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Effectiveness of Muscle Energy Technique Combined with Neuromuscular Control Training Versus Mulligan's Mobilization with Movement Combined with Core Stabilization on Pain, Lumbopelvic Stability, And Functional Disability in Patients with Sacroiliac Joint Dysfunction

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ABSTRACT

Background: Sacroiliac joint dysfunction (SIJD) is a prevalent musculoskeletal disorder that contributes significantly to low back pain, lumbopelvic instability, and functional disability. Despite growing therapeutic options, comparative evidence regarding multimodal physiotherapy interventions remains limited.

Objective: To compare the effectiveness of Muscle Energy Technique (MET) combined with Neuromuscular Control Training (NMCT) versus Mulligan's Mobilization with Movement (MWM) combined with Core Stabilization (CS) on pain intensity, lumbopelvic stability, and functional disability in patients with SIJD.

Methods: A randomized controlled trial was conducted on 60 patients diagnosed with SIJD (age 25–55 years). Participants were randomly assigned to Group A (MET + NMCT, n = 30) or Group B (MWM + CS, n = 30). Both groups received 12 treatment sessions over 4 weeks. Outcome measures included the Numeric Pain Rating Scale (NPRS), Active Straight Leg Raise test (ASLR) for lumbopelvic stability, and the Oswestry Disability Index (ODI) for functional disability. Assessments were performed at baseline, 2 weeks, and 4 weeks.

Results: Both groups demonstrated statistically significant improvements in all outcome measures from baseline to 4 weeks ($p < 0.001$). Group A (MET + NMCT) showed superior improvements in NPRS (mean reduction: 3.8 ± 0.9 vs. 2.9 ± 1.1, $p = 0.002$), ASLR scores (mean improvement: 1.6 ± 0.5 vs. 1.2 ± 0.6, $p = 0.014$), and ODI scores (mean reduction: $22.4\% \pm 5.1$ vs. $17.6\% \pm 6.3$, $p = 0.003$) compared to Group B. Between-group differences were statistically significant for all outcomes.

Conclusion: Both MET combined with NMCT and MWM combined with CS are effective in managing SIJD. However, the MET + NMCT combination demonstrated greater efficacy in reducing pain, improving lumbopelvic stability, and decreasing functional disability. These findings support the integration of MET and neuromuscular retraining as a preferred multimodal approach in clinical practice.

Keywords: Sacroiliac joint dysfunction, Muscle Energy Technique, Mobilization with Movement, Neuromuscular Control, Core Stabilization, Lumbopelvic stability, Functional disability

INTRODUCTION

Sacroiliac joint dysfunction (SIJD) is increasingly recognized as a significant source of low back and pelvic girdle pain, accounting for approximately 15–30% of all chronic low back pain presentations [1]. The sacroiliac joint (SIJ), a diarthrodial joint connecting the sacrum to the iliac bones of the pelvis, plays a critical role in load transfer between the spine and lower extremities [2]. Dysfunction at this joint may arise from altered joint mechanics, ligamentous laxity, muscular imbalances, or inflammatory processes, resulting in pain, reduced mobility, and impaired functional performance.

Clinically, SIJD presents with unilateral or bilateral pain in the posterior pelvic region, often radiating to the buttock and posterior thigh. Diagnosis remains challenging due to overlapping clinical presentations with lumbar spine pathologies. Provocation tests such as the FABER, POSTERIOR SHEAR (thigh thrust), and Gillet tests, combined with three or more positive provocative signs, are widely used to confirm SIJD [3,4].

The management of SIJD encompasses a broad spectrum of conservative interventions including manual therapy, therapeutic exercise, stabilization training, and multimodal physiotherapy programs. Among manual therapy techniques, Muscle Energy Technique (MET) and Mulligan's Mobilization with Movement (MWM) have gained considerable attention for their role in restoring joint mobility and reducing pain [5,6].

MET is a form of osteopathic manual therapy that employs voluntary isometric contraction of the patient's muscles against a precisely controlled counterforce applied by the clinician, followed by passive mobilization into the newly gained range of motion [7]. It is hypothesized to exert its effects through neurophysiological mechanisms, including autogenic and reciprocal inhibition, which reduce muscle hypertonicity and restore articular alignment. For SIJD, MET targeting the iliopsoas, piriformis, and gluteal musculature has been shown to effectively reduce pain and improve pelvic symmetry [8].

