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Study on the Effects of Tetrax®-based Combined Rehabilitation Exercise on Chronic Back Pain Cases

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The purpose of this research is to utilizing the Tetrax® balance measuring instrument in order to analyze the postural balance of males and females in their 30 s diagnosed with chronic lower back pain who have followed a 12-week rehabilitation exercise program. The research also examines the effects on any change in back pain level. In terms of the variables in this research, postural balance (left/right, front/back, postural balance) and pain level change (0~100 mm) were measured. Pre-/post-experimental differences were assessed using the paired-t test. In addition, to identify any gender gap, we set the preliminary scores as a covariate and ran the Analysis of Covariance. Statistical significance (a) herein was set at 0.05. As a result of this research experiment, the left/right, front/back, and overall postural balance were found to increase in both the male and female cases, but with no statistical significance or gender gap. However, both males and females showed a significant decrease in their back pain levels. These findings demonstrate the necessity of continuing clinical research based on the Tetrax® equipment for scientific evaluation of the effects of rehabilitation exercises on chronic lower back pain patients and their balancing ability.

Keywords: Tetrax®, Chronic lower back pain, Complex rehabilitation exercise, Posture balance, VAS

1. INTRODUCTION

The vertebral column has an unstable structure prone to many orthopedic diseases. It has been reported that approximately 80% of the entire world population complain about back pain or have a related medical record [1,2].

Back pains are caused by weakened ligaments between the paravertebral muscle and the vertebral body as well as the imbalance between the back-area flexor and extensor, etc. [3]. In general, back pain treatments are divided into surgeries and non-surgeries. In fact, surgeries are only required in approximately 5% or under, while non-surgery methods alone can be effective in most cases to ease back pain and restore lumbar functions [4]. As reported in recent studies, the segmental spinal stability is an important part of the etiopathogenic mechanism of back pain, whereby lumbar stability exercises or core stabilizer exercises have been widely applied for back pain treatment and rehabilitation, and can minimize segmental spinal instability and ultimately reduce back pain levels [5,6]. Therefore, to understand the effect of these exercises, balancing ability assessment is essential. Balance control ability is a fundamental element in performing ambulation and daily routine activities [7], and is related closely to preprioception and body position sense control ability based on myofunction [8,9]. Clinical assessment methods

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of bodily balancing ability include the Berg balance scale, the Function Reach Test, Tinetti performance oriented mobility assessment, etc. However, these methods are limited in viewing diverse aspects of balance control [10]. Recently, Tetrax® balance measurement (Tetrax, Ramat Gan, and Sunlight Medical, Tel-Aviv, Israel) has been broadly employed as a way to utilize the force plate. Tetrax® balance measurement is a very useful device that utilizes 4 force plates for both heels and a toe of each foot to analyze the diversity of balancing ability and reasons for balance weakening [11]. The aim of this research is therefore to examine the effects of combined rehabilitation exercise on chronic lower back pain patients by using the Tetrax® balance measurer and verify its effectiveness.

2. EXPERIMENTS

2.1 Subject

A total of 20 people (10 men and 10 women) who visited the J Oriental Medical Hospital in Seoul participated in this study. These participants were patients with chronic lower back pain (CLBP) who had suffered from lower back pain (LBP) for over 3 months and were receiving general oriental therapy. Those with severe cardiovascular disease, those who could not walk, or those with symptoms of spinal tumor, spinal or disk infection, inflammatory disease, mental illness, or neurological disorder accompanied by motor disturbance were excluded. The participants' physical characteristics are shown in Table 1.

2.2 Experimental design

The experimental procedure followed in this study is shown in Fig. 1.

2.3 Posture balance

Figure 2 shows a system that can diagnose, balance, and enable bio-feedback training and therapy (Tetrax Ltd, Ranmat Gan, Israel). The subjects were asked to stand on four separate force plates in a comfortable and natural posture with their eyes open to measure each area (right/left toes and heels) in the unit of weight (kg).

The ideal posture balance is maintained when 25% of the weight is distributed to each area. The absolute value of deviation between the front-rear weight of the right foot and that of the left foot was divided by the body weight to obtain a right-left balance. Likewise, the deviation between the weight of the toes of both feet and the weight of the heels of both feet was divided by the body weight to obtain the front-rear balance. The absolute value of the distance from the ideal center on the two-dimensional coordinates to the center of the subject, which was calculated trigonometrically, was divided by the body weight, with the directional properties removed, to obtain general posture balance, which was the combination of right-left and front-rear balance. It is determined that due to the posture balance improves the right-left, front-rear and general posture balance reaches closer to zero.

