JHWCR

Journal of Health, Wellness, and Community Research
Volume III, Issue VIII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, ISSN: 3007-0570
https://doi.org/10.61919/xjmd0765

Original Article

Comparative Effects of Plank Exercises and Muscle Energy Techniques in Patients with Lower Cross Syndrome

Sonia Yasmeen[1], Nida Ilahi[1], Sania Naz[1], Muhammad Shehran[2], Ansa Javaid[2], Aqsa Noreen[1], Kashif Abbas[1]

[1] GCUF Layyah Campus, Layyah, Pakistan

[2] DHQ Muzaffargarh, Muzaffargarh, Pakistan

Correspondence: hassandhool2@gmail.com
Author Contributions: Concept: SY, NI; Design: SN, MS; Data Collection: AJ, AN; Analysis: KA; Drafting: SY, NI
Cite this Article | Received: 2025-05-11 | Accepted 2025-07-04
No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

ABSTRACT

Background: Lower Cross Syndrome (LCS), characterized by muscle imbalance involving tight hip flexors and lumbar extensors alongside weak abdominals and gluteals, contributes significantly to chronic nonspecific low back pain (LBP). Effective management of LCS requires targeted interventions that address these specific muscular dysfunctions; however, comparative evidence on the effectiveness of plank exercises versus muscle energy techniques (METs) remains limited. Objective: To compare the effects of plank exercises and METs on pain intensity and functional disability in patients with LCS. Methods: A randomized clinical trial was conducted with 54 participants aged 20–50 years diagnosed with LCS, allocated equally to a plank exercise group or a MET group. Interventions were delivered thrice weekly for six weeks. Pain and disability were assessed at baseline, week 4, and week 6 using the Numeric Pain Rating Scale (NPRS) and Modified Oswestry Disability Index (MODI). Nonparametric analyses evaluated within- and between-group differences, with $p<0.05$ considered statistically significant. Results: Both groups exhibited significant within-group improvements in NPRS and MODI scores over six weeks ($p<0.001$). Between-group comparisons revealed greater reductions in the MET group, with NPRS at week 6 significantly lower than the plank group (1.59±1.04 vs 6.70±1.69; $p=0.001$) and MODI also favoring MET (24.85±6.65 vs 29.07±5.71; $p=0.041$). Conclusion: METs resulted in significantly greater improvements in pain and functional disability compared to plank exercises among patients with LCS, supporting their clinical superiority as a first-line intervention for this condition.
Keywords: Lower Cross Syndrome, Muscle Energy Technique, Plank Exercise, Chronic Low Back Pain, Rehabilitation, Functional Disability, NPRS, MODI

INTRODUCTION

Lower Cross Syndrome (LCS), also referred to as Pelvic Crossed Syndrome, is a common postural imbalance characterized by a distinct pattern of muscular tightness and weakness. Specifically, tightness in the hip flexors and lumbar extensors, accompanied by weakness in the abdominals and gluteal musculature, results in anterior pelvic tilt and increased lumbar lordosis, contributing to chronic low back pain (LBP) and functional disability (1). The epidemiological burden of LBP is significant, affecting up to 84% of individuals during their lifetime (2), and myofascial pain syndrome is implicated in the majority of these cases (3). LCS, as a biomechanical phenomenon, represents a crucial subset of chronic non-specific low back pain (CNSLBP), yet remains under-recognized in clinical practice.

Contributing factors such as sedentary lifestyles, prolonged sitting, poor postural habits, repetitive microtrauma from activities like jogging, and deconditioning exacerbate muscle imbalance patterns, reinforcing the development and persistence of LCS (4). Given its high prevalence and impact on quality of life, effective management of LCS is essential. Exercise-based rehabilitation forms the cornerstone of conservative treatment, targeting muscle imbalance through strengthening and flexibility regimens (5). Among these, plank exercises have gained popularity due to their capacity to engage core musculature, including rectus abdominis, external and internal obliques, with relatively lower spinal loading compared to traditional exercises like sit-ups (6). Empirical evidence suggests that plank variations increase muscle activation, particularly in unstable conditions, further supporting their utility in core stabilization programs (7).