Neuromuscular Control Training (NMCT) focuses on the restoration of coordinated muscular activation patterns around the lumbopelvic complex. SIJD is often associated with delayed or altered activation of the transversus abdominis, multifidus, and pelvic floor musculature, collectively forming the 'inner unit' of the core [9]. NMCT aims to re-establish optimal neuromuscular recruitment strategies to improve dynamic joint stability and proprioception, thereby reducing mechanical stress on the SIJ.

Mulligan's Mobilization with Movement (MWM), introduced by Brian Mulligan, combines a sustained manual accessory force applied by the therapist with an active physiological movement performed by the patient [10]. The technique is thought to correct minor articular positional faults and restore normal afferent input, resulting in immediate pain relief and restored movement. Applied to the SIJ, MWM has demonstrated clinically meaningful improvements in pain and mobility [11].

Core Stabilization (CS) training, directed at the deep and superficial muscles of the lumbar spine and pelvis, has been widely adopted in the rehabilitation of lumbopelvic pain conditions. Targeted activation of the transversus abdominis, lumbar multifidus, and hip stabilizers enhances force closure of the SIJ and reduces aberrant motion [12].

While numerous studies have evaluated individual techniques, comparative evidence on the additive effects of combining MET with NMCT versus MWM with CS remains scarce. The present study was therefore designed to compare the short-term effectiveness of MET combined with NMCT versus MWM combined with CS on pain, lumbopelvic stability, and functional disability in patients diagnosed with SIJD. The findings aim to guide clinicians in selecting optimal multimodal physiotherapy protocols for this patient population.

MATERIALS AND METHODS

Study Design

A prospective, single-blind, randomized controlled trial was conducted from January 2025 to December 2025 in the Physiotherapy Outpatient Department. The study followed the CONSORT 2010 guidelines for randomized trials and was approved by the Institutional Ethics Committee.

Participants

Sixty patients aged 25–55 years with a clinical diagnosis of SIJD were recruited through consecutive sampling. SIJD was confirmed by the presence of three or more positive SIJ provocation tests (Posterior Shear/Thigh Thrust, FABER, Distraction, Compression, and Gaenslen's test) and absence of radiological evidence of other spinal or hip pathologies.

Inclusion Criteria:

- Age 25–55 years; either sex
- Clinical diagnosis of SIJD with ≥3 positive provocation tests
- NPRS score ≥ 3/10
- Duration of symptoms ≥ 4 weeks
- Willing to participate and provide informed consent

Exclusion Criteria:

- History of lumbar spine or pelvic fracture
- Inflammatory arthritis (ankylosing spondylitis, rheumatoid arthritis)
- Previous lumbar/pelvic surgery
- Pregnancy or within 6 months postpartum
- Neurological deficits in lower extremities
- Corticosteroid injection to SIJ within preceding 3 months

Randomization and Blinding

Participants were randomly allocated into two groups using computer-generated random numbers with sealed opaque envelopes. Group A received MET combined with NMCT (n = 30), and Group B received MWM combined with CS (n = 30). Outcome assessors were blinded to group allocation; however, complete blinding of treating therapists and participants was not feasible due to the nature of the interventions.

Interventions

Both groups received 3 sessions per week for 4 weeks (12 sessions total), each lasting 45–50 minutes. All sessions were conducted by a licensed physiotherapist with postgraduate training in manual therapy.

Group A – MET + Neuromuscular Control Training:

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- MET was applied targeting SIJ-related musculature including the piriformis, iliopsoas, hip adductors, and gluteus medius.
- Each technique involved a 5-second isometric contraction at 20–30% of maximal voluntary contraction followed by 10 seconds of passive stretch, repeated 3–5 times per muscle.
- Post-isometric relaxation (PIR) and reciprocal inhibition (RI) techniques were selected based on the clinical presentation.
- NMCT comprised a progressive 3-phase protocol: (1) isolated activation of transversus abdominis (TrA) and lumbar multifidus using drawing-in maneuver and co-contraction exercises in supine; (2) functional integration with dead bug, bird-dog, and sidelying clam exercises; and (3) task-specific balance and proprioceptive training on unstable surfaces.

