

Effect of Graded Motor Imagery Training in Individuals with Chronic Lumbar Prolapsed Intervertebral Disc: A Research Protocol for a Randomised Controlled Trial

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ABSTRACT

Introduction: Prolapsed Intervertebral Disc (PIVD) causes lumbar pain, altered sensory processing, fear of movement, and reduced function. Chronic conditions disrupt central pain processing, motor planning, and body perception. Graded Motor Imagery (GMI), a recently used neuroscience-based intervention that targets altered central pain processing, cortical representation, and motor planning, has emerged as a promising intervention. Although GMI has demonstrated benefits in several chronic pain conditions, evidence regarding its effectiveness in chronic lumbar PIVD is limited.

Need of the study: Chronic lumbar PIVD is associated with pain, disability, impaired lower extremity function, and fear-avoidance behaviours that are not fully addressed by conventional physiotherapy. Although GMI targets altered central pain processing and cortical representation, evidence regarding its effectiveness in chronic lumbar PIVD remains limited. Therefore, the present study calls for a clinical trial to assess the effectiveness of GMI training.

Aim: To evaluate the effectiveness of GMI training on pain, lower extremity function, disability, and fear-avoidance in chronic lumbar PIVD patients.

Materials and Methods: This protocol describes a two-arm, parallel-group randomised controlled trial, which will be conducted at Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation (MMIPR), Mullana-Ambala, Haryana, from March 2026 to March 2027. A total of 60 participants with chronic lumbar PIVD aged 18-45 years will be randomly allocated into two groups: an experimental group, which will receive GMI training and conventional physiotherapy and a control group, which will receive conventional physiotherapy only, twice a week for four weeks. Pre- and post-intervention outcome measure assessments will be done for pain on the Numerical Pain Rating Scale (NPRS), for Disability on the Oswestry Disability Index (ODI), for fear avoidance on the Fear Avoidance Belief Questionnaire (FABQ), and for lower extremity function on the Lower Extremity Functional Scale (LEFS) at baseline and after the 4-week intervention period. Shapiro-Wilk test for normality, paired t-tests (within groups), independent t-tests (between groups), Wilcoxon Signed Rank and Mann-Whitney U test will be applied. A p-value of <0.05 will be considered statistically significant.

Keywords: Intervertebral disc, Kinesiophobia, Low back pain, Perception, Radiculopathy

INTRODUCTION

Low Back Pain (LBP) is one of the most common musculoskeletal disorders and a leading cause of disability worldwide [1]. A previous study reported that 46.2% of patients with Lumbar Disc Herniation (LDH) experienced long-term LBP, compared with a point prevalence of 11.9% in the general population [2]. LDH, prolapsed disc, is one of the most prevalent structural causes of LBP. LDH occurs when the nucleus pulposus breaks through the annulus fibrosus [3]. According to epidemiological data, it affects about 10% of the working-age population [4].

Chronic PIVD alters central pain processing, motor planning and body perception. Altered pain processing may be influenced by cognitive and psychosocial factors, including distraction and catastrophising [5]. Pain perception has been conceptualised as a neuromatrix-related process involving distributed neural representations that may become sensitised and disinhibited in chronic pain [6,7]. Although several techniques have been developed to address fear of movement (Kinesiophobia), pain, disability and lower extremity function, GMI has emerged as a relatively recent and effective approach which includes Motor retraining, explicit motor imagery, sensory discrimination, laterality training and graphesthesia. GMI normalises brain representations, lowers fear-avoidance, and enhances function [8]. GMI encourages safe, pain-free engagement

and potentially improves movement, reducing hypersensitivity [9]. This technique has been effectively used in several chronic pain conditions, including Complex Regional Pain Syndrome (CRPS), Phantom Limb Pain (PLP), and other neuropathic pain disorders and shows an effect in reducing pain and impairment [10]. Chronic lumbar PIVD is associated with pain, disability, impaired lower extremity function, and fear-avoidance behaviours that are not fully addressed by conventional physiotherapy. Although GMI targets altered central pain processing and cortical representation, evidence regarding its effectiveness in chronic lumbar PIVD remains limited. Therefore, the present study calls for a clinical trial to assess the effectiveness of GMI training.

REVIEW OF LITERATURE

The GMI retrains cortical motor networks to reduce pain and fear of movement and facilitate pain-free motor learning. Although Dudhani et al. evaluated GMI in individuals with postoperative lumbar degenerative disease, evidence regarding its effectiveness in non-postoperative chronic lumbar PIVD remains limited [11].

