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The Effects of 12-Week of Proprioceptive Exercise Programs on Chronic Low Back Pain and Sensorimotor Control in Middle-Aged Females in Rural Areasa

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12주간의 고유감각자극운동이 농촌지역 중년여성의 만성요통과 감각운동 조절능력에 미치는 효과

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요 약 본 연구는 만성요통을 호소하는 농촌지역 50대 중반 여성을 대상으로 고유감각자극을 위한 소도구 운동프로그램을 12주간 적용하여 VAS(visual analogue scale), 정적균형능력 좌·우, 전·후, 그리고 고유감각 운동능력 신체안정성 좌·우, 전·후의 신체적 변화를 알아보았다. 연구대상자는 실험집단(experimental group; EG) 24명, 통제집단(control group; CG) 20명으로 무작위 할당 하였다. 실험집단과 통제집단 간 동질성 검사는 독립 t-검정을 실시하여 평균의 유의차를 분석하였고, 동질성이 확보된 경우 Two-way ANOVA 반복측정 분산분석(repeated measures ANOVA)을 실시하였다. 그 결과 집단과 12주 시기 간 상호작용효과가 나타났다. 그러나 집단 내 시기 간 VAS, 정적균형능력 좌·우, 전·후, 그리고 고유감각 운동능력 신체안정성 좌·우, 전·후에서 유의한 평균차이로 개선된 결과를 나타냈으며, 집단 간 12주 후에서 실험집단이 모든 변인에서 유의한 개선 효과가 나타났다.

주제어 : 소도구 운동프로그램, 고유감각자극운동, 농촌지역, 중년여성, 만성요통, 감각운동 조절능력

Abstract This study applied a props-based exercise program for 12 weeks to women in their mid-50s in rural areas who complained of back pain, and applied VAS (visual analogue scale), static balance ability left and right, front and back, and sensory movement. Ability Physical stability The left and right, before and after physical changes were investigated. The study subjects were randomly assigned to an experimental group (EG) of 24 people and a control group (CG) of 20 people. For the homogeneity test between the experimental group and the control group, an independent t-test was conducted to analyze the significant difference in average. When homogeneity was secured, two-way ANOVA repeated measures ANOVA was performed. As a result, there was an interaction effect between the group and the 12 weeks period. However, the VAS between periods within the group, static balance ability left and right, before and after, and sensorimotor ability and body stability left and right, before and after showed improved results with significant average differences. After 12 weeks between groups, the experimental group showed significant improvement effects in all variables.

Key Words : Props-based exercise program, Proprioceptive exercise program, Rural areas, Middle-age females, Chronic low back pain, Sensorimotor control

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1. Introduction

Chronic low back pain (CLBP) is known as one of the work-related musculoskeletal disorders (WMSDs) that can occur in anyone [1]. It is a problematic condition for a relatively large segment of the population and has been estimated to be the sixth leading cause of disability in both developed and developing countries[2].

In addition, CLBP is a musculoskeletal disorder that occurs not only in urban areas but also in rural areas, reflecting the occupational characteristics of farmers, most of whom repeatedly flex and relax their backs. According to the 2020 Korean Farmers' Occupational Disease and Injury Survey conducted by the Rural Development Administration, the prevalence of musculoskeletal disorders among farmers was 84.6%, higher than circulatory system diseases 3%, skin diseases 2.9%, and neurological diseases 2.1%. The distribution of musculoskeletal disorders by major body parts included back pain 47.3%, knee 27.3%, shoulder 6.9%, hand 5.1%, and neck 4.1%, and the prevalence rate among the agricultural population was higher in females than males[3].

The development of CLBP, in a variety of settings[4-6], can result in postural dysregulation of static equilibrium, particularly under unstable conditions such as standing on an unstable support surface[5]. Furthermore, as the stimulation of the proprioceptive senses in the absence of vision provides the perceived timing of position and movement, force, effort, and heaviness associated with muscle contractions, it is important to the postural control system to help maintain equilibrium and stability[7].

