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Comparison of Effects of Walking Exercise and EMG Biofeedback on Lumbar Strength, Muscle Activity and Lumbar Dysfunction in Patients with Chronic Low Back

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Abstract

The purpose of this study was to investigate the effect of biofeedback walking exercise(BWE) on the lumbar deep muscle strengthening, muscle activity and lumbar functional disability index(LFDI) with chronic low back pain patients. The walking exercise program was progressed 30 minutes daily and 3 times a week for 8weeks. Both group participants were walking exercise applied on the treadmill. In addition, BWE group is received real-time visual biofeedback using surface electromyogram(sEMG). Measured of lumbar deep muscle was obtained using CENTAUR(0°, 90°, -90°, 180°), muscle activity was sEMG, LFDI was Oswestry disability Index(ODI). Compared lumbar deep muscle strengthening, muscle activity and LFDI were measured before exercise and 8weeks after exercise. The following results were proven through the study: First, compared with change of lumbar deep muscle strengthening using for CENTAUR were statistically significant increased 0°, 180°($p<0.05$). However, 90°, -90° were no statistically significant increase($p>0.05$). Muscle activity were statistically significant increased all of intervention. Finally, the LFDI was significant compared within groups but not significant differences between groups pre-test and post-test. sEMG walking can be used to provide a real-time visual biofeedback as a motor control approach, and BWE group was more effective than general walking exercise group(GWEG) in chronic back pain patient.

Keywords: Chronic low back pain, Biofeedback walking exercise, Lumbar deep muscle strengthening, Lumbar muscle activity, Lumbar functional disability.

INTRODUCTION

Chronic low back pain is a persistent disabling condition with rising significant healthcare, social and economic cost. In particular, modern society is experiencing an increase in chronic low back pain due to sedentary work and decrease moving activities [1]. Among the causes of low back pain, back pain due to weakness of the lumbar soft tissue occupies 80%, rather than structural factors [2]. Several previous studies have reported that passive treatment for back pain is temporary and does not reduce recurrence rate, but active type of exercise therapy has been shown to strengthen the trunk muscles to provide stability and increase spinal joint range of motion [3, 4]. Exercise training for patients with chronic low back pain was difficult to visualize deep muscle contraction and limited by subjective palpation of the therapist and deep muscle contraction by the verbal command [5]. However, if biofeedback is provided as a complementary measure, it can induce learners to perform accurate technical skills and provide more objective evaluation of motor learning [6]. Although there are several previous studies on walking exercise, there is a lack of research on deep muscle activity using biofeedback in patients with chronic low back pain. The purpose of this study was to investigate the effect of biofeedback walking exercise on the lumbar deep muscle strengthening muscle activation and lumbar functional disability with chronic low back pain patients.

EXPERIMENTS

Subject selection and Experiments procedure

In this study, the criteria for selection of the subjects were as follows: lumbago symptoms were reproduced periodically, the pain persisted for more than 3 months, the lumbar disability index was within 40-50%, and X-ray, CT and MRI Patients who were diagnosed with chronic low back pain from a doctor, who underwent surgery, and who had difficulty exercising and walking in the limited range of motion of the joint were excluded. Participants were informed about the content and procedures of the experiment and fully understood the significance of the study and agreed to participate voluntarily in the experiment. Subjects were randomly assigned to 10 GWEG and 10 Biofeedback walking exercise groups(BWEG). In this study, walking exercise was performed for 30 minutes, 3 times a week for 8 weeks in each group. Lumbar muscle activity, deep muscle strength and lumbar functional disability

index were measured before and after the experiment. 1)Walking exercise program: Walking exercise program was taught through pre-training to learn proper posture, movement and walked within target heart rate range using heart rate meter in treadmill. The target heart rate was 50~60%. 30 minutes a day, 3 times a week, and 8 weeks of walking. The warm up exercise and cool down exercise were performed for 10minutes each [7]. 2)Biofeedback waling exercise with electromyogram: Walking exercise posture and method were performed in the same way as general walking exercise program. The procedure to apply electromyography biofeedback was to educate the muscle to contraction to within 20~30% maximal voluntary isometric contraction (MVIC) [8], which has the highest activity to lumbar deep muscle using a stabilizer pressure biofeedback unit before walking. The deep muscles were defined as the transverse abdominal muscles and the subjects were placed electrode in an upright posture and walked in a treadmill. The experimenter walked watching the monitor, and the observer confirmed to the experimenter whether the posture and deep muscle contracted, so that the graph on the monitor could be kept constant.