Louw A et al., reported a case of a 56-year-old patient with an L5 herniated disc to evaluate the effects of GMI on pain, two-point discrimination, tactile acuity, disability, and fear-avoidance beliefs. GMI was delivered twice a week for three weeks. Outcomes-

ODI, NPRS, and FABQ were followed for one year. The study demonstrated improvement in pain, tactile acuity, two-point discrimination, disability, fear-avoidance beliefs, and movement, providing preliminary case-based evidence of GMI in LDH [8].

Dudhani S et al., conducted an RCT to evaluate the effect of GMI on fear of movement, LBP, leg pain, and disability in individuals with lumbar degenerative disease. Sixty participants were allocated into two groups (GMI and standard exercise). Both groups showed significant improvements in FABQ, NPRS, and ODI ($p < 0.0001$; 95% CI), with greater improvement in the GMI group, indicating reductions in pain, disability, and fear-avoidance beliefs. Supporting GMI as an effective adjunct to conventional rehabilitation [11].

Bowering KJ et al., conducted a systematic review that synthesises evidence for GMI and its components on chronic pain. Six RCTs were included in the systematic review; the meta-analysis comparing GMI with usual physiotherapy included two studies involving 63 participants [9]. The outcomes assessed: McGill Pain Questionnaire, Visual Analogue Scale (VAS), and NPRS. Positive effects were observed for both mirror therapy and GMI [9].

Limakatso K et al., conducted a systematic review and meta-analysis to evaluate the efficacy of GMI and its components in reducing PLP, with outcomes: VAS, 11-point numerical rating scale, and HRQoL. The study showed a significant reduction in PLP {Weighted Mean Difference (WMD) = -21.29; 95% CI: -31.55 to -11.02}. The sequential GMI produced superior outcomes. The evidence supported GMI in reducing PLP and highlighting its clinical effectiveness [12]. Ji EK et al., conducted an 8-week RCT in 42 participants with chronic stroke, evaluating home-based GMI for upper-limb recovery.

Ji EK et al., conducted an 8-week RCT in 42 participants with chronic stroke, evaluating home-based GMI for upper-limb recovery. Outcomes: Manual Function Test, Fugl-Meyer Assessment, and Modified Barthel Index were assessed. GMI group showed greater improvement in MFT arm-motion score (group $\times$ time interaction, $p = 0.042$). This suggests potential benefits for upper-limb motor recovery [13].

Yasaci Z and Celik D conducted a 6-week RCT in 38 participants with frozen shoulder, comparing multimodal physical therapy with and without GMI. Outcomes were assessed: disability index score, minimal clinical importance difference, NPRS, and Q-DASH. GMI produced greater improvements in pain and disability, with a mean between-group difference of 10 points in SPADI (95% CI: 4-17; $p = 0.01$), along with superior improvement in upper limb function (Q-DASH mean difference: 9 points; 95% CI: 3-14; $p = 0.01$), supporting GMI as an adjunct to rehabilitation [14].

Rierola-Fochs S et al., conducted an RCT, evaluating the effectiveness of home-based GMI intervention for the treatment of PLP. The study enrolled 36 participants and followed the protocol for nine weeks. Outcomes were assessed for PLP and Quality of life. GMI group demonstrated reductions in PLP post-intervention ($p = 0.02$); the effect was maintained at 12-week follow-up ($p = 0.05$). The intervention showed a low number needed to treat (NNT=2.27; 95% CI: 2.03-2.52), indicating high clinical effectiveness [15].

Overall, GMI appears to be an effective approach in reducing pain, disability, fear of movement, and improving functional outcomes. However, evidence in chronic LBP remains limited. Thus, this study aims to evaluate the effectiveness of GMI training on pain, lower extremity function, disability, and fear-avoidance in chronic lumbar PIVD patients. The primary objectives are to evaluate the effectiveness of GMI training along with conventional physiotherapy on pain intensity, lower extremity functional performance, disability, and fear-avoidance beliefs in individuals with chronic lumbar PIVD and to evaluate the effectiveness of conventional physiotherapy only on pain intensity, lower extremity functional performance, disability, and fear-avoidance

beliefs in individuals with chronic lumbar PIVD and secondary objectives are to compare which intervention is more effective in improving pain intensity, lower extremity functional performance, disability, and fear-avoidance beliefs in individuals with chronic lumbar PIVD.

Secondary Objective

1. To compare which intervention is more effective in improving pain intensity, lower extremity functional performance, disability, and fear-avoidance beliefs in individuals with chronic lumbar PIVD.

