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Efficacy of Trunk Proprioceptive Neuromuscular Facilitation Training on Chronic Low Back Pain

Kumar A.[1], Zutshi K[2], Narang N[3]

[1] M.P.T Sport Medicine, Jamia Hamdard, Delhi

[2]Dept, of Physiotherapy, Faculty of allied health sciences, Jamia Hamdard.Delhi

[3]MPT(Sports Medicine). Sr. Consultant Physiotherapist New Delhi.

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Abstract. *Background and Purpose:* Improving functional performance in patients with chronic low back pain is of primary importance. The purpose of this study was to examine the effects proprioceptive neuromuscular facilitation (PNF) programs on trunk muscle endurance, flexibility, and functional performance in subjects with chronic low back pain (CLBP).

Method: Thirty men (23.3250 ±2.60 [mean ± SD] years of age) who had complaints of CLBP were randomly assigned to 2 groups: Group A (experimental group) and group B (control group). To determine the effect of training, subjects were assessed on measures of trunk muscle endurance, lumbar mobility prior to and after 4-weeks of intervention. Disability and back pain intensity also were measured with the modified Oswestry Index and VAS respectively.

Results: Paired sample t-test indicated that Groups A demonstrated significant improvements in lumbar mobility, static and dynamic muscle endurance, pain and modified Oswestry Index, measurements. However group B also shows improvement on the measure of functional ability and pain.

Conclusion: the results of the study suggest that the PNF programs are appropriate for improving trunk muscle endurance, trunk mobility, pain and functional ability in people with CLBP.

Keywords: Low back pain, Muscle endurance, Proprioceptive neuromuscular facilitation, Range of motio,n Combination of Isotonics, Rehabilitation, Training

Back pain affects millions of people and is one of the most common maladies prompting patients to seek medical attention and remain most common cause of time off work.(19,20) The lifetime prevalence of low back pain in the general population approaches 85% with 2%-5% of people affected yearly. Furthermore, over 80% of such patients report recurrent episode. It is estimated that the rate of improvement is similar regardless of the type of care initially sought, and that 95% of the patients were able to return to their usual activity of daily living no longer than 6 months after the health care visit for an episode of LBP . However, few (7.7%) of them will develop chronic low back pain (CLBP).(20)

Although CLBP affects a small portion of the population, the medical cost of this group of patient is very high (80%).This group has been widely reported to be associated with large amount of care seeking and disability. (20, 4)

In patients with CLBP, a specific pain generator is not always found which often makes diagnosis and treatment challenging. Most often, it is not associated with an underlying structural abnormality.(6,14)

Although low back pain is self limiting and benign disease that tend to improve simultaneously overtime, varied therapeutic interventions are available for the treatment of low back pain. However effectiveness associated with most of the intervention has not been demonstrated.(12)

For the management of the patient with acute low back pain, there is never any shortage of devices, most of which are successful probably due to natural history of spontaneous remission that occurs in the majority of cases. When the pain become chronic, however, interest wanes, and the longer the history less likely is the patient to receive really constructive therapy.(17)

There are various interventions available for the treatment of CLBP, where most of them focus mainly

[1] Corresponding author. Kumar A. *E-mail address*: amit_mpt@hotmail.com.

[2] MSPT Asst Professor. *E-mail address*: zutshi.kalpana@gmail.com.

[3] *E-mail address*: nishant_narang@yahoo.com.

on the pain management rather than addressing the patho-mechanics behind the CLBP.