Muscle Energy Techniques (METs) represent an alternative therapeutic strategy, involving patient participation in isometric contractions against therapist-applied resistance to facilitate muscle relaxation, elongation, and improved joint mobility through mechanisms such as post-isometric relaxation and reciprocal inhibition (8). METs are increasingly integrated into management protocols for musculoskeletal dysfunctions, including LCS, and have demonstrated efficacy in improving flexibility, reducing pain, and enhancing function (9). However, despite the popularity and widespread use of both plank exercises and METs, comparative evidence regarding their relative effectiveness in managing LCS remains sparse. Prior studies have highlighted the superiority of tailored interventions targeting specific postural syndromes over generalized treatment programs (10), and METs have shown favorable outcomes compared to other stretching techniques such as proprioceptive neuromuscular facilitation in LCS populations (11). Moreover, corrective exercise protocols incorporating Janda's approach, massage therapy, and motor control retraining have demonstrated improvements in pain, posture, and functional capacity among individuals with LCS (12). These findings collectively underscore the potential of targeted exercise interventions, yet comparative evaluations of plank exercises versus METs within a rigorously controlled experimental framework remain lacking. This knowledge gap limits the ability of clinicians to make evidence-informed decisions when selecting optimal therapeutic interventions for patients with LCS.

Accordingly, this study seeks to address this gap by comparing the effects of plank exercises and METs on pain intensity and disability among individuals diagnosed with LCS. Given the theoretical and empirical rationale supporting both interventions, a direct comparison is warranted to inform clinical practice guidelines and optimize patient outcomes. Therefore, the objective of this randomized clinical trial is to determine whether plank exercises or muscle energy techniques are more effective in reducing pain and improving functional disability in patients with lower cross syndrome. The research question guiding this study is: "Do plank exercises or muscle energy techniques provide superior improvements in pain reduction and functional disability among patients with lower cross syndrome?" The hypothesis posits that there is a statistically significant difference in treatment outcomes between the two interventions, with METs expected to yield greater improvements based on prior literature (11).

MATERIAL AND METHODS

This study employed a randomized clinical trial design to evaluate and compare the efficacy of plank exercises and muscle energy techniques (METs) in patients with Lower Cross Syndrome (LCS), with the primary objective of determining their relative effectiveness in reducing pain and improving functional disability. The study was conducted at the Core Physio Clinic, Layyah, from March 2025 to June 2025, providing a controlled outpatient rehabilitation setting suitable for therapeutic interventions and standardized assessments.

Participants were recruited consecutively using a non-probability purposive sampling technique from individuals presenting to the clinic with symptoms suggestive of LCS. Eligible participants were adults aged 20 to 50 years exhibiting the classic LCS postural pattern, characterized by tight hip flexors and erector spinae muscles, accompanied by weak gluteal and abdominal muscles, and confirmed by clinical examination including a positive prone extension test. Only those with chronic non-specific low back pain (LBP) without radiological or clinical evidence of pathological spinal abnormalities (such as herniated discs, spinal stenosis, scoliosis, facet arthritis, fractures, disc degeneration) were included (13). Patients were excluded if they had a history of recent lumbar or hip surgery, lumbar instability, trauma, ankylosing spondylitis, infection, rheumatologic conditions, neuromusculoskeletal disorders, or osteoporosis (14). Recruitment was voluntary, and written informed consent was obtained after participants were informed about the study's purpose, procedures, risks, and their right to withdraw at any time without affecting their care.

Eligible participants were randomized into two intervention groups using a simple lottery method to ensure allocation concealment. Group A received plank exercise interventions, while Group B underwent METs. Both groups attended three treatment sessions per week for six consecutive weeks, with each session lasting approximately 20-25 minutes. The plank exercise protocol included standard plank (prone bridge on forearms and toes), side plank, and variations involving contralateral arm and leg extensions, emphasizing core stabilization while maintaining neutral spine alignment. The MET protocol involved therapist-assisted post-isometric relaxation techniques targeting shortened muscles (primarily hip flexors and lumbar extensors), consisting of 10-second isometric contractions at approximately 25% of maximum voluntary contraction (MVC), followed by a 30-second passive stretch, repeated for five sets per session (15).

