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The Effects of Proprioceptive Neuromuscular Facilitation Exercises on Pain, Function, Lumbar Mobility, and Lumbar Lordosis in Patients with Non-Specific Chronic Low Back Pain

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ABSTRACT

Background: *Exercise is one of the most important treatment methods suggested for patients with non-specific chronic low back pain (NSCLBP). It has documented positive effects on patients' performance. The purpose of this study was to evaluate the effects of proprioceptive neuromuscular facilitation (PNF) exercises on pain, function, lumbar spine mobility and degree of lumbar lordosis in patients with NSCLBP.*

Methods: *This study was single-blinded controlled randomized trial. Thirty patients with NSCLBP were recruited through simple non-probability sampling. Subjects were randomly divided into two equal groups: PNF exercises and control. The PNF exercises group received upper and lower trunk PNF patterns, in addition to control group intervention. The control group received burst- mode TENS and Hot Pack for 4 weeks, 5 sessions per week. Before and after intervention, pain was assessed with Mc Gill Questionnaire, function with Oswestry Disability Index, lumbar lordosis with flexible ruler and lumbar flexion and extension with modified-modified Schober test. Data were analyzed using paired and student t-tests.*

Results: *In PNF exercises group, the mean pain and disability decreased from 24.93±8.17 to 4.73±2.46 and 0.53±0.13 to 0.16±0.11, and range of flexion and extension increased from5.2±0.1 to 7±0.85 and from 1.56±0.59 to 2.43±0.5, respectively (P<0.0001). In this group degree of lumbar lordosis didn't change after treatment (p>0.05). In control group, only the mean pain decreased from 19.67±7.5 to 18.4±7.34 (P= 0.004). Significant difference was seen between two groups regarding pain, disability, and mobility of lumbar spine (P<0.0001).* ***Conclusion:*** *These results support that upper and lower trunk PNF exercises decrease pain and improve function and mobility of lumbar spine in NSCLBP.*

Keywords: *Low Back pain, Proprioceptive Neuromuscular Facilitation, Disability, Lordosis, Pain, TENS.*

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1. Introduction

Chronic low back pain (CLBP) is one of the most common and important problems of industrial societies and a major cause of disability (Danneels et al., 2001). Low back pain (LBP) affects work capacity of individuals and leads to loss of productive forces (Hides et al., 2001; Goldby et al., 2006). Epidemiologically, LBP is one of the ten primary reasons for patients who come to their family doctor. A significant proportion of population is suffering from LBP (Preyde, 2000). Its prevalence in different populations is about 7.6% to 36% (Borenstein, 1997). The highest prevalence was reported in the age group between 45 to 60 years. In general, the risk of LBP for a lifetime is estimated to be about 60% to 70% (Hart et al., 1995; Van Tulder et al., 2002). The most health care costs are for patients with chronic pain (Thomas et al., 1999).

In spite of numerous efforts, dating the determination of significant causes of LBP is very difficult (Danneels et al., 2001). A definite diagnosis of the cause of LBP is only possible in 15% of patients. In most cases, LBP is non-specific (Van Tulder et al., 2002; Waddell, 2004; Borkan et al., 2002). In 80% to 90% of cases who suffer a subacute phase of LBP, if the progression of the disease is negligible for more than three months, the prognosis is good for rapid decreasing of pain and disability and returning to work during one month (Pengel et al., 2003; Van Tulder & Koes, 2002). Nevertheless, in small proportion of patients, i.e. 10% to 20% of patients, pain were progressed and developed chronically, defined as LBP persisting more than 3 months (Waddell, 2004; Van Tulder et al., 2002; Airaksinen et al., 2005). NSCLBP is defined as a dull pain felt between the costal margin of lower ribs and buttock crease without any referring pain to the lower limb (Shahbandar & Press, 2005).