2.4 Measurement of VAS

Huskisson's [12] visual analogue scale (VAS) was used, as shown in Fig. 3. The degree of pain was indicated on a 10 cm ruler graduated in millimeters at 1 cm intervals to obtain a VAS with questions asked by the tester from the physical examination and the subject's subjective feeling as a response.

Table 1. Physical characteristics of subjects.

Group	Age	Height (cm)	Weight (kg)	BMI
Female(n=10)	34.40±2.83	163.20±2.74	53.50±4.06	20.11±1.80
Male(n=10)	35.30±2.86	176.60±2.98	72.80±2.57	23.34±0.74

BMI : body mass index

Subject select	→	·CLBP patient (above 30 years) (Male=10, Female=10)
↓		
Agreement	→	·Agreeement written
↓		
Pre-test	→	·Balance, VAS
↓		
Exercise program	→	·Complex rehabilitation ex. (Lumbar stabilization & muscle fitness)
↓		
Post-test	→	·balance, VAS

Fig 1. Experimental procedure (CLBP: chronic lower back pain, VAS: visual analogue scale).

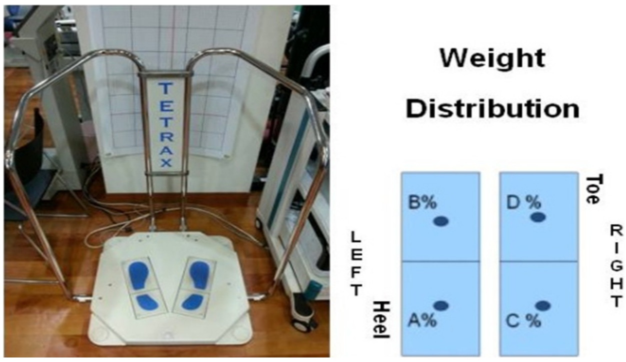

Fig. 2. Equipment used in the balance test.

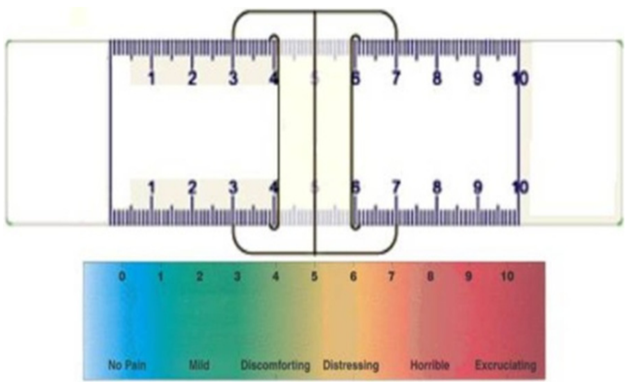

Fig. 3. Visual analog scale rulers.

2.5 Complex rehabilitation exercise

Table 2 show the three stage of complex rehabilitation exercise. The rehabilitation exercise program in this study was composed of a warm-up, main exercise, and a cool-down, and was provided in three sessions a week, 60 minutes per session. This program was composed of three stages in total - conditioning, improvement, and maintenance phases - by revising and complementing the complex rehabilitation exercise program developed by Pak et

Table 2. Complex rehabilitation exercise.

Phase	Complex rehabilitation program	
	Muscular strength	Stabilization
Phase I (1~4 wk)	Leg flexion/extension, dumbell biceps curl, dumbell triceps extension, calf raise, lat pull down *7~10 reps/2 sets	Quadruped arm/ leg lifts with bracing, gluteal squeezes, pelvic tilt *7~10 reps/2 sets: 7~10 reps with 5~7 s hold
Phase II (5~8 wk)	Medx exercise(isotonic), crunch machine, leg press, supine squat(non-weight bearing), multi-hip(adduction, abduction, flexion, extension) *7~10 reps/3 sets: Medx 15 reps/1set	Hip rotation exercise with elastic band, superman, Crunch on Gym-ball, side bridge on floor *7~10 reps/2 sets: 7~10 reps with 5~10 s hold
Phase III (9~12 wk)	Medx isotonic exercise, standing squat(weight bearing), push-up, dumbell lateral shouler raise *10~12 reps/3 sets: Medx 15 reps/1 set	PNF D1-D2, side bridge on Gym-ball, reverse curl with Gym-ball, superman position on Gym-ball, prone pull Ins on Gym-ball *7~10 reps/3 sets: 7~10 reps with 5~10 s hold

al. [13]. Tables 3 and 4 show the program, and the goals and considerations for each phase are shown in Table 5.