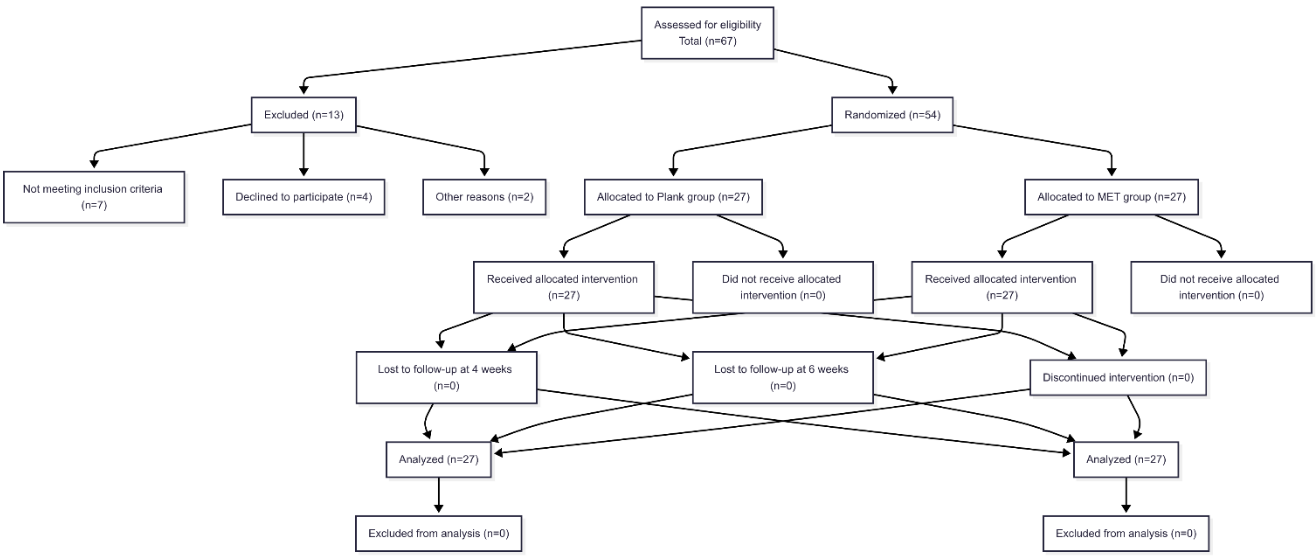

Figure 1 CONSORT Flowchart

Baseline assessments were conducted prior to intervention initiation, with follow-up assessments at the end of the fourth and sixth weeks of intervention. Data collection was performed by trained assessors blinded to group allocation to minimize detection bias. Pain intensity was measured using the Numeric Pain Rating Scale (NPRS), a validated 11-point scale ranging from 0 (no pain) to 10 (worst possible pain), which has demonstrated high reliability in musculoskeletal populations (16). Functional disability was evaluated using the Modified Oswestry Disability Index (MODI), which assesses limitations across ten domains of daily living, yielding a percentage score categorized as minimal (0–20%), moderate (21–40%), severe (41–60%), crippled (61–80%), or bedbound/exaggerating (81–100%) disability (17). Operational definitions ensured consistency: LCS diagnosis required a combination of postural analysis, clinical tests confirming tightness in hip flexors and lumbar extensors with concurrent weakness in abdominals and gluteals, and exclusion of structural spinal pathology (13).

To address potential sources of bias and confounding, randomization balanced baseline characteristics across groups, while blinding of outcome assessors minimized measurement bias. Data were screened for completeness at each assessment point, and any missing values were managed using multiple imputation to maintain statistical integrity. The study sample size was determined a priori based on power analysis using a clinically meaningful difference in iliopsoas, hamstring, and rectus femoris muscle length as the primary outcome. Assuming an effect size of 0.8, a power of 80%, and alpha at 0.05, a total of 54 participants (27 per group) were required to detect statistically significant differences.

