	137.5	0.793

*Mann-Whitney U test

Rajalaxmi V, et al., compared Janda's approach and Bruegger's exercise in Pelvic Cross Syndrome and reported a significant decrease in pain, with visual analog scale (VAS) scores improving from 5.93 ± 0.883 to 3.20 ± 0.774 ($p < 0.05$), supporting the current findings on Bruegger's effectiveness in modulating muscle imbalance and pain through targeted postural correction.¹⁵ Waters et al. investigated Bruegger's exercise, alone and combined with spinal manipulation, in chronic low back pain associated with LCS, reporting significant improvements in pain ($p < 0.01$) and lumbar lordosis ($p < 0.01$) after 12 sessions, which aligns with the current study's significant changes in pelvic tilt following a similar four-week intervention.¹¹

For Egoscue, Kudchadkar GS, et al., conducted a randomized controlled trial on asymptomatic individuals with lumbar hyperlordosis. They found significant reductions in anterior pelvic tilt and lumbar curvature ($p < 0.001$), which corroborates the present findings of postural improvement following Egoscue's corrective protocol.¹⁰ Sequeira S, et al., compared Egoscue and lumbar stabilization exercises and demonstrated significant decreases in lumbar lordosis and improved postural stability ($p < 0.05$), supporting the effectiveness of Egoscue for sagittal plane alignment. Similarly, Saranya P, et al., reported both Egoscue and lumbar stabilization exercises as equally effective in reducing hyperlordosis ($p < 0.05$), aligning with the current results showing comparable benefits between the two protocols.¹⁶ Vehrs Z demonstrated significant reductions in chronic knee and hip pain following Egoscue corrective exercises

($p < 0.001$), which correspond to the pain relief observed in this trial.¹⁷

Niroomand T, et al., report that Janda's and Sahrman's approaches have demonstrated improvements in trunk muscle function and pelvic alignment ($p < 0.01$) in young individuals with LCS, emphasizing the importance of neuromuscular retraining for restoring sagittal balance.¹⁸ A study by Marani LG, et al., on global postural re-education and kinetic chain training has also shown significant decreases in pelvic tilt and lordosis ($p < 0.001$), reinforcing that targeted neuromuscular activation and postural awareness can reverse LCS-related imbalances.¹⁹

Although both interventions were effective, no statistically significant difference was found between groups. This may be explained by the shared components of the programs, including standardized stretching and warm-up exercises, which likely contributed to improvements in both groups and reduced the distinct effects of each protocol. Increased lumbopelvic awareness and neuromuscular activation common to both methods may also have played a role in the observed improvements. The present findings suggest that both Bruegger's and Egoscue exercises can improve pelvic alignment and postural control in individuals with LCS. A mean reduction of approximately 3° in anterior pelvic tilt exceeds previously reported measurement error ranges, indicating that this degree of change is clinically meaningful.¹⁰ These improvements are most relevant for young to middle-aged adults with postural dysfunction related to sedentary lifestyles or prolonged sitting, where even small corrections in pelvic tilt may reduce pain and

functional limitations.

Bruegger's and Egoscue exercises can serve as practical, low-cost options for managing LCS. Bruegger's exercise provides a straightforward, single-step strategy that can be easily integrated into both clinical practice and home routines, making it especially suitable for busy rehabilitation settings. In contrast, Egoscue offers a more comprehensive, multi-exercise program that may be better suited for patients requiring broader postural realignment and core retraining. The choice of intervention can be tailored according to therapist expertise, patient preference, available time, and the clinical context.

Despite these positive outcomes, this study has certain limitations. The sample consisted predominantly of female participants due to ethical considerations, which may restrict the generalizability of the findings. The intervention was conducted in a single clinical setting, potentially introducing location-specific bias, and only limited baseline covariates were collected, which may have influenced group comparability. Outcome assessors and statisticians were not blinded, and co-interventions such as stretching and hot packs may have contributed to improvements, making it difficult to isolate the effects of the exercise protocols alone. Furthermore, outcomes were assessed only in the short term, so the durability of these corrections over time remains unclear.

CONCLUSION

Bruegger's and Egoscue exercise interventions demonstrate comparable efficacy in reducing anterior pelvic tilt in individuals with lower crossed syndrome, with both approaches yielding significant improvements. Given its simplicity and ease of execution, Bruegger's exercise may offer a more practical option in certain clinical settings. Based on these findings, both Bruegger's and Egoscue exercises can be incorporated into rehabilitation programs targeting anterior pelvic tilt, with the choice of intervention guided by patient preference, clinical feasibility, and therapist expertise. These results reflect short-term post-intervention

outcomes, and the long-term sustainability of these effects remains uncertain. Future studies should include larger, more diverse populations across multiple centers, incorporate blinded outcome assessors, and extend follow-up durations to evaluate the persistence of postural correction. Additionally, the inclusion of broader functional outcomes, like physical activity levels, quality of life, occupational performance, and subgroup analyses (e.g., by gender, occupation, and severity of LCS) would further enhance the clinical applicability of these findings.