Measurement Method

1)Lumbar stabilization strengthening test: In order to evaluate the lumbar deep muscle strength before and after the exercise, CENTAUR® (BFMC, Germany), a three-dimensional spinal stabilization exercise and strength test, was measured before and 8 weeks after the exercise program. The maximum muscle strength was measured by fixing the pelvis and thigh above the standing posture and keeping the transverse abdominal muscle contraction in the standing position until the body was flexed to 90 degrees to the ground. As the body tilts to the ground, the load increases due to gravity. The test is stopped when the pain is generated during the test, the involuntary contraction of the trunk, and the trunk movement over the limited range. The value is measured by computer. The measurement angles are 0, +90, -90, 180 degrees, all four angles, + indicates the right, and - indicates the left direction. The lumbar deep muscle strength was measured using CENTAUR, muscle activity measured by CENTAUR at each posture was normalized to EMG signal during %MVIC.

2)Surface EMG test: In this study, surface electromyography was performed using Nicolet's Viking 4P®, which is widely used in practice. The static surface electromyography method attaches four electrodes to the site skin where the bilateral para spinal muscles are located. The examiner relaxes the subject naturally, and is performed on the side of the vertebra from L1 to L5 on the left and right side of the stance, and detects the vertebral body through the iliac crest and attaches the electrode. The examiner was instructed to maintain a neutral posture while the subject was watching the front during the examination, and to maintain a good contact state because the contact failure between the skin and the electrodes could lead to a wrong result. Dynamic surface electromyography used the subject's flexion and re-extension of the lumbar, and used the ratio of the potential at re-extension and flexion to the final result. Four electrodes were placed symmetrically at 3 cm intervals from the vertebrae at the bilateral side of the vertebra from L1 to L5, and the ground electrode was placed on the left shoulder.

3)Oswestry disability index(ODI): The ODI was assessed to determine the outcome of low back pain and dysfunction treatment and to compare the results between groups. ODI is a highly reliable assessment tool with an Intra-class Correlation Coefficient (ICC) of 0.90 or higher [9]. 6)Statistical analysis: The data collected through this study were statistical package for the social science (SPSS, Chicago, IL) ver. 21.0 was used for statistical analysis as follows. The mean difference between pre- and post-experiment was compared by paired t-test, and the mean difference between groups was compared by independent t test. The significance level was set at $p < 0.05$ in all statistical processing.

RESULTS AND DISCUSSION

The results of the three dependent variables within the groups pre and post the experiment are shown in Table 1.

Table 1. The results of the three dependent variables within the groups pre and post the experiment

		GROUP	Pre-Test(M±S)	Post-Test(M±S)	t	P
Deep Muscle Strengthening	0°	BWEG	90.16±30.89	99.93±27.96	-4.098	0.003*
		GWEG	92.17±29.15	95.04±29.72	-2.475	0.035*
	90°	BWEG	71.50±24.71	84±74±22.85	-5.063	0.001*
		GWEG	77.16±25.46	83.64±21.79	-2.232	0.053*
	-90°	BWEG	74.41±25.92	84.88±24.78	-4.859	0.001*

