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# Effect of Motor Control Exercise on Swiss Ball and PNF Technique on Non-Specific Low Back Pain

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## ABSTRACT

***Objective:*** *Comparison between motor control exercise on swiss ball and PNF technique on patients with non-specific low back ache.* ***Study design:*** *Comparative study.* ***Setting:*** *All subjects were included from Forest Research Institute at Dehradun.* ***Method:*** *A total of 30 subjects were recruited for the study based on inclusion and exclusion criteria after signing the informed consent form. The subjects were divided into two groups (I-15 patients on swiss ball exercises program and II- 15 patients on PNF exercises program).* ***Outcome measures:*** *Visual analog scale (VAS), baseline digital inclinometer, Roland Morris low back pain and disability questionnaire (RMDQ).* ***Results:*** *Showed significant improvement in the outcome measures in both the techniques. However, both methods were found to be similarly effective in decreasing pain and disability and improving flexibility in subjects with chronic non-specific low back pain.* ***Conclusion:*** *The study showed a significant improvement in pain, disability, and ROM in patients with non-specific low-back pain employing rhythmic stabilization technique as well as motor control exercise on swiss ball. However, both methods proved to be similarly effective in decreasing pain, disability and increasing ROM in patients with non-specific low back pain.*

**Keywords:** Visual analog scale, Baseline digital inclinometer, RMDQ

## INTRODUCTION

The most used classification for pain in lumbar spine by the clinicians is "specific" or "non-specific" LBP [1,2]. A specific LBP diagnosis (about 1-2% of all patients with early back pain) is attributed to LBP, referring to any diagnosis from a systemic disease, infection, injury, trauma, cauda equine or structural deformity [3]. Nerve root pain usually represents about 5% of the pain in patients with disc prolapse and spinal stenosis [3-5]. The term "non-specific" indicates that no precise structure has been identified in causing pain. Non-specific low back pain includes common diagnosis such as lumbago, myofascial syndromes, and muscle spasms, mechanical LBP, back sprain, back strain [1].

Acute non-specific LBP has a favorable prognosis. However, some authors argue that if recovery from non-specific LBP has not occurred during the first 3 months, then non-specific LBP will be a chronic disease for life [6,7].

Non-specific low back pain is an uncomfortable medical condition that causes frequent disability and absence from work [8]. Approximately 70-85% of individuals experience during their lifetime, and over 80% of them report recurrent episodes. Recent inception cohort study demonstrated that 43% of patients with acute low back pain seen in primary care settings develop chronic low back pain and that nearly a third of them did not recover within one year. It is estimated that 80-90% of subjects will recover within six weeks, regardless of the type of treatment. However, 5-15% will develop low back pain [9].

International guidelines for the management of low back pain (LBP) recommend an initial triage to facilitate effective management of the problem [10]. This classification process differentiates between specific spinal pathology, nerve root pain and simple or non-specific low back pain (NSLBP) [11]. NSLBP represents about 85% of LBP patients seen in primary care and the clear majority of LBP patients seen by physical therapists are classified under this label [12].

In acute non-specific low back pain (0-4 weeks duration of pain) there is moderate to strong evidence that self-care with over-the-counter medication and maintaining activity as tolerated or treatment with a limited number of sessions with manipulative therapy is effective for pain relief. In sub-acute nonspecific low back pain (4-12 weeks duration of pain) there is moderate to strong evidence that a graded activity program including exercises and cognitive behavioral treatment in combination is more efficient than usual care about return to work. In cases of chronic non-specific low back pain (>12 weeks of pain duration) a variety of treatment are available with limited and similar efficacy on pain and disability reduction [13].

