

The Effects of Combination Patterns of Proprioceptive Neuromuscular Facilitation and Ball Exercise on Pain and Muscle Activity of Chronic Low Back Pain Patients

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Abstract. [Purpose] The purpose of this study was to compare two methods for the muscle stabilization of the trunk of patients with chronic low back pain. The methods comprised combination patterns of proprioceptive neuromuscular facilitation (PNF) and ball exercise. [Subjects and Methods] The subjects were 40 volunteers who had low back pain. All subjects were randomly assigned to either a group which received proprioceptive neuromuscular facilitation or a group which performed ball exercise. Measurements were taken four times in total, at pre-intervention, two weeks later, four weeks later, and six weeks later. The main measurement methods used were the visual analogue scale (VAS) for pain and electromyography (EMG) for muscle activity. [Results] VAS and EMG activity were significantly reduced in the PNF combination pattern group and the ball exercise group. A comparison of the groups showed significant differences. In VAS and EMG activity; in particular, the combination pattern group using PNF increased EMG activity more than the ball exercise group did after six weeks of intervention. [Conclusion] This study showed that PNF combination pattern training for six weeks was more effective for patients with low back pain than performing ball exercise.

Key words: PNF, Ball exercise, Chronic low back pain

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INTRODUCTION

Low back pain is classified as acute, sub-acute, or chronic according to the duration of symptoms¹⁾. Chronic low back pain is normally consistent back pain experienced for more than 12 weeks²⁾. More than 80% of the world population experiences low back pain at least once, and 15% of that 80% suffer from chronic low back pain due to unrecovered symptoms³⁾.

The biggest problem of low back pain is lumbar instability⁴⁾. Unbalanced mobilization order among stability muscles and mobility muscles, as well as muscle length, causes low back pain⁵⁾.

For patients with low back pain, deep muscle exercise is required to counteract muscle atrophy and damage to the deep muscles²⁾. It was found that patients with low back pain experienced a mobilization delay in their deep muscles, which generates activation and contraction before the

movement of the limbs⁶⁾.

For lumbar region stability, strengthening and co-contraction of the multifidus and transversus abdominis (TA), which are deep stability muscles, and the erector spinae (ES) and abdominal muscles, which are superficial stabilizer muscles, is required⁷⁾.

In recent years, the trunk stability approach has been widely used as a method of spine treatment, and many efforts have been made to objectively prove the effect. Among the exercises for trunk muscle activity of patients with low back pain, the effect of ball exercise has been reported to comprehensively improve muscle strength, endurance, and flexibility, as well as strengthen body reflexes, sense of balance and proprioception⁸⁾. In addition, Stanton et al.⁹⁾ reported that the Swiss ball exercise is an effective stability exercise for trunk core muscles.

PNF has been recommended for sensory-motor control training, as well as for stimulating lumbar muscle proprioception¹⁰⁾. Among the PNF patterns, the motions of the sprinter (SP) and skater (SK) patterns were reported to have the advantages of not only strengthening the muscle due to large-scale movement, but also functional training due to active motor control, the strengthening of coordination, increases in the active range of motion, and the efficient control of movement¹¹⁾.

This study aimed to determine effective methods for

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Table 1. Variation of VAS score during the intervention period (unit: score)

	Pre	2 weeks	4 weeks	6 weeks
PNF pattern group (n=20)	7.95±1.00	4.95±1.00	2.85±0.81	1.50±0.69 ^a
Ball exercise group (n=20)	7.85±1.00	5.20±0.83	3.25±1.12	2.10±0.85 ^{ab}

^a, significant difference between pre and 6 weeks, ^b, significant difference between PNF pattern group and Ball exercise group at 6 weeks.

pain reduction through the activation of the TA and the ES by comparing lumbar strengthening training using a ball, which is generally carried out along with traditional physiotherapy treatment for lumbar stabilization, and PNF combination patterns¹²⁾. The goal was to increase patients' muscle strength, stability, and coordination control ability by inducing isometric contractions in manufacturing workers who had chronic low back pain.