Disorders or deficits in proprioceptive senses in CLBP patients may lead to postural control deficits with respect to the patient's static and dynamic sense of balance, calling for attention because inappropriate interbody muscle responses may lead to errors in rapid repositioning movements of the body or balance disorders[8]. However, studies have also shown that the deficits in proprioceptive senses in CLBP cases can vary in consistency[4]. While no clear explanation for these inconsistent findings has been found to date, recent systematic reviews have indicated that impaired proprioceptive senses are correlated with pain-related intensity in CLBP patients[6], thus increasing interest in postural stability based on sensorimotor control of patients with low back pain.

On the other hand, the various findings regarding the inconsistencies in postural control in patients with CLBP may be a compensatory action by the central nervous system (CNS), i.e., inadequate or deficient stimulation of the proprioceptive senses in the body of patients with CLBP may be a compensatory action of the afferent nervous system of the intact visual and vestibular systems[9]. Successful compensation of impaired proprioceptive senses by other available afferent senses is known to allow intact postural control in patients with CLBP. It is proposed that the CNS does not rely on the pain sensation in the lower back, but rather decreases the function of the trunk proprioceptive senses and replaces them with other more reliable resources[9,10].

These compensatory mechanisms appear to be important for flexible postural control despite pain[9]. Therefore, it is believed that irregular stimulation of the proprioceptive senses does not result in loss of dynamic balance and falls[10], but it is necessary to examine whether stimulation exercises for the control of the proprioceptive senses using props have a positive effect on static balance and postural stability in middle-aged and elderly females with CLBP in rural areas.

The prop exercise program is generally developed and utilized as a props-based exercise tool that stimulates the proprioceptive senses of the human body to do movement, and the representative tools include gym balls, foam rollers, and tubing. The material of each tool is a resilient rubber material, and when you sit or stand on the tool, the human body responds to center itself, which is known to produce clinically and statistically significant improvements and effects through the application of neurophysiological and academic principles[11].

On the other hand, the occupational characteristics of farmers in rural areas include frequent movements that cause the body or spine to deviate from a neutral position due to improper working posture, and this uncomfortable posture is a major cause of musculoskeletal disorders such as CLBP. Therefore, it is important to develop an exercise program using props as a simple exercise method to prevent CLBP and improve discomfort. Therefore, this study aimed to compare the static balance-related postural control of female CLBP patients in rural areas with the postural control responses of asymptomatic participants, to compare their body stability and bilateral, anteroposterior sensorimotor control, and to investigate whether 12 weeks of proprioceptive sensory stimulation training using props could positively affect the static balance-related postural control system in the CLBP group.

2. Methods

2.1 Subjects

The subjects of the study involved 60 females in their mid-50s with back pain among farmers living in 17 rural areas in Gyeonggi-do, Chungcheongnam-do, Gyeongsangbuk-do, and Gangwon-do provinces in Korea. Among the subjects with a visual analogue scale (VAS) of 6 or more in the lower back area, 24 subjects were randomly assigned to the experimental group (EG) and 20 subjects to the control group (CG), making a total of 44 subjects for statistics. The subjects were patients with localized low back pain, defined as muscle tension and stiffness in the lower back area, without concomitant sciatica[12].

2.2 Design and instruments

This study is based on the results of female farmers who participated in an educational program for the prevention of musculoskeletal disorders organized by the Rural Development Administration. The purpose of this study is to analyze the effects of the exercise program using props on the improvement of low back pain, bilateral and anteroposterior static balance ability for sensorimotor control, and bilateral and anteroposterior body stability for props-based mobility in the experimental group of middle-aged females with low back pain and the control group of middle-aged females without low back pain. The independent variable of this study was the exercise program as shown in Table 2, and the dependent variable was the VAS (visual analogue scale) of chronic lower back pain. The sensorimotor control was measured with the MFT (multi-functional training) S3 Check. For postural stability, the MFT S3 Check was used based on the method of[14].