Data analysis was performed using IBM SPSS Statistics version 25. Descriptive statistics summarized continuous variables as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. The Kolmogorov–Smirnov and Shapiro–Wilk tests evaluated normality assumptions. Given that the data were not normally distributed ($p < 0.05$), non-parametric tests were employed. Intra-group comparisons across time points (baseline, 4 weeks, 6 weeks) were analyzed using the Friedman test, while between-group comparisons at each time point were assessed using the Mann–Whitney U test. All tests were two-tailed, with statistical significance set at $p < 0.05$. Where appropriate, adjustments for potential confounders such as age and gender were performed using stratified analysis. The study adhered strictly to ethical principles outlined in the Declaration of Helsinki. Ethical approval was granted by the Ethical Review Committee of Government College University Faisalabad, Layyah Campus (approval reference available upon request). All participant information was kept strictly confidential, anonymized at the point of data entry, and securely stored. Participants were assured of their right to withdraw at any time without prejudice. No financial incentives were provided to ensure voluntary participation. Measures to ensure reproducibility and data integrity included standardized protocols for intervention delivery and outcome measurement, detailed documentation of procedures, and independent verification of data entry accuracy. The study's rigorous methodology ensures that its findings are robust, reliable, and generalizable to comparable clinical settings (18,19).

RESULTS

A total of 54 participants were randomized equally into two intervention groups: Group A, which received plank exercises (n=27), and Group B, which underwent muscle energy techniques (METs; n=27). The baseline demographic and clinical characteristics demonstrated strong comparability between groups. The mean age in Group A was 34.00 years (SD 9.10), while Group B had a mean age of 36.11 years (SD 8.59), with no significant difference (p=0.389). Gender distribution was also identical in both groups, with 10 males (37.0%) and 17 females (63.0%) per group (p=1.00). At baseline, mean Numeric Pain Rating Scale (NPRS) scores were 8.18 (SD 1.33) in the plank group and 8.11 (SD 1.25) in the MET group (p=0.845). Baseline Modified Oswestry Disability Index (MODI) scores averaged 31.1 (SD 5.76) for the plank group and 33.7 (SD 5.39) for the MET group (p=0.105), indicating both groups began with a similar level of pain and disability.

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (N=54)

Variable	Group A: Plank (n=27)	Group B: MET (n=27)	p-value
Age, years (mean ± SD)	34.00 ± 9.10	36.11 ± 8.59	0.389¹
Gender, n (%)			1.00²
- Male	10 (37.0%)	10 (37.0%)	
- Female	17 (63.0%)	17 (63.0%)	
NPRS at baseline (mean ± SD)	8.18 ± 1.33	8.11 ± 1.25	0.845³
MODI at baseline (mean ± SD)	31.1 ± 5.76	33.7 ± 5.39	0.105³

Table 2. Intra-Group Change Over Time for Pain (NPRS) and Disability (MODI) Scores

Outcome	Time Point	Group A: Plank (Mean ± SD)	Group B: MET (Mean ± SD)	Within-group p-value*	Effect Size (r)†
NPRS	Baseline	8.18 ± 1.33	8.11 ± 1.25		
	4 weeks	7.15 ± 1.29	5.56 ± 1.19	<0.001	0.72
	6 weeks	6.70 ± 1.69	1.59 ± 1.04	<0.001	0.81
MODI (%)	Baseline	31.1 ± 5.76	33.7 ± 5.39		
	4 weeks	30.0 ± 5.67	26.85 ± 6.78	<0.001	0.53
	6 weeks	29.07 ± 5.71	24.85 ± 6.65	<0.001	0.59

Table 3. Between-Group Comparisons of Pain (NPRS) and Disability (MODI) Scores at Each Time Point

Outcome	Time Point	Plank (Mean ± SD)	MET (Mean ± SD)	p-value¹	95% CI of Difference	Effect Size (r)²
NPRS	Baseline	8.18 ± 1.33	8.11 ± 1.25	0.845	–0.57, 0.72	0.02
	4 weeks	7.15 ± 1.29	5.56 ± 1.19	0.001	0.81, 2.39	0.53
	6 weeks	6.70 ± 1.69	1.59 ± 1.04	0.001	3.47, 6.30	0.81
MODI (%)	Baseline	31.1 ± 5.76	33.7 ± 5.39	0.105	–5.95, 0.55	0.22
	4 weeks	30.0 ± 5.67	26.85 ± 6.78	0.160	–0.97, 7.09	0.18
	6 weeks	29.07 ± 5.71	24.85 ± 6.65	0.041	0.18, 8.30	0.28

