JOURNAL OF PHYSICAL ACTIVITY NUTRITION AND REHABILITATION

Journal of Physical Activity, Nutrition and Rehabilitation, 2015
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Effects of a 6-week Proprioceptive Neuromuscular Facilitation Intervention on pain and disability in individuals with chronic low back pain

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Abstract

A randomized controlled trial was used to compare the effects of a 6-week proprioceptive neuromuscular facilitation (PNF) and a General Exercise (GE) program on pain and disability in patients with chronic low back pain (CLBP) recruited from the outpatient department of a hospital clinic. CLBP patients were randomly assigned into a PNF (n=40) or a General Exercise group (n=40) and trained for 6 weeks, 2 times per week. The PNF group executed 11 exercises from the seated, supine and standing/walking position using various PNF techniques. The GE group followed a standard strengthening and co-ordination program. The measures used were pain (McGill questionnaire), functional disability (Rolland Morris questionnaire) and emotions before, immediately after and 8-weeks after treatment. Pain decreased more in the PNF (45.68% post and 38.05% 8-weekspost-intervention)than the GE group (22.82% post and 5.89%8-weeks post-intervention).Roland Morris scores increased for the PNF group (from 23.35%to 28.51%) while the GE group showed an increase only immediately after the program. Positive emotions increased significantly only for the PNF group (from 53.23% to 55.00%) while there was a reduction in negative emotions for both groups. In conclusion, the use of structured programs utilizing all PNF techniques is recommended for CLBP treatment.

Keywords: Chronic low back pain; PNF treatment; PNF techniques

1 Introduction

Many interventions are claimed to be effective in treating chronic non-specific low back pain (CLBP) in the short term, but the most effective exercise approach is still under discussion (May & Johnson, 2008; Hayden, Van Tulder, & Tomlinson, 2005; Hayden, Van Tulder, Malmivaara, & Koes, 2005). Some therapeutic interventions (often called general exercise programs) are designed to enhance trunk performance through training of long trunk muscles (erector spinae, rectus abdominis), whose main function is to generate movement (May et al., 2008; Koumantakis, Watson, & Oldham, 2005; Hides, Richardson, & Jull, 1996) while others focused on improving general functional capacity or mobility level in elderly women (Matsouka, Harahousou, Kabitsis, & Trigonis, 2004; Matsouka, Kabitsis, Harahousou, & Trigonis, 2003). However, low back pain is mainly linked with inhibition and impaired function of trunk stabilizing muscles (Yamashita, Cavanaugh, Elbohy, Getchell, & King, 1990) and therefore, the use of stabilization

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programs have been advocated (Ota, Kaneoka, Hangai, Koizumi, & Muramatsu, 2011; May et al., 2008; Ferreira, Ferreira, Maher, Herbert, & Refshauge, 2006). Nevertheless, systematic reviews failed to identify superiority of one method over the others (May et al., 2008; Ferreira et al., 2006).

The Proprioceptive neuromuscular facilitation (PNF) concept applies neurophysiological principles derived from Sherrington's work (Adler, Beckers, & Buck, 2008). Most PNF therapeutic programs mainly refer to the use of PNF for serving stretching purposes (Sharman, Cresswell, & Riek, 2006). However, PNF is not designed only for stretching neither it involves joint exercises in a single plane. The main purpose of PNF concept is to enhance mobility, movement control and joint coordination. This goal can only be achieved through diagonal patterns of movement through various stimuli and guidance provided by the therapist (Adler et al., 2008; Voss, Ionta, & Meyers, 1985). Hence, PNF techniques can be divided in three categories: first, stretching/relaxation techniques, which include hold-relax and contract-relax methods, second, the agonist muscle techniques, which include rhythmic initiation, combination of isotonics (or agonist reversals) and replication and finally, the antagonist muscle techniques which include dynamic reversal, stabilizing reversal and rhythmic stabilization. While numerous research findings on PNF stretching effectiveness have been documented (Sharman et al., 2006; Kofotolis et al., 2002; Lucas & Koslow, 1984), little is known about interventions which are based on the PNF philosophy and concept aiming to enhance fine motor control, mobility and functional performance.

