

EFFECTS OF MODIFIED CLAMSHELL TRAINING VERSUS SLING SYSTEM TRAINING ON PAIN, FUNCTIONAL DISABILITY AND SIJ NUTATION CONTROL IN POSTPARTUM WOMEN WITH SIJ DYSFUNCTION

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Abstract

Background: Postpartum sacroiliac joint (SIJ) dysfunction is a common musculoskeletal condition associated with pelvic pain, impaired lumbopelvic stability and functional disability. Modified Clamshell Training (MCT) and Sling System Training (SST) are used to improve pelvic stability, gluteal muscle activation and neuromuscular control; however, limited evidence is available regarding their comparative effectiveness in postpartum women with SIJ dysfunction.

Objective: The objective of the study was to compare the therapeutic effects of MCT and SST on pain, functional disability and SIJ nutation control in postpartum women with SIJ dysfunction.

Method: The study was a randomized clinical trial. Total 36 postpartum women diagnosed with SIJ dysfunction. Participants were allocated into two groups with 18 participants receiving MCT and 18 receiving SST. MCT consisted of modified side-lying clamshell exercises emphasizing pelvic control and activation of the gluteal muscles. SST targeted LS, POS and DLS through functional exercises designed to improve lumbopelvic stability and force transfer. For six weeks, both interventions were carried out three times a week for 30 to 40 minutes each. NPRS was used to measure pain, PGQ was used to measure functional disability and a digital inclinometer was used to measure SIJ nutation control. Paired samples t test and independent samples t tests were used to examine the data with a statistical significance level of $p > 0.05$.

Results: The MCT group demonstrated a significantly lower NPRS score (1.67 ± 0.97) compared with the SST group (3.78 ± 0.81), $p < 0.001$. Similarly, the post-treatment PGQ score was significantly lower in the SST group (30.11 ± 2.49) than in the MCT group (34.39 ± 2.68), $p < 0.001$. Digital

inclinometer measurements were significantly higher in the SST group ($9.42 \pm 1.13^\circ$) compared with the MCT group ($8.22 \pm 1.43^\circ$), $p=0.009$. Both interventions produced significant within-group improvements in pain, functional disability, and SIJ nutation control.

Conclusion: Both Modified Clamshell Training and Sling System Training were effective in reducing pain and improving functional disability and SIJ nutation control in postpartum women with SIJ dysfunction. However, Modified Clamshell Training demonstrated greater effectiveness in reducing pain, whereas Sling System Training showed greater improvements in functional disability and SIJ nutation control.

INTRODUCTION:

The SIJ is a paired synovial joint that attaches the sacrum to left and right ilia. It provided a vital mechanical link between spine and pelvis for the transfer of load to the lower body(1). Its stability is maintained by the joint surfaces, capsule and strong ligaments like the interosseous, anterior and posterior sacroiliac, sacrotuberous, sacrospinous and iliolumbar ligaments. These ligaments also allow for the restricted nutation and counternutation necessary for walking, absorbing stress and giving birth(2).

Gluteals, transversus abdominis, pelvic floor and trunk muscles are among the surrounding muscles even the SIJ lacks the primary muscles involved in direct movement. By increased compression across the joint, they contribute significantly to dynamic stability through the force-closure process(3).

Sacroiliac joint had limited range of motion. Sliding and rotational motions led to nutation and counternutation. The physiological motion of the sacroiliac joint is often less than 1 mm. However, this small movement is necessary for the distribution of the load, shock absorption and reduction of mechanical stress between the lower limbs and trunk (4).

Lumbopelvic and hip muscle coordination may be essential for optimal SIJ stability and movement control. Clinically, the SIJ is a crucial mechanical bridge that transfers kinetic stresses between the upper spine and lower limbs. Hence, its failure immediately affects activities such as sitting, walking and lifting. The buttocks, groin and thighs are often affected by its pain patterns. It easily caused hip osteoarthritis and lumbar disk herniations(5).