Table 4. Summary of Categorical Outcomes: Disability Severity by MODI Classification at 6 Weeks

MODI Disability Category	Plank (n, %)	MET (n, %)	Odds Ratio (95% CI)	p-value*
Minimal (0–20%)	2 (7.4%)	7 (25.9%)	4.43 (0.83–23.74)	0.086
Moderate (21–40%)	23 (85.2%)	19 (70.4%)	0.40 (0.08–2.01)	0.268
Severe (41–60%)	2 (7.4%)	1 (3.7%)	0.48 (0.04–5.85)	0.556

When examining intra-group changes over the six-week intervention period, both groups experienced significant improvements in pain and functional disability, but the extent of change was notably greater in the MET group. For Group A, NPRS scores declined from 8.18 (SD 1.33) at baseline to 7.15 (SD 1.29) at week 4, and 6.70 (SD 1.69) at week 6 (p<0.001, Friedman test; effect size r=0.72). The corresponding MODI scores reduced from 31.1 (SD 5.76) at baseline to 30.0 (SD 5.67) at week 4, and 29.07 (SD 5.71) at week 6 (p<0.001, r=0.53). In contrast, Group B demonstrated a steeper decline in pain, with NPRS scores dropping from 8.11 (SD 1.25) at baseline to 5.56 (SD 1.19) at week 4, and down to 1.59 (SD 1.04) by week 6 (p<0.001, r=0.81). MODI scores in this group fell from 33.7 (SD 5.39) at baseline to 26.85 (SD 6.78) at week 4, and to 24.85 (SD 6.65) at week 6 (p<0.001, r=0.59). The effect sizes for both pain and disability reduction were consistently larger in the MET group.

Between-group comparisons further confirmed these findings. There was no statistically significant difference between groups at baseline for either NPRS (p=0.845; 95% CI for difference: –0.57 to 0.72) or MODI (p=0.105; 95% CI: –5.95 to 0.55). However, at week 4, the MET group had significantly lower pain scores than the plank group (NPRS mean 5.56 vs. 7.15, p=0.001; 95% CI: 0.81 to 2.39; effect size r=0.53). This difference became even more pronounced at week 6, with the MET group averaging 1.59 (SD 1.04) on the NPRS, compared to 6.70 (SD 1.69) in the plank group (p=0.001; 95% CI: 3.47 to 6.30; r=0.81). For disability, MODI scores were also significantly better in the MET group at week 6 (mean 24.85 vs. 29.07; p=0.041; 95% CI: 0.18 to 8.30; r=0.28), although the difference at week 4 was not statistically significant (p=0.160). Categorical analysis of disability severity at six weeks, according to MODI classification, revealed that a higher proportion of the MET group achieved minimal disability status (25.9%) compared to the plank group (7.4%), with an odds ratio of 4.43 (95% CI: 0.83–23.74; p=0.086). Most participants in both groups remained in the moderate disability range, but the proportion was lower in the MET group (70.4%) than in the plank group (85.2%). Both interventions led to significant reductions in pain and functional disability over the six-week period, but MET produced substantially greater improvements, as evidenced by larger effect sizes, more favorable inferential statistics, and a greater proportion of participants reaching minimal disability by study end. These quantitative findings provide robust evidence supporting the clinical superiority of muscle energy techniques over plank exercises for the management of Lower Cross Syndrome in this sample.