Despite numerous studies, there are still controversies about the most appropriate intervention method on the treatment of LBP (Machado et al., 2005). However, there is an agreement on usefulness of active participation methods on patients in the treatment of LBP in subacute and chronic phases (Koumantakis et al., 2005). Exercise is the most current modalities for rehabilitation of subjects with CLBP (Kofotolis & Sambanis, 2005). The primary goal of physical exercises in the treatment of CLBP is to increase muscle strength, flexibility, and endurance, to release of injured tissues, and as well to gain ability to perform normal activities of life (Malkia, & Ljunggren, 1996). There are various exercise programs for treating CLBP according to the duration, frequency, intensity and type of exercise (Kofotolis & Kellis, 2006). However, the effects of specific types of exercises, their efficacy and superiority of certain components of exercise on function should be determined (Mayer et al., 1985; Hultman et al., 1993). Some patients with CLBP used long term programs; however, the effects of short term programs can be achieved through hard and massive treatment (Grindrod et al., 1983; Loeser & Melzack, 1999). Although specific effects of short term programs compared with long-term plans are not clear, majority of patients prefer short term exercise programs due to financial costs, rapid recovery, improving functional performance, reducing pain, and increasing muscle function (Kofotolis & Kellis, 2006). Some exercise programs, often called general exercise programs, are designed to enhance trunk performance through the training of long trunk muscles, erector spinae and rectus abdominis, whose primary function is to generate movement (Koumantakis et al., 2005). Enhancement of function of such muscles may improve trunk muscle strength, endurance, and flexibility (Kofotolis & Kellis, 2006). However, current research has shown that in most cases of CLBP, certain muscles of the back, multifididus and transversus abdominis, which stabilize the spine, are reflexively inhibited after injury (Hultman et al., 1993; Grindrod et al., 1983). These muscles do not spontaneously recover even if patients are pain-free while returning to normal activity levels (Kofotolis & Kellis, 2006).

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 (Loeser & Melzack, 1999; Yamashita, 1990). Therefore, exercise programs that enhance proprioception may be beneficial for managing CLBP (Kofotolis & Kellis, 2006). Normal functional motion is composed of mass movement patterns of the limbs and the synergistic trunk muscles. The motor cortex generates and organizes these movement patterns, and the individual cannot voluntarily leave a muscle out of the movement pattern to which it belongs. This does not mean that we cannot contract muscles individually, but our discrete motions spring from the mass patterns (Adler et al., 2008). The patterns of PNF exercises have a spiral, diagonal direction, and the performance of these patterns is in line with topographic arrangement of the muscles being used (Voss et al., 1985). 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 (Kofotolis et al., 2002; Lusting et al., 1992). These synergistic muscle combinations form the PNF patterns of facilitation (Adler et al., 2008). We can combine the patterns in many ways (Adler et al., 2008). Choosing how to combine the patterns for the greatest functional effect is a part of the assessment and treatment planning (Adler et al., 2008). The emphasis of treatment is on the arms or legs when the limbs move independently. The emphasis is on the trunk when the arms are joined by one hand gripping the other arm or when the legs are touching and moving together (Adler et al., 2008). A strong trunk activity is essential for good function. The trunk control is the base that supports extremity motions. For example, supporting trunk muscles can contract synergistically with arm motions. This is often clear in patients with neurologic problems. When the trunk is unstable, normal movement in the extremities is impossible. While the trunk is able to move and stabilize effectively, patients gain improved control of their arms and legs. Strengthening the muscles of the trunk is only one reason for using the trunk patterns in patient treatment (Adler et al., 2008). PNF exercises are designed to enhance the response of neuromuscular mechanisms by stimulating proprioceptors. Therefore, these exercises may be better suited for performance enhancement than conventional single-plane or single-direction weight-training programs (Kofotolis et al., 2002; Kofotolis et al., 2005). Furthermore, PNF techniques often have been used to improve the range of motion of a joint and endurance as well performance in a vertical jump (Lusting et al., 1992; Osternig et al., 1990).