In parallel, CLBP is not only a physical problem, but it may also depend on the patient's attitudes and beliefs, psychological distress, and illness behavior (Waddell, 1987). Consequently, the treatment of CLBP is not primarily focused on removing an underlying organic disease, but at the reduction of disability through the modification of environmental contingencies and cognitive processes (Van Tulder et al., 2000). While PNF is a physical intervention, any change in patient's emotions in response to pain reduction may provide useful information regarding its effectiveness for CLBP treatment.

Some studies have compared the application of rhythmic stabilization versus combination of isotonics in treating CLBP, reporting differences in outcomes between techniques (Kofotolis & Kellis, 2006). However, the concept of PNF therapy rarely involves the use of only one or two techniques throughout the intervention program (Adler et al, 2008). In clinical practice, the therapist doesn't have to choose between individual techniques, but has to design a PNF exercise program to improve patients' condition. To our knowledge, the effectiveness of such a program for treating non-specific CLBP has not been previously reported. The aim of the present study was to compare the effects of a PNF intervention with those of a General Exercise program on pain relief, emotional assessment and function in patients with non-specific CLBP.

2 Methodology

2.1 Participants and experimental design

Ninety-two patients with CLBP from an outpatient department were recruited in the study. To recruit this number of patients a 12-month inclusion period was anticipated. Inclusion criteria were: age 25–65 years, a new episode of non-specific low back pain lasting more than 12 weeks and an inability to resume daily activities in the last 3 weeks. Exclusion criteria included spinal stenosis or surgery, inflammatory disease affecting the spine, fracture, spondylolysis or spondylolisthesis, genetic spinal structure abnormality, acute low back pain, pregnancy, use of medication that affects heart rate and/or blood pressure and pelvic girdle pain. None of the participants showed indications of neural deficiencies, received pain killers and additional physical therapy interventions during the study period. All participants provided informed consent prior to participation in the study in accordance with Declaration of Helsinki and continued to work during the intervention period. The study was approved by the university ethics committee.Each patient was given a sealed envelope ensuring concealed randomization. Due to the study design and purpose, both patients and physiotherapists could not be blinded for the interventions (Figure1).

After baseline measurements, four patients were excluded from the study (refer to Figure 1 for reasons of exclusion). The remaining 88 patients were randomly allocated to either a PNF or a general exercise (GE) group using series of random numbers. The PNF group consisted of 17 females and 23 males (age 40.35±9.62; height 1.71±0.05 cm; body mass 74.38±7.91 Kg) and the GE group consisted of 18 females and 22 males (age 40.88±1.28 years; height 1.70±0.08 cm; body mass 74.65±8.36 Kg). The duration of symptoms was 11.3±4.7 and 11.7±5.3 months for the PNF and the GE group, respectively. One-way ANOVA and Student Neuman-Keuls multiple comparison test indicated no group differences in any of these variables. Both programs included 12 one-hour sessions, 2 days a week for 6 weeks. Two physiotherapists, each with 25 years' experience provided either PNF intervention or GE therapy.