Motor control exercise (also known as specific stabilization exercise) was first considered as a treatment for LBP about 13 years ago. When a group of researchers from the University of Queensland in Australia published the first article on this topic [14]. The biological rationale for motor control exercise is fundamentally based on the idea that the stability and control of the spine are altered in people with LBP [14]. Physiological studies have demonstrated that patients with LBP may exhibit a delayed onset of activity of the deep trunk muscles (e.g., Transversus abdominis, Multifidus) when the stability of the spine is challenged in dynamic tasks [15,16]. It was demonstrated that patients who recovered from an episode of LBP are more susceptible to recurrence and chronicity if these changes were not treated with motor control exercises [17]. It was therefore presumed that motor control exercises on swiss ball will prove to be effective in patients with low back pain.

Motor training induces experience specific patterns of plasticity across the motor cortex and spinal cord. Robust pattern of anatomic and physiological plasticity was seen that occurs within the cortico-spinal system in response to differential motor experience [18].

Proprioceptive neuromuscular facilitation (PNF) exercises are designed to enhance the response of neuromuscular mechanisms by stimulating proprioceptors. The patterns of PNF exercises have a spiral, diagonal direction, and the performance of these patterns is in line with the topographic arrangement of the muscles being used [19]. Therefore, these exercises may be better suited for performance enhancement than is conventional single-plane or single-direction weight-training programs. Furthermore, PNF techniques often have been used to improve the range of motion of a joint and endurance as well as performance in a vertical jump [20-26].

Various techniques of PNF training are used like rhythmic initiation, combination of isotonics (reversal of agonists), reversal of antagonists (dynamic reversal of antagonists, stabilizing reversal, rhythmic stabilization), Repetitive stretch, contract-relax, hold-relax and replication. We used rhythmic stabilization technique in our study. The rhythmic stabilization technique uses isometric contraction of antagonistic patterns and results in co-contraction of the antagonists if the physical therapist does not break the isometric contraction. It is used mainly to manage conditions in which weakness is a primary factor and in which stabilization provides stimulation of the agonistic pattern [19]. The goals of rhythmic stabilization include increasing active and passive range of motion, strength, increasing stability and balance and decreasing pain. Although these forms of PNF exercises are used in physical therapy practice, their effects on chronic non-specific low back pain are not clear [27].

**Motor Control Exercise on Swiss Ball**

Trunk muscle co-activation of several muscles is considered necessary in achieving adequate spinal stability to prevent and treat low back injury [28]. All terms describe the muscular control required around the lumbar spine to maintain functional stability. The “core” has been described as a box with the abdominals in the front, paraspinals and gluteal in the back, the diaphragm as the roof, and the pelvic floor and the hip musculature as the bottom [29]. Attention has been paid to the core because it serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement as depicted by the Lucas, et al., in 1961 [21].

The importance of trunk muscles in providing adequate spine stability is well established and the role of trunk muscles during a variety of tasks has been well documented [30]. Although several processes are likely to be involved, the model provided by Panjabi in 1992 could provide an explanation for recurrences after painful symptoms have subsided [31,32]. This model of spinal stability encompasses the passive, active, and neural control sub systems. It has been proposed that instability at the spinal segmental level is a loss of control or excessive motion in the spinal segment's neutral zone, which is associated with injury, degenerative disc disease, and muscle weakness [31,32].

Multiple studies have examined core muscle recruitment during varying types of swiss ball abdominal exercise and during traditional abdominal exercises like the crunch (abdominal curl-up) and bent-knee-sit-up [12]. The biological rationale for motor control exercise is fundamentally based on the idea that the stability and control of the spine are altered in people with LBP [14].

Finally, it was demonstrated that the patients who recovered from an episode of acute LBP are more susceptible to recurrence and chronicity if these changes were not treated with motor control exercise as depicted by Hides, et al., in 2001 [17].

## PNF

Proprioceptive neuromuscular facilitation (PNF) exercises are designed to promote the neuromuscular response of the proprioceptors. Neuromuscular facilitation exercise is based on some movement patterns to facilitate and correct sensory motor function. It has been suggested that these exercises correct the impaired impulses emerging from the proprioceptive receptors in the muscles. Therefore, pain may be decreased, and strength of the muscles may be improved [19].

