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Changes in Gait Patterns after Physical Therapy in Patients with Non-specific Chronic Low Back Pain: a Pilot Study

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Objective: Nonspecific low back pain (NS-LBP) causes pain and disability, affecting the neuromuscular system and altering gait patterns. The purpose of this study is to investigate the effect of improvement of low back pain symptoms through physical therapy on foot pressure and spatiotemporal gait parameters.

Design: A pilot study.

Methods: Participants received manual therapy and supervised therapeutic exercise, which consisted of 12 sessions for 6 weeks. Participants were assessed for pain intensity (a numeric pain rating scale), disability index (oswestry disability index), and spatiotemporal gait parameters before and after intervention. Wilcoxon signed rank test was used to analyze the before-and-after differences in a single group.

Results: All seven NS-LBP patients completed the study without dropout. After six weeks of physical therapy, the numeric pain rating scale and oswestry disability index showed significant improvement ($Z = -2.388$, $P = 0.017$). There was no significant improvement in both static and dynamic conditions in foot pressure ($P > 0.05$). However, in the spatiotemporal gait parameters, there were significant differences in all variables except the right stance phase and left mid stance ($P < 0.05$).

Conclusions: In our pilot study, 12 sessions of physical therapy in NS-LBP patients improved gait quilty in spatiotemporal gait parameters. Similarly, it has resulted in clinically positive improvements in pain and disability.

Key Words: Low back pain, Physical therapy, Manual therapy, Therapeutic exercise, Spatio-temporal analysis, Gait

Introduction

85% of low back pain(LBP) is non-specific low back pain (NS-LBP) without structural changes or inflammatory response in a specific region[1]. It is called non-specific because the cause of pain is not precisely identified despite the high prevalence[2], and most of the LBP treated by physical therapists in the clinic is NS-LBP[3].

Although there is no clear mechanism, various mechanisms are suggested in the pathogenesis for treatment[4, 5]. Changes in the neuromuscular system are linked to biomechanical variables (kinetics and kinematics)[6] and affect changes in movement. For example, abnormal excessive muscle activity, such as compensatory motion, results in slower motion and reduced range of motion[7]. The most common motion that can detect impaired motor control is walking[8]. Although there are not many studies on gait in patients with LBP, it has been shown that the step length is shortened and the ground reaction force (GRF) is decreased[9-12]. This means a decrease in the displacement of the center of gravity, as reported in LBP patients that walking is uncomfortable and

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walking speed is slow[13, 14].

Maher et al. [15] emphasized non-pharmacological treatment rather than pharmacological treatment in the continuous management of NS-LBP, and recommended that non-pharmacological treatment should be managed in systematic review with network meta-analysis[16]. Among non-pharmacological treatments, according to the results of network meta-analysis by Gianola et al. [16], manual therapy and therapeutic exercise were effective in pain and disability in immediate and short-term follow-up results.

The purpose of this study is to investigate the effect of manual therapy and therapeutic exercise on the pain, disability and spatiotemporal gait parameters of individuals with low back pain, and the hypothesis is that there will be differences before and after treatment with manual therapy and therapeutic exercise for 6 weeks.

Methods

Study design

This study is a pilot study to analyze the gait patterns of NS-LBP patients. As an open-label, single arm intervention trial, pain, disability and spatiotemporal gait parameters were evaluated before and after physical therapy.

Participants

Seven patients diagnosed with NS-LBP and admitted to a hospital located in Paju were enrolled in a pilot study. Participants were patients who wished to participate in the study and met the eligibility criteria.

The inclusion criteria were 18 to 65 years of age, recurrent LBP for 3 months or longer, and pain score of 3 or higher NPRS[17]. Exclusion criteria were moderately obese persons with a BMI of 30 or higher according to the criteria of the Korean Society for the Study of Obesity, idiopathic scoliosis, spondylolisthesis, ankylosing spondylosis, spine fusion surgery, or a history of potential lower extremity orthopedic surgery[18].

Before the study, participants were explained about the purpose and procedure according to the ethical standards of the Declaration of Helsinki.

Intervention

Physical therapy was performed twice a week for a total of 6 weeks by a physical therapist with 7 years of experience, 30 minutes of manual therapy and 20 minutes of supervised therapeutic exercise per session.