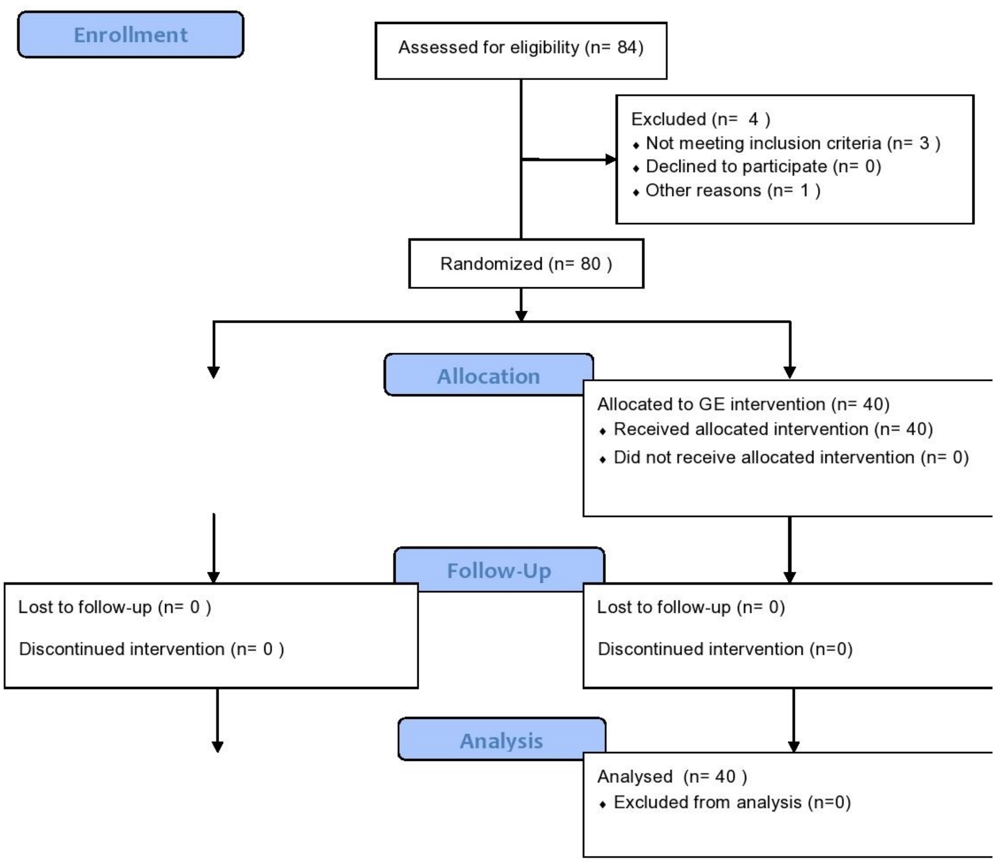

Figure 1: Participant Flowchart

2.2 Procedures

PNF Group The PNF program involved exercises from three different starting positions: supine, seated and standing/walking. In each starting position, the first step was to initiate learning of pain free pelvic girdle neutral positions. Particularly, the therapist guided the patient to assume an aligned and pain-free pelvic position, using rhythmic initiation. This involved rhythmic motion of the pelvis through the desired range, starting with passive motion and progressing to active resisted movement. To facilitate further learning, the replication technique was applied. Particularly, patients were placed at the “corrected” pelvic neutral (pain free) position and they were asked to hold this position while the therapist provided resistance to various directions. After a short period of relaxation, the pelvis was passively moved by the therapist in various directions and the patient was asked to re-gain pain-free pelvis position. At the final stage, the patient assumes pain free position independently (without therapist facilitation).

Once a “new” pain-free pelvis position was established, further exercises were introduced. In the supine position, six exercises were used: First, patients had to assume a hook lying position by moving their hips whilst keeping their pelvic neutral position. Second, patients moved their hips and pelvis by maintaining the upper trunk constant. Third, bridging exercises by asking the patients to lift their pelvis with adequate resistance and facilitation provided by the therapist. Four, patients lifted their pelvis upwards and then moved their pelvis left and right whilst the arms were kept firm on the ground. Five, a gait simulation exercise was performed with one leg extended and the other leg flexed, by providing resistance on the support leg and facilitating the swinging leg. Sixth, participants moved from the supine to a side sitting position with and without therapist facilitation. Facilitation was achieved by placing the hands on the pelvis and scapula and assisting patient movement through minimal upper trunk rotation.

In the seated position, four exercises were performed. First, stabilizing reversals were applied by asking the patient to maintain trunk position against pushing or pulling forces provided by the therapist. Second, upper trunk flexion/extension with minimal lower trunk rotation was performed. Third, body transfers on the chair in different directions were performed with and without arms’ use. Finally, sit-to-stand movement was performed. Subsequently, patients maintained standing posture against therapist resistance in all directions and performed weight shifts from a stepping starting position by correcting pelvis position through rhythmic initiation and replication.