PNF exercises maximize improvements in flexibility. Such exercises take advantage of body's inhibitory reflexes to improve muscle relaxation. Also, it has been shown in previous studies that back pain and spinal pathologies cause spasm in the muscle which leads to the development of pain-spasm-pain cycle. PNF exercises by promoting muscle relaxation may break this pain-spasm-pain cycle and hence leads to improvement of lumbar mobility in the pain free range of motion [33].

## PATIENTS AND METHODS

Thirty adults with non-specific low back pain were chosen by convenient sampling and included in this study. The subjects were chosen from Forest Research Institute, Dehradun. Comparative study was designed for this research, pre and post interventions were made for data analysis. Samples were undersigned based on inclusion and exclusion criteria that included subjects between the ages 20-40 years, with a primary report of low back pain with anyone of the following features.

- Patients with non-specific low back pain.
- Pain lasting more than 12 weeks.
- Patients less able to perform functional movements due to pain and stiffness.

Subjects excluded for this study were patients who exhibited the following symptoms nerve root pain, acute and sub-acute LBP, specific causes of LBP (disc herniation, lumbar stenosis, spinal deformity, spondylolisthesis), systemic illness (tumor and rheumatologic disease), any history of fractures of spine, infection, or inflammatory bone disease.

Instruments used in the study were a Couch, Swiss Ball, Roland Morris low back pain and disability questionnaire, inclinometer, VAS for pain. Outcome measures taken in the study were visual analog scale, baseline digital inclinometer, Ronald Morris disability questionnaire.

### Method

Subjects were assigned into two groups based on inclusion and exclusion criteria. Then Subjects were assessed for pre-intervention pain by VAS, functional impairment by RMDQ and ROM by inclinometer.

Two groups namely Group A (motor control exercise on swiss ball) and Group B were assigned rhythmic stabilization training. After 5 weeks at the end of protocol post-intervention measurement of pain, functional impairment and ROM was recorded with the help of VAS, Rolland-Morris disability questionnaire and inclinometer.

**Procedure**

**Group A-Rhythmic Stabilization Technique (RST)**

Patients were asked to sit on couch in high sitting. The patients were given isometric resistance alternatively in flexion and extension direction to the therapist.

Therapist was standing facing the patients. Hands were placed in front or behind the shoulder as required for the need of resistance.

- The RST program consisted of alternating (trunk flexion-extension) isometric contractions against resistance for 10 seconds, with no motion intended.
- Subjects performed 3 sets of 15 repetitions at maximal resistance provided by the same physical therapist.
- Rest intervals of 30 seconds and 60 seconds were provided after the completion of 15 repetitions for each pattern and between sets, respectively.

**Group B-Motor Control Exercise**

Subjects in group B received motor control exercises on swiss ball. Motor control exercises included sit-up and back extensor exercises on a swiss ball.

**Sit-up exercise:** Patients were asked to sit on the swiss ball with pelvis in a neutral position, knees hip width apart and flexed, both hands clasped behind the head, toes were pointing forward. The patients then performed the sit-up exercises coming up flexing the spine and going down. Therapist was standing beside the patient.

**Back extension exercise**: The ball was positioned under the abdomen with feet hip width apart. The patients flexed forward onto the ball, arms at sides with elbows flexed and palms down. The patients then extended up without hyper-extending the spine and again flexed back down. Therapist was standing beside the patient.

- A total of 5 weeks intervention was given to all subjects. The program consisted of training five days per week, with each session lasting 15 minutes.
- During the first week, all subjects performed three sets of 15 repetitions of each exercise, alternating the sit-up with the back-extension exercises.
- During the second week the training routine consisted of 4 sets of 15 repetitions of each exercise.
- During the third and fourth weeks, the training routines included four sets of 20 repetitions of each exercise.
- During the fifth week, participants performed four sets of 25 repetitions of each exercise.
- No rest periods were taken between all sets of repetitions [14].

**Data Analysis**

- SPSS version 12 was used for data analysis. The statistical significance was set at 0.05 at 95% confidence interval.
- Wilcoxon signed ranks test was used for the analysis of data comparisons between variables, within group pre and post data.
- Mann Whitney test was used for the analysis of data comparisons between variables between group pre and post data.