Maher et al. (2005) showed that motor control exercises significantly improve short term and long term outcomes in CLBP subjects (35). Akbari et al. (2008) demonstrated that the motor control and general exercises decrease pain and increase lumbar multifidus and transversus abdominis muscles thickness and lumbar mobility in patients with chronic LBP without any signs of spinal instability. Although, the motor control exercises were more effective than general exercises in pain decreasing (Akbari et al., 2008). The contribution of transversus abdominis to spinal stabilization was evaluated indirectly in people with and without LBP using an experimental model identifying the coordination of trunk muscles in response to a disturbance to the spine produced by arm movement. The delayed onset of contraction of transversus abdominis indicates a deficit of motor control and it is hypothesized to result in inefficient muscular stabilization of the spine (Hodges & Richardson, 1996). Hayden et al. (2005) evaluated the effectiveness of exercise therapy in adult with non-specific acute, subacute, and chronic LBP versus no treatment and other conservative treatments. They showed that exercise therapy seems to be slightly effective on decreasing pain and improving function in adults with CLBP, particularly in health care populations. In subacute LBP populations, some evidence suggests that a graded-activity program improves absenteeism outcomes, although evidence for other types of exercise is unclear. In acute LBP populations, exercise therapy is as effective as either no treatment or other conservative treatments (Hayden et al., 2005). Kofotolis and kellis (2006) examined the effects of 2 PNF programs on trunk muscle endurance, flexibility, and functional performance in subjects with CLBP. Subjects were randomly assigned to 3 groups: rhythmic stabilization training, combination of isotonic exercises, and control. They stated that static and dynamic PNF programs may be appropriate for improving short-term trunk muscle endurance and trunk mobility in people with CLBP (Kofotolis & Kellis, 2006). Macedo et al. (2008) showed that motor control exercises decrease pain and increase function in patients with NSCLBP at 2 and 6 months after treatment (Macedo et al., 2008)). Luomajoki et al. (2010) assessed whether patient-specific functional impairment and experienced daily disability improved after treatment to address active movement control of the CLBP. They showed that movement control, patient specific functional complaints and disability improved significantly following specific individual exercise programs, performed with physiotherapeutic intervention (Luomajoki et al., 2010).

There are different forms of PNF exercises. Although several forms of PNF exercises are used in physical therapist practice, their effects on CLBP are not clear (Kofotolis & Kellis, 2006). Moreover, the influence of different types of programs on trunk muscle strength, endurance, and range of motion is unclear (Kofotolis & Kellis, 2006). On the other hand, due to insufficient evidences and researches on the impact of PNF exercises on NSCLBP, it seems to be necessary to conduct a study to determine the effects of PNF exercises on pain, function, and lumbar spine flexibility in these patients. Nevertheless, there are sufficient evidences on the significant role of PNF exercises in the reorganization of neutral control of spine muscles over the increasing physical and functional demands. Accordingly, we decided to determine the effectiveness of PNF exercises on NSCLBP. The purpose of this study was to evaluate the effect of PNF exercises on pain, function, lumbar spine mobility and degree of lumbar lordosis in patients with NSCLBP. It was hypothesized that adding PNF exercises to a burst-mode TENS lead to decrease pain, disability, and degree of lumbar lordosis and to increase lumbar spine mobility in patients with NSCLBP. The effects of PNF exercises would be more in PNF exercises group compared with controlled one.

2. Methods

2.1 Study Design

This study was a single-blinded, randomized controlled trial. The administrator and physiotherapist who assessed the subjects, measured the outcome, and analyzed the data were informed about the grouping data. But the participants were blinded about the grouping. Subjects were randomly assigned into two equal groups; PNF exercises (N=15) and control (N=15). Randomization was done via lottery conducted by clinical therapists. A 20 individually supervised forty five minutes sessions' treatment program which lasted 4 weeks and five per week was performed for both groups in Razmejo-e-Moghadam Physiotherapy Clinic, Zahedan University of Medical Sciences, Zahedan, Iran, in 2014. Data were recorded before and after intervention (Kofotolis & Kellis, 2006). Those subjects who were eligible to take part in the study signed an informed consent before entering the study. This study was approved by the Scientific and Ethics committee of the School of Rehabilitation Sciences of Zahedan University of Medical Sciences, and the rights of the subjects were respected throughout the study.