Manual therapy was performed by combining mobilization and soft tissue techniques, which were suggested to be effective in improving pain and quality of life[19]. For joint mobilization, Grade III mobilization by Maitland technique was performed for the cervical and lumbar spine[20]. Cervical spine mobilization was added to influence pain control and functional restructuring by altering somatosensory processing and sensorimotor integration through changes in cortical plasticity[21]. The soft tissue technique was performed for the purpose of relaxation of muscles (suboccipital muscles, levator scapulae, rhomboid minor, erector spinae, latissimus dorsi, quadratus lumborum, piriformis, and hamstring muscles) that were mainly tightened according to each muscle imbalance state[22, 23].

Supervised therapeutic exercise was performed with a focus on core training. It consists of a 5-minute aerobic warm-up on a stationary bicycle or treadmill, and a dynamic trunk strengthening exercise and abdominal exercise. Six static stretches of the lumbar, gluteal, and hamstring muscles were performed once before and after exercise[24, 25].

Outcomes

Pain and disability

An 11-point numeric pain rating scale (NPRS) was used for pain intensity. A score of 0 is no pain and a score of 10 is the worst pain imaginable[26]. The reported minimal clinically important difference (MCID) was 2 points[27].

LBP-related disability was assessed using the Oswestry disability index (ODI). Each question is scored on a six-point scale into ten sections to assess the severity of pain and interference with several physical activities, including sleep, self-care, sex, social life, and travel. Scores are summed to calculate a score from 0 to 50. The higher the score, the greater the degree of pain-related disability[28, 29]. The

MCID value for ODI was 12.88 points (sensitivity 88%, specificity 85%)[30].

Spatiotemporal gait parameters

The zebris FDM-T system (zebris Medical GmbH, Isny im Allgä, Germany) is integrated with existing treadmill machines to capture and analyze natural gait motions under various conditions to evaluate static and dynamic gait patterns[31]. Evaluated variables were static and dynamic pressures of forefoot and backfoot (Figure 1), and spatiotemporal variables (step width, step length, stride length, phase time, cadence, and velocity). The reported repeatability and sensitivity have intraclass correlation coefficients greater than 0.86[32, 33].

Statistical analysis

We used SPSS (SPSS 25.0, IBM Corp., USA) for all statistical analyzes. The general characteristics of all 7 participants were indicated and also descriptive statistics. All variables evaluated were compared between time points to find out changes before and after 6 weeks of intervention, so Wilcoxon signed-rank test was used. The statistical significance level (α) was set to 0.05.

Results

This study was conducted from April to September 2021. A total of 7 NS-LBP patients were recruited and there was no dropout. Table 1 shows the general characteristics of the participants.

Pain and disability

Table 2 shows the results of NPRS, indicating pain intensity, and ODI, indicating disability due to LBP. There was a significant decrease in NPRS after intervention ($Z=-2.388$, $P=0.017$). ODI was significantly decreased after intervention ($Z=-2.388$, $P=0.017$).

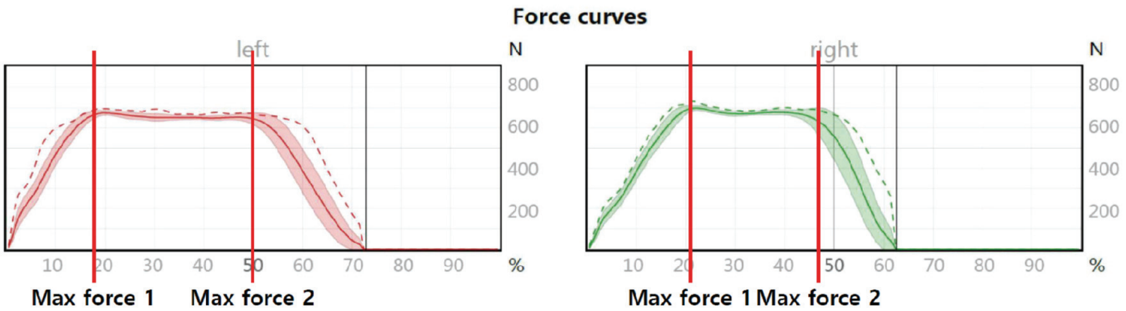

Figure 1. Force curves plot meaning max force at dynamic foot pressure.

Table 1. General Characteristics of Participants (n=7)

Cases	Age (years)	Sex	Weight (kg)	Height (m)	BMI (kg/m^2)	Gait speed (km/h)
Case 01	64	Male	72	1.65	26.45	0.8
Case 02	24	Female	85	1.72	28.73	2.3
Case 03	20	Male	68	1.69	23.81	3
Case 04	18	Male	56	1.59	22.15	1.7
Case 05	64	Female	62	1.58	24.84	1
Case 06	47	Female	70	1.67	25.10	1.4
Case 07	32	Female	52	1.57	21.10	2.5
Mean (SD)	38.43 (19.95)		66.43 (11.01)	1.64 (0.06)	24.60 (2.57)	1.81 (0.82)

BMI: body mass index, SD: standard deviation.