		GWEG	76.28±25.20	86.58±20.21	-2.148	0.060*
	180°	BWEG	55.32±19.86	68.49±21.93	-4.390	0.002*
		GWEG	68.49±21.93	71.43±22.40	-2.382	0.041*
Muscle Activity	FLEX MIN(μN)	BWEG	26.88±20.71	6.43±1.64	3.059	0.014*
		GWEG	16.29±7.93	11.99±7.55	2.686	0.025*
	NEUTRAL MIN(μN)	BWEG	20.21±10.23	8.18±2.63	3.603	0.006*
		GWEG	16.91±7.66	13.98±7.23	3.186	0.011*
	RP/FP RATIO	BWEG	1.59±0.58	2.95±0.58	-4.274	0.002*
		GWEG	2.26±0.80	2.80±0.39	-2.398	0.040*
PAIN	ODI(score)	BWEG	22.81±6.85	8.93±6.12	6.185	0.000*
		GWEG	21.43±7.91	12.18±8.59	3.937	0.001*

1) Effects of EMG biofeedback walking exercise on deep muscle strength: The results of the comparison within the groups pre and post the experiment are as follows: In BWEG, CENTAUR 0°, 90°, -90° and 180° showed statistically significant increase at all angles($p<0.05$). But in the GWEG, CENTAUR 0° and 180° showed statistically significant increase ($p<0.05$). but 90° and 180° angles no showed statistically significant increase ($p>0.05$).

2)Effects of EMG biofeedback walking exercise on muscle activity: The results of the comparison within the groups pre and post the experiment are as follows: The FLEX MIN and NEUTRAL MIN of the BWEG & GWEG showed a statistically significant decrease($p<0.05$). The RP/FP RATIO of the BWEG and GWEG showed statistically significantly increased ($p<0.05$). 3) Effects of EMG biofeedback walking exercise on lumbar function disability: The results of the comparison within the groups pre and post the experiment are as follows: The lumbar dysfunction index of the BWEG and GWEG was significantly decreased ($p<0.05$).

The results of the three dependent variables between the groups pre and post the experiment are shown in Table 2.

Table 2. The results of the three dependent variables between the groups pre and post the experiment

	Parameters	Group	Mean±SD	t	P
Deep Muscle Strengthening	0°	BWEG	9.78±7.55	-2.568	0.023*
		GWEG	2.97±3.64		
	90°	BWEG	13.30±8.16	-1.759	0.096
		GWEG	6.46±9.19		
	-90°	BWEG	10.47±6.81	-1.831	0.084
		GWEG	4.96±6.64		
	180°	BWEG	13.06±9.66	-3.255	0.040*
		GWEG	2.44±3.62		
Muscle	FLEX MIN(μN)	BWEG	20.44±21.13	2.350	0.030*

Activity		GWEG	4.29±5.05		
	NEUTRAL MIN(μV)	BWEG	12.02±10.55	2.627	0.032*
		GWEG	2.93±2.91		
	RP/FP RATIO	BWEG	-1.357±1.01	-2.109	0.017*
		GWEG	-0.535±0.70		
PAIN	ODI(score)	BWEG	13.87±8.97	1.424	0.165
		GWEG	9.25±9.39		

1)The results of the comparison between the groups pre and post the experiment are as follows: CENTAUR 0 ° and 180 ° showed statistically significant difference between groups($p<0.05$), but CENTAUR 90 ° and -90 ° showed no statistically significant difference between groups. 2)The results of the comparison between the BWEG and GWEG groups muscle activity pre and post the experiment are as follows: There was statistically significant difference between FLEX MIN, NEUTRAMIN and Flexion/Re-extension Ratio(FRR)($p<0.05$). The results of the comparison between the BWEG and GWEG groups ODI no statistically significant difference($p>0.05$).

