3D Analysis of immediate pelvic kinematic changes post single session of SI Joint Mulligan Mobilization: A case study

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ABSTRACT

Background: Subtle variations in SIJ mobility may influence pelvic kinematics without necessarily constituting pathology. Manual therapy techniques such as Mulligan's Mobilisation with Movement (MWM) are commonly applied to optimize joint mechanics; however, their immediate effects on three-dimensional (3D) pelvic kinematics remain underexplored. **Objective:** The objective of this study was to investigate the immediate effects of a single session of SIJ Mulligan Mobilisation with Movement on pelvic kinematics during gait using 3D motion analysis. **Case description:** A 24-year-old male participant underwent 3D gait analysis before and immediately after a single session of SIJ MWM. Pelvic kinematics were quantified using the Gait Variable Score (GVS) for pelvic obliquity, pelvic tilt, and pelvic rotation. **Outcomes:** Post-intervention findings demonstrated reductions in GVS values across all variables, particularly in pelvic tilt and rotation. These findings highlight the sensitivity of 3D analysis and GVS in detecting subtle, immediate biomechanical changes following manual therapy interventions.

Key words: Sacroiliac joint, 3D analysis, Mulligan with Mobilization, Gait variable score.

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BACKGROUND

During gait, controlled SIJ motion supports the pelvic movements in three planes- anterior and posterior tilt (sagittal plane), pelvic drop/downslip or hike/ upslip (frontal plane), and anterior and posterior rotation (transverse plane), thereby facilitating efficient vertical and lateral displacement of the center of mass.[1] Repetitive unilateral loading, or sustained habitual postures, may contribute to SIJ asymmetry. Alterations in SIJ mobility, alignment, or symmetry may disrupt normal pelvic kinematics and influence gait mechanics. Although these asymmetries are not inherently pathological, they may provoke compensatory adaptations to maintain functional movement.[2] Manual therapy approaches aimed at restoring optimal SIJ mechanics have gained clinical attention. Studies have reported improvements in symptoms and functional changes following SIJ MWM at follow-up periods of days or weeks. The isolated immediate effects of SIJ mobilization on pelvic motion remain largely unknown. Existing research has largely focused on pain, range of motion outcomes, or patient-reported measures; such methods cannot quantify or detect subtle alterations in multi-planar pelvic kinematics. In recent years, three-dimensional (3-D) gait analysis has allowed researchers to examine pelvic movement with high precision and accuracy. Such an analysis could provide insight into how manual therapy may influence real-time pelvic mechanics and bridge the gap between clinical observations and objective biomechanical evidence. Therefore, this study aims to investigate the immediate 3-D pelvic kinematic changes following a single session SIJ MWM.

CASE DESCRIPTION

A 24-year-old male college student (height: 171 cm, weight: 74.8 kg, BMI: 25.6 kg/m^2) was enrolled as a participant in an ongoing research project at the Biomechanics Gait Laboratory of a tertiary care hospital in Belagavi, Karnataka. At the time of recruitment, the participant reported no musculoskeletal complaints. During the analysis, it was accidentally observed that the participant demonstrated reduced pelvic mobility across all three planes. Notable findings included reduced anterior pelvic tilt, diminished anterior rotation, and reduced lateral pelvic movement, with more pronounced findings on the left side compared to the right. Owing to the presence of such findings, the participant was considered a dropout from the existing study. On further history taking, the participant reported experiencing occasional pain and discomfort around the left side SIJ after prolonged standing and walking. Before physical examination, the purpose of the assessment, gait analysis procedure, proposed intervention, and photographic documentation were explained to the participant, and a written informed consent form was obtained. All the procedures were conducted in accordance with principles outlined in the

Declaration of Helsinki. Subsequent clinical examination revealed a left-sided pelvic upslip, i.e., superior positioning of both the Anterior superior iliac spine (ASIS) and Posterior superior iliac spine (PSIS) on the left compared to the right. Additionally, the left side hemipelvis was positioned posteriorly, as compared to the right, i.e., posterior positioning of both left side ASIS and PSIS compared to the right. These two findings were confirmed by the palpatory method. Pelvic mobility was asymmetrically reduced, more prominently on the left side, confirmed by a positive forward bending test.