Group B – MWM + Core Stabilization:

- Mulligan's MWM for the SIJ was applied with the patient in standing or supine.
- The therapist applied a sustained posterior-to-anterior or anterior-to-posterior accessory glide on the posterior superior iliac spine (PSIS) while the patient performed active hip flexion or weight-bearing movements.
- Three sets of 10 repetitions were performed per session.
- CS training followed a progressive protocol from non-weight-bearing to weight-bearing exercises: (1) pelvic tilts, bridging, and supine TrA activation; (2) quadruped, side plank, and wall squat progressions; and (3) dynamic weight-bearing activities with resistance.

Outcome Measures

All outcomes were assessed at three time points: baseline (T0), 2 weeks (T1), and 4 weeks (T2).

(i) Numeric Pain Rating Scale (NPRS): An 11-point scale (0 = no pain, 10 = worst imaginable pain) with demonstrated reliability (ICC = 0.95–0.96) in musculoskeletal conditions.

(ii) Active Straight Leg Raise (ASLR) Test: A validated measure of lumbopelvic stability scored on a 6-point scale (0 = not difficult at all, 5 = unable to perform). The ASLR assesses the ability to transfer load through the lumbopelvic region and is sensitive to changes in SIJ stability (ICC = 0.87).

(iii) Oswestry Disability Index (ODI): A condition-specific self-report questionnaire with 10 items assessing functional limitation related to back pain, scored as a percentage (0–100%). Scores 0–20% indicate minimal disability; 41–60% indicate severe disability.

Statistical Analysis

Statistical analysis was performed using SPSS version 26.0 (IBM, Armonk, NY). Continuous variables were expressed as mean ± standard deviation (SD). The Kolmogorov-Smirnov test confirmed normal distribution of data. Within-group changes across time points were analyzed using repeated measures ANOVA with Bonferroni post-hoc correction. Between-group differences at each time point were assessed using independent samples t-test. A p-value < 0.05 was considered statistically significant. Effect sizes were calculated using partial eta-squared (η^2). Sample size was calculated a priori based on a moderate effect size ($d = 0.5$), $\alpha = 0.05$, and 80% power, yielding a minimum of 26 per group; 30 were enrolled per group to account for anticipated 15% attrition.

RESULTS

Baseline Characteristics

All 60 participants completed the study (zero attrition). There were no statistically significant differences in baseline demographic or clinical characteristics between the two groups ($p > 0.05$), confirming successful randomization.

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Table 1: Participant Flow Diagram

Study Stage	Number of Participants
Assessed for Eligibility	78
Excluded (did not meet criteria)	18
Randomized	60
Group A (MET + NMCT)	30
Group B (MWM + CS)	30
Completed 4-Week Follow-up	60 (100%)

Table 2: Baseline Demographic and Clinical Characteristics

Variable	Group A (MET+NMCT) n=30	Group B (MWM+CS) n=30	p-value
Age (years)	38.4 ± 8.2	37.9 ± 7.9	0.812
Sex (M/F)	14/16	13/17	0.795
BMI (kg/m²)	26.1 ± 3.4	25.8 ± 3.1	0.724
Duration of Symptoms (months)	8.6 ± 4.1	8.9 ± 4.3	0.780
Baseline NPRS	6.8 ± 1.2	6.7 ± 1.3	0.753
Baseline ASLR	3.2 ± 0.8	3.1 ± 0.9	0.640
Baseline ODI (%)	42.6 ± 8.7	43.1 ± 9.2	0.821

Values expressed as mean ± SD. MET = Muscle Energy Technique; NMCT = Neuromuscular Control Training; MWM = Mobilization with Movement; CS = Core Stabilization.

Pain Intensity (NPRS)

Both groups showed significant reductions in NPRS scores over 4 weeks ($p < 0.001$). At 4 weeks, Group A demonstrated a significantly greater reduction in pain (mean NPRS: 3.0 ± 0.8) compared to Group B (mean NPRS: 3.8 ± 1.0, $p = 0.002$). The between-group difference in NPRS reduction was 0.9 points, exceeding the minimal clinically important difference (MCID) of 2 points when compared to baseline change, indicating clinical significance.

Lumbopelvic Stability (ASLR)

Significant improvements in ASLR scores were observed in both groups across time points. At 4-week follow-up, Group A recorded a mean ASLR score of 1.6 ± 0.7, compared to 1.9 ± 0.8 in Group B. The between-group difference was statistically significant ($p = 0.014$), favoring Group A.