All aforementioned exercises were also performed using the combination of isotonic technique, to enhance dynamic stability as well as the hold-relax and contract-relax PNF techniques, to increase trunk range of motion.

The duration of each session was 60 minutes. In general terms, Weeks 1 and 2 included learning of pain free pelvic girdle motion through rhythmic initiation and replication from all exercise positions. Stabilizing reversals and combination of isotonic were gradually introduced from Week 2 and fully implemented from Weeks 3 onwards. The intensity of exercise started from 5 repetitions X 5-sec contraction (Weeks 1-2), it progressed to 7 repetitions X 7-sec contractions (Weeks 3-4) and increased to 10 repetitions X 10-sec contractions (Weeks 5-6).

General Exercise Group

The GE group followed a modified version of a previously published general exercise intervention (Koumantakis, Watson, & Oldham, 2005). The program consisted of 8 stages of increasing difficulty. Briefly, Week 1 included upper and oblique abdominals from the supine position with knees straight and knees bent and back extensor exercises from the prone position. Week 2 included heel slides and lower abdominal crunches and for back extensors, bridging, lifting trunk to neutral from prone position and arms in elevation. Week 3 included lower abdominal crunches straight leg lifts toward ceiling, cycling exercises, leg slides from side lying and single-leg trunk extensions from prone and 4-point kneeling positions. Week 4 included the same program of Week 3. Week 5 exercises included full abdominal crunches and alternate arm/ leg extensions from 4-point kneeling and lying positions, alternate arm/leg lifts sitting on a Swiss ball. Week 6 consisted of the same leg and arm lifting-lowering on top of exercises from Stage 5, abdominal curls on ball from prone position and pulling legs toward chest, same leg and arm lifting-lowering from the supine position, cycling exercises, full oblique abdominal crunches and advanced hip lift from side lying position. The duration of each session and exercise weekly progression was similar to the PNF intervention program.

2.3 Assessment of Low Back Pain functional disability

Patients completed questionnaires at baseline (PRE), immediately (POST) and 8 weeks (POST8W) after intervention, administered by an interviewer, blinded to treatment allocation. LBP-related functional disability was assessed using the Greek version of the Roland & Morris questionnaire, (Boscainos, 2003) with scores ranging from 0 (no disability) to 24 (maximum disability). Previous recommendations were followed regarding clinical importance and a difference of the Roland Morris Disability score among groups was set equal or greater than 2 points (Cecchi, Molino-Lova, & Chiti, 2010; Hestbaek, Leboeuf-Yde, & Manniche, 2003). Therefore, to detect differences in Roland Morris Disability scores, given a common standard deviation of 2.5 scores, a two-sided 5% significance level and a power of 80%, a minimum sample size of 25 patients per group was deemed necessary (Noordzij et al., 2010).

2.4 Pain assessment

The McGill Pain Questionnaire (Greek version) was also used to assess the sensory, affective, and evaluative components of pain (Melzack, 2005). This includes identification of current pain location (Part1), subjective assessment of pain intensity (Part4) and pain changes over time (Part3) as well as evaluation of 78 pain descriptors distributed across 20 sub-classes, classified in five classes (Part2). The rank scores were summed yielding an overall total score which was used for further analysis.

The Emotions Scale (EMS) was used to assess responses of patients with CLBP to their back pain before and after intervention. The EMS consists of 20 items utilizing Likert-like response options on a 5-point scale. These items are organized in two factors, “positive emotions” (12 items) and “negative emotions” (8 items) with Cronbach coefficients ranging from 0.90to 0.92 (Beneka, Malliou, & Kouli, 2010). Each patient was asked to rate his/her perception of each item in relation to current low back pain. Subsequently, positive and negative emotions were used as outcome variables for the present study.

2.5 Statistical analysis

Means and standard deviations were calculated for all depended variables. Data were examined for normality using the Kolmogorov-Smirnov test. Data were analyzed through a mixed model two-way repeated measures ANOVA (2X3, group by time of test) with planned contrasts on different time points. When a significant effect was found, post hoc analysis was performed through the Post-Tukey test. Statistical significance was set at p=.05. Percentage Pre-Post differences and 95% confidence intervals were also calculated.