## RESULTS

Mean age for group A was 33.7 ± 6.66 years. Mean age for group B was 31.5 ± 4.83 years. Wilcoxon signed rank test was done to compare the data for VAS within each group (Tables 1-4 and Figures 1-4).

**Table 1 Mean and SD of age between Group A and Group B**

| Groups | No. | Mean and SD |
|---|---|---|
| A | 10 | 33.7 ± 6.66 |
| B | 10 | 31.5 ± 4.83 |

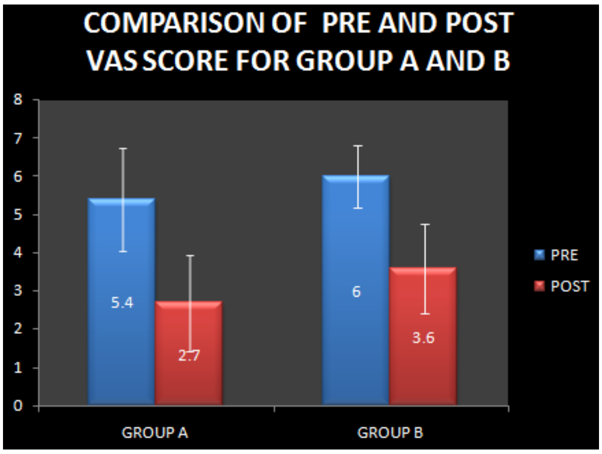


**Figure 1 Comparison of VAS within both groups**

**Table 2 Group analysis for RMDQ**

| Groups | Mean | | SD | | Z | p |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | | |
| A | 14.3 | 6.3 | 4.295 | 3.33 | -2.8 | 0.005 |
| B | 12.9 | 6.2 | 4.121 | 3.01 | -2.8 | 0.005 |

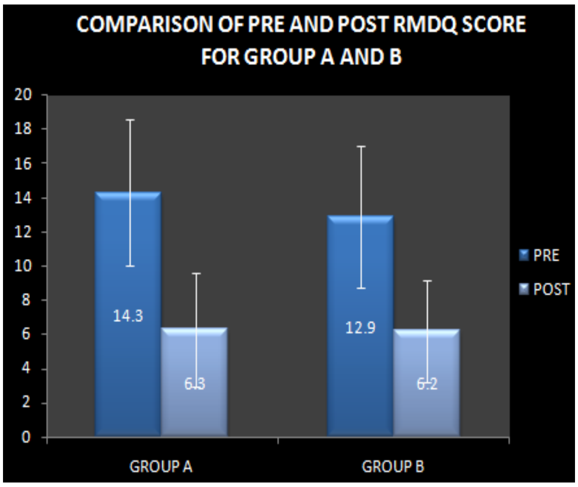


**Figure 2 RMDQ within Group A and Group B**

**Table 3 Group analysis for flexion ROM**

| Group | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | | |
| A | 44.1 | 52.6 | 8.99 | 8.2 | -2.8 | 0.005 |
| B | 39.2 | 49.2 | 7.22 | 7.05 | -2.8 | 0.005 |

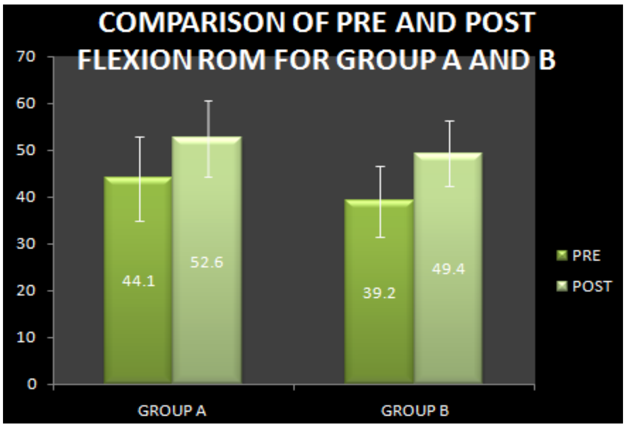


**Figure 3 Flexion ROM within groups**

**Table 4 Group analysis for extension ROM**

| Group | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | | |
| A | 44.1 | 52.6 | 8.99 | 8.2 | -2.8 | 0.005 |
| B | 39.2 | 49.4 | 7.62 | 7.03 | -2.8 | 0.005 |