Table 2. Post-intervention changes in pain and disability (n=7)

	Pre-test	Post-test	Z (P)
NPRS	4.86 (1.35)	2.29 (0.95)	-2.388 (0.017)
ODI	43.00 (2.71)	23.57 (1.99)	-2.388 (0.017)

Values are presented as mean (standard deviation).
NPRS: numeric pain rating scale, ODI: oswestry disability index.

Spatiotemporal gait parameters

There was no significant improvement in all variables of foot pressure (P < 0.05) (Table 3). However, it was confirmed that the forefoot pressure was increased in both feet as the changing pattern in the static condition (Figure 2). Although it was asymmetric in the changing pattern in the dynamic condition, it was confirmed that max force 1 was increased in the right foot (Figure 3).

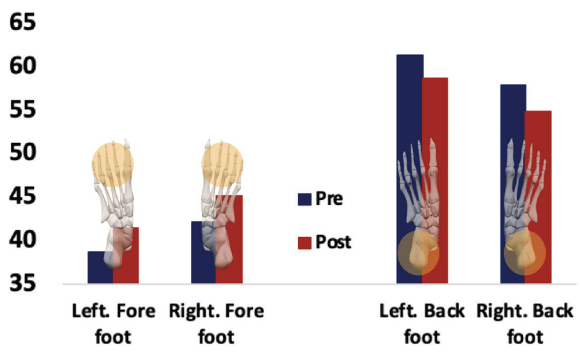

Figure 2. Changes in foot pressure in a static condition.

Table 3. Post-intervention changes in spatiotemporal parameters (n = 7)

Types	Parameters	Pre-test	Post-test	Z (P)
Foot pressure				
Static (N)	Lt. Forefoot	38.71 (7.09)	41.43 (12.14)	−0.169 (0.866)
	Lt. Backfoot	61.29 (7.09)	58.57 (12.14)	−0.169 (0.866)
	Rt. Forefoot	42.14 (11.31)	45.14 (10.09)	−0.593 (0.553)
	Rt. Backfoot	57.86 (11.31)	54.86 (10.09)	−0.593 (0.553)
Dynamic (N)	Lt. Max force 1	593.80 (120.76)	603.50 (127.00)	−0.338 (0.735)
	Lt. Max force 2	560.61 (110.46)	566.49 (126.35)	0.000 (1.000)
	Rt. Max force 1	514.50 (226.25)	567.56 (117.64)	−1.183 (0.237)
	Rt. Max force 2	604.86 (120.77)	575.76 (124.03)	−0.338 (0.735)
Spatiotemporal gait parameters				
Stride length (cm)		73.86 (31.33)	99.29 (24.29)	−2.366 (0.018)
Lt. Stance phase (%)		68.40 (3.72)	65.83 (2.53)	−2.366 (0.018)
Rt. Stance phase (%)		67.57 (3.79)	66.01 (2.62)	−1.524 (0.128)
Lt. Mid stance (%)		32.37 (3.82)	34.23 (2.63)	−1.866 (0.062)
Rt. Mid stance (%)		31.49 (3.82)	34.44 (2.60)	−2.366 (0.018)
Double stance (%)		36.06 (7.49)	31.46 (5.15)	−2.366 (0.018)
Cadence (steps/min)		94.57 (9.81)	85.71 (10.37)	−2.366 (0.018)
Velocity (km/h)		2.06 (0.86)	2.54 (0.67)	−2.207 (0.027)

Values are presented as mean (standard deviation).
Lt: left, Rt: Right.

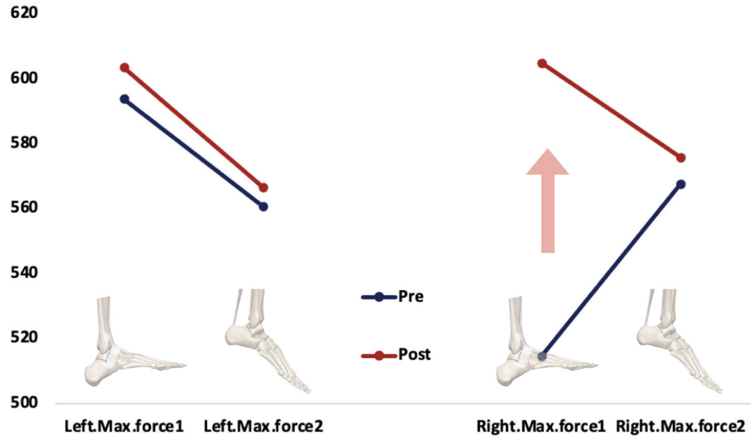

Figure 3. Changes in foot pressure in dynamic conditions.