SUBJECTS AND METHODS

The subjects of this study were 40 adult manufacturing workers from D Industrial, located in Daegu Metropolitan City, who had previously experienced cardiovascular system but not orthopedic illnesses, who currently had no specific exercise plan, and carried out daily living activities experiencing had chronic low back pain. The participants in this study were told prior to the start of the experiment about the purpose and procedure of the experiment, as well as potential effects of the experiment. All the participants understood the purpose of this study and provided their written informed consent prior to their participation in the study in accordance with the ethical standards of the Declaration of Helsinki. Only subjects who participated voluntarily were admitted to the experiment. The participants were randomly and equally assigned to a PNF combination pattern group (experimental group) and a ball exercise group (control group). The average age, height, and weight of the experimental group were 34.75±0.85 years, 174.07±1.05 cm, and 71.25±4.59 kg, respectively. The average age, height, and weight of the control group were 34.20±0.69 years, 172.85±1.24 cm, and 70.75±3.81 kg, respectively. The experimental group performed a combination of sprinter/skater posture in a bridge position, sprinter/skater posture in a side-lying position, sprinter/skater posture in a sitting position, and sprinter/skater posture in a standing position for 15 minutes in parallel with PNF. The exercise schedule was four times a week for six weeks. The ball exercise group in the control group was told that the femoral region must be parallel to the floor while sitting on the ball, and that their knees should maintain a 90-degree angle, using Janda's¹³⁾ basic principle program. Motion speed was constant during the ball exercise. Fifteen seconds of rest were taken between sets. The ball exercise was done with two 20-repetition sets of pelvic tilts (anterior/posterior, right/left, circle) while sitting on the ball. Then, two sets of hip lifts while lying back on the ball were performed, lifting one leg while lifting the hip, lifting the hip while bending the knees, and lifting the hip while bending the knee and lifting one leg for 10 seconds. Following this, one set of marching was performed while lying with the chest on the ball and crunch-

ing, followed by arching while holding the ball between the calves, moving the body right and left while lifting the legs on the ball, bridging, and right and left stretches while leaning on the ball, for 10 seconds each. These exercises were performed four times a week for six weeks.

The VAS was used to examine pain intensity. The participants subjectively recorded their pain on a sheet of 10-cm-long paper divided by 10 lines. Pain was rated on a scale of 0 to 10, in which 0 indicated that the participant could not feel the symptom of low back pain and could carry out daily life without any problems, while 10 indicated that the participant could not stand the pain and could not conduct daily living activities at all due to continuous severe pain. Pain measurement was performed prior to the exercises, and again at two weeks, four weeks, and six weeks after the start of the intervention.

In order to measure muscle activity, the maximal voluntary isometric contraction (MVIC) of each muscle was obtained by manual muscle testing, and root mean square (RMS) values of the MVIC of each muscle were calculated. The FlexComp Infiniti EMG (Thought Technology Ltd. Canada), a surface electromyogram (EMG), was used for muscle activity measurement. Muscle activity was measured by attaching surface electrodes 3 cm away from the spinous process at the lateral side for ES, and 2 cm from the inferior medial area of the anterior superior iliac spine (ASIS) for TA¹⁴⁾. The recorded surface EMG analog signal was converted to a digital signal, and then filtered and processed using Infiniti software (v. 3.0) on a personal computer.

For statistical processing of data in this study, SPSS v. 18.0 was used to analyze the data with its significance level of $\alpha=0.05$. In order to determine the changes in pain and muscle activity of the PNF and ball exercise groups, repeated ANOVA measurements were performed and the Bonferroni correction was used to compare data between measurement times. In order to find the significance of differences between the groups with regard to muscle activity and pain, the independent t-test was performed.

RESULTS

The PNF combination pattern group and the ball exercise group showed significant reductions of VAS over time ($p<0.05$) (Table 1). After 6 weeks of the intervention, the PNF combination pattern group showed a more significant reduction of VAS than the ball exercise group ($p<0.05$).

In the ball exercise and PNF combination pattern groups, each group showed muscle activity increases in TA and ES over time (Table 2). While TA showed no statistically significant difference between the two groups over time

Table 2. Variation of transverse abdominal and erector spinae muscles during the intervention period (unit: %MVIC)

Muscle	Group	Pre	2 weeks	4 weeks	6 weeks
TA	PNF pattern (n=20)	33.86±7.45	38.06±6.22	39.91±6.92	42.06±6.70 ^a
	Ball exercise (n=20)	34.50±7.31	40.26±7.11	40.07±7.43	40.72±7.27 ^a
ES	PNF pattern (n=20)	50.06±15.89 ^b	51.69±13.70 ^b	53.46±15.31 ^b	56.10±15.96 ^a
	Ball exercise (n=20)	49.87±10.26 ^b	53.58±9.03 ^b	53.92±9.41 ^b	55.35±8.42 ^a

^a, significant difference between pre and 6 weeks, ^b, significant difference between PNF pattern group and Ball exercise group at 6 weeks.