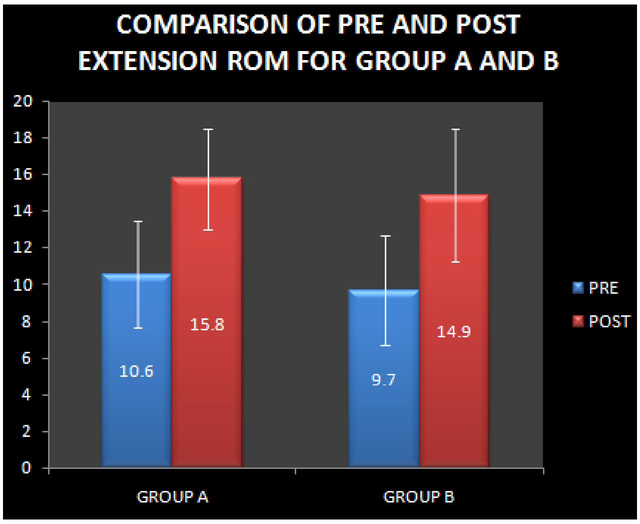


**Figure 4 Extension ROM within groups**

Mann-Whitney test was done to compare pre-data of VAS between Group A and Group B and post data of VAS between the groups (Tables 5-8 and Figures 5-8).

**Table 5 Group analysis for VAS**

| Variable | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | A | B | A | B | | |
| Pre | 5.4 | 6 | 1.34 | 0.8 | -1.1 | 0.2 |
| Post | 2.7 | 3.6 | 1.25 | 1.1 | -1.9 | 0.1 |

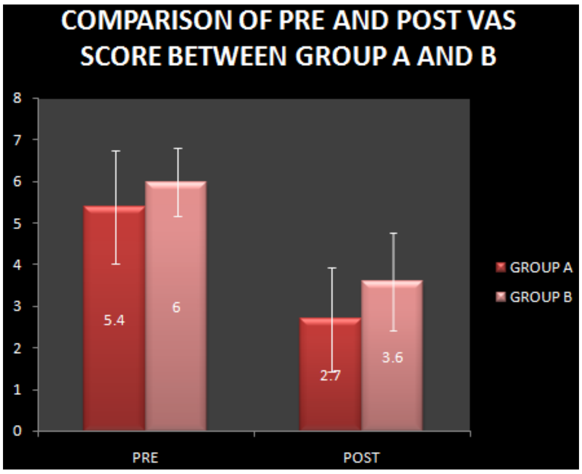


**Figure 5 Comparison b/w groups for VAS**

**Table 6 Group analysis for RMDQ**

| Variable | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | A | B | A | B | | |
| pre | 14.3 | 12.9 | 4.2 | 4.1 | -0.8 | 0.4 |
| post | 6.3 | 6.2 | 3.3 | 3 | -0.3 | 0.9 |

