J Korean Soc Phys Med, 2024; 19(1): 11-22
https://doi.org/10.13066/kspm.2024.19.1.11

Online ISSN: 2287-7215
Print ISSN: 1975-311X

Research Article

Open Access

Effects of Lumbar Stabilization Exercises Using a Pilates Reformer on Pain, Function, and Quality of Life in Patients with Chronic Low Back Pain

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Received: October 17 2023 / Revised: October 26 2023 / Accepted: November 25 2023

| Abstract |

PURPOSE: This study examined the effects of lumbar stabilization exercise using a Pilates reformer on the visual analog scale (VAS), Oswestry disability index (ODI), and quality of life of patients with chronic low back pain.

METHODS: The study evaluated individuals aged 30 years and above who had been suffering from persistent back pain exceeding three months. The participants were allocated into two groups: an experimental cohort of 15 individuals utilizing a reformer and a control group of 15 individuals engaging in lumbar stabilization exercises on a mat without a reformer for eight weeks. Each exercise session encompassed a 10-minute warm-up, a 30-minute main exercise, and a 10-minute cool-down, totaling 50 minutes. The lumbar stabilization group using the reformer was also subjected to the same level of resistance provided by the springs. Assessments were conducted before and after the intervention using the VAS, ODI, and quality of life evaluations.

RESULTS: Significant disparity existed between the experimental group utilizing the reformer and the control group before and after the intervention in terms of the VAS, ODI change, and quality of life change ($p < .05$). Furthermore, a significant distinction was observed in the comparison between the experimental and control groups ($p < .05$).

CONCLUSION: Both cohorts showed a decrease in pain, a decrease in the ODI, and an improvement in the quality of life. Furthermore, the experimental group exhibited superior outcomes to the control group regarding pain reduction, reduction in the ODI, and improved quality of life.

Key Words: Chronic low back pain, Lumbar stabilization exercise, Pilates

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Ⅰ. Introduction

Low back pain (LBP) is a common and growing cause of disability worldwide, with high public health costs. For some people, due to multifactorial reasons [1], LBP persists

and becomes a chronic condition [2,3]. Constant pain can also diminish the quality of life [4].

The limitation of functional activity in patients with chronic LBP results from pain caused by mechanical changes in the tissues around the spine, which restrict the movement of the joints around the spine, leading to adverse changes in posture and movement patterns [5,6]. This results in a decrease in joint range of motion, flexibility, strength, and endurance of the body [7]. Chronic LBP can lead to a delayed contraction of the transversus abdominis, which does not provide the required stability for functional movement. As the body becomes less stable due to core muscle weakness, proper contraction timing of the transversus abdominis is not corrected, and the individual continues to experience LBP [8].

Lumbar stabilization exercise is a rehabilitation exercise method for low back pain. It refers to the movement of muscles to maintain functional stability around the lumbar spine. It is also called the normalization term of dynamic stabilization, movement adjustment training, spinal neutral adjustment, and interbody stability [9]. The lumbar stabilization exercise aims to strengthen the core muscles, including the transverse abdominal muscle and the multifidus muscle, which support the lumbar spine, by improving the adjustment ability of muscle movement to improve the effect of body imbalance [10].

On the other hand, the resistance of the springs helps increase balance and flexibility while controlling movement on uneven ground. The reformer allows the patient to perform various posture-specific exercises, such as standing, lying, side-lying, sitting, and prone, and helps improve the overall strength, including the abdomen, shoulders, legs, and trunk. It can also do open and closed kinetic chain exercises. Hence, performing Pilates on a reformer can facilitate proper breathing and alignment and improve balance, improving the quality of life [12]. In addition, eight weeks of consistent reformer exercise has been shown to enhance foot balance by reducing variations in the left, right, anterior, and posterior plantar pressure. The exercise also leads to significant positive changes in sagittal plane alignment by stabilizing the lower back and improving pelvic alignment by strengthening the abdominal and back muscles [13]. Pilates is an exercise that improves chronic lower back pain, which has recently been researched and proven effective [14-16].

Previously, a study showed that body stability and sensory-motor regulation ability could be improved using gym balls and tubing for eight weeks of small tool Pilates to stabilize the waist. In addition, studies have found that using Cadillac Pilates can reduce lower back pain in patients with spondylolisthesis and strengthen the central muscles of the trunk [17]. A substantial body of research exists on the beneficial impact of Pilates exercises on pain reduction and the enhancement of the functional quality of life of individuals with LBP [18]. On the other hand, there has been limited research on the potential of reformer Pilates to improve the quality of life, functionality, and pain in individuals with chronic low back pain.