Most commonly, the treatment includes the use of wide range of electrical modalities for CLBP however; their inclusion or exclusion as an intervention has shown poor evidence by the Philadelphia panel. (7)

Apart from the electrical modalities, exercises also form the integral part of rehabilitation and in fact, it is one of the most frequently used modality for CLBP(15). The physical exercises lead to gain in muscle strength (force-generating capacity), flexibility, endurance, restoration of the injured tissues, and also contribute to the ability to sustain normal life activities, such as those at work. (11)

Exercise can be prescribed for patients with chronic low back pain with three distinct goals. The first and most obvious goal is to improve back flexibility and strength, and to improve performance of endurance activities. The second goal of exercise is to reduce the intensity of back pain. The third and most important goal of exercise is the reduction of back pain–related disability. (9)

There is now considerable evidence documenting the efficacy of exercise in the conservative treatment of LBP. Exercises can be a relatively inexpensive, easily administered treatment method; which may prove to be the most effective solution for the patients whose pain appears to be resistant to other treatment options. However, the choice of exercise therapy is also fraught with difficulty for the clinician because aerobic exercises (2), strengthening exercise (2, 18), coordination exercises (10) and specific stability exercises (5) have all shown to be effective in the treatment of this coordination. The clinician is therefore in an uncertain position as to what form of exercise therapy to prescribe and in what manner. (16).

Neurophysiologic studies have linked pain development in the lumbar spine region of the vertebral column with disturbances in the mechanoreceptors and probably with impairment of the superior proprioception centers.(21) Therefore, exercise programs that enhance proprioception may be beneficial for managing CLBP.(15)

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. (13) The performance of movements in PNF patterns may permit muscles to act in ways that are close to the actions and movements found in various sports. Therefore, these exercises should be better suited for performance enhancement than is conventional single-plane or single-direction training programs.(15)

Although PNF are widely used in rehabilitation of various conditions for the past few decades, but is rarely used for managing CLBP.

There are very few studies on effect of PNF training on chronic low back pain. Nick Kofotolis, (2006) In a study demonstrate that PNF training program showed improvement in back endurance, flexibility & pain in CLBP patients.(15) In other similar study by the Nick Kotofolis & colleagues (2006), he found the effectiveness of PNF training over TENS in reducing pain in women with low back pain.(16)

Till date, information on the effectiveness of PNF exercises for improving pain, trunk muscle endurance, and functional status in chronic LBP patient, is lacking.

The present study will examine the efficacy of one of the PNF techniques, the combination of isotonic (COI) as an adjunct to conventional training program in patients with chronic low back pain.

1. Methodology

Subjects: 30 male patients with recurrent mechanical CLBP with duration of symptoms more than 3months, Modified ODI score ≥30%, and who were able to follow commands and can comprehend English, participated in the study. Exclusion criteria included any red flag signs for low back pain, nerve root compression, severe instability in spine, or severe spinal deformity.

Subjects were randomly selected for the study and randomly assigned to 2 different intervention groups: Group A received PNF training, Group B received only conventional treatment for the back pain.

Protocol: Descriptive variables of all subjects, such as age, height, and weight were recorded. All subjects underwent a detailed orthopedic assessment. A baseline measurement of dependent variables was taken on *curl-up test, Sorenson test, lumbar mobility measurements, modified ODI score and VAS score.*

Lumbar Mobility (3): It was measured by the use of "Fingertip-To-Floor" test. For measurement of flexion range patient was instructed to bend forward. Using the tape measure, and the distance between the tip of the patient's right long finger and the floor was measured with help of a measuring tape. For extension range, the patient was instructed to lean backwards and the distance from right middle finger to floor was recorded.

*Trunk Flexion Endurance (*15): The endurance of the abdominal muscles was measured with the curl-up test. In particular, the subjects were asked to lay supine with the knees at an angle of 90 degrees and with arms straight at the sides of the body and pointing toward their knees. A Velcro strap was used to secure their feet on the table. The subjects were instructed to curl up with straight arms pointing toward their knees until their iliac crests were raised from the table and to hold this posture for a maximum of 240 seconds. During the test, maintenance of performance was inspected visually. The test was terminated when the subject could not maintain the same position. The recorded time for the test was used for further analysis. Verbal instructions on correct positioning were provided only at the start of the test.