2.3 Sensorimotor control measurement

The measurement of sensorimotor control used the Multi-Functional Training (MFT) S3 Check (Australia). It is a measurement tool for measuring the core stability, body response, joint stability, balance, and coordination of subjects to assess body stability, sensorimotor control, and symmetry. The system uses a circular platform with a diameter of 530 mm and moves in one direction at an inclination between +20° and -20° (0.5% measurement accuracy). The subject steps onto the platform and tries to balance his or her body, and internal sensors record the subject's status on a USB memory. The subject balances on the platform for 30 seconds, and the results of the body's repeated response for medial-lateral and anterior-posterior movements are recorded[13].

Table 1. Physical characteristics of subjects

Variables	EG(n=24)	CG(n=20)	t	p
	M±SD	M±SD		
Age(yrs)	54.4±8.4	58.3±9.3	-1.432	.160
Height(cm)	159.3±3.3	157.6±2.8	1.807	.078
Weight(kg)	57.5±5.9	58.4±6.4	-.505	.616
BMI(kg/m^2)	22.6±2.2	23.5±2.4	-1.230	.226
VAS	7.2±1.1	7.5±1.4	-.781	.439

EG: exercise group, CG: control group
VAS: visual analogue scale

Table 2. Group exercise program for prop exercise

Exercise	Props	Exercise	Frequency	Position	Time
Warm-Up	Gym Ball	Clapping Over Head Reaching Circles Open Chest Flying		Bounce series	5 min
Main Exercise	Gym Ball	Swimming Spine Extension	× 4 time × 4 time		30 min
		Side Bending Pront Bending One Leg Balance	× 4 time × 4 time 8 counts		
		Mermaid Spine Stretch Forward	× 4 time × 4 time		
		Spine Twist Bridge Bridge & One Leg Lift Drumming	× 4 time × 4 time × 2 time 32 counts		
	Foam Roller	Breathing Side Rolling Arms Circles Bridge One Arm Circle(Side Lying) Open Chest(Side Lying) Open Twist(Side Lying) Chest Stretching Thoracic Release Side Thigh Massage Quad Massage	× 4 time × 8 time × 8 time × 4 time × 8 time × 4 time × 4 time × 4 time × 4 time × 4 time× 4 time		30 min
	Tubing Band	One Leg Lift Double Legs Lift One Leg Circles Bicycles Leg Pull(Side Lying)	× 8 time × 8 time × 8 time × 8 time × 4 time	Supine Position	30 min
Cool Down		Deep Breathing & Partner Stretching			5 min

2.4 Prop-based exercise program

In the case of exercise using props-based, an exercise program using gym balls, foam rollers, and elastic bands was conducted twice a week for 12 weeks to stimulate the body's proprioceptive senses to induce muscle contraction of the deep muscles and limbs, strengthen coordination, and maintain the body's equilibrium and postural stability in static and dynamic exercises[14].

The exercises were carried out with adjusted intensity so that the load could be self-regulated depending on the elasticity of the props and the weight of the subjects. The exercises were performed in groups of two for the first two weeks to prevent falls during exercise. Before the subjects performed the exercises, the instructor demonstrated the exercises and explained the precautions for each exercise movement. From the third week on wards, the subjects were provided with their own props and worked out by applying the subjective intensity of each exercise, but the number of repetitions for each exercise program was guided by the instructor. Furthermore, considering the characteristics of the experimental group with a VAS of 6 or more for low back pain, the subjects were instructed to exercise within the pain-free range.

2.5 Data processing

This study reported the descriptive statistics of the mean and standard deviation of the experimental and control groups using SPSS statistical program Ver. 21. An independent t-test was conducted to test for homogeneity between the experimental and control groups, and if homogeneity was confirmed, a Multivariate ANOVA was conducted. If no interaction effect between group and time period was found, a dependent t-test within groups and an independent t-test between groups were carried out to analyze the main effect of experimental groups. The significance level was set at α=.05.