Null Hypothesis (H0): There will be no significant effect of GMI training on pain, lower extremity function, disability, and fear-avoidance in individuals with chronic lumbar PIVD.

Alternative Hypothesis (H1): There will be a significant effect of GMI training on pain, lower extremity function, disability, and fear-avoidance in individuals with chronic lumbar PIVD.

MATERIALS AND METHODS

A randomised controlled trial will be conducted at Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala, Haryana, from March 2026 to March 2027. Eligible participants will provide written informed consent after receiving information and may withdraw voluntarily at any time without affecting their treatment. The study has been approved by the Institutional Ethics Committee of Maharishi Markandeshwar Institute of Medical Science and Research College with Project No: IEC-PT-26/80, and the trial is prospectively registered with Clinical Trial Registry-India under reference number CTRI/2026/05/110135.

Inclusion criteria: Both male and female individuals aged between 18-45 years will be included. Participants will be eligible if they have a score of ≥ 29 on the Work subscale of the Fear-Avoidance Beliefs Questionnaire (FABQ-W) or ≥ 14 on the Physical Activity subscale (FABQ-PA), an NPRS pain score of $\geq 4/10$, and no sensory deficit [11,16].

Exclusion criteria: Participants will be excluded if they are unable to understand or perform the motor-imagery tasks, decline participation, have a history of lumbar spine surgery, or have undergone surgery secondary to tumour, trauma, infection or spinal fusion.

Sample size calculation: NPRS is used as a primary outcome measure in the study, and effect size is calculated from NPRS [11].

- Experimental group = 3.87 ± 1.14
- Control group = 2.07 ± 1.51

Mean Difference (MD) = 1.80

Calculated pooled Standard Deviation (SD {pooled})

$$SD_{\text{pooled}} = \sqrt{\frac{\{1.14^2 + 1.51^2\}}{2}} = 1.34$$

Calculate Cohen's d (difference)

$$d = \frac{MD}{SD_{\text{pooled}}} = \frac{1.80}{1.34} = 1.34$$

However, to avoid underestimating the sample size and ensure adequate statistical power, a large effect size (Cohen's $d = 0.8$) was assumed for sample size estimation.

$$n = \frac{2 \left(Z_{\alpha/2} + Z_{\beta} \right)^2}{d^2}$$

Where:

$Z_{\alpha/2} = 1.96$ (5% significance level)

$Z_{\beta} = 0.84$ (80% power)

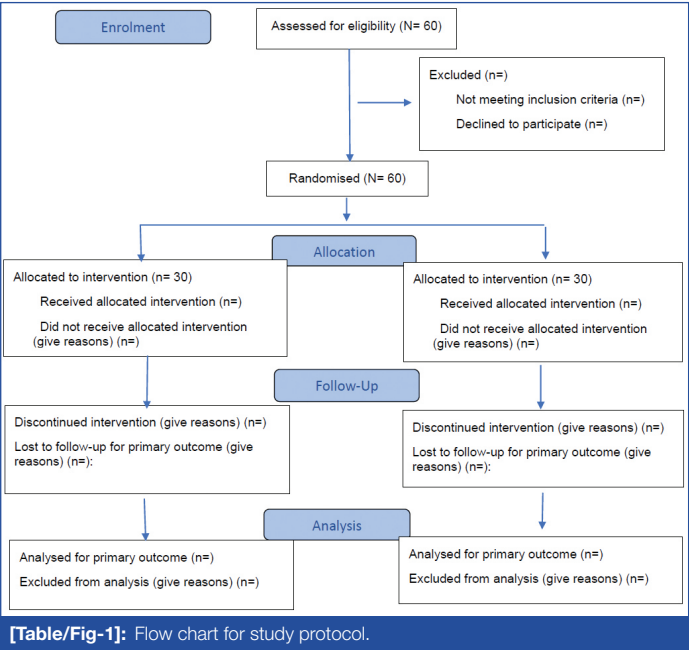
$d = 0.8$ (assumed effect size)

Calculation:

$$n = \frac{2(1.96 + 0.84)^2}{(0.8)^2} = 24.8$$

The calculated sample size was 25 participants per group. After allowing for a 20% attrition rate, the required sample size was increased to 32 participants per group, but 30 was considered, resulting in a total sample size of 60 participants.