2.2 Participants

In this study, thirty patients with NSCLBP were selected through simple non-probability sampling method. The inclusion criteria for this study were the age between 18 to 60 years, pain felt between costal margins and buttock crease without any referring pain to the lower extremity (Shahbandar & Press, 2005), lasted more than 3 months (Waddell, 2004; Van Tulder et al., 2002; Airaksinen et al., 2005), causes malfunction and disability, and has not subsided, the patient is referred for treatment, no history of trauma, recent fracture, neurological or spinal disorders in lumbar area, as well sever lumbar spine disorder such as disk herniation, rheumatoid disease, inflammatory disease, peripheral nerve lesions, psychological disease, previous surgery at lumbar region, spondylolysis or spondylolysthesis, neuromuscular and joint disease, systemic diseases, malignancy, pregnancy, cardiovascular and metabolic diseases (Koumantakis et al., 2005). Patients were excluded if they had any type of exercises for low back muscles, signs of nerve root compression, did not complete sessions of treatment in the current study, currently enrolled in physical therapy or other training program, surgery or having trauma at lumbar region during study, and aggravating of pain and disability following exercises (Akbari et al., 2014a, 2014b; Cooper et al., 2005).

2.3 Data Collection

We interviewed and examined all subjects, to ensure that the inclusion and exclusion criteria were fulfilled. Age, weight, and height were also measured. The heights and the body weight of the subjects were measured by a meter with 1 cm accuracy and a digital scale, respectively. Based on following procedures pain, function, lumbar lordosis, and lumbar flexion and extension range of motion were measured through Mc Gill Questionnaire, Oswestry Disability Index, flexible ruler, and modified-modified schober test, respectively.

2.4 Outcome Measures

2.4.1pain measurement

Pain perception was measured using the Short-Form McGill Pain Questionnaire (SF-MPQ), a responsive pain scale that yields reliable and valid data, derived from the original McGill Pain Questionnaire. The SF-MPQ consists of 15 descriptors of pain quality (11 sensory, 4 affective), each rated on an intensity scale from 0 to 3 and on a visual analog scale (VAS) for pain intensity from 0 to 100 mm, with higher scores representing higher levels of pain on both scales. Scores could range from 0 to 33 for the sensory scale and from 0 to 12 for the affective scale (Koumantakis et al., 2005).

2.4.2 Lumbar flexion and extension range of motion measurement

Lumbar flexion and extension range of motion were measured using the modified-modified schober test. This test was done at standing position. Subjects stand with 15 cm width between feet. The midpoint between the posterior superior iliac spines (PSIS) was marked with a pen. Then one point 15 cm proximal to first point identifies by tape and was marked by pen. As the client flexes the spine as far as possible, the distance between the superior and inferior marks was measured and recorded in centimeter. Similarly, the distance between the superior and inferior marks was measured and recorded in centimeter as the subjects extend the spine as far as possible (Bronner, 1997).

2.4.3 Functional measures

The Oswestry Disability Index was used to give a percentage score that indicated each patient's level of functional disability. It is a gold standard measurer for evaluation of disability following LBP. This questionnaire is used widely to monitor treatment effect with regard to changes in the functional mobility of patients with CLBP and is sufficiently sensitive to monitor these changes. It has ten sections. Pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex Life (if applicable), social life, and traveling are assessed through this questionnaire. Every section has 6 items and they are rated from 0 to 5. The maximum score is 50. The scores are added at the end, divided by 50 (or 45 if they leave out one section) and multiplied by 100 to get the percentage of disability (Fairbank & Pynsent, 2002).