SIJ dysfunction refers to a clinical issue marked by abnormal SIJ alignment or faulty biomechanics. It frequently manifests as stiffness and localized discomfort. Pregnancy-related ligamentous laxity, birth trauma, acute falls, leg-length discrepancies and adjacent segment stress associated with lumbar spinal fusion causes of lower back and pelvic discomfort (6). When this joint isn't working properly then it appears as referred pain pattern that might be confused with lumbar, hip or visceral pathology (7).

According to epidemiology, SIJD is a major postpartum musculoskeletal problem in Pakistan; incidence rates vary greatly among studies. In 2026, a researcher found a 51.2% prevalence among 202 women in Lahore who were evaluated by using five SIJ provocation tests three to seven days after giving birth (8) In 2022 a study of 340 postpartum women showed a significantly higher prevalence of 79.7% in Pakistan. South Asian females reported a 10–20% greater prevalence of PGP at various prenatal and postpartum time points in many cohort studies. In that group, 38% of South Asian women reported having PGP at 14 weeks postpartum (9).

The SIJ is exposed to a high-load mechanical environment and helps to support and transmit body weight. Dysfunction may arise due to an imbalance in joint mechanics, such as hypomobility or hypermobility(10). Acute trauma, repetitive mechanical stress, ligamentous laxity and pregnancy-related hormonal changes all have the potential to impact SIJ function. During pregnancy, increased body weight, altered pelvic morphology, postural alterations and increased intra-abdominal pressure exert additional mechanical stresses

on the lumbopelvic region. These changes may test the ability of the SIJ and adjacent muscles to maintain optimal stability and movement control(11).

Impaired nutation control may cause greater micromotion and a different distribution of weight-bearing stresses over the SIJ. Repeated mechanical stress can lead to localized discomfort and compensatory muscle guarding in the lower back, gluteal region, and pelvis. As a result, SIJ pain might interfere with key postpartum activities like walking, climbing stairs, turning in bed, lifting and carrying a newborn. These constraints may directly affect a mother's capacity to execute childcare, household and occupational tasks(12, 13).

The postpartum period is also characterized by increased physical demands placed on women. Caring for a newborn frequently requires repeated lifting, carrying, feeding, bending and prolonged postures.(14) When the deep core, abdominal, pelvic floor and spinal muscles are weaker or unable to generate efficient dynamic force closure, the pelvic ring becomes more susceptible to mechanical stress. Lifting car seats, maintaining breastfeeding positions and carrying a baby on one side may all cause shear strains in the SIJ. Repeated loading may lead to altered movement patterns, discomfort and decreased functional capacity. (15, 16)

Functional disability is a significant result of postpartum pelvic girdle diseases. Pain and poor pelvic stability may impede extended walking, standing, sitting, stair climbing, turning in bed and lifting or carrying a baby(17). These limits can extend beyond specific physical activities to include childcare, domestic obligations, occupational demands, sleep and overall quality of life. The Pelvic Girdle Questionnaire (PGQ) is a specialized method for assessing activity constraints and participation restrictions related with pelvic girdle pain and can thus be used to measure functional disability in women with postpartum pelvic girdle difficulties(18).

Pain is another therapeutically significant outcome because prolonged SIJ-region pain might modify movement behavior and increase defensive muscle activation. Pain intensity does not fully describe the effects of SIJD. Two women with comparable pain levels may have very different limitations when it comes to walking, babysitting and other daily tasks (19).

SIJD can be managed by using a variety of physiotherapy methods. These include neuromuscular re-education, stabilization exercises, pelvic floor exercises, spine mobilization, Kinesio taping, acupuncture, dry cupping and transcutaneous electrical nerve stimulation.(20). External pelvic compression belts can give mechanical support and lessen shear stresses across the SIJ; however, passive support can only provide symptomatic or temporary mechanical aid and does not treat muscular weakness or reduced motor function. As a result, physical exercise-based approaches to lumbopelvic stability and neuromuscular coordination may be particularly helpful in postpartum rehabilitation (21).