*Trunk Extension Endurance (*15): This was measured by use of a modification of Sorensen back extension test. The participants laid face down along the top platform with the trunk cantilevered from the top of the table. Velcro straps were used to stabilize the mid thigh of the subjects, and their calves were held by the physical therapist. Their iliac crests were positioned at the edge of the top platform of the steps. In particular, the participants maintained a horizontal position for as long as possible for a maximum of 240 seconds with no rotation or lateral shifting. The test was terminated when the upper torso dropped below the horizontal. The recorded time for the test was used for further analysis. Tests for evaluating trunk muscle endurance were performed twice and rest of at least 15 minutes was given before performing retest. Electromyography frequency spectrum signal usually return to normal after subjects have rest for 5 minute.

Functional Impairment Assessment: The degree of functional impairment was assessed by means of the Modified Oswestry Disability questionnaire.

The Intensity of the Low Back Pain Symptoms: This was assessed by means of the visual analogue Scale (10 points). Subjects were required to rate their pain level from normal (0 points) to emergency (10 points)

Respective interventions were given to all the participants in each group. Group A received PNF training and conventional treatment for back pain. PNF training consisted of "Combination of Isotonic Exercise" (COI). These exercises include concentric, isometric and eccentric contraction of agonists without relaxation. COI Exercises were performed with the subject in a seated position. Resistance was provided by placement of the hands on the scapula-shoulder region.

Exercises were given 5 times a week for 4 weeks. 3 sets of 15 reps of each exercise were given. Rest interval of 30 sec was included between the repetitions. The sets were repeated at the interval of 60 seconds. In addition to PNF exercises group a also received conventional treatment for back pain, which was same with that of group B. exercises performed by the subjects in control group were alternate Knee to chest, Pelvic bridging, Pelvic rolling, Alternate arm leg extension(for both left & right sides).

Data was collected one week prior to start of treatment program and after the end of treatment session.

Data Analysis

Data analysis was done using SPSS (version 15) software system. Demographic data of subjects including age, height, weight were descriptively summarized. The dependent variables were analyzed for within group comparison using Paired t- test for continuous variables (trunk muscle endurance, lumbar mobility, VAS) and Wilcoxon signed ranks test for ordinal variable (modified Oswestry Index). Independent t-test was used for continuous variables for between- group analyses. For ordinal variables, Mann whitnay Test was used for between- group analysis. A value of $p < 0.05$ was accepted as significant.

2. Results

Descriptive variables: Demographic details of all the three groups are reported in Table 1. There was no significant difference between the groups on demographic information and the groups were found to be comparable.

Outcome measures of trunk muscle endurance: Table 2 shows the pre and post treatment results for the trunk flexor and extensor muscle endurance. Between-group analysis reveals that there is significant difference in the outcome measure in both the groups after 4 weeks of intervention (trunk flexion, t=2.095, p=0.0225; trunk extension, t= 8.375, p= 0.00). And with-in group analysis reveals that there is a significant improvement in experimental group (Group A) while control group (Group B) fails to resister any changes. Trunk flexion: group A (t=13.164, p=0.000; group B (t=0.543, p=0.298); Trunk extension: Group A (t=11.875, p=0.000); group B (t= 1.375.p=0.0955).

Outcome measures of lumbar mobility: table2 shows the pre and post treatment result of lumbar mobility for both flexion and extension. Between-group analysis reveals that there is significant difference in the post reading of flexion ROM (t= 2.066, p= 0.024), while non significant difference was observed in extension ROM (t= 0.643; p=0.153). But with-in group analysis reveals that there is a significant improvement in experimental group (group A) while control group (group B) fails to resister any changes. Flexion ROM Group A, t=9.274, p=0.00, group B, t=0.732, p=0.238); Extension ROM: Group A, t=2.399,p=0.003; Group B, t=1.435, p=0.0865).