2.4.4 Lumbar lordosis measurement

Angle of lumbar lordosis was measured in standing position through flexible ruler. The flexible ruler molded to the contours of the subject's lumbo-sacral spine. Two markers were fixed with double-sided adhesive tape to the skin of the spinous processes of T11 and S1. These marker positions facilitated lumbar lordosis measurements. Sites along the flexible ruler that intersected with adhesive dots marking were marked with twist-ties attached to the flexible ruler. The shape of the curve's outline was traced on a piece of poster board and marks corresponding to the spinous processes were made along the curve's contour. Quantification of the curve (degrees) was done with a technique that involved drawing a line from one end of curve to the other (L line) and then drawing a right angle line from middle of L line to apex of the curve (H line). Then the amount of curve calculated through following formula: formula: (Lundon, 1998). $\theta = 4\left[ARCtag\left(\frac{2H}{L} \right) \right]$

2.4 Intervention

In control group, subjects received a burst-mode TENS (pulse width, 200 µs; frequency, 100 Hz; burst frequency, 2 Hz) for 20 minutes and a Hot Pack also for 20 minutes (Ghiasi, 2007). The PNF exercises group received upper and lower trunk PNF patterns, in addition to control group intervention, as the same dosage as the first group. Two antagonistic patterns i.e. head, neck and upper trunk, and lower trunk were done. Upper trunk patterns include D_FR (flexion with rotation to the right) and D_FL (flexion with rotation to the left) patterns of head, neck and upper trunk and their antagonistic patterns i.e. DEL (extension with rotation to the left) and DER (extension with rotation to the right). Lower trunk patterns include D_FR (flexion with rotation to the right) and D_FL (flexion with rotation to the left) patterns of lower trunk and their antagonistic patterns i.e. DEL (extension with rotation to the left) and DER (extension with rotation to the right) (Voss et al., 1985). Three sets of 15 repetitions of each exercise were done per session. Resting time between repetitions and sets was 30 s and 60 s, respectively.

2.5 Sample size estimation

The sample size was determined based on a pilot study. Ten subjects were divided randomly into two equal groups, and the main part of study was conducted on them. The means and SDs for the parameters from this pilot study, with α= 0.05 and 90% power were used to calculate the sample size.

2.6 Statistical analysis

Data were analyzed statistically using SPSS 17 (SPSS Inc, Chicago, Illinois). Kolmogorov-Smirnov test for normality was performed for all outcome variables. Levene's test was used for equality of variances. Independent and paired t-tests were used for comparison between pretreatment and posttreatment test results between groups and within groups, respectively. A p-value >0.05 was accepted as being statistically different. All data are presented as mean ± standard deviation.

3. Results

Figure 1 presents the recruitment strategy and experimental plan. The pilot study showed that 15 subjects would be needed for each group (a total of 30 subjects). Ultimately, 30 subjects finished the study procedure. Demographic characteristics of the patients such as age, weight, and height were shown in Table 1. There was no significant difference between two groups regarding to age and weight (P>0.05). However, height of patients in the PNF exercises group was more than control one (p=0.02) (Table 1).

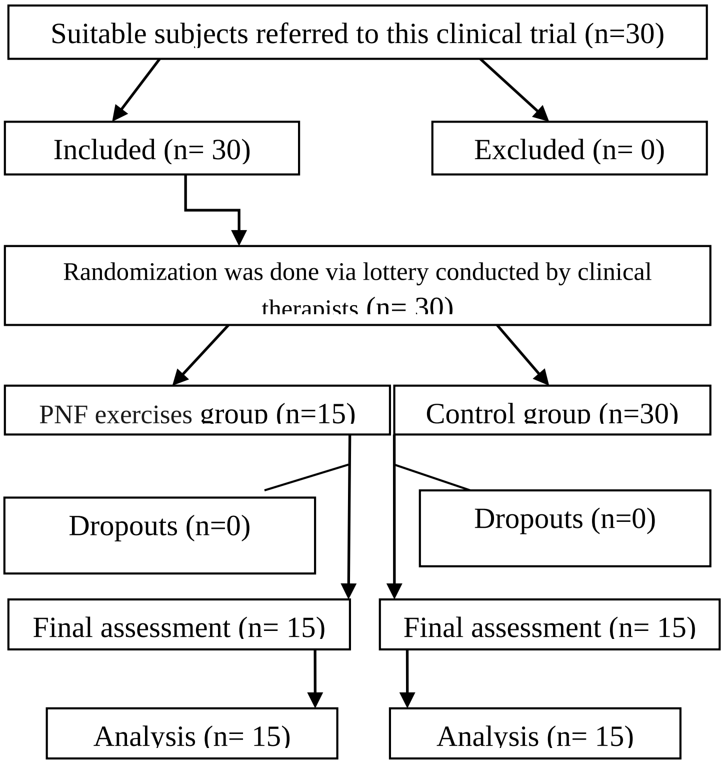

Figure 1. Flow diagram of the progress through the phases of the randomized trial.