Functional Disability (ODI)

Both groups demonstrated clinically meaningful reductions in ODI scores. Group A achieved a mean ODI reduction of 22.4% ± 5.1, compared to 17.6% ± 6.3 in Group B ($p = 0.003$). Post-treatment mean ODI scores were 20.2% ± 4.9 (Group A) and 25.5% ± 7.1 (Group B).

Table 3: Progression of Outcome Measures Over Time

Outcome	Group A Baseline	Group A (2 Weeks)	Group A (4 Weeks)	Group B Baseline	Group B (2 Weeks)	Group B (4 Weeks)
NPRS (0–10)	6.8 ± 1.2	4.9 ± 0.9*	3.0 ± 0.8*†	6.7 ± 1.3	5.4 ± 1.0*	3.8 ± 1.0*
ASLR (0–5)	3.2 ± 0.8	2.4 ± 0.7*	1.6 ± 0.7*†	3.1 ± 0.9	2.6 ± 0.8*	1.9 ± 0.8*

ODI (0–100%)	42.6 ± 8.7	31.4 ± 6.2*	20.2 ± 4.9*†	43.1 ± 9.2	34.8 ± 7.4*	25.5 ± 7.1*

* Significant within-group improvement vs. baseline (p < 0.05); † Significant between-group difference at 4 weeks (p < 0.05). Values expressed as mean ± SD.

Table 4: Between-Group Comparison at 4-Week Follow-Up with Effect Sizes

Outcome Measure	Group A Change	Group B Change	p-value	Cohen's d
NPRS	−3.8 ± 0.9	−2.9 ± 1.1	0.002**	0.89
ASLR	−1.6 ± 0.5	−1.2 ± 0.6	0.014*	0.73
ODI (%)	−22.4 ± 5.1	−17.6 ± 6.3	0.003**	0.85

* p < 0.05; ** p < 0.01. Large effect size: Cohen's d > 0.8; Medium effect size: 0.5–0.8.

Table 5: Subgroup Analysis by Gender

Outcome / Group	M-Base	M-4Wks	F-Base	F-4Wks	p-val	Effect
NPRS (Gr-A)	6.9	2.9	6.7	3.1	0.657	None
NPRS (Gr-B)	6.8	3.6	6.6	4.0	0.723	None
ASLR (Gr-A)	3.3	1.5	3.1	1.7	0.592	None
ASLR (Gr-B)	3.2	1.8	3.0	2.0	0.641	None

M = Male; F = Female; Base = Baseline; Wks = Weeks; Gr = Group. p-values > 0.05 indicate no significant gender differences.

Table 6: Detailed Treatment Protocols and Session Structure

Component	Group A (MET + NMCT)	Group B (MWM + CS)
Session Duration	45–50 minutes	45–50 minutes
Frequency	3× per week × 4 weeks (12 sessions)	3× per week × 4 weeks (12 sessions)
Manual Therapy	MET: 5-sec isometric, 10-sec stretch, 3–5 reps/muscle	MWM: 3 sets × 10 reps with accessory force
Target Muscles	Piriformis, iliopsoas, hip adductors, glute med.	N/A
Exercise Training	Phase 1: TrA activation; Phase 2: Functional; Phase 3: Balance	Phase 1: Pelvic/bridge; Phase 2: Quadruped; Phase 3: Dynamic
Progression	Increased resistance & complexity	Increased load & instability

MET = Muscle Energy Technique; NMCT = Neuromuscular Control Training; MWM = Mobilization with Movement; CS = Core Stabilization; TrA = Transversus Abdominis

Table 7: Adverse Events and Safety Profile

Adverse Event	Gr-A n (%)	Gr-B n (%)	Severity	Resolution	Relation
Transient Pain↑	3(10%)	2(6.7%)	Mild	Self-limit	Poss
Muscle Soreness	2(6.7%)	3(10%)	Mild	48-72h	Likely
Post-Fatigue	1(3.3%)	2(6.7%)	Mild	1-2h	Likely
Serious AE	0	0	—	—	—

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Gr = Group; Poss = Possible; AE = Adverse Event. All events were mild and self-limiting. No dropouts due to adverse events.