3. Results

A 12 weeks program of props-based exercises was conducted on a group of middle-aged females with low back pain in rural areas, and the results were as follows.

3.1 VAS

The pre and post-test VAS changes of the 12 weeks props-based exercise using props performed by females in their mid-50s with low back pain are shown in Table 3.

The VAS test with dependent variable showed an interaction effect between the experimental group (EG) and the control group (CG) and the pre and post 12 weeks periods ($p<.01$). However, the dependent t-test results of VAS before and after the exercise program in EG showed a 34.7% decrease from 7.2±11.1 at pretest to 4.7±1.4 at post test ($p<.001$) and an 8% decrease from 7.5±1.4 to 6.9±1.2 in the control group CG ($p<.05$). After 12 weeks of the exercise program, the independent t-test results for EG and CG were 4.7±1.4 and 6.9±1.2, respectively, resulting in a 31.9% greater reduction in EG, indicating a significant mean difference ($p<.001$).

The results of the subjects' bilateral static balance test showed an interaction effect between the experimental group (EG) and the control group (CG) as well as between the pre and post 12 weeks periods of the props-based exercise program ($p<.01$). However, the dependent t-test results of the bilateral static balance test of EG before and after the exercise program showed a 20.1% decrease from 5.58±1.14 to 4.46±.82 at post-test ($p<.001$) and an 11.6% decrease from 6.03±1.22 to 5.67±.70 at post-test in the control group CG. Comparing the results of the independent t-test of the EG and CG after 12 weeks of the exercise program, the results were 4.46±.82 and 5.67±.70, respectively, resulting in a 21.3% greater reduction in the EG, showing a significant mean difference ($p<.001$).

Table 3. Changes of visual analog scale

Group	Pre(M±SD)	Post(M±SD)	t	Effects	p
EG	7.2±11.1	4.7±1.4	7.460^{***}	Group	.000
CG	7.5±1.4	6.9±1.2	2.238^{*}	Time	.000
t	−.781	$-5.749^{\dagger\dagger\dagger}$		Group×Time	.01
p	.439	.000			

M±SD=mean±standard deviation. EG: Exercise group, CG: Control group
* Result of paired t-test, †Result of independent t-test. $^{***}p<.001$, $^{**}p<.01$, $^{*}p<.05$, $^{\dagger\dagger\dagger}p<.001$

Table 4. Stability test results between the left and right feet in a standing position

Group	Pre(M±SD)	Post(M±SD)	t	Effects	p
EG	5.58±1.14	4.46±.82	7.141^{***}	Group	.003
CG	6.03±1.22	5.67±.70	1.452	Time	.001
t	−1.241	$-5.216^{\dagger\dagger\dagger}$		Group×Time	.009
p	.221	.001			

M±SD=mean±standard deviation. EG: Exercise group, CG: Control group
* Result of paired t-test, †Result of independent t-test. $^{***}p<.001$, $^{**}p<.01$, $^{*}p<.05$, $^{\dagger\dagger\dagger}p<.001$

Table 5. Stability test results between the front and back of the foot in a standing position

Group	Pre(M±SD)	Post(M±SD)	t	Effects	p
EG	5.73±.85	4.67±1.01	4.682^{***}	Group	.034
CG	5.93±1.13	5.53±.70	2.163^{*}	Time	.001
t	−.672	$-3.202^{\dagger\dagger}$		Group×Time	.032
p	.505	.003			

M±SD=mean±standard deviation. EG: Exercise group, CG: Control group
* Result of paired t-test, †Result of independent t-test. $^{***}p<.001$, $^{**}p<.01$, $^{*}p<.05$, $^{\dagger\dagger\dagger}p<.001$

Table 6. Sensorimotor test results between the left and right of the foot in a standing position