This study examined whether there is a distinction in the effectiveness of lumbar stabilization exercises using the Pilates reformer compared to other lumbar stabilization exercises in addressing pain, low back pain disability index, and quality of life in patients with chronic low back pain. If so, this study evaluated which method is more effective. The aim was to provide basic data for developing exercise programs using Pilates reformers for rehabilitating, treating, and preventing chronic low back pain.

Ⅱ. Methods

1. Participants

The participants were divided into an experimental group (EG = 15, mean age: 35.92 ± 1.6 years, seven men and eight women) and a control group (CG = 15, mean age: 34.31 ± 1.55 years, seven men and eight women) to perform

back stabilization exercises. The study includes 30 outpatient young men and women diagnosed with chronic LBP at Daegu K Hospital from March to May 2023. The patients were informed about the purpose and agreed to participate (Table 1). After fully explaining all the processes of the experiment and the contents of this study, the research was conducted with the voluntary consent of the participants twice a week for eight weeks. The Institutional Review Board of Daegu University approved the study (IRB No. 1040621-202301-HR-008).

The eligibility criteria were as follows: 1) individuals experiencing chronic lower back pain for a duration exceeding three months and not currently undergoing any form of treatment; 2) individuals capable of engaging in rehabilitation exercises despite their lower back pain; 3) individuals who have not undergone surgical interventions, such as lumbar plastic surgery, neurosurgery, or other related procedures; 4) individuals without neurological abnormalities, sensory deficits, or muscle paralysis symptoms; 5) individuals whose lower back pain was not attributed to systemic conditions, such as pregnancy or cancer; 6) individuals without mental health issues or motor impairments.

The exclusion criteria were as follows: 1) individuals with prior experience in lumbar stabilization exercises and manual therapy; 2) individuals with persistent pain; 3) pregnant individuals; 4) individuals with a history of spinal surgery; 5) individuals experiencing severe neuromuscular compression caused by neurological impairment; 6) individuals diagnosed with inflammatory joint conditions; 7) individuals with severe osteoporosis.

Table 1. General characteristics of the subjects

Group	EG (n = 15)	CG (n = 15)	t	p
Sex (M/W)	7/8	8/7	-.532	.605
Age (year)	35.92 ± 1.6	34.31 ± 1.55	-.193	.854
Height (㎝)	172.93 ± 8.11	174.67 ± 9.20	-.572	.572
Weight (㎏)	66.47 ± 13.42	69.40 ± 14.11	-.535	.601
Date of onset (month)	31.93 ± 9.41	29.47 ± 8.29	.912	.377

EG: experimental group- lumbar stabilization exercise using a Pilates reformer
CG: control group- lumbar stabilization exercise

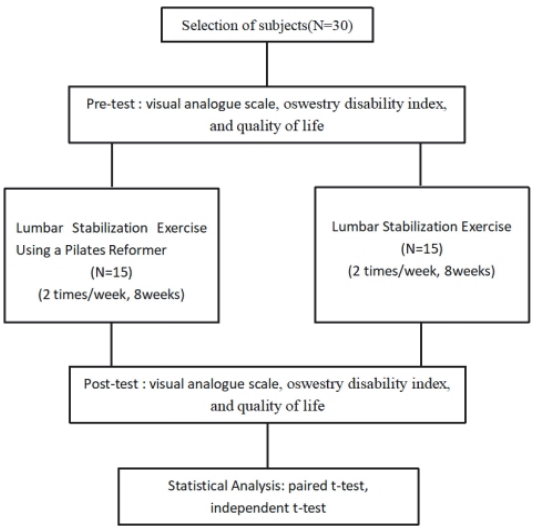


Fig. 1. Diagram of the experimental design.

2. Experimental Design

This study was a randomized, single-blind, pre-post experimental design to investigate the impact of a Pilates reformer on chronic low back pain.

3. Experimental Method

1) Experimental Time

In this study, an eight-week arbitration experiment was conducted after one test before arbitration, and another test was conducted after arbitration. The total test time was eight weeks.