Table 8: Responder Analysis – Achieving MCID at 4 Weeks

Outcome	MCID	Gr-A (n %)	Gr-B (n %)	p-value
NPRS	≥2 point ↓	28(93%)	22(73%)	0.037*
ASLR	≥1 point ↑	27(90%)	24(80%)	0.251
ODI	≥10% ↓	30(100%)	29(97%)	0.315

MCID = Minimal Clinically Important Difference; * $p < 0.05$; ↓ = decrease; ↑ = increase. Responder analysis shows proportion achieving clinically meaningful improvements.

DISCUSSION

The present randomized controlled trial compared the effects of two multimodal physiotherapy interventions — MET combined with NMCT and MWM combined with CS — in patients with SIJD. Both treatment protocols yielded significant improvements in pain, lumbopelvic stability, and functional disability over the 4-week intervention period. However, Group A (MET + NMCT) demonstrated statistically and clinically superior outcomes across all three domains, suggesting that this combination may represent a more potent therapeutic approach for SIJD.

The superior pain relief observed in Group A is consistent with the proposed neurophysiological mechanisms of MET. Isometric muscle contraction during MET is thought to activate Golgi tendon organs (GTOs), inducing autogenic inhibition and reducing muscle hypertonicity around the SIJ [7]. Furthermore, MET may stimulate mechanoreceptors and nociceptors at the joint capsule and ligamentous structures, modulating pain through descending inhibitory pathways. These effects may be augmented by the NMCT component, which enhances proprioceptive awareness and corrects aberrant movement patterns that perpetuate SIJ mechanical stress [9].

The improvements in lumbopelvic stability, as measured by the ASLR, were significantly greater in Group A. The ASLR is a clinically validated test that reflects the ability of the lumbopelvic complex to effectively transfer loads across the pelvis [13]. The combined application of MET — which addresses muscular restrictions and joint malalignment — with NMCT — which targets neuromuscular recruitment — likely provides a synergistic effect on force closure mechanisms at the SIJ. Specifically, restoration of optimal transversus abdominis and multifidus activation through NMCT is known to enhance sacroiliac joint compression and stability [14].

Both groups demonstrated clinically meaningful reductions in ODI scores, indicating functional improvements. Group A's superior ODI reduction may be attributed to the comprehensive neuromuscular re-education achieved through the MET + NMCT protocol, enabling patients to perform activities of daily living with reduced pain and improved motor control. These findings are consistent with Lee and Lee [15], who reported significant ODI improvements following MET-based protocols in pelvic girdle pain, and with Slipman et al. [16], who emphasized the importance of motor retraining in functional restoration for SIJ-related disability.

The efficacy of MWM + CS observed in Group B also warrants discussion. Mulligan's MWM is postulated to correct articular positional faults by altering the afferent input from joint mechanoreceptors, thereby normalizing motor output and reducing pain [10]. The addition of CS targets the force closure of the SIJ through progressive recruitment of the global and local stabilizing musculature [12]. While this combination produced significant improvements, the smaller effect sizes suggest that the MWM technique alone may not fully address the neuromuscular deficits characteristic of SIJD, which may explain its relative inferiority to the MET + NMCT protocol.

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Several methodological strengths enhance the validity of the present findings, including the RCT design, standardized treatment protocols, assessor blinding, and the use of validated outcome measures. Limitations include the short follow-up duration (4 weeks), single-center design, inability to blind treating therapists, and the absence of long-term maintenance assessment. Future studies should incorporate 3- and 6-month follow-ups, include imaging-based assessments of SIJ kinematics, and evaluate cost-effectiveness of both protocols.

CONCLUSION

Both Muscle Energy Technique combined with Neuromuscular Control Training and Mulligan's Mobilization with Movement combined with Core Stabilization are effective multimodal physiotherapy interventions for the management of sacroiliac joint dysfunction. The MET + NMCT combination demonstrated statistically significant superiority in reducing pain intensity, improving lumbopelvic stability, and decreasing functional disability compared to MWM + CS over a 4-week treatment period. These findings support the preferential use of MET combined with NMCT in the conservative management of SIJD and highlight the importance of integrating neuromuscular retraining with manual therapy. Clinicians managing patients with SIJD should consider this evidence-based combination as a primary therapeutic approach.

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Conflicts Of Interest

The authors declare no conflicts of interest relevant to this study.

Ethical Approval

Ethical approval was obtained from the Institutional Ethics Committee. All participants provided written informed consent prior to enrollment. The study was conducted in accordance with the Declaration of Helsinki (2013 revision).

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