Group	Pre(M±SD)	Post(M±SD)	t	Effects	p
EG	4.62±1.29	3.64±.86	4.542^{***}	Group	.015
CG	4.92±1.20	4.73±.84	.704	Time	.001
t	−.209	$-4.222^{\dagger\dagger\dagger}$		Group×Time	.026
p	.835	.001			

M±SD=mean±standard deviation. EG: Exercise group, CG: Control group
* Result of paired t-test, $^{***}p<.001$, $^{\dagger\dagger\dagger}p<.001$

Table 7. Sensorimotor test results between the front and back of the foot in a standing position

Group	Pre(M±SD)	Post(M±SD)	t	Effects	p
EG	4.46±1.31	3.72±1.25	4.682^{***}	Group	.520
CG	4.39±.91	4.14±1.13	.745	Time	.035
t	−.672	$-3.202^{\dagger\dagger}$		Group×Time	.285
p	.505	.003			

M±SD=mean±standard deviation. EG: Exercise group, CG: Control group
* Result of paired t-test, †Result of independent t-test. $^{***}p<.001$, $^{\dagger\dagger}p<.01$

In terms of subjects' pre and post static balance test results, there was an interaction effect between the experimental group (EG) and the control group (CG) and between the pre and post 12 weeks periods ($p<.05$) for the props-based exercise program. However, the dependent t-test results of the anteroposterior static balance test before and after the exercise program in the EG showed an 18.5% decrease from 5.73±.85 at pretest to 4.67±1.01 at posttest ($p<.001$) and a 6.7% decrease from 5.93±1.13 to 5.53±.70 in the control CG ($p<.05$). Comparing the results of independent t-tests of the EG and CG after 12 weeks of the exercise program, the means were 4.67±1.01 and 5.53±.70, respectively, resulting in a 15.5% greater reduction in the EG, showing a significant mean difference ($p<.01$).

3.2 Static balance

The results of the bilateral body stability test in relation to props-based exercise showed an interaction effect between the experimental group (EG) and the control group (CG) as well as the time period before and after the 12 weeks exercise program ($p<.05$). However, the test-dependent t-test results of the body stability test conducted before and after the props-based exercise program in the EG showed a 21.2% decrease from 4.62±1.29 at pre-test to 3.64±.86 at post-test ($p<.001$), while in the CG, the decrease was 3.9% from 4.92±1.20 to 4.73±.84. After 12 weeks of the exercise program, the results of the independent t-test between the EG and CG were 3.64±0.86 and 4.73±.84, respectively, resulting in a 33% greater reduction in the EG, showing a significant mean difference ($p<.01$).

3.3 Body stability during props-based exercise

In terms of the results of the anteroposterior body stability test in props-based exercises, there was no interaction effect between the experimental group (EG) and the control group (CG) as well as the time period before and after the 12 weeks exercise program. The test-dependent t-test results of the body stability test conducted before and after the props-based exercise program in the EG showed a 16.6% decrease from 4.46±1.31 at pre-test to 4.14±1.13 at post-test ($p<.001$), whereas the CG showed a 5.7% decrease from 4.39±.91 to 4.14±1.13. After 12 weeks of the exercise program, an independent t-test between the EG and CG showed a significant mean difference of 3.72±1.25 and 4.14±1.13, respectively, resulting in a 10% greater reduction in the EG ($p<.01$).

4. Discussion

The purpose of this study was to compare the results of the experimental group consisting of females in their mid-50s in rural areas with low back pain to the control group by conducting a 12-weeks prop exercise program designed to stimulate the proprioceptive senses as an independent variable. The dependent variables were VAS, bilateral and anteroposterior static balance ability, and physical changes in bilateral and anteroposterior body stability in props-based exercise.

Interaction effects were found between groups and time periods regarding VAS, bilateral and anteroposterior static balance ability, and bilateral body stability in props-based exercises, but not anteroposterior body stability in props-based exercises. This indicates that the 12 weeks relaxation period acted as a factor in the conservative treatment approach to reducing low back pain in the control group.