2) Experimental Procedure

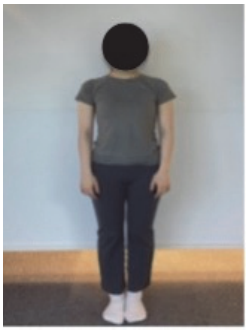
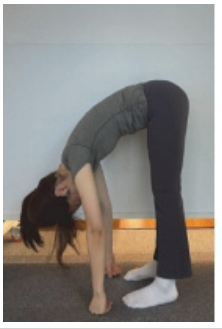
The participants were allocated randomly to the experimental or control group. The experimental group engaged in lumbar stabilization exercises using a reformer, while the control group performed similar exercises using

a mat. During the eight weeks, the participants were instructed to refrain from participating in any other rehabilitation or physical activities except Pilates and to maintain their regular diet and daily routines.

3) Pilates Program

Both groups underwent a 50-minute program twice a week for eight weeks, consisting of a 10-minute warm-up, 30 minutes of main exercise, and a 10-minute cool down. If personal movements were difficult to complete during exercise, the subjects could complete more than a few more movements to practice and become familiar with them. A physiotherapist and Pilates instructor supervised each workout.

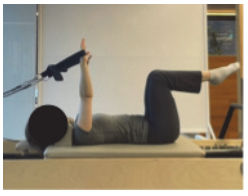
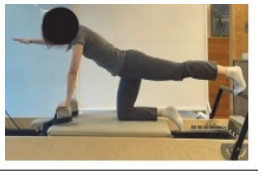
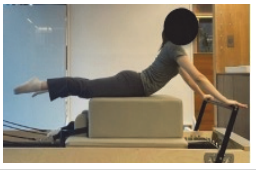
Table 2. Warm-up exercise and cool-down exercise

Warm-up exercise (10min) / cool-down exercise (10min)	
	Adjust breathing in the correct posture and check the body alignment correctly.
Breathing and alignment check	30sec × 3set
	Stretch the neck by placing the palms on the other ear. Put the palm on the back of the head and stretch the neck in the direction of looking at the big toe.
Neck stretching	Once on both sides, 30 seconds
	Bend the spine in an upright position and go down until the fingertips touch the floor. Breathe in and out, and come back up with the strength to stretch the spine.
Spinal flexion, extension movement	1 to 3 times

(1) Experimental Group (Lumbar stabilization exercise using a Pilates reformer)

In the Pilates reformer provided for the experimental group, the lumbar stabilization exercise program was modified and supplemented with reference to the exercise program of Bakhtiary et al. [19]. Abdominal drawing-in breathing, upper body raising, bridge exercise, quadruped and bird dog posture, and spinal extension exercises were carried out. Each action was performed 15 times in a group, and three groups were implemented. Each action was held for five seconds with a 10-second rest time between actions. The rest time between groups was two minutes. In this study, the spring strength of the reformer was applied uniformly to a yellow spring.

Table 3. Lumbar stabilization exercise using a Pilates reformer

lumbar stabilization exercise using a Pilates reformer (30min)	
	It starts with lying down right away. Hold the strap with the arms. Move forward side by side, and keep the lower body in a desk-leg position.
Abdominal drawing-in breathing	30sec × 3set
	Stretch the arms in an attention position and float the head and upper body from the reformer.
upper body raising	15times × 3set
	In an upright position, place both feet on the mat, support the ground with both arms and lift the pelvis.
bridge exercise	15times × 3set
	Put the legs on the foot bar, put the hands on the shoulder bar, and push the foot bar with the legs.
Quadruped and bird dog posture	Once on both sides, 15 times × 3 sets
	Lie on the stomach with the abdomen and pelvis on the box. Press the footbar down with the hands and lift the chest.
spinal extension exercise	15 times × 3 sets

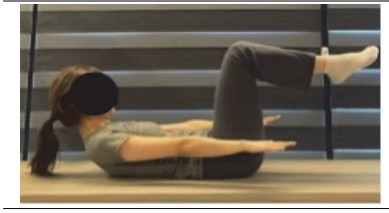
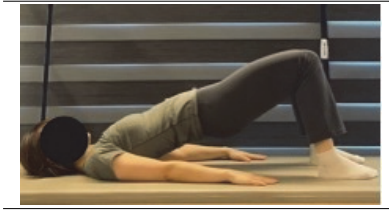
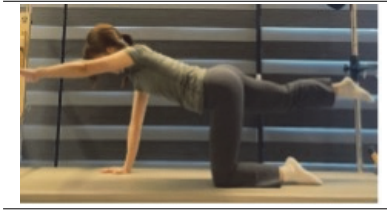
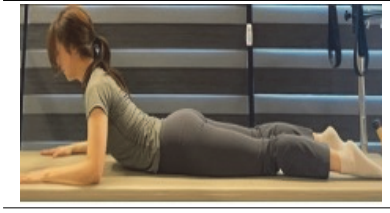
(2) Control Group (Lumbar stabilization exercise)

The Pilates exercise in the control group consisted of abdominal drawing-in breathing, upper body raising, bridge exercise, quadruped and bird dog posture, and spinal extension exercises performed on a mat.