Modified Clamshell Training (MCT) is an exercise-based strategy that focuses on regulated activation of hip stabilizing muscles while maintaining proper pelvic and trunk posture. To perform properly, the trunk and pelvis must be regulated as the hip moves in a controlled range. Maintaining proper lumbopelvic alignment may avoid excessive compensatory pelvic rotation and aid in the coordinated recruitment of hip stabilizers. Improved hip muscle function and pelvic control may help to regulate pelvic posture during weight-bearing and functional activities. Previous clinical research has demonstrated excellent benefits when clamshell exercises are included in rehabilitation programs for SIJD and postpartum lumbopelvic dysfunction (22).

Sling System Training (SST) is another exercise-based technique for improving lumbopelvic stability, postural control, muscular coordination and functional force transmission. Sling-based training allows for supported and regulated activation of the trunk and pelvic musculature. This method may be particularly significant during postpartum therapy because the abdominal, pelvic floor and deep trunk muscles may exhibit decreased strength or poor coordination following pregnancy and childbirth (23).

Sling System Training comprises functional sling systems that help with pelvic stability, spinal control, balance and force transfer. The lateral sling system (LS), posterior oblique sling (POS) and deep longitudinal sling (DLS) all play significant roles in lumbopelvic mobility and stability. The LS promotes frontal-plane pelvic stability, whereas the POS facilitates coordinated force transfer between the trunk and pelvis. The DLS helps

to maintain posterior-chain stability and efficient load transfer during functional movement. These methods give a framework for training coordinated muscle activation rather than focusing solely on discrete muscle strengthening. (24, 25).

In this study, LS, POS, and DLS were chosen for their roles in lumbopelvic stability, balance, postural control and force transfer. Targeting these sling systems is a practical way to improve movement control in postpartum women with SIJD. Although exercise-based rehabilitation is widely utilized for SIJD, there is little direct evidence comparing Modified Clamshell Training (MCT) to Sling System Training (SST) in postpartum women. It is yet unclear which intervention is more effective at relieving pain, improving functional impairment and improving SIJ nutation control. This study could give important evidence for choosing appropriate physiotherapy interventions based on patients' clinical needs.

SIJ nutation management is essential for proper force transmission and lumbopelvic stability. As a result, the current study examined pain using the NPRS, functional impairment using the PGQ and SIJ nutation control with a digital inclinometer. When these outcomes are assessed jointly, the effects of MCT and SST are evaluated comprehensively. Understanding the efficacy of these therapies may assist physiotherapists in developing tailored rehabilitation plans for postpartum mothers with SIJD. The purpose of this study was to examine the effects of MCT and SST on pain, functional impairment and SIJ nutation control in postpartum women with SIJ dysfunction.

Materials and Methods:

This study was designed as a randomized controlled trial (RCT) to compare the effects of Modified Clamshell Training (MCT) and Sling System Training (SST) on pain, functional disability and sacroiliac joint (SIJ) nutation control in postpartum women with SIJ dysfunction. The study was conducted at Rehab Healthcare Clinic Lahore, Hazrat Ayesha Saddiqua Hospital Lahore and Rafiq Medical Centre Lahore over a period of 6 months following approval from the Board of Advanced Studies and Research (BASR). Participants were selected using a nonprobability purposive sampling method. The required sample size was 36, with 18 participants assigned to each group. The sample size was estimated with G*Power version 2.1.9.7 for comparing means between two independent groups using a two-tailed independent-samples t-test with 95% confidence, 80% statistical power, a significance threshold of 0.05 and an effect size of 0.97.

Inclusion criteria included postpartum females aged 20-35 who had a normal vaginal delivery and were 6 weeks to 6 months postpartum with clinically confirmed unilateral SIJ dysfunction. SIJ dysfunction was validated through clinical evaluation using the Laslett criteria, which included the distraction test, compression test, thigh thrust test, sacral thrust test, and Gaenslen test. Exclusion criteria included females experiencing lower back or leg pain due to other etiologies, a history of SIJ sprain or other SIJ abnormalities, tuberculosis affecting the SIJ or spine, tumor, fracture, ankylosing spondylitis or inability to understand the study procedures or provide informed consent.