Table 1: Between-Group baseline comparison of subjects' characteristics

	PNF[a] exercises group	**Control group**	**P value**
Age (y)	40.53±10.83[b]	40.33±11.37	0.92[c]
Height (cm)	166.33±4.7	162.33±4.11	0.48
Weight (kg)	68.33±0.6	66.53±7.02	0.02

[a] PNF= proprioceptive neuromuscular facilitation.

[b] Values are Mean ± Standard Deviation.

[c] Statistical different at P<0.05.

The means and SDs of the all variables include pain, disability percentage, angle of lumbar lordosis, and mobility of lumbar flexion and extension in bothgroups, p-value of within group comparisons and p-value of between group comparisons are shown in Table 2. The result of kolmogrov-smirnov test showed that all of variables include pain, disability percentage, angle of lumbar lordosis, and mobility of lumbar flexion and extension in both group had normal distribution (p> 0.05).

Table 2. Means and standard deviations of the pain, disability percentage, angle of lumbar lordosis, and mobility of lumbar flexion and extension in both group, and p-values for within and between-group comparisons

Outcome measures	**PNF[a] exercises group (n=15)**			**Control group (n=15)**			
	Before	After	P value	Before	After	P value	P value
Disability (ordinal)	0.53±0.13[b]	0.16±0.11	0.000[c]	0.46±0.11	0.46±0.11	--	0.000[c]
Pain (ordinal)	24.93±8.17	4.73±2.46	0.000	19.67±7.5	18.4±7.34	0.004[c]	0.000
Lumbar flexion (cm)	5.2±0.1	7±0.85	0.000	5.33±1.29	5.33±1.29	--	0.000
Lumbar extension (cm)	1.56±0.59	2.43±0.5	0.000	1.3±0.5	1.3±0.5	--	0.000
Lumbar lordosis (degree)	55.6±18.1	55.6±18.1	--	63.26±13.5	63.26±13.5	--	0.213

[a] PNF= proprioceptive neuromuscular facilitation.

[b] Values are Mean ± Standard Deviation.

[c] Statistical different at P<0.05.

3.1 Within group comparison

Paired t-tests revealed significant differences in the PNF exercises group, with an increase in lumbar flexion and extension, and decrease in pain and disability (P<0.0001). In control group, only pain was significantly decreased (P<0.05) (Table 2).

3.2 Between group comparisons

To ensure that the randomization process had been done correctly, the pretesting data were compared with the two groups, and no significant differences were found between the recorded variables. So the groups were matched properly (p>0.5). After treatment data was compared between two groups using an independent t-test. There was no significant difference between two groups regarding to degree of lumbar lordosis. However, the mean score of pain, disability percentage, lumbar flexion and extension range of motion were significantly decreased in PNF exercises group compared with the control one (P<0.05) (Table 2).

4. Discussion

The results of this study support the initial hypothesis that PNF exercises accompanied with a burst-mode TENS are effective in increasing lumbar flexion and extension range of motion and decreasing pain and disability severity in patients with NSCLBP. However, pain severity was decreased in the control group. Also, the results support the second hypothesis that PNF exercises accompanied with a burst-mode TENS are more effective in increasing lumbar flexion and extension range of motion and decreasing pain and disability severity in patients with NSCLBP than the burst-mode TENS alone. However, contrary to the part of second assumption of this study, there was no significant difference between the two methods regarding degree of lumbar lordosis.