Pre and post-treatment data were recorded using the BTS Smart DX 3D Gait analyzer to establish baseline kinematics. Bilateral anthropometric measurements were obtained, including pelvic width, pelvic depth, limb length, knee diameter, and malleolar width. Markers were secured with silicone straps and micropore tape after cleansing the skin. 15 retroreflective markers were placed following the Simple Helen Hayes protocol: sacrum (1), bilateral ASIS (2), mid-thigh (2), lateral femoral condyles (2), mid-leg (2), lateral malleoli (2), second metatarsal heads (2), and calcanei (2). The participant walked barefoot along a 10-meter walkway at a self-selected speed. Three to five trials were recorded, and the most representative trial was used for analysis. To prevent fatigue-related variation, rest breaks were provided as needed throughout the assessment process. (figure 1) Data was extracted using the BTS GAITLAB software, including the Gait variable score (GVS), which quantifies overall deviation by comparing the patient's joint kinematics to normative reference values. A higher GVS indicates greater deviation, while lower scores reflect movement patterns closer to normal.

The participant received a single session of SIJ MWM as follows (Table 1):

SIJ MWM	Dosage
Antero-lateral MWM (left side)	10 repetitions × 3 sets (figure 2)
MWM for Up-slip correction (left side)	10 repetitions × 3 sets (figure 3)
MWM for SIJ Nutation and counternutation	10 repetitions × 3 sets (figure 4)

OUTCOMES

Gait Variable Scores obtained were as follows: for pelvic obliquity, a decrease was observed bilaterally, with the left side reducing from 3.8 ± 0.0° to 3.0 ± 0.0° (9.1% reduction) and the right side reducing from 2.2 ± 0.0° to 2.0 ± 0.0° (21.1% reduction). Pelvic tilt showed pronounced improvement, with left-sided values decreasing from 4.8 ± 3.0° to 2.8 ± 0.0° (45.8% reduction) and right-sided values decreasing from 4.8 ± 4.0° to 2.6 ± 0.0° (41.7% reduction). Pelvic rotation demonstrated substantial bilateral reductions, with the left side decreasing from 7.2 ± 0.0° to 4.2 ± 1.1° (43.7% reduction) and the right side decreasing from 7.1 ± 0.0° to 4.0 ± 0.9° (41.7% reduction). (Table 2)

DISCUSSION

The present study examined pre- to post-intervention changes in pelvic kinematics using the Gait Variable Score (GVS), focusing on pelvic obliquity, pelvic tilt, and pelvic rotation. The results demonstrate marked reductions in pelvic tilt and pelvic rotation GVS values bilaterally, while changes in pelvic obliquity were comparatively small.

Prominent improvements were observed in pelvic tilt, indicating changes in sagittal plane movement. Previous research has shown that sagittal pelvic alignment is responsive to therapeutic interventions. Soumik Basu et al. (2023), reported that MWM is effective in mitigating the positional fault at the SIJ, reducing the pain status of the patient, thereby alleviating disability and return to activity.

Substantial reductions were also noted in pelvic rotation GVS values. Transverse plane pelvic motion has been shown to respond to interventions that enhance lumbopelvic and SIJ mobility (Baker et al., 2009). The sensitivity of the GVS in detecting these changes highlights its usefulness as an outcome measure for evaluating subtle kinematic adaptations following manual therapy. Previous studies using the Gait Profile score and GVS have demonstrated their ability to capture meaningful changes in pelvic kinematics following clinical interventions, supporting their application in this study.

In contrast, pelvic obliquity showed smaller immediate changes. Frontal plane pelvic motion is known to be influenced by multiple factors and may require repeated or targeted interventions to demonstrate measurable change (Perry and Burnfield, 20210).

CONCLUSION

The present study demonstrates clinically meaningful reductions in pelvic tilt and pelvic rotation GVS values following intervention, indicating improved sagittal and transverse plane pelvic control during gait. These findings underscore the importance of the GVS as a sensitive, interpretable measure for evaluating specific kinematic adaptations in gait. Incorporating GVS analysis alongside functional outcome measures may further enhance clinical decision-making and research interpretation.