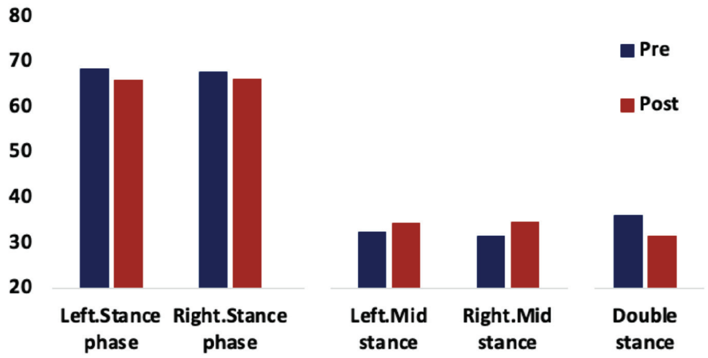

Figure 4. Post-intervention changes in the gait cycle.

In spatiotemporal gait parameters, significant differences were found in all variables except for Rt. stance phase and Lt. mid stance ($P < 0.05$). However, the changes were similar.

Discussion

The purpose of this study was to investigate the pain, disability, and spatiotemporal gait parameters improved through intervention in the changed gait patterns of NS-LBP patients. Therefore, we investigated changes in pain, disability, and spatiotemporal gait parameters in patients with NS-LBP over 6 weeks by performing physical therapy consisting of 12 sessions of manual therapy and therapeutic exercises.

Our results confirmed that the reduction in pain was reduced through a decrease of 2.57 points in NPRS. The reported MCID is 2 points [22], which can be considered a clinically significant improvement. In addition, it was confirmed that the disability index decreased through a decrease of 19.43 points in the ODI indicating disability, and a significant improvement in symptoms was observed considering the reported MCID was 12.88 points [25]. These results were similar to those of Bade et al. [34], which showed significant improvement in NPRS and modified ODI through two weeks of manual treatment in patients with mechanical LBP. Although it is not clearly explained as a physiological mechanism, it is judged that manual therapy had an effect on symptom improvement, as in the results of network meta-analysis by Gianola et al. [14].

In the results of spatiotemporal gait parameters, we found that the stride length was longer in LBP and it was not a significant change, but considering the change in GRF, it is consistent with the previous studies[9-12] that the stride length was shortened and the GRF was decreased in the gait change caused by

LBP. Also, in the gait cycle, a significant decrease in stance phase and double stance and a significant increase in mid stance, along with a significant increase in stride length, cadence, and velocity, mean an increase in quality as well as improvement in gait speed. Although there was no additional significant change, the symmetrical pattern of foot pressure in Figure 2 and the increase in foot pressure in the force curve of Figure 3 are results that complement the improvement of gait quality.

These results were similar to the gait characteristics of patients with LBP reported in other studies[9-14] on the inefficient forward movement of the center of gravity, decrease in GRF, shortening of stride length, and decrease in gait speed due to discomfort during walking. Therefore, positively improved results through physical therapy are considered to have contributed to gait quality change. Also, in a study on the relationship between pain intensity and gait characteristics in patients with low back pain, it was reported that 10% of the change in gait cycle duration and 74% of the change in speed were related to pain intensity[35]. In the results of this study, it is thought that a significant decrease in NPRS had an effect on the gait.

However, this study had some limitations. It is a single arm intervention study with no comparison group with a design close to a pragmatic clinical trial to identify improvement after physical therapy for hospitalized patients. In addition, it was difficult to enroll in a study that included gait analysis for LBP patients, and it was limited to presenting objective evidence in a pilot study with seven participants. Therefore, in further studies, randomized controlled trials with a larger number of participants and comparison group are needed.

Conclusion

We induced clinically significant improvement in pain and disability through 12 sessions of physical therapy for six weeks in NS-LBP patients, and there was no significant improvement in foot pressure, but partial improvement in gait quality.

Conflicts of interest

The authors declare no conflict of interest.

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