International Journal of Medical Research and Practice

IntJMRP

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ORIGINAL ARTICLE

Effectiveness of exercise regime in reducing pain and improving functional stability in lumbar spondylolisthesis patients: A randomized multicentre comparative interventional study

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Submission: 29-04-2016 **Revision: 23-05-2016** **Publication: 29-06-2016**

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How to cite this article: Das S, De C, Das M, Roy S, De S. Effectiveness of exercise regime in reducing pain and improving functional stability in lumbar spondylolisthesis patients: A randomized multicentre comparative cohort study. IntJMRP 2016;1(1):6-14

ABSTRACT

Background: Poor working posture and overuse of back have been implicated in the development of spondylolisthesis. The present comparative study has been carried out to evaluate the effectiveness of specific stabilizing exercise training regime in reducing pain and improving the functional ability in patients with lumbar spondylolisthesis.
Material and Methods: This is a multicentre, balanced-randomized, double-blind, parallel-group comparative, randomized control trial. Thirty subjects of either sex, between 40 and 65 years of age having chronic low back pain with radiologic diagnosis of grade 1 spondylolisthesis for more than 3 months duration participated in this study. After screening, using inclusion and exclusion criteria, 30 patients were randomly assigned into Group A (n = 15) and Group B (n = 15). Both the groups had received Interferential Therapy for 1 week followed by different exercise training programs. Group A received specific stabilizing exercise training of the deep abdominal muscles and Group B back flexion exercise training, both thrice a week for 5 weeks. Back pain and functional disability were recorded by Visual Analogue Scale and Oswestry Disability Index, respectively, both at the beginning and at the end of the treatment period. Changes in the outcome variables were analyzed as improved or unchanged/deteriorated.
Results: Clinical and demographic characteristics were similar among both the groups at baseline. Significant difference from baseline was found after a stipulated time between the interventions: specific stabilizing exercise training (Group A) and back flexion exercise training (Group B). Group A more significantly improved after the stipulated time of 6 weeks treatment follow-up. There was significant decrease in pain and disability in Group A than in Group B.
Conclusion: The results indicate that specific stabilizing exercise training is more effective in reducing pain as well as in improving function than back flexion exercise training.

Key words: Chronic low back pain, Spondylolisthesis, Specific stabilizing exercise training, Back flexion exercise training, Oswestry Disability Index

INTRODUCTION

Back pain has been cited as the fifth most common reason for which patients visit a physician.[1] Low back pain is a major health problem among the Western industrialized countries and a major cause of medical expense, absenteeism and disability.[2] Although the cause of low back pain is often multifactorial, many authors have suggested that instability of lumbar vertebral segments can result in pain. Segmental instability of lumbar spine is a potential cause of low back pain and particularly in children and adolescents may be the result of spondylolysis and/or

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spondylolisthesis.[3] Spondylolisthesis is a well-recognized cause of low back pain.

Approximately 2–5% of the general population have spondylolisthesis of which 50% are asymptomatic.[4] Spondylolisthesis in the adult population is associated with radiculopathy, activity related low back pain and neurogenic claudication. About 80% of spondylolisthesis patients have sleep disturbances, back stiffness and worsening of pain when walking and sitting.[5] Spondylolisthesis can be diagnosed using plain radiography, computed tomography (CT) and single-photon emission CT.[6]

Stabilization of the lumbar spine is thought to occur as a result of two mechanisms: antagonistic spinal muscle co-activation and increased intra-abdominal pressure.[7] Panjabi[8,9] redefined spinal instability in terms of a region of laxity around the neutral resting position of a spinal segment called the "neutral zone". The importance of Lumbar Multifidus (LM) muscle regarding its potential to provide dynamic control to the motion segment in its neutral zone is well acknowledged.[8,10,11] The deep abdominals, in particular the Transversus Abdominis, are primarily involved in the maintenance of intra-abdominal pressure, while imparting tension to the lumbar vertebrae through the thoracolumbar fascia. In spondylolisthesis, translation causes a change in the neutral zone and resultant instability. This instability causes dysfunction and resultant weakness in the lumbar multifidus and transversus abdominis muscles, the two of the local stabilizing muscles in the lumbar spine,[12] which forms a deep and dynamic internal corset enhancing segmental stability of the lumbar spine during functional tasks and the maintenance of neutral spinal postures. This altered biomechanics results in low back pain. It is necessary to switch on the local stabilizing muscles via exercise therapy to decrease the size of the neutral zone and ultimately decrease the symptoms related to instability.