Eligible participants will be recruited using criterion-based sampling and randomly allocated in a 1:1 ratio to the intervention or control group using a computer-generated random sequence. Allocation concealment will be maintained using sequentially numbered, opaque, sealed envelopes prepared by an independent researcher [Table/Fig-1]. Both groups will receive twice-a-week intervention for four weeks, with allocation concealed using sequentially numbered, sealed, opaque envelopes. Because of the nature of the intervention, participants and treating therapists cannot be blinded. To minimise potential bias, a single therapist will administer the intervention, and a blinded assessor will evaluate NPRS, ODI, FABQ, and LEFS at baseline and post-intervention. Any unblinding will be documented with justification.



Group A

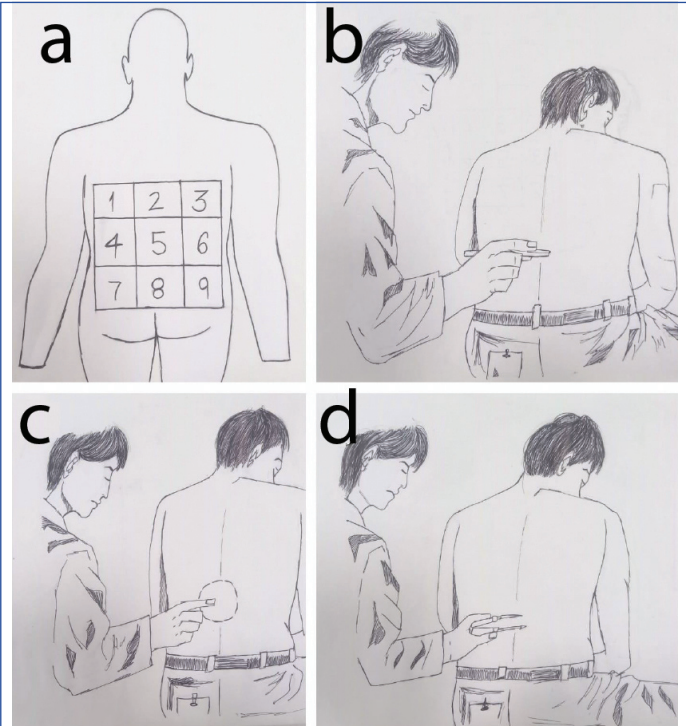
Participants in the GMI group will receive GMI training along with conventional physiotherapy, twice a week for four weeks. GMI training will include motor imagery (10 minutes), localisation training (5 minutes), sensory discrimination (5 minutes), graphesthesia (5 minutes), two-point discrimination (5 minutes), and laterality training (5 minutes).

- **Laterality training:** Left/Right discrimination will be divided into five stages, using random pictures of either the left/right-side of the trunk, progressing by increasing the challenge at each stage. Participants will be instructed to recognise and answer verbally [11].
- **Motor imagery:** Two videos, each consisting of 10 slow repetitions of selected movements, will be used progressively. Week 1 will include small-range lumbar spine movements (pelvic tilt/rotations), bilateral arm elevation while keeping the back still, and standing hip flexion with a stable back. The second week will be followed by the 2nd video, including full-range lumbar flexion, extension, side flexion, and rotation. Participants will be instructed to watch the videos and imagine themselves performing the same movements in a pain-free manner twice per session, three times each day [11].
- **Localisation training:** Participants will be in a high sitting position with the lower back exposed. A grid picture of the lumbar spine with nine marked dots will be shown to the participants. The therapist will apply light pressure using the

blunt end of the pen on a randomly selected point for about two seconds. Participants will be instructed to refer to the picture and answer which point has been stimulated. [Table/ Fig-2a] [11].

- **Sensory discrimination:** Participants will be instructed to localise the stimuli applied to the lower back with the dull end of the pen and the sharp end of a paper clip to facilitate sensory discrimination [Table/Fig-2b] [11].
- **Graphesthesia:** Various letters or numbers will be written over the participant’s lower back with the dull end of a pen, and task difficulty will be progressively increased based on participant accuracy [Table/Fig-2c] [11].
- **Two-point discrimination:** An aesthesiometer will be used by alternating the skin pressure between one- and two-point stimulation. The participant will be asked to determine the feeling of the points [Table/Fig-2d] [11].

The overall schedule of participant recruitment, allocation, interventions, and outcome assessments is presented in [Table/Fig-3].



[Table/Fig-2]: a) Localisation testing grid; b) Sensory discrimination; c) Graphesthesia; d) Two-point discrimination.

Study activity	Week 0	Week 1	Week 2	Week 3	Week 4
Eligibility and consent	X				
Allocation	X				
Interventions		X	X	X	X
Baseline assessments	X				
Post-intervention assessments					X
NPRS, LEFS, ODI, FABQ	X				X

[Table/Fig-3]: Timeline/SPIRIT figure.