Chronic LBP is a multifactorial phenomenon and it is not surprising that many therapeutic approaches exist (Moseley, 2002). There are ample evidences that active approaches, such as exercise therapy, are beneficial for patients with subacute and chronic LBP (Abenhaim et al., 2002). Positive results have been documented with different types of exercise, suggesting there are few evidences that a particular “type” of exercise is any better than another (Van Tulder et al., 2002). The effectiveness of classic trunk exercises, that they activates the abdominal and paraspinal muscles (McGill, 1998), were reported on the several randomized controlled trials (RCTs) (Risch et al., 1993).While some trials of exercise therapy have reported clinically important effects of treatment (O’Sullivan et al., 1997), others have not (Yelland et al., 2004). Many factors contributed to the inconsistent results across trials. Importantly, interpretation of the results of exercise trials is difficult because most trials have been pragmatic trials. Secondly, the quality of exercises was not controlled (Maher et al. 2005). Lastly, methodological quality varies greatly across previous exercise trials. No RCT has tested the assertion that PNFexercises is beneficial in patients with chronic LBP using pain and disability as outcomes.

Large reviews conclude that there is strong evidence for the effectiveness of exercise as a treatment for LBP (Hayden et al., 2005). For instance, activity and general exercise therapy improves pain and disability and reduces the number of sick days in patients with non-specific chronic low back pain. Nevertheless, it is not clear what kind of exercises should be used (Kool et al., 2005). Studies have shown that exercise therapy reduce pain and improve function in patients with chronic low back pain, effectively (Hides et al., 1994). In a study, comparing stabilization exercise against general exercise in patients with lumbar spondylolysis or spondylolisthesis indicated large short-term and long term improvement in favor of the stabilization exercise group on pain and disability. We believe that stabilization exercises do not provide additional benefit to patients with chronic LBP who have no spinal instability. However, O’Sullivan et al. (1997) demonstrated that stabilization exercises are more effective in reduction of pain and disability than general exercises (O’Sullivan et al., 1997).

On the other hand, some researchers believe that there is a strong relationship between injuries and proprioceptive sensation in lumbar spine. The proprioceptive deficit is usually accompanied with risk of lumbar region injuries. Thus, one of the goals of lumbar exercises should be increasing proprioception of lumbar region (Twomey and Taylor, 2000)

Kofotolis and Kellis (2006) found that 4 weeks PNF exercises significantly increases the lumbar spinal range of motion and spinal muscle endurance in people with CLBP. This is the first study to examine the use of PNF exercises for management of CLBP. In this study, lumbar flexion mobility increased after both rhythmic stabilization training and combination of isotonic exercises programs. This finding was in agreement with previous findings indicating that it is possible to significantly increase range of motion and endurance in people with CLBP by using a a 4 weeks intensive PNF exercise program. The positive effects of the present training programs could be attributed to the nature of PNF exercises, which are designed primarily to maximize improvements in flexibility. Such exercises take advantage of the body’s inhibitory reflexes to improve muscle relaxation. This muscle relaxation allows a greater stretch magnitude during stretch training, which should result in superior gains in flexibility. These results provided further support of previous findings on the positive effects of PNF techniques on joint flexibility (Kofotolis & Kellis, 2006). Our finding is in agreement with the results of Kofotolis and kellis. Also, our finding is in agreement with the results of Manniche et al, (1988) who demonstrated that among patients with low back pain, intensive training had to continue for more than 2 months to achieve significant pain reduction, whereas a 3 week daily intensive training program was found to be equally efficient (Mayer et al., 1985).The improvements in functional ability (as registered by the Oswestry Index) could be seen as a direct result of flexibility and endurance improvements, thereby providing further support for the effectiveness of PNF exercises for CLBP treatment. The exercise programs applied in the present study were short-term intensive programs. An important limitation of such programs is that any improvements may not be permanent.

5. Conclusion

The results of this study showed that PNF exercises accompanied with a burst-mode TENS are effective in increasing lumbar flexion and extension range of motion and decreasing pain and disability severity in patients with NSCLBP. Accompanied with little studies and according to the available evidences, we suggest that PNF exercises should be added to a burst-mode TENS therapy for patients with NSCLBP.

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