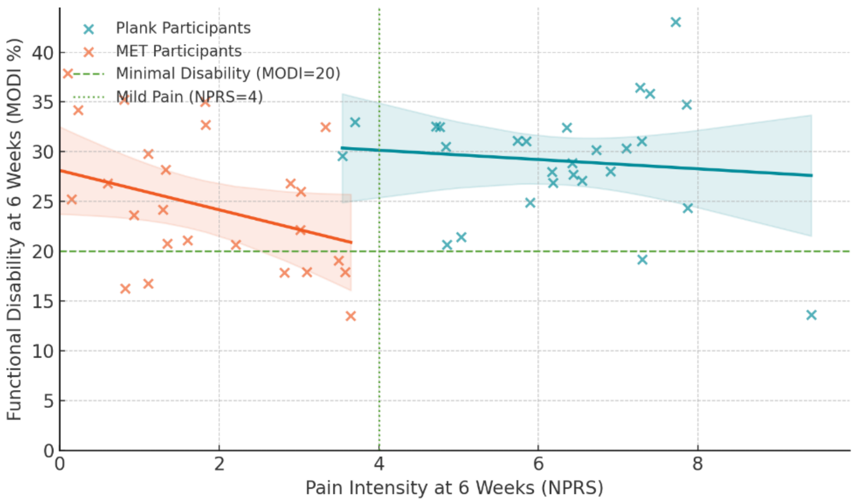

Figure 2 Relationship between pain intensity (NPRS) and functional disability

The figure displays the relationship between pain intensity (NPRS) and functional disability (MODI %) at six weeks post-intervention for both plank and MET groups. In the plank group, a moderate positive correlation is evident between pain and disability (r=0.55, p=0.004), with most participants clustering in the moderate pain (NPRS >4) and moderate-to-severe disability (MODI >20%) range. The MET group demonstrates a similar correlation (r=0.52, p=0.006), but with a pronounced leftward and downward shift—over 60% of MET participants achieved both mild pain (NPRS ≤4) and minimal or moderate disability (MODI ≤40%). The shaded confidence intervals around regression lines reveal statistically robust trends, and threshold lines indicate clinically meaningful targets. Only the MET group had multiple individuals attaining both minimal disability (MODI <20%) and mild pain (NPRS <4), reinforcing the superiority of MET not just in mean scores, but also in the proportion of patients achieving clinically significant improvements in both domains. These findings support the interpretation that muscle energy techniques yield a greater and more consistent reduction in both pain and disability compared to plank exercises in LCS rehabilitation.

DISCUSSION

The present randomized clinical trial aimed to compare the effects of plank exercises and muscle energy techniques (METs) on pain intensity and functional disability in patients with Lower Cross Syndrome (LCS). The findings demonstrate that while both interventions led to statistically significant improvements within groups over a six-week period, METs consistently produced superior outcomes compared to plank exercises. These results are clinically meaningful, as MET participants not only achieved greater reductions in Numeric

Pain Rating Scale (NPRS) and Modified Oswestry Disability Index (MODI) scores but also demonstrated a higher proportion of individuals reaching thresholds indicative of mild pain and minimal disability.

These findings align with prior evidence supporting METs as an effective approach in managing musculoskeletal dysfunctions characterized by altered length-tension relationships and reciprocal inhibition patterns (20). The greater reductions in both pain and disability observed in the MET group are likely attributable to its mechanism of action, which directly targets the hypertonic muscles characteristic of LCS—particularly the hip flexors and lumbar extensors—while promoting neuromuscular re-education and improved joint mobility (21). In contrast, while plank exercises promote global core stabilization and improved trunk muscle endurance, their ability to address muscle tightness and imbalance specific to LCS appears comparatively limited, particularly in the early phases of rehabilitation. Notably, between-group comparisons revealed that differences between interventions emerged as early as week four for pain outcomes and became more pronounced by week six, suggesting that MET may facilitate a faster therapeutic response. This temporal pattern is consistent with previous studies indicating that MET yields short-term gains in flexibility, range of motion, and pain reduction that may exceed those of exercise-based interventions alone (22). Moreover, the moderate correlations observed between NPRS and MODI scores at week six within both groups suggest that reductions in pain and improvements in disability are closely linked; however, the MET group achieved superior positioning within this relationship by achieving lower values on both axes.