In low grade, i.e. Meyerding Grade 1 spondylolisthesis, conservative treatment which includes physiotherapy is the first treatment of choice.[13–15] It was noted that pain intensity and functional disability in chronic spondylolisthesis patients can be improved by specific stabilizing exercises.[13]

Until this time very limited number of studies have evaluated the benefit of specific training of these muscles in patients with chronic low back pain, where the segmental stability of the lumbar spine has been compromised. This study has been performed to find out the effectiveness of specific stabilizing exercise and back flexion exercise as well as to compare these two exercise regime in reducing pain and improving functional ability to the patient with Grade 1 lumbar spondylolisthesis. This comparison is presented for analyzing and determining the better between the two efforts for establishing an alternative treatment protocol for conservative treatment of spondylolisthesis.

MATERIAL AND METHODS

This is a multicentre, double-blind, parallel-group comparative, randomized control trial conducted at the Nil Ratan Sircar Medical College and Hospital, Kolkata, West Bengal and The Vidyasagar Institute of Health, Paschim Midnapore, West Bengal in Eastern India between January 2008 and December 2011. Patients between 40 and 65 years of age, both the men and women, complaining of recurrent low back pain persisting longer than 3 months with Meyerding Grade 1 spondylolisthesis were selected depending on willingness of the patients to adhere to the treatment. Patients with higher grade of spondylolisthesis, history of spinal injury and spinal surgery, inflammatory joint disease, hip pathology, circulatory disorder, severe osteoporosis, lower limb fracture, psychological disorder and patients with neurological signs and symptoms, e.g. peripheral nerve entrapment, spinal cord compression or other corresponding disorders were excluded from the study. Low back pain persisting more than 3 months has been mentioned as chronic low back pain in this study.

A total of 30 patients among 45 patients with spondylolisthesis were selected based on selection criteria by the first group of independent caregivers. The patients were randomly assigned to Group A ($n = 15$) and Group B ($n = 15$). The second group of independent caregivers dispensed either of the each exercise group patients according to a computer generated randomisation list. Group A had 7 male patients with 8 female patients and the Group B had 8 male patients and 7 female patients. The exercise program was demonstrated by the third group of independent caregivers while post-treatment assessment was done by the fourth group of independent caregivers. The participants, people demonstrating and following up the exercise program and those assessing the outcomes were blinded to group assignment.

Null Hypothesis

There is no significant difference between the two groups (Group A and Group B) in the pretreatment Visual Analogue Scale (VAS) score, Oswestry Disability Index (ODI) score, flexion range of motion (ROM) and extension range of motion (ROM). There is no significant difference between specific stabilizing exercise training and back flexion exercise training in VAS score, ODI score, flexion ROM and extension ROM at the end of 6 weeks of treatment.

Alternative Hypothesis

There is significant difference between the two groups (Group A and Group B). There is significant difference between specific stabilizing exercise training and back flexion exercise training in VAS score, ODI score, flexion ROM and extension ROM at the end of 6 weeks of treatment.

Interferential Therapy (IFT) Unit was used as instrumental tool. The assessed selected variables were pain intensity and functional disability. Assessment was carried out using the assessment proforma, Oswestry Disability Index, Visual Analogue Scale. Assessment was carried out at the pretreatment stage, i.e. on the 1st day before treatment started and post-treatment, i.e. at the end of 6th week. All the measurements were blinded to subjects for the outcome assessment and statistical analyses. The ethical approval was taken from the Ethical Approval Committee of the aforementioned institutions.