4. Measurement Methods and Tools

Measurement tools, such as the VAS, ODI, SF-36 quality of life test, and mental health assessment, were used to evaluate the changes in pain in patients with chronic back pain and their impact on the LBP disorder index and overall quality of life.

Table 4. Lumbar stabilization exercise

Lumbar stabilization exercise (30min)	
	With the knees up and lying down, breathe, imagining air is filled from the bottom of the pelvis to the top of the upper body.
Abdominal drawing-in breathing	30 sec × 3 set
	Stretch the arms toward the knees and float the head and upper body off the mat.
upper body raising	15 times × 3 sets
	Bend the legs in an upright position, support the ground with both arms, and lift the pelvis.
bridge exercise	15 times × 3 sets
	In a quadruped position, lift the right hand and left leg 90°. At this time, to ensure that the body does not shake, it is carried out by crossing the opposite side.
quadruped and bird dog posture	Once on both sides, 15 times × 3 sets
	Lie face down with the head, abdomen, and ribs in contact with the mat, and slowly lift the chest as the palms and lower the arms to push the floor.
spinal extension exercise	15times × 3set

1) Visual Analogue Scale (VAS)

In this study, the pain was evaluated using the VAS. The VAS is represented by a digital straight line from 0 to 10 points, with 0 points indicating a painless state and 10 points representing an unbearable level of pain. This scale is used to display the average level of pain experienced by the patient within the past 24 hours. It is a simple way for the patient to indicate the level of pain. Using a highly reproducible expression method, ICC = .90 demonstrated high sensitivity and reliability [20].

2) Oswestry Disability Index (ODI)

The disability index was assessed using the Korean version of the ODI. The ODI is a self-administered assessment tool that can evaluate the extent of dysfunction caused by LBP in research subjects, with high reliability and validity. Hence, it is essential to assess the level of disability in patients with LBP [21]. The ODI comprises 10 categories: communication, personal hygiene, lifting, walking, sitting, standing, sleeping, sexual activity, social life, and travel. A score of 0–20% is considered mild disability, 20–40% moderate disability, 40–60% severe disability, and 80–100% bedridden. The reliability and validity of this tool were reported to be relatively high [22].

3) Quality of Life

The quality of life was assessed using the Medical Outcome Study 36-item short-form health survey (SF-36) developed by Ware and Sherbourne in 1992 [23]. The SF-36 assesses the health status in two parts (functional health and well-being) and consists of eight subscales [24]. These subscales included a physical health domain with four items: (1) physical functioning, (2) role limitations due to physical health problems, (3) bodily pain, and (4) general health perception. An additional four items were assessed: (1) vitality, (2) social functioning, (3) role limitations due to emotional problems, and (4) mental health status, which consisted of four items. These were divided further into 36 sub-scales, with 35 items covering the above eight subscales and one item assessing perceptions of health change. Each item in the subscale was scored and summed to produce a 0–100 point scale, where 0 was the worst, and 100 was the best [25].

5. Statistical Analysis

The measurement data of this study were processed statistically using IBM SPSS 22.0 (International Business Machines, Armonk, USA), with 15 participants in each group, giving a total of 30 participants. The experiment investigated the impact of the lumbar stabilization exercises using a Pilates reformer on the VAS, ODI, and quality of life in patients with chronic low back pain.

This study utilized the measured data to calculate the mean and standard deviation for the overall characteristics of the subjects. A Shapiro-Wilk normality test was also conducted. The test revealed a normal distribution assumption, and a parametric test was conducted. A paired t-test was used to determine the difference before and after exercise in each group, including the experimental and control groups. An independent t-test was used to analyze the difference between before and after exercise. The statistical significance probability a was set to .05.