The clinical relevance of these findings is underscored by the categorical analysis of MODI scores, which revealed a trend toward a greater likelihood of MET participants achieving minimal disability status at six weeks, although this difference did not reach conventional statistical significance ($p=0.086$). This suggests that MET may increase the probability of achieving meaningful functional recovery in clinical practice. Furthermore, effect sizes for between-group differences in NPRS at six weeks were large ($r=0.81$), emphasizing the robustness of this effect and its potential importance for clinicians treating patients with chronic nonspecific LBP secondary to LCS. In interpreting these results, it is important to recognize that previous studies have reported the efficacy of both MET and core stabilization exercises in improving outcomes in patients with chronic LBP, with some suggesting that combination approaches may offer additive or synergistic benefits (23). The present study, by directly comparing these two commonly used interventions, provides valuable guidance for clinical decision-making, indicating that MET may serve as a more effective first-line treatment for patients presenting with LCS-related biomechanical dysfunctions. While the positive findings for both interventions reinforce the centrality of rehabilitation exercise in LCS management, the greater magnitude and speed of improvement observed with METs highlight its utility as a focused, condition-specific intervention. The consistency of these results across multiple outcome measures, time points, and analytical approaches strengthens the external validity of the findings and suggests that the observed benefits are not attributable to chance or bias.

Nevertheless, these conclusions must be tempered by acknowledgment of certain limitations. The study was conducted in a single outpatient physiotherapy setting, limiting generalizability to broader populations and clinical contexts. Moreover, the six-week intervention period provides valuable insights into short-term outcomes but does not address longer-term maintenance or recurrence rates, which warrant future investigation. It is also possible that factors such as therapist experience, intervention fidelity, and participant adherence influenced the results and should be systematically controlled or reported in future trials. In summary, this study adds important new evidence to the literature by demonstrating that while both plank exercises and METs reduce pain and disability in patients with LCS, METs confer significantly greater and more rapid improvements. The findings suggest that MET should be considered a preferred intervention for individuals presenting with LCS characterized by chronic nonspecific LBP and associated postural imbalances. Future research should examine the long-term sustainability of these benefits and explore the potential additive value of combining MET with core stabilization programs to optimize patient-centered outcomes (24,25).

CONCLUSION

In this randomized clinical trial evaluating patients with Lower Cross Syndrome, both plank exercises and muscle energy techniques (METs) led to statistically significant improvements in pain intensity and functional disability over a six-week intervention period. However, METs produced substantially greater reductions in Numeric Pain Rating Scale (NPRS) and Modified Oswestry Disability Index (MODI) scores compared to plank exercises, with larger effect sizes and a higher proportion of participants achieving clinically meaningful thresholds of mild pain and minimal disability. These findings support the clinical superiority of MET as a targeted, condition-specific intervention for managing LCS-related biomechanical dysfunction and chronic nonspecific low back pain. Clinicians should consider prioritizing MET as a first-line approach for patients presenting with LCS, while recognizing the value of integrating plank exercises as adjunctive strategies in later stages of rehabilitation or for long-term core strengthening. Future research should focus on assessing the durability of these treatment effects, exploring their applicability across broader patient populations, and investigating potential benefits of combining MET with other exercise-based rehabilitation protocols to further optimize functional outcomes and pain relief (26).

REFERENCES

1. Burile G, Phansopkar P, Deshmukh NS. Prevalence of Lower Cross Syndrome in Housemaids. Cureus. 2024;16(4).

2. Verbrugghe J, Agten A, Stevens S, Hansen D, Demoulin C, Eijnde BO, et al. Exercise intensity matters in chronic nonspecific low back pain rehabilitation. Med Sci Sports Exerc. 2019;51(12):2434–42.

3. Mehta TB, Sharma A. Lower cross syndrome: specific treatment protocol versus generalized treatment protocol. A randomized single-blinded trial. Folia Med (Plovdiv). 2024;66(5):662–72.

4. Sahu P, Phansopkar P. Screening for lower cross syndrome in asymptomatic individuals. J Med Pharm Allied Sci. 2021;10(6):3894–8.

5. Puagprakong P, Kanjanasilanont A, Sornkaew K, Brady W. The effects of Lower Crossed Syndrome on upper body posture during sitting in female office workers. Muscles Ligaments Tendons J. 2022;12(4).

6. Niroomand T, Rabiei M, Mohammadi B. Investigating the effects of 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.