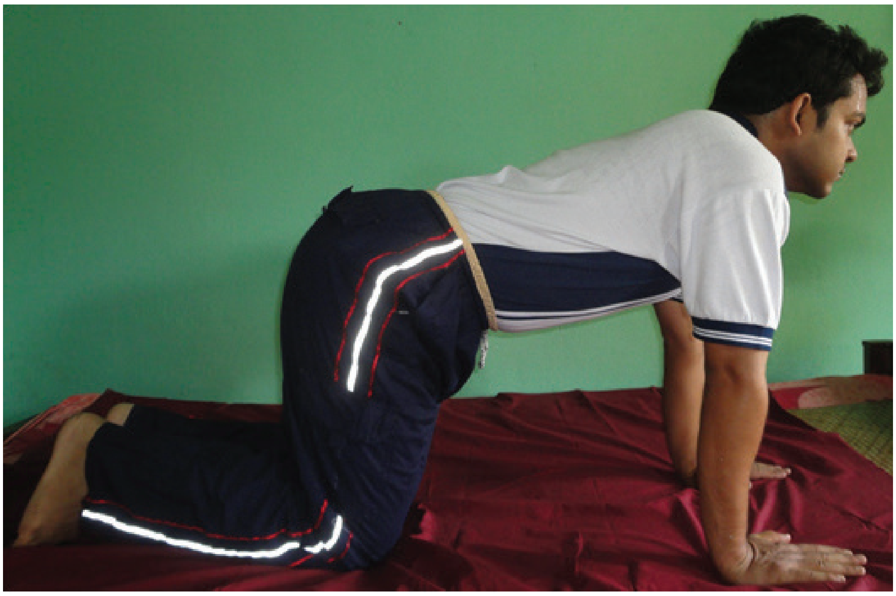


Figure 1:

Patients of the both groups first received IFT for the 1st week. The parameter chosen for the treatment were a 4 kHz frequency and a 100 Hz sweep for 15 min duration. The intensity of the IFT was adjusted according to the patient tolerance.

Group A: Specific Stabilizing Exercise

After IFT, specific stabilizing exercises were performed for next 5 weeks. Beginners performed the exercises with adequate time to do each and every movement perfectly. In the progression of this new type of exercise, the holding time of the isometric contraction is increased as well as the number of repetitions. The setting exercises can be progressed from low grade with minimal body weight to move functional body positions with gradually increasing external load. Advances need to be made from performing the exercise with a static neutral lumbar spine to other static positions at more extremes of range. Finally, patients should be able to hold a co-contraction of the deep muscles during dynamic functional movements of the trunk.

1. *Abdominal Drawing-In Maneuver (Figure 1)*: The three recommended body positions to perform the maneuver are—four-point kneeling, sitting and upright positioning. In this maneuver the lower abdomen is drawn up and in or the naval is pulled up towards the spine and contraction is held. The rib cage and pelvis should remain still and the patients continue to breathe normally. Each exercise was performed for 2 sets with 10 repetitions. Each repetition is kept for 10 s with the holding time increasing gradually with a Pressure Biofeedback Monitor using for 3 consecutive days in a week for 5 weeks.
2. *Side Bridge Exercise (Figure 2)*: The side bridge exercise is performed by lying in lateral position. The patient was

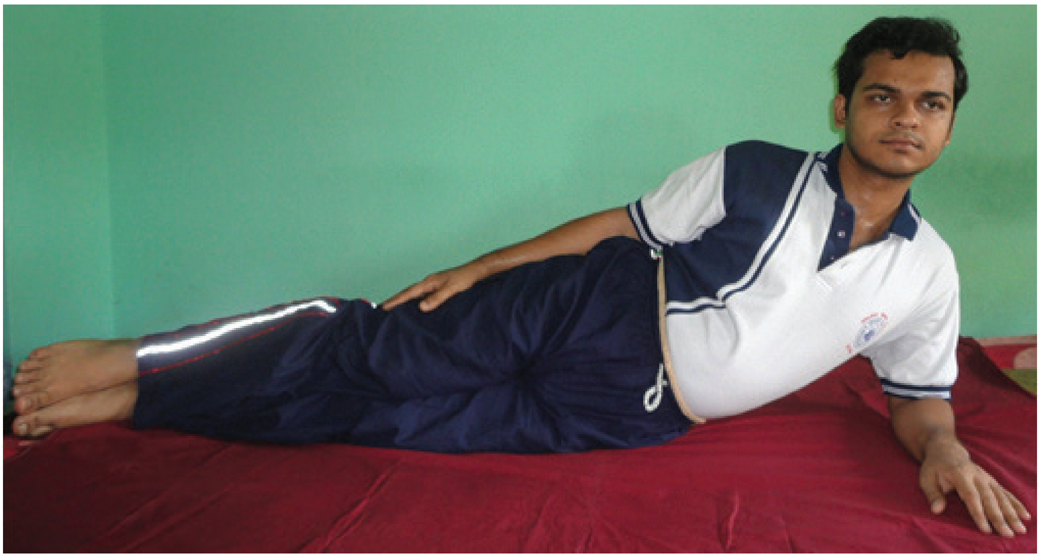


Figure 2:

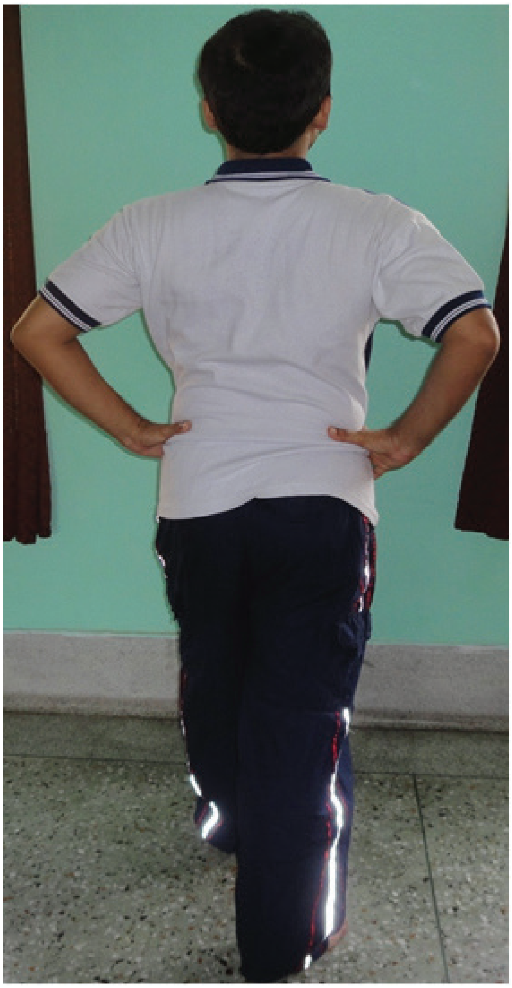


Figure 3:

instructed to start on his/her right side to press up with right arm forming a bridge and to hold there for 10 s. Gradually it was continued to build up a pyramid-like fashion as follows:

a) 4 repetitions for 10 s hold (each side)
b) 3 repetitions for 10 s hold (each side)
c) 2 repetitions for 10 s hold (each side)

3. The isometric exercise of Lumbar Multifidus (LM) (Figure 3) was performed in a static lunge position while standing. Patient was instructed to initiate LM contraction by imaging drawing his/her coccyx towards his/her head. It was done for 10 repetitions with 10 s each repetition.

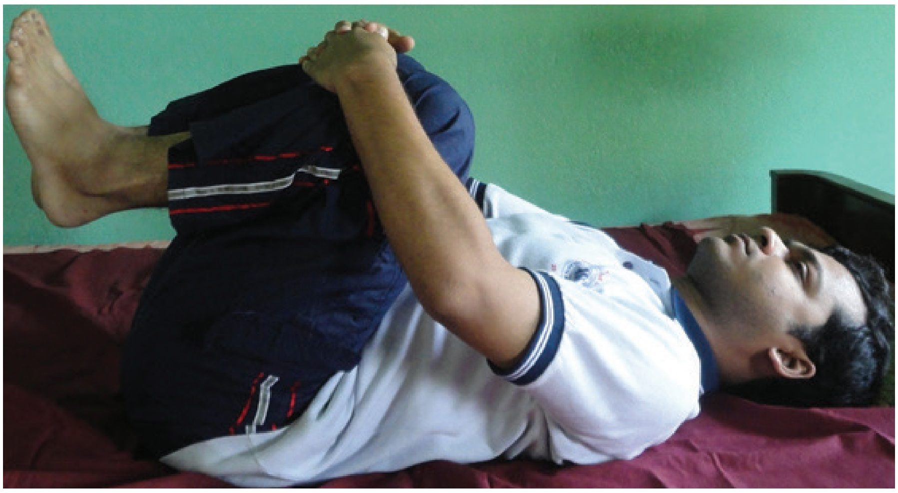
Each of the above exercises was given in 2 sets with 10 repetitions for 3 non-consecutive days in a week for 5 weeks.