Ⅲ. Results

The general characteristics of the subjects showed similar homogeneity and normality tests in the two groups ($p > .05$) (Table 1). Significant statistical differences were observed within the experimental and control groups before and after interventions ($p < .05$). In addition, a significant difference was found when comparing the two groups, with a further reduction in the experimental group in terms of changes in the VAS ($p < .05$) (Table 5).

Significant statistical differences were noted between the experimental group and the control group before and

Table 5. Comparison of changes in the visual analog scale before and after intervention

Group	Pre-test	Post-test	Different value	t	p
EG	6.27 ± 1.43	3.93 ± 1.48	2.3 ± 0.15	14.642	.001*
CG	5.67 ± 1.63	4.60 ± 1.29	1.07 ± 0.15	6.953	.001*
t	1.068	-1.308	-5.227		
p	.14	.10	.001*		

*p < .05
EG: experimental group- lumbar stabilization exercise using a Pilates reformer
CG: control group- lumbar stabilization exercise

Table 6. Comparison of the changes in the Oswestry disability index before and after intervention

Group	Pre-test	Post-test	Different value	t	p
EG	28.80 ± 5.29	23.93 ± 3.73	6.86 ± 0.72	9.582	.001*
CG	27.60 ± 4.27	24.53 ± 3.99	3.06 ± 0.32	9.718	.001*
t	0.683	-1.841	-3.640		
P	.252	.038*	.001*		

*p < .05
EG: experimental group- lumbar stabilization exercise using a Pilates reformer
CG: control group- lumbar stabilization exercise

Table 7. Comparison of changes in the quality of life before and after intervention

Group	Pre-test	Post-test	Different value	t	p
EG	54.27 ± 4.94	69.00 ± 2.92	-14.73 ± 1.02	-14.36	.001*
CG	57.87 ± 9.92	60.67 ± 6.87	-7.80 ± 1.29	-6.022	.001*
t	0.489	4.320	4.554		
P	.313	.001*	.001*		

*p < .05
EG: experimental group- lumbar stabilization exercise using a Pilates reformer
CG: control group- lumbar stabilization exercise

after the interventions ($p < .05$). In addition, the experimental group showed a significantly larger reduction in the ODI than the control group ($p < .05$) (Table 6).

Significant differences before and after interventions were observed between the experimental group and the control group ($p < .05$). Furthermore, the experimental group showed a significantly larger improvement in the quality of life than the control group ($p < .05$) (Table 7).

Ⅳ. Discussion

This study compared the impact of lumbar stabilization exercises using a Pilates reformer on the VAS, ODI, and quality of life in patients with chronic low back pain with a control group that did not use a reformer for lumbar stabilization exercises.

The research focused on individuals suffering from

persistent LBP, who were segregated into two cohorts: one comprising 15 patients who undertook lumbar stabilization exercises using a reformer, and another consisting of 15 patients who did not utilize the reformer. Each group participated in exercises for 50 minutes, twice weekly, over an eight-week period. The findings revealed notable disparities between the lumbar stabilization exercise group using the reformer and those who did not. Before and after the intervention, the VAS and ODI demonstrated significant reductions in the cohort engaging in lumbar stabilization exercises with the reformer. The group performing lumbar stabilization exercises using a reformer exhibited substantially improved quality of life compared to the control group.

Core stabilization exercises are more effective in alleviating pain and enhancing functional capacity by reducing disability in individuals suffering from nonspecific LBP. Recently, various approaches, including stretching, aerobic exercise, and sling exercises, have been suggested as interventions for ameliorating chronic LBP. In particular, ongoing research has investigated the effectiveness of rehabilitation exercises utilizing Pilates equipment for individuals with chronic LBP [14].

Pilates rehabilitation exercises effectively enhance lumbar muscle strength by engaging the transverse abdominis, diaphragm, multifidus, and pelvic floor muscles through repetitive and coordinated movements and breathing, which are essential for lumbar stability [26]. Furthermore, reformer Pilates exercises are popular because they involve resistance against springs rather than gravity. A previous study reported that gravity provides a consistent external resistance to the movement angle during exercise, whereas springs increase the external resistance as the muscles extend [27]. Reformer exercises, which focus on aligning movements around the powerhouse while maintaining spinal neutrality, are well-suited for promoting joint stabilization and balance through movements involving weight loads [28].