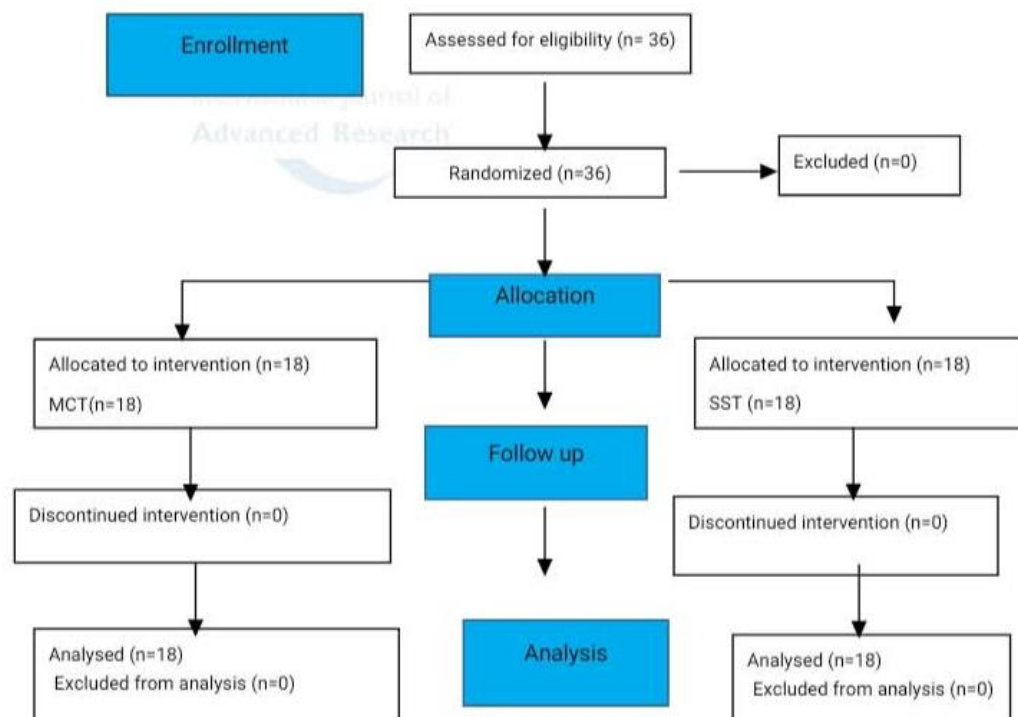
Data were collected using three primary outcome measures: the Numeric Pain Rating Scale (NPRS) to assess pain intensity, the Pelvic Girdle Questionnaire (PGQ) to assess functional disability and a digital inclinometer to assess SIJ nutation control. Participants were randomly assigned to two treatment groups using computer-generated randomization. Group A received Modified Clamshell Training (MCT), Participants were positioned on their sides with the affected limb looking upward, hips flexed to around 45° and knees flexed to 90°. Modified clamshell exercises were carried out with wall contact and around 10% submaximal contraction in the foot, followed by controlled knee separation and external rotation while maintaining pelvic neutrality and minimizing lumbopelvic compensation.

Group B underwent Sling System Training (SST), which focused on the lateral sling (LS), posterior oblique sling (POS) and deep longitudinal sling (DLS). The exercises comprised side-lying hip abduction, resisted lateral walking, supported side-lunge, bridging with contralateral arm movement, single-leg bridging, controlled diagonal movements, a single-leg Romanian deadlift and hamstring-focused workouts. Both groups

received standardized conventional treatment, which included a hot pack for 10-15 minutes, TENS for 15-20 minutes, postural and body mechanics education, gentle pelvic and lumbar range-of-motion exercises, diaphragmatic breathing, relaxation techniques, and comfortable walking based on tolerance. Before beginning the intervention, all participants were told about the study's objectives and methods, and they supplied signed informed consent. Both interventions were administered three sessions per week for six weeks, with each session lasting approximately 30-40 minutes. Each exercise was performed for 12-14 repetitions for 3 sets.