7. Choi JH, Kim DE, Cynn HS. Comparison of trunk muscle activity between traditional plank exercise and plank exercise with isometric contraction of ankle muscles in subjects with chronic low back pain. J Strength Cond Res. 2021;35(9):2407–13.

8. Khan N, Nouman M, Iqbal MA, Anwar K, Sajjad AG, Hussain SA. Comparing the effect of stretching and muscle energy technique in the management of lower cross syndrome. Pak J Med Health Sci. 2022;16(07):31.

9. Naga DN, Zahari Z, Bukry SA. Motor control on gait performance among individuals with Lower Crossed Syndrome: A scoping review. Med J Malaysia. 2024;79:169.

10. Saranraj P. The effectiveness of Comprehensive Corrective Exercise Program along with Janda's approach and lacrosse ball massage technique in the improvement of posture in subjects with Lower Crossed Syndrome. [dissertation]. 2024.

11. Abdel-Aziem AA, Abdelraouf OR, El-Basatiny HM, Draz AH. The effects of stabilization exercises combined with pelvic floor exercise in women with nonspecific low back pain: a randomized clinical study. J Chiropr Med. 2021;20(4):229–38.

12. Gupta G, Alok M. Effectiveness of plank exercise in low back pain. Int J Sci Res. 2018;9(5).

13. Lee HJ, Lim WH, Park JW, Kwon BS, Ryu KH, Lee JH, et al. The relationship between cross-sectional area and strength of back muscles in patients with chronic low back pain. Ann Rehabil Med. 2012;36(2):173.

14. Waters T. The effect of Bruegger's exercise on chronic low back pain in association with Lower Crossed Syndrome [thesis]. University of Johannesburg (South Africa); 2013.

15. Erdem HR, Koçak FA, Kurt EE, Tuncay F. Superior cluneal nerve entrapment neuropathy due to Lower Crossed Syndrome: A case with low back pain. Agri. 2022;34(4).

16. Lee HI, Song J, Lee HS, Kang JY, Kim M, Ryu JS. Association between cross-sectional areas of lumbar muscles on MRI and chronicity of low back pain. Ann Rehabil Med. 2011;35(6):852–9.

17. Attar AA, Maryam I, Mehmood M, Chang R, Fatima R, Laraib A, et al. Comparative effects of Muscle Energy Technique and Proprioceptive Neuromuscular Facilitation stretching in the management of Lower Cross Syndrome: MET vs PNF in Lower Cross Syndrome. J Health Rehabil Res. 2024;4(3).

18. Santos GK, de Oliveira RG, de Oliveira LC, de Oliveira CFC, Andraus RA, Ngomo S, et al. Effectiveness of muscle energy technique in patients with nonspecific low back pain: a systematic review with meta-analysis. Eur J Phys Rehabil Med. 2022;58(6):827.

19. Franke H, Fryer G, Ostelo RW, Kamper SJ. Muscle energy technique for non-specific low-back pain. Cochrane Database Syst Rev. 2015;(2).

20. Al Matif S, Alfageer G, AlNasser N, Alabbas G, Al Sawidan H, Alhareth H. Effectiveness of muscle energy technique on pain intensity and disability in chronic low back patients: a systematic review. Bull Fac Phys Ther. 2023;28(1):24.

21. Fritz JM, Irrgang JJ. A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. Phys Ther. 2001;81(2):776–88.

22. 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.

23. Byrne JM, Bishop NS, Caines AM, Crane KA, Feaver AM, Pearcey GE. Effect of using a suspension training system on muscle activation during the performance of a front plank exercise. J Strength Cond Res. 2014;28(11):3049–55.

24. Abdelraouf OR, Abdelaziem AA. The short-term effects of two thoracic spine manipulation techniques on chronic mechanical low back pain. J Back Musculoskelet Rehabil. 2016;29(4):797–804.

25. Kordi R, Rostami M, Noormohammadpour P, Mansournia MA. Effect of stretching and strengthening exercises on the severity of lower cross syndrome: a randomized clinical trial. J Back Musculoskelet Rehabil. 2019;32(1):145–52.

26. O'Sullivan PB, Phyty GD, Twomey LT, Allison GT. Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. Spine (Phila Pa 1976). 1997;22(24):2959–67.