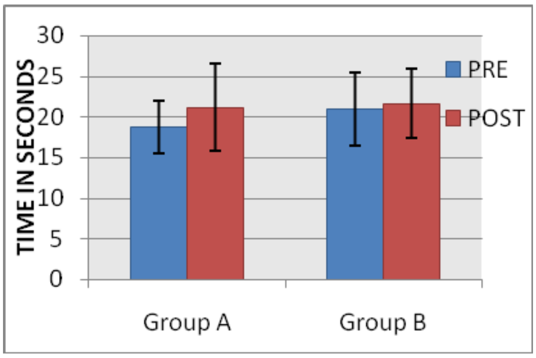
Outcome measures of pain and functional ability: table -2 shows pre and post treatment outcome of pain scores. Between-group analysis reveals that there was a significant difference between the both the groups in VAS score after the treatment (t= 5.557, p= 0.000). While with-in group analysis shows that there was significant improvement in both the groups (Group A t=9.352, p=0.001; Group B t= 1.848.p=0.043).Table 2 shows pre and post treatment outcome of functional ability. Between-group analysis reveals that there a significant difference between the Groups for MODI after the treatment.(z=1.386, p=0.00). While with-in group analysis shows Both the groups improved in their scores on the MODI after the 4 weeks intervention and this improvement was found to be statistically significant (Group A p= 0.004, Group B p=0.004)

Table 1: Demographic information

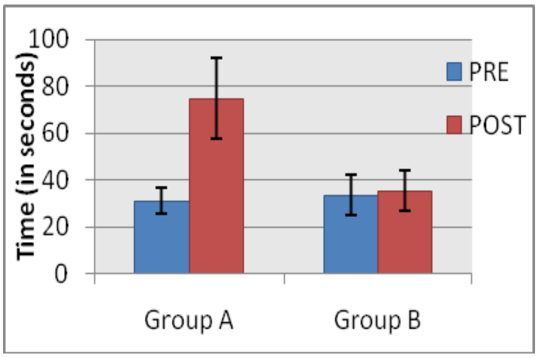
	Group A (n= 15)		Group B (n=15)	
	Mean	SD	Mean	SD
Age(Yrs)	24.0667	2.1865	22.53	2.8502
Height(cms)	170.7333	5.4571	170.00	3.5673
Weight(kg)	66.933	9.0195	68.066	6.4858

Table 2: Mean and SD for the Outcome measures

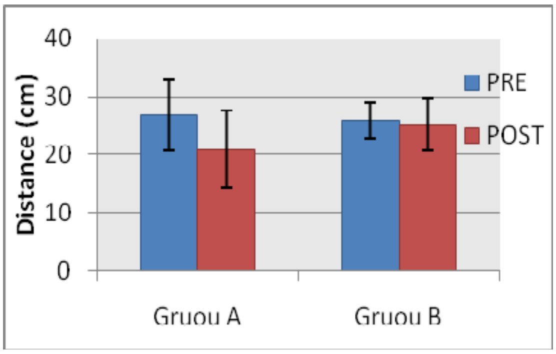
	Group A		Group B	
	Pre Mean±SD	Post Mean±SD	Pre Mean±SD	Post Mean±SD
Curl-up test	18.740±3.2425	24.53±4.2	20.931±4.4991	21.131±4.61
Sorenson test	31.070±5.8595	74.699±17.0303	33.443±8.5639	35.045±8.6007
Flexion ROM	26.773±6.1852	23.268±7.2784	25.913±3.1679	25.160±4.5210
Extension ROM	56.093±2.3224	55.047±2.0712	56.060±2.1440	55.867±2.2388
VAS	4.267±0.7988	1.400±0.6325	4.067±0.7988	3.400±1.2421
MODI	39.200±3.9857	16.133±7.9090	37.200±3.6095	33.600±5.3023