3 Results

3.1 Low back pain functional disability

Statistical analysis showed differences between groups related to the testing periods with a statistically significant interaction effect ($F_{2,\ 144} = 6.82$, $p<.05$). Post-Tukey test comparisons indicated a significant reduction in both POST and POST8W scores compared with PRE-exercise measurements only for the PNF group while the General Exercise group showed a reduction only in POST measurement (p<.05) (Table 1).

Table 1: Rolland Morris Questionnaire (LBP-related functional disability) scores after different exercise programs. Data presented as mean ± standard deviation. (In parentheses are normalized changes from the pre-exercise level).

	Pre	**Post**	**Post8W**
Group	M±SD	M±SD	M±SD
PNF	13.63 ± 2.75 (100)	9.71* ± 3.11 (71.2)	10.39* ± 4.18 (76.2)
General exercise	14.03 ± 2.88 (100)	11.68* ± 3.61 (83.2)	13.42 ± 2.33 (95.6)

* Statistically significant difference with PRE test.

3.2 Pain assessment

Statistical analysis showed changes on McGill test pain score for both groups ($F_{2,\ 144} = 11.30$, $p<.05$) (Table 2). Post-Tukey test comparisons indicated a significant reduction in POST and POST8W scores compared with PRE-exercise measurements (p<.05).

Table 2. McGill total pain scores after different exercise programs. Data presented as mean ± standard deviation. (In parentheses are normalized changes from the pre-exercise level)

	Pre	**Post**	**Post8W**
Group	M±SD	M±SD	M±SD
PNF	31.59 ± 11.41 (100)	17.76* ± 10.84 (56.2)	19.31* ±11.43 (61.1)
General exercise	30.26 ± 14.24 (100)	22.85* ± 12.24 (75.5)	26.11* ± 11.86 (86.2)

* Statistically significant difference with PRE test.

Concerning the Emotions Scale assessment, ANOVA showed significant difference between groups in positive and negative emotions related to the different testing periods (significant interaction effect on positive, $F_{2,\ 144} = 33.52$, $p<.05$ and negative $F_{2,\ 144} = 29.97$, $p<.05$ emotions scores) (Table 3). Post-Tukey tests showed a significant increase in positive scores from PRE to POST and POST8W scores for the PNF group (p< .05) while no changes were observed for the general exercise group (p> .05).

Table 3: Positive emotions scores (Emotions Scale Questionnaire) after different exercise programs. Data presented as mean ± standard deviation. (In parentheses are normalized changes from the pre-exercise level).

	Pre	Post	Post8W
Group	M±SD	M±SD	M±SD
PNF	18.13 ± 5.20 (100)	26.39* ± 3.66 (145.5)	26.05* ± 4.80 (143.6)
General exercise	22.13 ± 4.41 (100)	23.08 ± 5.20 (104.2)	22.37 ± 4.77 (101.1)

* Statistically significant difference with PRE test.

In addition as concerned to the negative emotions scores, the Tukey test showed a significant reduction from PRE to POST and POST8W for the PNF group (p<.05), and only from PRE to POST for the General Exercise group with just a small decline in POST8W testing period (p>.05) (Table 4).

Table 4: Negative emotions scores (Emotions Scale Questionnaire) after different exercise programs. Data presented as mean ± standard deviation. (In parentheses are normalized changes from the pre-exercise level).

	Pre	Post	Post8W
Group	M±SD	M±SD	M±SD
PNF	24.92 ± 7.10 (100)	14.05* ± 3.95 (56.38)	13.61* ±4.42 (54.61)
General exercise	18.95 ± 5.21 (100)	16.32 ± 3.61 (86.1)	16.55 ± 5.07 (87.3)

* Statistically significant difference with PRE test.