Table 1 – Detailed intervention

Objective	SIJ MWM	Technique	Dosage
Improve rotation on the left side	Antero- lateral MWM	Participant – Lion position Therapist- stands on right side, pushes the left PSIS antero-laterally with one hand, and the other hand stabilizes sacrum. Mobilisation - Glide is maintained, and the participant moves forward and backward.	10 repetitions × 3 sets
Address left-sided upslip	MWM for Up-slip dysfunction	Participant – Standing position Therapist – stands on the left side, both hands are clasped and placed over the iliac crest of the left side . Mobilisation –	10 repetitions × 3 sets

		therapist pushes the iliac crest of left side downward maintains it and participant performs lumbar flexion and extension	
Improve general SIJ mobility and sagittal plane mobility	MWM for nutation and Counter nuation	Participant – Prone lying position Therapist – standing beside, puts heel of the hand on the sacrum. Mobilisation – presses the scarum anteriorly and posteriorly , maintains it while the participant lumbar flexion and extension.	10 repetitions × 3 sets

Table 2 – Pre and Post intervention gait variable score values for left and right side for three pelvic kinematic variables: pelvic obliquity (frontal plane), pelvic tilt (sagittal plane), and pelvic rotation (transverse plane)

Gait Variable Score (GVS)	Pre Test (degrees)		Post Test (degrees)		Percentage Reduction (%)	
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
Pelvic Obliquity	3.8±0	2.2±0	3.0±0	2.0±0	21.1	9.1
Pelvic Tilt	4.8±3	4.8±4	2.8±0	2.6±0	45.8	41.7
Pelvic Rotation	7.2±0	7.1±0	4.2±1.1	4.0±0.9	43.7	41.7

Figure 1

Gait Analysis in a 3D Gait Laboratory

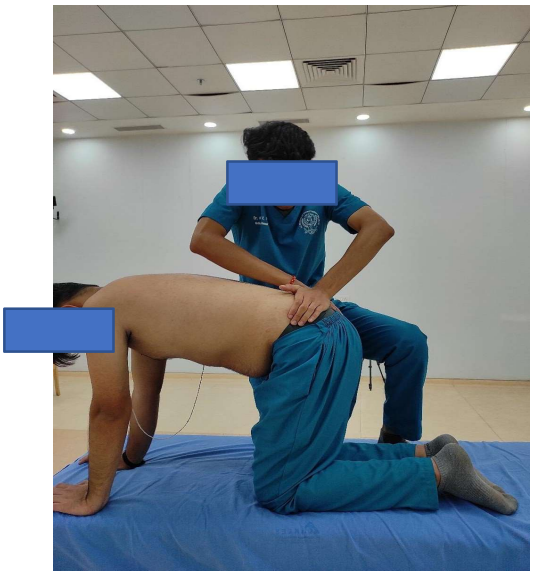

Figure 2
Antero- lateral MWM – left side

Figure 3

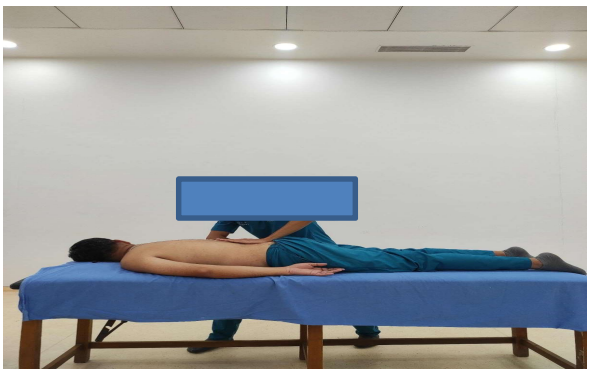

Figure 4

MWM for nutation and Counternuation

DECLARATIONS

Ethics Approval

The study has received ethical clearance from the Institutional Ethical Committee. All the procedures were conducted in accordance with principles outlined in the Declaration of Helsinki.

Consent to Participate

Before physical examination, the purpose of the assessment, gait analysis procedure, proposed intervention, and photographic documentation were explained to the participant, and a written informed consent form was obtained.

Consent to Publish

The participant has consented to the submission of the case report to the journal and regarding publishing their data and photographs.

FUNDING RESOURCES

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DISCLOSURE OF INTEREST

The authors have no conflict of interest to report.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study will be made available upon reasonable request.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Dr. Varsha Huddar - Conceptualization, data curation, methodology, project administration, supervision, visualization, writing – review and editing.

Dr. Samta Gandhi– Conceptualization, visualization, writing – review and editing.

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Declaration for use of AI

Artificial intelligence–based tools were used to support manuscript preparation, including language refinement and organization. No AI tool was used for data analysis, result generation, or clinical decision-making. All content was reviewed and approved by the authors.

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