Baseline assessments were undertaken prior to treatment and post-intervention assessments were conducted at the end of the 6-week treatment period. The outcome measures were NPRS, PGQ and digital inclinometer readings of SIJ nutation control. To minimize assessment bias, the trial was single-blind with the outcome assessor ignorant of the participants' group allocation.

CONSORT FLOW DIAGRAM



Statistical analysis: The data were analyzed with SPSS version 27. Descriptive statistics were used to summaries participant characteristics and outcome factors. Quantitative data were reported as mean $\pm$ SD and categorical data as frequencies and percentages. The Shapiro-Wilk test was used to determine the normality of the data. Because the outcome variables followed a normal distribution, paired-samples t-tests were used to evaluate changes within each group, while independent-samples t-tests were used to analyze

differences between the Modified Clamshell Training and Sling System Training groups. A $p > 0.05$ was judged statistically significant.

Results:

A total of 36 postpartum women with sacroiliac joint dysfunction participated in the study and were randomly allocated into two treatment groups with 18 participants in each group. In Table 1 mean age of participants in Group A was 27.11 ± 4.84 years, while that of Group B was

26.78 ± 5.35 years. The mean postpartum period was 13.28 ± 7.02 weeks in Group A and 12.61 ± 6.28 weeks in Group B. The Figure 1 shows that

we have 2 treatment groups, Group A (MCT) and Group B (SST). 18 participants are enrolled in each group.

Table 1. Demographic Characteristics of Participants

Variable	Group A (n=18) Mean ± SD	Group B (n=18) Mean ± SD
Age (years)	27.11 ± 4.84	26.78 ± 5.35
Postpartum period (weeks)	13.28 ± 7.02	12.61 ± 6.28



Figure 1: Illustrate the frequency of participants in treatment groups. each group comprises of n=18.

In Table 2, The Shapiro-Wilk test showed that all baseline outcome variables were approximately

normally distributed with $p > 0.05$ and met the assumptions required for parametric analysis.

Table 2. Test of Normality at Baseline

Outcome	Shapiro-Wilk Statistic	Df	p-value
NPRS Pre	0.945	36	0.072
PGQ Pre	0.947	36	0.084
Digital Inclinator Pre (°)	0.946	36	0.079

Table 3 presents the within-group analysis for the Modified Clamshell Training group. Significant improvements were observed in all three outcome measures following the intervention. NPRS pain scores decreased significantly from 7.00 ± 1.33 to 1.67 ± 0.97 ($p < 0.001$), while PGQ scores

decreased from 53.583 ± 10.185 to 34.389 ± 2.682 ($p < 0.001$). Digital inclinometer measurements increased from $6.794 \pm 1.348^\circ$ to $8.217 \pm 1.431^\circ$ ($p < 0.001$). These findings indicate that MCT was effective in reducing pain and functional disability and improving SIJ nutation control.

Table 3. Within-Group Comparison of Outcome Measures in the MCT Group

Outcome Measure	Pre-treatment Mean $\pm$ SD	Post-treatment Mean $\pm$ SD	Mean Difference	p-value
NPRS	7.00 $\pm$ 1.33	1.67 $\pm$ 0.97	5.33	<0.001
PGQ	53.583 $\pm$ 10.185	34.389 $\pm$ 2.682	19.194	<0.001
Digital Inclinometer (°)	6.794 $\pm$ 1.348	8.217 $\pm$ 1.431	-1.423	<0.001

Table 4 presents the within-group analysis of the Sling System Training group. The intervention resulted in significant improvements in all three outcome measures. The NPRS pain score fell from 7.72 $\pm$ 1.81 to 3.78 $\pm$ 0.81 ($p < 0.001$), and the PGQ score reduced from 52.256 $\pm$ 10.790 to

30.111 $\pm$ 2.494 ($p < 0.001$). The digital inclinometer results increased from 7.222 $\pm$ 1.262° to 9.417 $\pm$ 1.131° ($p < 0.001$). These findings suggest that SST was helpful at reducing pain and functional impairment while also improving SIJ nutation control.