Group B

Group B (Control) will receive conventional physiotherapy only. It includes strengthening exercises, manual therapy, physiotherapeutic modalities and ergonomics. The total session duration will be approximately 45-60 minutes per session, twice per week for four weeks.

- **Physiotherapy modalities:** Participants will be given a hot pack in a prone lying position to the lumbar paraspinal region for 15 minutes [17], and ultrasound for 10 minutes with 1.0 MHz frequency to reduce pain, spasm and promote relaxation in the patient.

- **Manual therapy [18]:** Spinal mobilisation- gentle joint mobilisation of lumbar vertebrae to improve range of motion and alleviate pain. Patient will be positioned in prone lying. Initially, Maitland grade 1-2 technique will be used, and progressed to grade 3 based on participant tolerance, with a duration of 2-3 sets for 30-60 seconds per session.
- **Lumbar traction:** Mechanical traction to reduce radicular pain will be administered in a supine position with a 10 sec hold/10 sec rest, for a duration of 10-15 minutes.

Exercise therapy [19]:

- Core stabilisation exercises: Pelvic bridging with abdominal contractions will be performed in a crook-lying position to strengthen core musculature, with a dosage of 10 repetitions, 5-10 seconds hold for 2-3 sets.
- Extension (McKenzie) exercises: Prone lumbar extension movements will be performed with a dosage of 10 repetitions for 2-3 sets.
- Stretching exercises: Targeted stretches will be performed in a supine position with a dosage of 10 repetitions, 20-30 seconds hold for two sets, to improve flexibility.
- Aerobic/activity exercises: Walking to improve mobility and endurance without aggravating the disc for 10 to 15 minutes initially, with progression to 20-30 minutes.

Ergonomics [19]:

- Postural and ergonomic training: Participants will receive instructions on maintaining proper posture during work and daily activities.
- Activity modification: Participants will be advised to avoid aggravating positions (for example, prolonged bending or sitting on the floor).
- Home exercise program: Participants will receive education to continue prescribed exercises and ergonomics advice at home.

Participants will be advised to avoid additional physiotherapy/treatment during the study, with reminders and follow-up calls to promote compliance and minimise dropouts. Any protocol changes will be updated or communicated to the ethics committee and registry. Any adverse events will be managed appropriately. Participants may withdraw at any time and continue standard care post-study if required.

Primary Outcomes

1. **Numerical Pain Rating Scale (NPRS):** The NPRS is used to measure pain intensity, in which participants are asked to select a number (from 0 to 10) to represent their pain severity and will be assessed at baseline and after the intervention period of four weeks. Reliability of NPRS: ICC=0.991, and it shows good construct validity [20].

Secondary Outcomes

1. **Fear-avoidance Beliefs Questionnaire (FABQ):** FABQ comprises 16 items and is rated on a 7-point Likert scale (0-6), with work (FABQ-W, 7 items, maximum score=42) and physical activity (FABQpa, 4 items, maximum score=24) subscales. Higher scores indicate greater fear-avoidance beliefs [21]. It takes approximately 10 minutes to complete and demonstrates good test-retest reliability (FABQ-W ICC=0.82 and FABQ-PA ICC=0.66) and validity [22].
2. **Oswestry Disability Index (ODI):** It is comprised of 10 dimensions, with six levels set in each dimension. Each item is scored from 0 to 5, with higher scores indicating greater disability; the total score is commonly expressed as a percentage. High test-retest reliability: ICC values range from 0.84-0.94 and demonstrate strong construct and criterion validity [23].

3. **Lower Extremity Functional Scale (LEFS):** The LEFS had high internal consistency (Cronbach α :0.94), and good test-retest reliability (intraclass correlation coefficient:0.86). The modified LEFS had satisfactory psychometric properties in participants with LBP [24].

Outcome measures will be evaluated and assessed by the primary outcome assessor at baseline and after the intervention period of four weeks.

STATISTICAL ANALYSIS

Data will be analysed using Statistical Package for Social Sciences (SPSS) v27.0 (IBM Corp., Armonk, NY, USA). Normality will be assessed using the Shapiro-Wilk test. Normally distributed data will be reported as Mean $\pm$ SD and analysed using parametric tests (paired t-tests (within groups) and independent t-tests (between-groups)), while non normal data will be presented as median (interquartile range) and analysed using non parametric tests (Wilcoxon, Mann-Whitney). A p-value <0.05 is considered statistically significant.

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