Group B: Back Flexion Exercise

Group B patients received spinal flexion exercises for 5 weeks after receiving IFT initially. The spinal exercises are as follows:

1. *Single Knee to Chest (Figure 4)*: Double knee to chest exercise was performed with the patient in a supine position with both legs flat on the couch. The patient was instructed to bend one hip and knee up towards his/her chest with grasping the knee with his/her hand and pulling it gently towards chest. The other lower limb is to be kept flat on the couch while doing this exercise. It was repeated with the opposite side. It was advised to do this exercise for 10 repetitions and each repetition was kept for 10 s.
2. *Double Knee to Chest (Figure 5)*: It was performed with the patient in supine position with both legs flat on the couch. The patient was instructed to bend both the hip and knee towards his/her chest with grasping the knee with his/her hands and pull them towards the chest. Then it was instructed to hold the stretched position for 10 s and to release one knee allowing the leg to return to the couch and then to release the other. This exercise was repeated for 10 times keeping 10 s for each.
3. *Partial Sit-up (Figure 6)*: It was performed with the patient in supine position with hips and knees flexed, feet supported on the floor and hands resting on the thighs. The patient was instructed to tuck the chin to the chest and slowly sit up until touching the top of the knee. This position was maintained for 10 s. This exercise was repeated for 10 repetitions keeping each for 10 s.
4. *Abdominal Crunch (Figure 7)*: Abdominal crunch was performed with the patient in supine position with the hips and knees flexed, feet planted unsupported on the

Figure 4:



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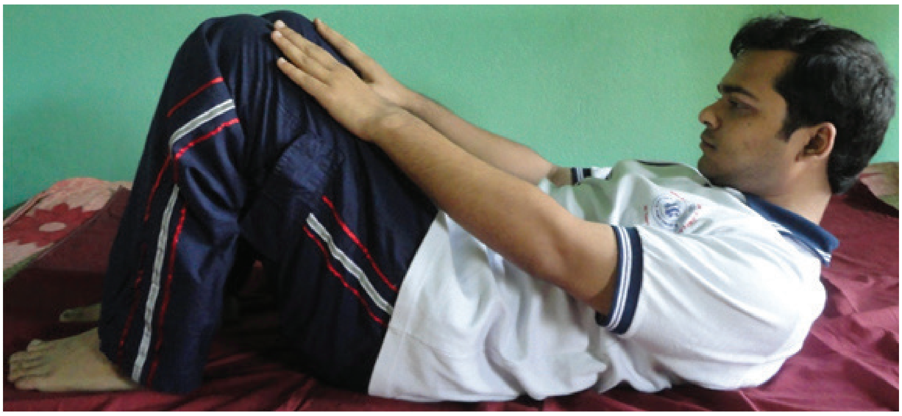

Figure 6:

couch and hands held behind the head. The patient was instructed to curl the thorax by contracting abdominal muscles in an isometric fashion until the scapulae were just off the floor. This contraction was maintained for 3 s with 10 repetitions.

5. *Posterior Pelvic Tilt (Figure 8)*: It was performed with the patient in a supine position with the hips and knees flexed, feet planted supported on the floor. The patient was instructed to flatten the small of his/her back against the floor without pushing down the legs. This contraction was maintained for 10 s with 10 repetitions.

Each of the above exercises was done in 2 sets with 10 repetitions for 3 non-consecutive days in a week for 5 weeks.

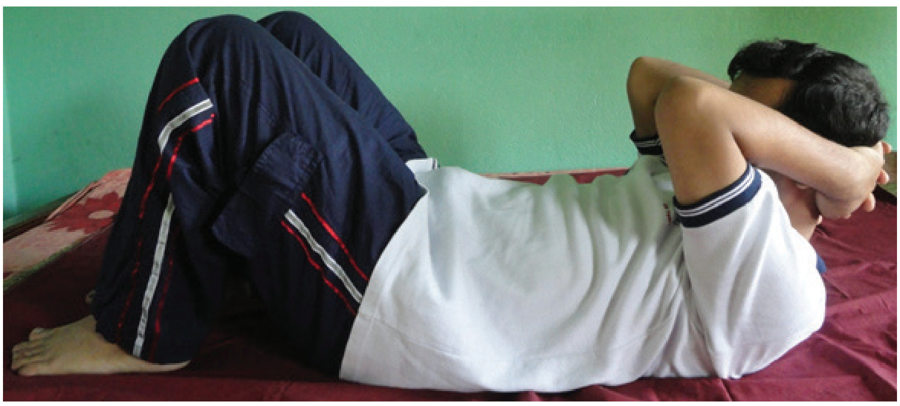

Figure 7:

Figure 8:

RESULTS

Tables 1–4 show that since observed *t*-value is less than the critical value, the pre-treatment null hypothesis has been accepted, i.e. Group A and Group B were equal in terms of pretreatment VAS score, ODI score, flexion ROM and extension ROM at 1% level of significance ($p > 0.01$). Thus the two groups can be regarded as almost identical.

Since at the post-treatment stage the observed *t*-value is greater than the critical value (Tables 1 and 2), we reject the null hypothesis and accept the alternative hypothesis, i.e. treatment applied in Group A is more effective treatment applied in Group B in terms of reducing pain at 1% level of significance ($p < 0.01$). Table 1 represents the comparison of VAS score between the groups at the end of 6 weeks and appears that the VAS mean value is significantly more in Group B after 6 weeks therapy as the mean value of Group B (2.82) is more than that of Group A (1.68). It can be concluded that Group A therapy was significantly better than group B. Table 2 represents the comparison of ODI score between the groups at the 6 weeks of treatment and appears that the ODI score value is significantly more in Group B after 6 weeks of therapy as the mean value of Group B (30.26) is more than that of Group A (26.96). It can concluded that Group A therapy was significantly better than Group B.

Since at the post-treatment stage the observed *t*-value is less than the critical value (Tables 3 and 4), accept the null

Table 1: Visual Analogue Scale (VAS) Score

Serial no.	Pretreatment VAS Score		Post-treatment VAS Score	
	Group A	Group B	Group A	Group B
1	6.6	6.8	2.2	3.0
2	7.2	3.9	2.3	2.7
3	6.3	5.3	1.4	2.8
4	3.8	7.0	1.3	4.5
5	5.0	3.8	1.6	1.2
6	7.1	5.9	1.5	4.4
7	6.1	4.4	1.6	1.1
8	6.3	5.3	2.0	2.3
9	4.4	5.5	1.7	2.2
10	3.5	6.8	1.9	3.0
11	4.8	7.0	1.0	3.4
12	6.5	5.9	2.2	4.4
13	5.3	5.0	2.0	2.8
14	3.5	3.5	0.9	1.2
15	6.1	6.6	1.6	3.3
	Pre-treatment two sample '*t*'-test		Post-treatment two sample '*t*'-test	
Mean	5.50	5.51	1.68	2.82
Standard deviation	1.268858	1.207043	0.424601	1.112398
Observation	15	15	15	15
Degree of freedom	28		28	
t-Value	0.0221152		3.708	
Tabulated value for *t* statistics at 1% level of significance at degree of freedom=28 is 2.467				

Table 2: Oswestry Disability Index (ODI) Score

Serial no.	Pretreatment ODI Score		Post-treatment ODI Score	
	Group A	Group B	Group A	Group B
1	42.00	44.44	31.50	37.77
2	48.89	24.44	38.13	19.55
3	37.87	31.11	30.30	26.44
4	34.00	46.67	26.52	39.20
5	31.11	34.00	23.33	28.90
6	46.67	33.33	36.40	27.66
7	35.56	32.00	27.03	25.60
8	40.00	38.00	31.20	31.16
9	28.89	36.00	21.67	29.52
10	22.22	42.00	16.89	35.28
11	32.50	33.33	25.35	28.33
12	36.00	48.00	28.80	40.80
13	28.50	31.11	21.95	26.44
14	26.67	28.00	20.00	23.52
15	33.33	42.22	25.33	33.78
	Pre-treatment two sample '*t*'-test		Post-treatment two sample '*t*'-test	
Mean	34.95	36.31	26.96	30.26
Standard deviation	7.31974	7.00023	5.90743	6.03401
Observation	15	15	15	15
Degree of freedom	28			
t-Value	0.520		2.518	
	Tabulated value for *t* statistics at 1% level of significance at degree of freedom=28 is 2.467			