2.6 Data processing

To process the results of this study, an SAS ver. 9.2 statistical program was used to estimate the descriptive statistics of each item. A paired-t test was carried out to determine the differences between genders for before and after the exercise. ANCOVA was performed with prior scores set as the covariate to determine the gender differences according to the experimental treatment. The significance level (α) for testing hypotheses in this study was set at 0.05.

3. RESULT AND DISCUSSION

3.1 Changes in posture balance

The gender differences in the mean and standard deviation of posture balance before and after the experimental procedure are shown in Table 3.

1) ANCOVA of right-left balance

To determine the gender differences in the right-left balance after the experimental procedure, Analysis of Covariance (ANCOVA) was carried out, with the scores from the pretest as the covariate, the results of which are shown in Table 4.

No gender difference was caused by the experimental procedure, as shown in Table 4 (F=0.03, p<.87).

2) ANCOVA of front-rear balance

To determine the gender differences in the front-rear balance after the experimental procedure, ANCOVA was carried out with scores from the pretest as the covariate, the results of which are shown in Table 5.

In terms of the right-left balance, the ANCOVA model was not suitable for the front-rear balance, as shown in Table 5 (F=0.07, p<.80).

Table 3. Changes of posture balance factor according to gender.

variable	Group	Pre-test	Post-test	△%
R/L	Female	6.61±4.85	5.31±6.58	-1.29±1.40
	Male	7.57±6.30	5.31±3.53	-2.26±2.27
F/R	Female	26.99±13.47	14.40±10.32	-12.58±6.76
	Male	19.40±15.34	12.53±8.35	-6.87±4.11
PB	Female	28.66±12.26	16.17±11.01	-12.49±6.73
	Male	22.33±14.25	14.14±8.11	-8.19±3.96

Note: R/L, right/left; F/R, front/rear; PB: Posture balance; △%,: difference value pre and post; Mean±SD

Table 4. ANCOVA of right and left balance.

Source	df	SS	MS	F-value	Pr>F
Covariate	1	79.64	79.64	3.20	0.09
Group	1	0.64	0.646	0.03	0.87
Model	2	79.64	39.82	1.60	0.23
Error	17	422.68	24.86		
Corrected total	19	502.32			

Y_1 = 2.48+0.37*X1-0.36 (note : Y_1,femalepost-balance X_1, femalepre-balance)

Y_2 = 2.48+0.37*X2 (note : Y_2,malepost-balance; X_2,malepre-balance)R^2=0.16

Table 5. ANCOVA of forward and backward balance.

Source	df	SS	MS	F-value	Pr>F
Covariate	1	6.09	6.09	0.07	0.80
Group	1	22.11	22.11	0.24	0.63
Model	2	23.70	11.85	0.13	0.88
Error	17	1582.39	93.08		
Corrected total	19	1606.09			

Y_1 = 13.31-0.04*X1+2.18 (note: Y_1,femalepost- balance; X1,femalepre-balance)

Y_2 = 13.31+0.04*X2 (note: Y_2,malepost-balance;X_2,malepre-balance)R^2=0.15

Table 6. ANCOVA of posture balance.

Source	df	SS	MS	F-value	Pr>F
Covariate	1	30.92	30.92	0.32	0.58
Group	1	33.10	33.10	0.34	0.56
Model	2	51.506	25.75	0.26	0.77
Error	17	1655.42	97.37		
Corrected total	19	1706.92			

Y_1 = 16.34-0.08*X_1+2.65 (note: Y_1,femalepost-balance; X_1, femalepre -balance)

Y_2 = 16.34-0.08*X_2 (note: Y_2,malepost-balance; X_2,malepre-balance)R^2=0.03

3) ANCOVA of posture balance

To determine the gender differences in the right-left and front-rear posture balance after the experimental procedure, ANCOVA was carried out with personal measurement as the covariate, the results of which are shown in Table 6.

The experimental procedure caused no inter-group difference in general posture balance, as shown in Table 6 (F=0.34, p<.56).

3.2 Changes in VAS

Table 7 shows the VAS for men and women before and after implementing the exercise program.