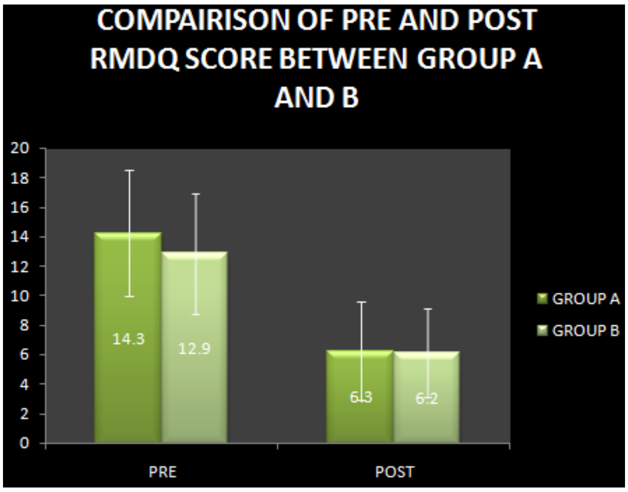


**Figure 6 Comparison between groups for RMDQ**

**Table 7 Group analysis for flexion ROM**

| Variable | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | A | B | A | B | | |
| Pre | 44.1 | 39.2 | 8.9 | 7.6 | -1.3 | 0.1 |
| Post | 52.6 | 49.4 | 8.2 | 7 | -1.2 | 0.2 |

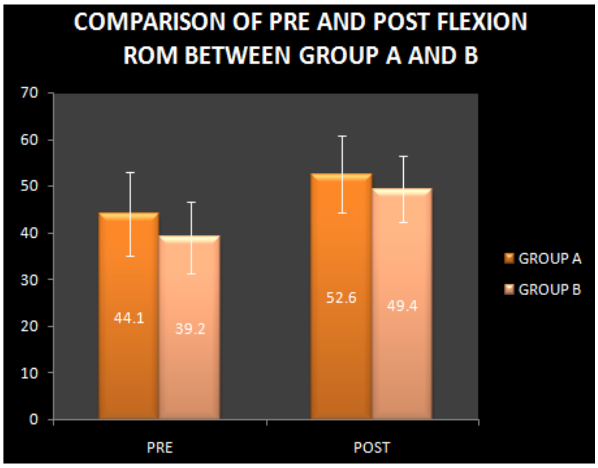


**Figure 7 Comparison between groups for flexion ROM**

**Table 8 Group analysis for extension ROM**

| Variable | Mean | | SD | | z | p |
|---|---|---|---|---|---|---|
| | A | B | A | B | | |
| pre | 10.6 | 9.7 | 2.9 | 2.9 | -0.9 | 0.3 |
| post | 15.8 | 14.9 | 2.7 | 3.6 | -0.6 | 0.5 |

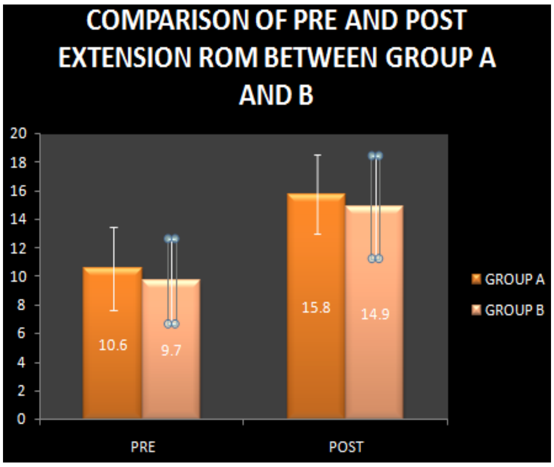


**Figure 8 Comparison between groups for extension ROM**

## DISCUSSION

The aim of our present study was to find out the effects of two treatment techniques, that is rhythmic stabilization and motor control exercise on swiss ball on patients with non-specific low back pain and find out whether there was significant difference between these two techniques on pain, disability, and flexibility. Visual analog scale (VAS) was used to measure pain, Ronald-Morris disability questionnaire (RMDQ) for disability and digital inclinometer measured range of motion (ROM) of lumbar spine. The results showed significant improvement in the outcome measures in both the techniques. However, both methods were found to be similarly effective in decreasing pain and disability and improving flexibility in subjects with chronic non-specific low back pain.