Table 3: Flexion Range of Motion (ROM) Score

Serial no.	Pretreatment Flexion ROM Score (expressed in cm)		Post-treatment Extension ROM Score (expressed in cm)	
	Group A	Group B	Group A	Group B
1	15	14	18	16
2	14	17	17	20
3	16	16	18	18
4	19	13	22	17
5	18	19	21	21
6	14	17	18	20
7	16	18	20	20
8	15	17	18	21
9	19	16	23	19
10	20	14	24	16
11	18	12	20	14
12	14	17	18	20
13	17	18	21	21
14	19	20	22	22
15	17	15	20	18
	Pre-treatment two sample '*t*'-test		Post-treatment two sample '*t*'-test	
Mean	16.73	16.20	20.00	18.87
Standard deviation	2.051712	2.242448	2.13809	2.29492
Observation	15	15	15	15
Degree of freedom	28			
t-Value	0.675		0.1612	
	Tabulated value for *t* statistics at 1% level of significance at degree of freedom=28 is 2.467			

Table 4: Extension Range of Motion (ROM) Score

Serial no.	Pretreatment Extension ROM Score (expressed in cm)		Post-treatment Extension ROM Score (expressed in cm)	
	Group A	Group B	Group A	Group B
1	11	10	8	8
2	12	9	9	8
3	10	10	8	9
4	9	8	8	7
5	13	10	10	8
6	10	9	8	7
7	11	13	9	11
8	11	12	8	10
9	10	11	8	9
10	9	10	7	8
11	11	9	9	6
12	12	10	10	7
13	9	11	6	9
14	10	11	7	8
15	11	12	8	10
	Pre-treatment two sample '*t*'-test		Post-treatment two sample '*t*'-test	
Mean	10.60	10.33	8.20	8.33
Standard deviation	1.183216	1.345185	1.08233	1.34519
Observation	15	15	15	15
Degree of freedom	28			
t-Value	0.583		0.293	
Tabulated value for *t* statistics at 1% level of significance at degree of freedom=28 is 2.467				

hypothesis was accepted, i.e. treatment applied in Group A is more or less the same as Group B in terms of reducing pain at 1% level of significance ($p < 0.01$).

DISCUSSION

The result of this comparative study demonstrated that there was more statistical improvement with Group A treatment than Group B treatment in patients with chronic low back pain with radiologic diagnosis of lumbar spondylolisthesis. Both the interventions resulted in reduced pain and improved function with chronically symptomatic spondylolisthesis in short-term follow-up.

The present study findings support the Panjabi's hypothesis that the stability of the lumbar spine is dependent not solely on the basic morphology of the spine but also on the correct functioning of the neuromuscular system.[9]

The strength of this study are the standardized measured procedure, the use of reliable and valid outcome measures, the measurements were blinded to both groups for the outcome assessment and statistical analyses, the attempt to follow a treatment guideline and the good compliance in the interventions.

In view of some limitations of this study the suggested consideration for further studies are as follows:

1. The duration and sample size can be increased.
2. Pressure biofeedback can be used to measure abdominal pressure.
3. Electromyography could not be used due to inherent ethical limitations, which can be used.
4. Insistence on a fixed follow up program for each and every patient even after the completion of sessions to assess the longevity of the improvement.

CONCLUSIONS

Lumbar spinal instability from spondylolisthesis is related to an increase in the size of the neutral zone which results in pain and dysfunction. The result of this study concluded that specific stabilizing exercises have effectively reduced low back pain and improved function after a 6 weeks intervention in patients with chronic low back pain with radiologic diagnosis of Grade 1 lumbar spondylolisthesis. However, both interventions appear to have a positive effect in pain reduction and function. As the differences for all outcome measures were greater for specific stabilizing exercise group, hence seem to be a favorable treatment option for patients with chronic low back pain with radiologic diagnosis of spondylolisthesis.

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Author Contribution: **SD:** Conceptualization and design of the study; Data acquisition, analysis and interpretation; Manuscript editing, revision and final approval; **SR:** Conceptualization and design of the study; Data analysis and interpretation; Manuscript editing, revision and final approval; **MD:** Data acquisition; Preparation and drafting of manuscript; Review of literature; **SD:** Data acquisition; Preparation and drafting of manuscript; Review of literature; **CD:** Data analysis and interpretation; Review of literature; Manuscript editing, revision and final approval
Source of Support: Nil. **Conflict of Interest:** None declared.