($p > 0.05$), ES showed a statistically significant difference between the two groups over time ($p < 0.05$).

DISCUSSION

Patients with chronic low back pain frequently experience a decrease in lumbar flexibility and a weakening of muscle strength and endurance due to decreased motility. As a result, low back movement depression can lead to increased pain in patients with chronic low back pain and muscle fatigue. Strengthening low back muscles is essential for the reduction of low back pain¹⁵. Therefore, this study aimed to determine whether conduct of the PNF combination pattern and ball exercise were effective at increasing trunk muscle activity in patients with chronic low back pain, in order to find an effective method of exercise for chronic low back pain.

In this study, low back pain was assessed using the VAS in order to determine the effect of the exercise treatment on the subjective pain intensity of patients with low back pain. Pain intensity significantly decreased in both groups following treatment. The reason for the reduction in pain in both groups was the training of unbalanced trunk muscles, which induced an interaction between the trunk muscles which reduced pain. In a related study, Lee et al.¹⁶ reported a significant reduction in pain of patients with chronic low back pain after training the patients with a ball, a result consistent with our study result. Kofotolis and Kellis¹⁷ also reported the reduction of pain in the lumbar muscle of patients with chronic low back pain after a PNF program consisting of static and dynamic PNF programs, a result which was also consistent with our study result. Furthermore, our present study also showed that pain reduction was greater in the PNF combination pattern group than in the ball exercise group after six weeks of training. The reasons for this are that the PNF combination patterns used a technique that used the limbs to indirectly affect the pain area in a posture which did not cause pain to the patients with low back pain, in order to avoid direct stimulation of the pain area. In particular, the PNF technique is one that controls the proprioception and sensory-motor functions to reduce pain further. Nachemson et al.¹⁸ reported that extensor muscles are more closely related to low back pain than flexor muscles. In this study, the PNF combination patterns technique started in a side-lying position, which was followed by a standing position, so the extensors acted as an anti-gravity muscle, thereby strengthening extensor muscle strength to effectively reduce pain.

Hodges and Richardson¹⁹ reported that unbalanced trunk muscles in patients with chronic low back pain should be trained to balance the trunk muscles interactively, and that trunk muscle strength was an essential element for maintaining spinal stability, so that muscle strength becomes a foundational support for maintaining balance. In that sense, the PNF combination pattern and ball exercise groups in our study significantly reduced low back pain through the balanced training of trunk muscles and training induced increase in muscle strength. In a similar study, Kofotolis and Kellis¹⁷ directly applied the PNF technique to the shoulder area of the trunk for four weeks. They reported that trunk endurance increased significantly by indirectly inducing the motion of the trunk, giving resistance to the limbs.

In this study, while muscle activity increased in both the PNF combination pattern ball exercise groups, the PNF combination pattern group showed a more significant increase than the ball exercise group. This can be explained by the fact that the PNF combination patterns technique concentrated on sprinter and skater patterns, and that trunk muscle activity increased more than in the lumbar stabilization group using ball exercise, which used a combination of isotonic techniques. Accordingly, we anticipate that low back pain would be reduced if the sprinter and skater PNF combination patterns used in this study are applied to patients with chronic low back pain, in order to improve trunk stability. Therefore, our study results can be a clinical foundation for the effectiveness of exercise treatment for trunk muscle stabilization of patients with chronic low back pain.

Our study had several limitations. First, the intensity of the application of the isotonic combination was not uniform when the PNF combination patterns were applied. Also, we did not measure the subjects' balance abilities, so the quantitative improvement of balance ability due to improvement of stabilizing muscles could not be presented. In the future, the limitations of this study can be overcome by demonstrating the appropriate application intensity and proper way of measuring balance ability in order to verify the effectiveness of the PNF combination patterns.

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