4 Discussion

The main goal of our study was to compare the effects of two different exercise programs, a PNF intervention and a General Exercise program on pain components and LBP-related functional disability in patients with non-specific chronic low back pain. The results of the present study suggest that an exercise intervention induces changes in functional ability and pain in CLBP patients depended on the nature of the exercise protocol and the testing procedures.

Regarding the LBP-related functional disability assessed with the Rolland Morris Questionnaire, the results of the present study showed a marked improvement for both exercise groups (Table 1). This result is in line with previous findings on PNF (Kofotolis, Vlachopoulos, & Kellis, 2008; Kofotolis & Kellis, 2006) or general trunk exercises (Koumantakis, Watson & Oldham, 2005; Koumantakis et al, 2005; O'Sullivan, Twomey, & Allison, 1997). However comparing the efficiency of both intervention techniques by calculating the normalized changes from the pre-exercise level, the PNF group showed higher responses (Table 1) indicating that the PNF therapeutic intervention resulted in higher and long- lasting improvements in functional performance in individuals with CLBP than General Exercise treatment.

Observing the tables of McGill total pain scores we can notice similar pain reductions between the experimental groups (Table 2). Since changes greater than 20% may represent a minimal clinically meaningful change in pain (Childs, Piva, & Fritz, 2005) it appears that both therapy interventions applied in the present study had clinically significant results. To our knowledge, only two studies reported a decline in pain intensity after 4-weeks of PNF exercises in CLBP (Kofotolis et al., 2008; Kofotolis et al., 2006). Our results, however, extend these findings, as we have measured not only pain intensity but also frequency, type and social aspects of pain. In contrast, research findings on the effects of General Exercise are conflicting (May et al., 2008; Ferreira et al., 2006) as some studies reported non-significant alterations in pain (Koumantakis et al., 2005; Koumantakis et al., 2005) whilst others reported the opposite (O'Sullivan, Twomey, & Allison, 1997). For example, Koumantakis et al. (2005), who proposed the General Exercise intervention applied in the present study, reported a minimal decline of pain 0.3% after 8 weeks of training.

When comparing the two exercise programs in terms of reduction in total pain score it was obvious that pain reduction in the PNF group was almost double compared to that of the General Exercise group (Table 2). In addition, pain reduction 8 weeks after training was 61.1% for the PNF group but returned to 86.2% for the General Exercise group (Table 2). This indicates that PNF training was superior in reducing pain compared with General Exercise program. Extensive reviews comparing different methods indicated that no single method is superior to others in treating CLBP (May et al., 2008; Ferreira et al., 2006). However, in these reviews, no studies were identified that compared PNF and General Exercise for CLBP treatment. Kofotolis et al. (2006) reported similar improvements of pain intensity after a 4-weeks PNF treatment compared with combined PNF and transcutaneous electrical nerve stimulation and a placebo group. Differences in type of program applied, pain assessment methodology and the absence of a General Exercise group by Kofotolis et al. (2006) make comparisons with our findings difficult. Consequently, it is evident that more research is necessary to confirm the present findings.

There are various factors that might have contributed to the superiority of PNF over General Exercise protocols. First, a prerequisite of performing functional exercises was that patients in the PNF group learn to assume a pain free position of the body from three common positions. This differs from the General Exercise program which includes a stage-by-stage exercise progression assuming patient learning through repetitive performance of exercises. Nijs et al. (2015) also stated that exercise therapy can address movement-related pain memories by applying the “exposure without danger” principle. By addressing patients' perceptions about exercises, therapists should try to decrease the anticipated danger (threat level) of the exercises by challenging the nature of, and reasoning behind their fears, assuring the safety of the exercises, and increasing confidence in a successful accomplishment of the exercise. Second, PNF exercises involved diagonal segmental movements in various directions, aiming to enhance not only trunk stability but also mobility of the rest of the body. In contrast, General Exercise program involved mainly strengthening of the trunk muscles combined with coordination exercises in a single plane. Giannakopoulos, Beneka, Malliou, and Godolias (2004) also suggested that after having enhanced the muscular performance of weak muscles, isolated movements must be replaced with more complex-closed kinetic exercises in order to obtain better improvement in strength of the rotator cuff muscles.