Table 4. Within-Group Comparison of Outcome Measures in the SST Group

Outcome Measure	Pre-treatment Mean $\pm$ SD	Post-treatment Mean $\pm$ SD	Mean Difference	p-value
NPRS	7.72 $\pm$ 1.81	3.78 $\pm$ 0.81	3.94	<0.001
PGQ	52.256 $\pm$ 10.790	30.111 $\pm$ 2.494	22.145	<0.001
Digital Inclinometer (°)	7.222 $\pm$ 1.262	9.417 $\pm$ 1.131	-2.195	<0.001

Table 5 presents the between-group comparison of post-treatment outcome measures between the Modified Clamshell Training (MCT) and Sling System Training (SST) groups. A statistically significant difference was observed in NPRS pain scores ($p < 0.001$), with the MCT group demonstrating a lower post-treatment pain score compared with the SST group. A statistically

significant difference was also observed in PGQ scores ($p < 0.001$), with the SST group demonstrating lower functional disability compared with the MCT group. Digital inclinometer measurements also showed a significant difference between groups ($p = 0.009$) with higher measurements observed in the SST group.

Table 5. Between-Group Comparison of Post-Treatment Outcome Measures

Outcome Measure	MCT Group (n=18) Mean $\pm$ SD	SST Group (n=18) Mean $\pm$ SD	p-value
Post-NPRS	1.67 $\pm$ 0.97	3.78 $\pm$ 0.81	<0.001
Post-PGQ	34.389 $\pm$ 2.682	30.111 $\pm$ 2.494	<0.001
Post-Digital Inclinometer (°)	8.217 $\pm$ 1.431	9.417 $\pm$ 1.131	0.009

Discussion:

The present randomized controlled study investigated and compared the effects of Modified Clamshell Training (MCT) and Sling System Training (SST) on pain, functional disability, and SIJ nutation control in postpartum women with sacroiliac joint dysfunction (SIJD). The results

demonstrated that both interventions produced statistically significant improvements in pain, functional disability, and SIJ nutation control after the six-week treatment period. However, the between-group analysis showed a statistically significant difference in favor of MCT for pain reduction, whereas SST demonstrated greater

improvement in functional disability and SIJ nutation control.

The findings of the current study are consistent with previous research investigating exercise-based interventions in postpartum women with pelvic girdle pain. Yang et al. (2026) reported that structured exercise-based training significantly reduced VAS pain scores and improved PGQ scores among postpartum women with pelvic girdle pain (26). These findings lend support to the current study's findings of significant NPRS reductions and PGQ improvements in both groups. The favorable response shown in both groups implies that active and focused exercise programs could help manage postpartum pelvic girdle discomfort and improve functional abilities. The findings regarding SST are reliable with Alqhtani et al. (2023), who reported that a combination of motor control and balance training produced significant improvements in pain and functional outcomes in individuals with SIJD. Their findings revealed that proprioceptive and control-based exercise techniques could enhance joint stability while also lowering symptoms. (27). Similarly, the current study found significant improvements in SIJ nutation control after SST. The coordinated activation of the lateral, posterior oblique, and deep longitudinal sling systems may increase neuromuscular control and force transfer throughout the lumbopelvic region, resulting in better SI joint control.

The improvement in functional disability following both interventions is also supported by Ruchat et al. (2025), The meta-analysis comprised 37 studies with 3,769 postpartum individuals. The authors reported that exercise-based therapies, particularly trunk-focused strengthening exercises, were beneficial in lowering lumbopelvic pain and associated disability, with moderate-certainty data confirming improvements in symptom severity and disability(28). These findings are congruent with the current study, which found that MCT and SST significantly improved NPRS and PGQ scores. The findings also imply that gradual strengthening and motor-control exercises could help reduce postpartum lumbopelvic discomfort and improve everyday function.