In both men and women, the VAS for LBP decreased by about 44% and 47%, with statistically significant differences between before and after the experimental procedure.

1) ANCOVA of VAS

To observe the differences in the VAS, ANCOVA was carried out, the results of which are shown in Table 8.

As shown in Table 8, the ANCOVA of VAS demonstrated statistically significant reliability on the model (F=7.57, p<.01). No gender difference was observed in VAS as a main effect (F=2.05, p=.17). In other words, both men and women found an equal amount of pain reduction.

Tetrax® is a system capable of diagnosing current balancing ability while simultaneously realizing a biofeedback training treatment. It employs 4 independent force plates to measure 4 different areas (left, right toes and heels) to examine these area-to-area interactions and synchronization. The measurement outcomes are utilized for rehabilitation treatments for falling risk assessment, orthopedic injuries, spinal cord injuries, back and waist problems, and neurological damages, etc. In this sense, the present research studied CLBP patients to assess their postural balancing ability by utilizing Tetrax® equipment and to determine its effects on any change in bodily postural balancing ability and back pain levels. Segmental spinal instability has been reported as a key reason for CLBP occurrence [14], and it accelerates body imbalance to undermine arthromyalgia functionality. To address such a problem, lumbar stabilizer exercise has been reported as a key to secure appropriate postural balance for full rehabilitation [15]. Recently, the Tetrax®-based visual biofeedback exercise program and its analysis have also been widely utilized in the clinical field as a good tool for rehabilitation exercise and assessment.

In a previous research [16], 39 CLBP cases were examined to evaluate the patients' balancing ability through Tetrax® and found a significant difference between groups. However, in this research, Tetrax® was also employed to evaluate the effects of the combined rehabilitation exercise on patients with back pain and no statistically significant difference was found. This appears to be due to the fewer number of subjects and some examination failures in consideration of diverse individual conditions which possibly affected this research outcome. However, the inclination signaling of the regression equation in postural balance was found to gradually change (Table 7).

This research finding shows a short-term result of 12 weeks and suggests that a long-term follow-up research, if conducted, would provide a statistically significant outcome. Also, this research has found a significant reduction in the pain level of both males and females as measured together with postural balance. This means the rehabilitation exercise decreased the back pain level and contributed considerably to restoring the normal spinal functions. This finding is consistent with that in other researches [13], which reported that exercise programs were effective in spinal stability and bodily balance maintenance. It also concurs with the ACSM guidelines [17], which actively recommend performing an exercise at least once a week for postural balancing around the lumbar and abdominal part for back pain relief. Thus, applying the 12-week combined rehabilitation exercise program for the spinal stability to chronic lower back pain patients has been shown to work very effectively in pain relief by inducing normal vital dynamic moves. As this research has utilized Tetrax®, which only assesses stability during the static status, the research findings may be difficult to use clinically for balancing ability assessment in the dynamic status. Considering this, we believe that more studies will be necessary on Tetrax®'s visual biofeedback and that with continued follow-up studies, objective balancing assessment devices need to be developed that can evaluate balancing ability in the dynamic status.

Table 7. Changes of VAS according to gender (% point).

variable	Group	Pre-test	Post-test	△%
VAS	Female	65.10±5.78	18.02±2.49	-47.10±1.41***
	Male	64.00±9.44	19.60±5.13	-44.40±2.24***

Table 8. ANCOVA of VAS.

Source	df	SS	MS	F-value	Pr>F
Covariate	1	130.92	130.92	13.78	<.01
Group	1	19.47	19.47	2.05	.17
Model	2	143.72	71.86	7.57	<.01
Error	17	161.47			
Corrected total	19	305.20			

Y_1 = -2.45+0.34*X_1-1.98 (note: Y_1,femalepostVAS; X_1, femalepre VAS);Y_2= -2.45+0.34*$X_2$$R^2$=0.47

4. CONCLUSIONS

The aim of this research was to analyze the effects of Tetrax®-based combined rehabilitation exercise on chronic lower back pain patients. The combined rehabilitation exercise program (60 min per 3 times a week for 12 weeks) was administered to 20 chronic lower back pain patients (10 males & 10 females) in their 30s. The gender-specific changes in postural balance and pain levels were then examined. The results of the present research are as follows. The left/right, front/back, and overall balancing ability were found to increase in both the male and female cases, though showed no statistical significance or any gender gap.

Also, the back pain levels were significantly reduced in both males and females.

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