In this study, walking exercise was performed by applying electromyography biofeedback to men and women with chronic low back pain. Compared to pre and post the experiment, the biofeedback walking exercise showed changes in the deep muscular strength, lumbar muscle activity, and lumbar function disability index of patients with chronic low back pain. The specific discussion of this study is as follows: First, this study walking exercise with EMG biofeedback significantly increased deep muscle strength of chronic low back pain patients. In this study, three-dimensional spinal stabilization exercise and strength test instrument CENTAUR was used to measure deep muscle strength. In the lumbar stabilization muscle strength test using the CENTAUR, the results of EMG measurement by muscle according to the test position were analyzed as follows. 0° (erector spinae, multifidus, gluteus maximus muscle), 90° (right multifidus, gluteus maximus, internal & external oblique abdominis), -90 °(left multifidus, gluteus maximus, internal & external oblique abdominis), 180 °(rectus abdominis internal & external oblique abdominis). The results of this study showed significant difference at 0 and 180 degrees. However, at 90 and -90 degrees, there was an increase in muscle strength but no statistically significant results were obtained. The results of previous studies on upright posture walking exercise on the balance of the trunk with back pain patient showed that the upright posture walking exercise had a positive effect on the recovery of normal balance on the sagittal plane [10, 11]. In other words, walking exercise had more influence on the anterior and posterior balance recovery than the left and right balance recovery. The results of this study showed that the statistical significance was not shown at 90 and -90 degrees. It was thought that the walking exercise had more influence on the movement in the sagittal plane and less influence on the muscles of the left and right side.

Also, several studies of lumbar stabilization exercise using visual biofeedback showed recovery around the lumbar spine. For these results, the attention provided by visual biofeedbacks suggests that during the repetitive training, the first step of motor learning has a great effect on the first step of motor learning by providing the key information on the recognition phase. The shape of the learned muscle contraction is located in the motor cortex through the integration step, and it affects the automatic step that occurs automatically in the daily movement or the exercise posture without conscious control [12, 13]. In this study, visual biofeedback training using EMG showed significant results in lumbar stabilization muscle strength.

Second, this study, changes in muscle activity in the BWEG and the GWEG were statistically significant. A decrease in muscle activity means that the patient has a low level of muscle activity with lumbar full flexion. Reduced muscle activity refers to a decrease in muscle activity with the patient fully flexed at the lumbar, which indicates muscle relaxation. When lumbar full flexion in the normal range, the activity of the muscle is small and the ligament is mainly held. Therefore, the lumbar full flexion(FLEX) minimum(MIN) muscle activity is defined as 10uV below normal, 10-15uV the boundary lines, and above 15uV above the abnormality Also, the neutral minimum value was below 9uV, and above that, it was related to the spinal disease. Both FLEX MIN and NEUTRAL MIN values were significantly decreased in both BWEG and BWEG. However, both of the values of BWEG appeared to be normal reference values, but in GWEG, the FLEX MIN values showed boundary lines and the NEUTRA MIN values showed abnormal values. These results indicate that the muscle activity of GWEG was significantly lowered post experiment than pre experiment, but the spinal disease was not recovered yet. Also, it is a result of demonstrating the effect of using

biofeedback using walking exercise. FRR test is the ratio of flexion peak to re-extension peak. Previous studies have shown that normal ratios are higher than 3.2 and those lower than 1.8 are associated with back pain. In this study, FRR test was statistically significant in both groups [14]. However, the normal range of 3.2 was not reached. These results suggest that muscle movement during flexion and re-extension is not yet normal, and that the 8-week intervention period is still insufficient to restore normal motion.

Third, in this study, both BWEG and GWEG had a positive effect on lumbar function disability index of patients with chronic low back pain. There was a significant difference within the groups but there was no significant difference between the groups. These results although the muscle activity of this study was statistically decreased but not in the perfect normal range in the results of the study, it is considered that the reason for not recovering the normal function. These results are in part supportive of the results of O'Sullivan, who tested the effect of lumbar stabilization [15].

CONCLUSION

The results of this study showed that walking exercise with biofeedback had a good effect on patients with chronic low back pain. Especially, it is thought that contraction deep muscles during walking exercise is helpful for deep muscular strength, muscle activity and lumbar function. However, there are limitations in generalizing the results of the research because the sample size is small and the research period is short. In future studies, it may be necessary to subdivide the back pain and to prolong the study period.

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