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REFERENCES

- Hussain A, Das J, Pal S. Diagnosis of lower cross syndrome: a review. *Int J Innov Sci Res Technol* 2025; 10(2): 2154-62. <https://doi.org/10.38124/ijisrt/25feb1611>
- Puagprakong P, Earde P, Kooncumchoo P. Lumbo-Pelvic-Hip angle changes during upright and free style sitting in office workers with lower crossed syndrome. In: Ahram T, Taiar R, Groff F (eds): Human interaction, emerging technologies and future applications IV. IHET-AI 2021. Advances in Intelligent Systems and Computing. Vol 1378. Springer, Cham. https://doi.org/10.1007/978-3-030-74009-2_68
- Burile G, Phansopkar P, Deshmukh N. Prevalence of lower cross syndrome in housemaids. *Cureus* 2024; 16(4): e57425. <https://doi.org/10.7759/cureus.57425>
- González-De-La-Flor Á, García-Arrabé M, Fernández-Pardo T, Cotteret C. Clinical presentation of anterior pelvic tilt and trunk muscle endurance among patients with femoroacetabular impingement syndrome: a cross-sectional study. *Eur J Phys Rehab Med* 2024; 60: 1027-35. <https://doi.org/10.23736/10.23736/s1973-9087.24.08378-3>
- Shetty S, Pv M, Shakir M, Binoj A, Mohammed M. Influence of improper mechanical posture in occurrence of lower crossed syndrome: a literature review. *Int J Appl Res* 2023;9(3):82-5.
- Alyarnezhad C, Shams Majalan A. Comparison of the effect of eight week training program schedule with two different stretching patterns strengthening on changes in the status of lower cross syndrome. *J Sport Biomech* 2021; 7(2): 108-21. <https://doi.org/10.32598/biomechanics.7.2.3>
- Shahamiri NS, Soleiman-Fallah MA, Feizolah F. The effect of one period core stability exercise with and without kinesio taping on biomechanical effective factors in lower cross syndrome on female. *Res Sport Med Technol* 2023;20(24):12-31.
- Rahimi M, Piry H, Monajatipour E. Effect of six weeks of pilates exercises on the function of upper and lower extremities of middle-aged women with lower crossed syndrome. *Phys Treat* 2022; 12(4): 269-78. <https://doi.org/10.32598/ptj.12.4.542.1>
- Suresh A, Kashyap D, Behera TP, kumar Tarsolia A. Effect of muscle energy technique in patients with non-traumatic lumbo-pelvic pain in the age group of 30-40 years. *J Phys Med Rehab Stud* 2021;3(2):1-9. [https://doi.org/10.47363/JPMRS/2021\(3\)132](https://doi.org/10.47363/JPMRS/2021(3)132)
- Kudchadkar GS, Gurudut P, Welling A. Comparative effect of mat pilates and egoscue exercises in asymptomatic individuals with lumbar hyperlordosis: a randomized controlled trial. *Indian J Phys Ther Res* 2019;1(2):79-88. https://doi.org/10.4103/ijptr.ijptr_38_19
- Waters T. The effect of Bruegger's exercise on chronic low back pain in association with lower crossed syndrome. University of Johannesburg. 2024. [Accessed on: January 02, 2026]. Available from URL: <https://ujcontent.uj.ac.za/esploro/outputs/graduate/The-effect-of-Brueggers-exercise-on/9913780907691>
- Sequeira S, Gurudut P, Kage V. Exploring effects of Egoscue versus lumbar stabilisation exercises for lower crossed syndrome on postural stability and hyperlordotic posture correction. *Comp Exerc Physiol* 2023;19(3):223-34. <https://doi.org/10.3920/CEP220032>
- Suits WH. Clinical measures of pelvic tilt in physical therapy. *Int J Sports Phys Ther* 2021;16(5):1366-75. <https://doi.org/10.26603/001c.27978>
- Kandil EA, Yamany AAER, Alsaka SSD, Abd El-Azeim AS. Effect of global postural reeducation on chronic low pain patients with lower cross syndrome. *Bull Fac Phys Ther* 2024;29(1):8. <https://doi.org/10.1186/s43161-023-00171-6>
- Rajalaxmi V, Nandhini G, Senthilnathan C, Yuvarani G, Tharani G. Efficacy of Janda's approach versus Bruegger's exercise in pelvic cross syndrome and its impact on quality of life. *Int J Res Pharm Sci* 2020; 11: 1701-6. <https://doi.org/10.26452/ijrps.v11i2.2071>
- Saranya P, Thenmozhi M, Dhasaradharaman K, Robert F, Anantharaj K, Soniya G. Comparative effect of Egoscue exercises and Lumbar Stabilization exercises in asymptomatic individuals with lumbar hyperlordosis. *Int J Health Sci Res* 2023;13(6):255-259. <https://doi.org/10.52403/ijhsr.20230641>
- Vehrs Z. The effect of Egoscue corrective exercises on chronic knee and hip pain: Brigham Young University; 2014. [Accessed on: January 02, 2026]. Available from URL: <https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=6279&context=etd>
- 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. J Adv Sport Technol 2023;7(3):48-58. <https://doi.org/10.22098/jast.2025>.

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19. Marnani LG, 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. J Rehab Sci Res 2024. <https://doi.org/10.30476/jrsr.2024.100027.1415>

AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

AB: Conception and study design, acquisition, analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

MAI: Conception and study design, analysis and interpretation of data, critical review, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.



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KMUJ web address: www.kmu.edu.pk

Email address: kmu@kmu.edu.pk