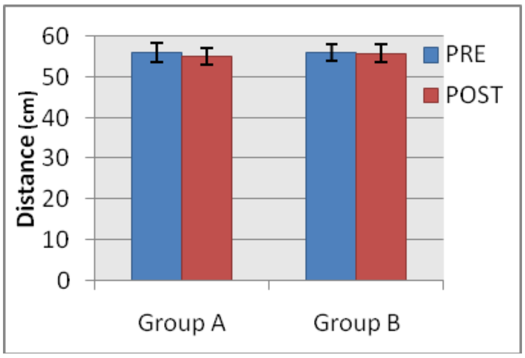
Graph 1: Comparison of Curl-Up Test



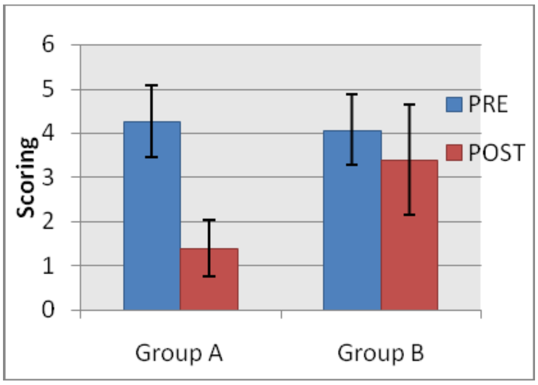
Graph 2: Comparison of Sorensen Test



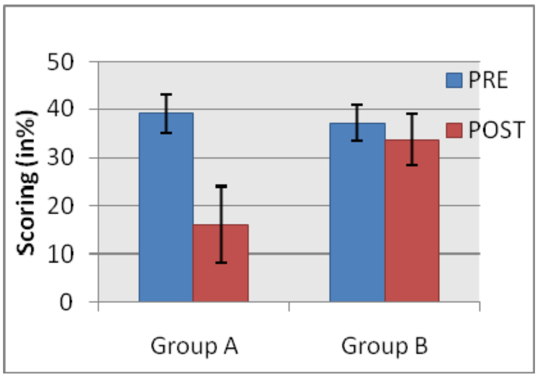
Graph 3 Comparison of Lumbar Flexion ROM



Graph 4 Comparison of Lumbar Extension ROM



Graph 5: Comparison of VAS score



Graph 6: Comparison of MODI scores

3. Discussion

This study was designed to find out the effect of PNF exercises in non specific chronic low back pain. It primarily aimed to assess the effect of 4 weeks PNF exercises on patients' pain, disability, trunk muscle endurance and lumbar mobility. Subjects were randomly allocated to two groups; Group A received PNF in addition to conventional exercises and Group B received conventional treatment only. The dependent variables taken for this purpose were curl up test, Sorenson test, lumbar mobility (flexion and extension), pain intensity and functional disability score.

Comparison of Trunk Muscle Endurance: Between-group analysis revealed significant differences in between Group A and B. Group A was found to be better in trunk muscle endurance tests (for both flexion and extension) as compared to group B. Within- group analysis showed significant improvement in static trunk muscle endurance (of both flexors and extensors) in Group A, while Group B failed to register any significant difference. These results are in agreement with other studies which conclude that PNF training improves trunk muscle endurance. Nikolaos D (2008) showed gain in muscle endurance with 4 week of PNF exercises in patient with CLBP.

Nick k. et al, (2006)showed that 4 weeks of intensive PNF training for the CLBP patients is very effective in improving trunk muscle endurance. They attributed these findings to the dynamic nature of the

PNF exercises (COI), which used all muscle action types (eccentric, concentric, and isometric) through a progressively increased range of motion, and also to the fact that PNF exercises involve significant muscle work that results in muscle strength and endurance improvements(15). In a similar study Nick k, et al (2004) demonstrated positive improvement (10%-70%) in trunk performance after 4-12 weeks of PNF training.

In our study, the inclusion of same exercises may explain the similar findings. Also, the exercises were subject specific i.e. the exercise intensity was progressively increased and adjusted to each subject's performance; therefore, significant muscle system adaptations were observed at the end of exercise program.