The patients in Group A (motor control exercise on swiss ball) showed significant improvement in VAS (p=0.004), RMDQ (p=0.005) and flexion ROM (p=0.005) and extension ROM (p=0.005) at the end of five weeks of intervention program. The patients in this group had a mean age of 33.7 ± 6.66 years. Abdominal curl-up and back extension on swiss ball was used in the motor control exercise. The positive changes may be attributed to the implementation of the swiss ball core training which improves core stability and portrays the complex interaction of passive (joint articulations and spinal ligaments) and active (neural and muscular) subsystems that maintain intervertebral neutral zones within the physiological limits [32]. Research also suggests the adaptation gained from Swiss Ball training is likely to result in better coordination of synergistic and stabilizer core muscles [34]. Performing curl-ups and back extensions on the swiss ball may be a better method of strengthening core muscles since exercises are performed on an unstable surface. Also, this type of functional training could enhance the body's ability to improve stability and balance since the core muscles stabilize the axial skeleton [35-38]. Lehman and Oliver concluded that swiss ball is capable of influencing trunk muscle activity in the rectus abdominis and external oblique musculature during exercises [31].

It is known that abdominal and back exercises on unstable surfaces stressed the musculature and activated the neuro-adaptive mechanisms that led to early phase gains in stability and proprioceptor activity [35-37]. Dynamic stabilization exercises have been emphasized for improving neuromuscular control, strength, and endurance of specific trunk and pelvic floor muscles that are believed to play an important role in the dynamic stability of the spine [39]. It has been reported that the increased vertebral stiffness by co-activation of the local and global muscles is important in improving the stability of the lumbar spine. Lumbar stabilization exercises are intended to train the motor control of both the local and global muscles thus improving the pain and disability.

The results showed that there was a statistically significant difference in Group A after 5 weeks of intervention for reducing pain, disability and improving ROM, which is also well supported by evidence. The improvement in lumbar spine ROM in flexion and extension could be due to decrease in pain and reduction in spasm in muscles.

In Group B (rhythmic stabilizing) there was again a statistically significant difference at the end of 5 weeks of intervention program for reducing pain, disability and improving ROM. The mean age of the participants in this group was 31.5 ± 4.83 years. The decrease in VAS (p=0.004), RMDQ (p=0.005) may be linked to increased endurance of muscles in low back region following rhythmic stabilization training as suggested by Kofotolis in 2006 [33]. Previous findings state that in patients with non-specific low back pain endurance exercises reduce the pain. Ingjer demonstrated that endurance training leads to increased oxygen uptake (25.2%), and increased capillaries density per muscle fiber [40], and thus, helps in washing away of waste products thereby reduces pain.

It has been seen that four weeks of training can bring about significant changes in the disability scores. The improvements in functional ability could be a direct result of pain, lumbar mobility, and endurance improvements, thereby providing further support for the effectiveness of PNF exercises for non-specific low back pain treatment [41].

The second part of the hypothesis was to compare between the effects of motor control exercise on swiss ball; a dynamic stabilization exercise with rhythmic stabilization technique; a static stabilization exercise. After the end of 5 weeks of intervention program, both groups showed significant difference in decreasing pain and disability and improving ROM.

In the present study when motor control exercise on swiss ball and rhythmic stabilization exercise were compared post-treatment, there was no statistically significant difference in the outcome measures VAS (p=0.101), RMDQ (p=0.908), flexion ROM (p=0.222), extension ROM (p=0.514), which showed that both the treatment groups were more or less equally effective in decreasing pain and disability and increasing ROM. Swiss ball training for low back pain had slightly better results clinically, so it might be that larger sample size with longer duration of treatment could have given a better picture of the results.

## CONCLUSION

The study showed a significant improvement in pain, disability, and ROM in patients with non-specific low-back pain employing rhythmic stabilization technique as well as motor control exercise on swiss ball. However, both methods proved to be similarly effective in decreasing pain, disability and increasing ROM in patients with non-specific low back pain.

### Limitations and Future Scope

Small sample size, few people involved in activities which further aggravated their symptoms during the treatment period and here were more male patients in motor control group and more female patients in rhythmic stabilization group despite random sampling. Future research include follow-up should be added. Larger sample size can be used. More specific techniques of motor-control exercises can be used. The study can be continued for a longer duration.

## DECLARATIONS

**Conflict of Interest**

The authors have disclosed no conflict of interest, financial or otherwise.

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