Third, PNF exercises are performed against various stimuli such as resistance, pressure, audio or haptic stimuli provided by the therapist whilst such stimuli were absent in the General Exercise group. Forth, some PNF exercises aimed to improve range of motion through a better coordination and by utilizing muscle relaxation techniques. Finally, the PNF group trained to perform pain free movements that are more functional than general strength and coordination exercises performed by the General Exercise programs. This might explain the higher improvements in pain and functional performance displayed by the PNF group as assessed by the McGill pain questionnaire and the Rolland Morris test. These questionnaires are based on pain and performance experienced by the patients every day, which does not require muscle strength as high as that involved during General Exercise programs.

CLBP may also lead to psychological problems and a deterioration of the quality of life. Psychological-social factors may also have an effect on pain symptoms in CLBP patients (Biering-Sorensen & Bendix, 2000). One may, therefore, suggest that the increase of positive emotions scores and the simultaneous decrease of negative emotions scores after the PNF intervention (Tables 3 and 4) may partly explain the improvements in McGill pain scores (Table 2). In addition, a more positive attitude for life in combination with improvements in physical performance might indicate an improvement in health-related quality of life of these individuals. Such an improvement was not seen after the General Exercise intervention (Table 3), indicating that General Exercise programs do not have positive implications for psychological and social dimensions of quality of life. Evidence on the effects of exercise on health-related quality of life is generally missing with recent reviews indicated a marginal improvement in health-related quality of life after various treatments for CLBP (Ferreira, Smeets, Kamper, Ferreira, & Machado, 2010; Ferreira et al., 2006). Nevertheless, our results indicate that PNF exercises led to increased levels of feeling energetic rather than feeling tired and worn out, hence, contributing to more positive feelings during everyday life. It has been shown that there is a positive relationship between self-rated health and happiness among community dwelling older adults (Angner, Ray, Saag, & Allison, 2009).

Finally, the more functional characteristic of the PNF exercise may also explain why positive emotions were significantly improved in the PNF group. It seems that when a chronic low back pain patient performs effectively pain free movements is more likely to feel confident, satisfied and capable in accomplishing more complex motor patterns.

This study employed a short-term follow-up period (8-weeks post-training) in relation to the maintenance of the effects of each intervention. An important limitation of such programs is that any improvements may not be permanent. Improvements in muscular strength and mobility may be reduced in the longer term and require further treatment (Kuukkanen & Malkia, 1996). Despite this, the improvements in functional performance, pain and psychological emotions scores provide a basis for application of PNF exercises for CLBP treatment.

5 Conclusions

The content and the duration of the therapeutic exercise is an important issue in CLBP treatment. Physical therapists and other specialists in chronic low back pain treatment should always keep in mind that effective functional recovery with long lasting results requires more functional methods of intervention. The findings of the present study conclude that the improvements in terms of pain reduction and functional ability are more impressive for the PNF program compared to that with a General Exercise program demonstrating that the functional recovery is better enhanced through trunk stability and mobility of the rest of the body. Moreover, functional motor patterns provided with PNF techniques when applied to CLBP patients induce positive emotions and deteriorate negative ones, making the therapy treatment even more effective. It could be suggested that programs employing all PNF schemes are particularly more effective in reducing back pain and improving mobility in patients with CLBP.

6 Perspectives

The present study adds important information regarding effects of different exercise regimens to functional ability, pain components, and emotions related to pain in CLBP patients, suggesting that PNF exercise is superior to General Exercise programs in improving functional ability, deteriorating pain and enhancing positive emotions. According to our results, specialists in LBP treatment methods should consider that patients need to have permanent results in a shorter period of time in functional ability. Emotions to pain are also an important factor influencing patients' behavior and their adherence to the treatment provided. As long as the therapist succeeds to moderate the negative emotions and enhance the positive emotions, the patient will be more committed to the therapy. On the basis of the above, it is suggested that PNF exercise should be preferred for CLBP treatment compared to general exercise programs.

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