Comparison of pain score: In between-group analysis, the findings show that the improvement was marginally better in Group A at the end of 4th week when compared with Group B. However, within group analysis revealed that both group showed statistically significant improvement in the pain score after treatment. The positive finding in each group can be explained on the basis that CLBP causes muscle spasm or refractory inhibition of the muscle of the injured area substantially leading to functional disability. In the long run this may lead to development of so called deconditioning syndrome which includes impairment in back muscle force, endurance and spinal mobility. (1). This impairment in the muscle function can be explained in terms of structural changes in the back extensor muscles and physiologic changes that are reversible with intensive back muscle raining. In general, exercise help in reducing pain by breaking the pain spasm pain cycle irrespective of cause.

In our study, significant pain relief at the end of 4 weeks treatment in group A was attributed to the addition of PNF exercises. This can be linked to increased trunk muscle endurance. This is in agreement with previous findings which state that in patients with CLBP endurance exercises reduce the pain. Frank Ingjer demonstrated that Endurance training leads to increased oxygen uptake (25.2%), and increased capillaries density per muscle fiber(8) , and thus, helps in washing away of waste products thereby reduces pain.

Also, some neurophysiologic studies (Yamashita 1990) have linked pain development in the lumbar spine region of the vertebral column, with disturbances in the mechanoreceptors and probably with impairment of the superior proprioception centers (21). PNF exercises are designed to enhance the response of neuromuscular mechanisms by stimulating proprioceptors. Thus PNF exercises by enhancing proprioception may be beneficial for managing CLBP(15).

Comparison of the scores of Modified Oswestry Disability Index: between-group analysis depicts no significant difference among the groups, although there was a difference in the mean percentage improvement (48.4%) but this difference was found to be statistically insignificant. In within-group analysis the functional ability measurements showed statistical significant improvement in both the training groups; however, the mean percentage improvement in the experimental group (58%) was better than in control group (9.6%). It has been seen that four weeks of training can bring about significant changes in the MODI scores (Julie M. 2005). In our study, after 4 weeks of intervention, improvement was seen in this measure but between- group differences were not significant.(n30) In the present study Group A demonstrated better improvement in mean percentage in functional ability (as registered by the Oswestry Index) which can be attributed to the addition of PNF exercises. The improvements in functional ability could be seen as a direct result of pain, lumbar mobility and endurance improvements, thereby providing further support for the effectiveness of PNF exercises for CLBP treatment.

These findings are in line with study by Nick K et al (2006), who demonstrated improvement in the functional ability (on Oswestry index) following 4 weeks of PNF training.(15). Although, the experimental group showed better improvement in all these measures than the control group, still the improvements in MODI score were similar for both groups. This finding can be attributed to the difference in self perceived improvement and the improvement seen by using clinical tests.

Comparison of Range of Motion of Lumbar Spine: Between-group analysis reviled that there is significant improvement in the flexion range of motion in Group-A in comparison with Group B, while no significant difference was found in trunk extension range. However; within group comparison demonstrated significant improvement in both flexion and extension range of motion in experimental group at the end of PNF training program.

This could be related to the fact that as pain and spasm decreases, range of the lumbar spine increases. The positive effects of the present training program could also be attributed to the nature of PNF exercises, which are designed to maximize improvements in flexibility. Such exercises take advantage of the body's inhibitory reflexes to improve muscle relaxation. Also, it has been shown in previous studies that back pain and spinal pathologies causes spasm in 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 pain free range of motion (15).

This finding is in agreement with previous findings indicating that it is possible to significantly increase range of motion of the spine in patients with CLBP by means of 4 week intensive PNF exercise program. Nick Kofotolis (2006) demonstrate that 4-weeks of PNF training program significantly improve the lumbar mobility in subjects with chronic low back pain (15).

Conclusion: To conclude, our study suggests that there was significant performance improvement on selected measures of trunk muscle endurance, and lumbar mobility with PNF training as compared to conventional exercises only. However, there was improvement in both the groups on the measure of pain and functional ability.

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