The larger improvement in functional impairment seen with SST is also consistent with current research on stabilization-based exercise. A 2026 systematic review and meta-analysis revealed that core stabilization exercises can reduce pain and disability and enhance quality of life in women with postpartum lumbopelvic pain, with especially notable improvements observed in functional disability.(29). Although the review focused on core stabilization rather than sling training, both treatments emphasize trunk muscle activation, neuromuscular control, and lumbopelvic stability. As a result, SST's emphasis on coordinated activation of trunk and pelvic stabilizing muscles during controlled and functional movements may explain the larger functional improvement observed in the current study.

Javadov et al. (2021) compared sacroiliac and lumbar home exercise programs with manual therapy and reported no significant difference among the treatment groups in improving clinical outcomes (30). These findings differ from the current study, which found a significant outcome-specific difference between the two exercise programs. In the current investigation, MCT improved pain more than SST improved functional disability or SIJ nutation control. This difference could be attributed to the specific workout features and muscle activation patterns used in the current therapies.

Similarly, Sabrina et al. (2023), in a meta-analysis of physical therapy techniques for SIJD, reported that most conventional physiotherapy interventions improved pain and disability, without a clear difference between approaches in their effects on these outcomes (31). This contrasts with the current findings, in which the two therapies displayed differing strengths depending on the outcome measured. MCT was more beneficial for pain relief, whereas SST was more effective for functional disability and SIJ nutation management. This shows that exercise choices may influence specific clinical outcomes rather than having a uniform effect across all dimensions.

Sabrina et al. (2022) investigated kinesio taping combined with muscle energy technique in postpartum women with SIJD and reported

improvement comparable to an exercise-based approach (32). The findings contribute to the growing body of data that various physiotherapy therapies can alleviate postpartum SIJ symptoms. However, the current study focused on vigorous exercise therapies and found that the type of exercise can influence the primary result. As a result, the current findings emphasize the need of selecting an intervention based on the patient's primary therapeutic need, whether pain relief, functional improvement, or enhanced SIJ movement control.

In conclusion, the findings of this study show that both Modified Clamshell Training and Sling System Training are beneficial in relieving pain, functional disability and SIJ nutation control in postpartum women with SIJ dysfunction. However, the between-group results revealed outcome-specific disparities. MCT was more effective in pain relief, whereas SST improved functional disability and SIJ nutation control. These data imply that both therapies may be beneficial in postpartum SIJD rehabilitation, but exercise selection may be influenced by the unique clinical target. MCT may be preferable when pain relief is the primary goal but SST may be more appropriate for enhancing functional capacity and dynamic SIJ regulation.

Limitations:

This study had several limitations. First, the sample size was small, with only 18 individuals in each group, potentially limiting applicability of the findings to the larger postpartum community. Second, the follow-up period was only six weeks, thus the long-term impacts and sustainability of treatment outcomes could not be determined. Third, due to the physical nature of the interventions, participant blinding was not possible, potentially introducing performance or expectation bias. Finally, potentially relevant factors such as parity, route of delivery, level of physical activity and psychological stress were overlooked, which could have altered treatment outcomes.

Recommendations:

This study recommends that Modified Clamshell Training (MCT) and Sling System Training (SST) should be used in physiotherapy for postpartum women with sacroiliac joint dysfunction to reduce discomfort, improve functional capacity, and improve SIJ nutation control. MCT may be given special consideration for pain relief, but SST may be recommended for functional impairment and SIJ nutation management. Future studies should combine MCT and SST and assess long-term results, treatment adherence and quality of life.

Conclusion:

Both MCT and SST showed significant improvements in pain, functional disability and SIJ nutation control after six weeks. Sling System Training was more effective in improving functional disability and SIJ nutation control, while Modified Clamshell Training provided greater pain relief. These findings suggest that combining both exercises may offer more comprehensive benefits for postpartum women with SIJD.

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