This study observed a significant decrease in LBP in the experimental and control groups, as assessed by the VAS before and after the intervention. The reduction amounted to 37.32% and 18.87% in the experimental and control groups, respectively ($p < .05$). These findings suggest that, compared to the control group, the experimental group, which engaged in lumbar stabilization exercises with the reformer, experienced a 28.45% greater reduction in pain than the control group. These results align with previous research reporting a significant decline in the VAS and ODI when Pilates was used to treat patients with chronic LBP [29]. Furthermore, the outcomes are consistent with Stolze et al. [30], who reported the effectiveness of Pilates exercises using a reformer in alleviating chronic LBP. The study also showed that lumbar stabilization with a Pilates reformer induces effective muscle contraction through spring resistance, activating muscles [31]. Incorporating Pilates to treat patients with chronic lower back pain can help activate the deep muscles in the lumbar spine, reduce pain, and enhance the overall spinal function [19]. Pilates contributes to spinal stability by fortifying the body's core muscles, supporting the notion that it is an effective rehabilitative exercise for alleviating back pain [32].

The degree of impairment, as evaluated by the ODI, showed a significant decrease in the experimental and control groups after the intervention compared to before the intervention, with 16.90% and 11.12% reductions, respectively ($p < .05$). Hence, compared to the control group, the experimental group exhibited a 5.78% greater enhancement by utilizing the reformer for lumbar stabilization exercise to mitigate the patient's ODI. Deficient motor control of muscles in the lumbar region is associated with discomfort. Strengthening the muscles in this region diminishes impairment and alleviates discomfort, which aligns with prior studies [33]. A study

dividing patients with chronic LBP into deep and superficial muscle exercise groups found that the deep muscle exercise group displayed a reduction in LBP [34].

The lumbar stabilization exercise performed on a mat without a reformer relies solely on the individual's strength. In contrast, the experimental group conducted more effective exercises by incorporating various operating ranges and resistances using reformers. This approach is believed to have reduced the ODI.

Chronic pain, lasting for more than a few months and recurring, has enduring consequences on patients' lives. Conditions, such as chronic LBP, can lead to financial burdens and discomfort during treatment. Persistent chronic LBP causes physical pain and dysfunction and has psychological implications that diminish the quality of life. Therefore, the evaluation aims to assess the impact of lumbar stabilization exercises using a reformer on the quality of life of patients with chronic LBP and determine the effectiveness of physical and mental factors. The SF-36 assessment tool measured the impact on quality of life. The experimental and control groups showed significant improvements in the quality of life after the intervention, with 27.14% and 14.75% increases, respectively ($p < .05$), compared to before the intervention. These results suggest that the experimental group showed a more significant improvement in the quality of life by using the reformer for lumbar stabilization exercise than the control group (12.39% greater improvement than the control group). This is consistent with the findings of substantial improvements in the quality of life scale as measured by SF-36 when Pilates is combined with NSAID medication [18]. These results suggest that lumbar stabilization exercises using a reformer can enhance physical and mental well-being and help improve the quality of life.

The study indicated that the experimental and control groups displayed a disparity between the pre- and post-tests. The impact was more evident in the experimental group than in the control group, substantiating the research hypothesis. Overall, engaging in reformer Pilates and general back stabilization exercises may alleviate pain and improve the quality of life for patients with LBP when integrated into clinical practice. Nevertheless, this study was limited by its small sample size, which hindered the generalizability of the research results. In addition, there was a lack of quantitative assessment of the subjects' recovery of core muscle function, and no functional evaluation was conducted to align or evaluate patient movement. Therefore, more study is needed to compare the overall spinal alignment and functional movement performance of patients with chronic low back pain. Moreover, there is a risk of committing a type II error because of the insufficient sample size achieved through power analysis in this study.

Ⅴ. Conclusion

Based on the findings, the lumbar stabilization exercise using the reformer group and the lumbar stabilization exercise using the mat group showed improvements in the VAS, ODI, and quality of life. On the other hand, the group utilizing lumbar stabilization exercises with the reformer showed greater improvements than the control group. These outcomes suggest that for individuals suffering from chronic lower back pain, employing unstable support surfaces and spring resistance for stable rehabilitation exercises in the lower back is beneficial. Substituting the reformer with Pilates for lumbar stabilization exercise may assist patients with chronic LBP in reducing the VAS and ODI and improving the quality of life. Therefore, it is recommended as a method for lumbar stabilization. Future research will require a larger sample size, quantitative evaluation of core muscles, assessment of posture and movement, and power analysis.

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