Since low back pain is a commonly treated condition in primary care settings[12], the 12 weeks treatment period may have been a therapeutic factor for the control group. In particular, the effectiveness of conservative treatment can be attributed to the fact that the subjects in this study were not suffering from disc disease, which is the cause of sciatica, but from muscle strain and fatigue. Both the experimental and control groups on the VAS in this study showed a gradual decrease in low back pain over time ($p<.001$, $p<.05$), which can be judged as a musculoskeletal disorder that can be further improved in the exercise group, just like the results of this study, as the international guidelines (2018-2021) for patients with chronic low back pain recommend exercise therapy, physical activity, physical therapy, and education[15].

Among the previous studies on whether the improvement of low back pain scale has a positive effect on static balance ability and body stability of props-based exercise, Hwangbo et al[16] reported that interbody stability exercise has a significant effect on pain, flexibility, and static balance ability in low back pain patients, which is consistent with the results of this study, and Patti et al[17] reported that proprioceptive neuromuscular fascilitation (PNF) exercise is effective in improving balance in workers with chronic low back pain. However, props-based exercises using props are different in that they stimulate the muscles of the whole body and core[18,19], whereas PNF exercises involve rehabilitation techniques in which a trainer stimulates or facilitates a localized area of the body[20]. They share a commonality in that they improve the body's instability by training the coordination of body posture and functional joint movements, such as stimulating the body's proprioceptive senses and facilitating the neuromuscular system simultaneously[14].

Consistent with preceding studies, which reported that the body's balance ability improves with balanced musculoskeletal system, enhanced muscle strength, stable neuromuscular function, and seamless operation of the sensorimotor system[21-24], the static balance and body stability variables in this study showed significant results in the experimental group, suggesting that props-based exercise using props is an effective method. In addition, the abnormally high scores of static balance ability and body stability are considered to be potential risk factors for falls, suggesting that middle-aged female workers in rural areas with low back pain may have the same risk factors; thus, props-based exercises using props in this study are emphasized.

On the other hand, if the imbalance of the body shape, i.e., the anterior tilt of the upper body, is abnormal, low back pain occurs[21], and the body shape imbalance, such as turtle neck, causes pain in the back of the body. This increases the risk of falling[25], and studies have shown that normalizing abnormal body shape such as anterior tilt of the upper body improves low back pain, neck and shoulder pain, and fall risk factors. In the case of this study, it is believed that low back pain is caused by working postures that always maintain an anterior tilt of the upper body by leaning forward, and that while the upper body is anteriorly tilted, the shortening of the muscles at the front of the body, especially the flexors located at the front of the lumbar pelvis, leads to strain on the lumbar extensors at the back of the body, causing low back pain. However, the prop-based exercise program stimulates the proprioceptive senses of the whole body to induce muscle contraction, relaxation, and coordination, thereby relieving low back pain and activating the body's sensory nerves while significantly improving bilateral and anteroposterior static balance ability and body stability as there is no shortening of the muscles due to muscle tension in the whole body.

5. Conclusion and recommendation

This study compared the results of a 12 weeks props-based exercise program designed to stimulate the proprioceptive senses in a group of mid-50's females in rural areas with low back pain with the control group. The results showed an interaction effect between the groups and the 12 weeks period, but there were significant mean differences in VAS, bilateral and anteroposterior static balance, and bilateral and anteroposterior body stability in props-based exercise between the periods within the groups, and the experimental group showed significant improvement in all variables after 12 weeks. Therefore, it is assumed that props-based exercise utilizing props has a positive effect on pain improvement, static balance improvement, and body stability improvement in mid-50s females in rural areas with low back pain. However, it is considered necessary to conduct further experiments involving various age groups and genders. In addition, in order to improve health in rural areas, it is believed that the quality of life of the elderly should be improved by improving overall physical strength, strength, and flexibility through various exercises such as strength and back strengthening exercises, flexibility exercises, walking exercises, and stretching.

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