

The Effect of Swiss Ball Stabilization Exercise on Pain and Bone Mineral Density of Patients with Chronic Low Back Pain

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Abstract. [Purpose] The purpose of this study was to carry out a 16-week treatment of lumbar stabilization exercise with a ball targeting patients with chronic low back pain and investigate its effect on alleviation of low back pain and bone mineral density. [Subjects and Methods] The subjects of this study were 36 patients who were diagnosed with chronic low back pain. They were divided into a conservative treatment group (CTG, n=12), floor exercise group (FEG, n=12), and ball exercise group (BEG, n=12). The degree of recovery from pain was looked into using a visual analogue scale (VAS) and DEXXUM T (OsteoSys, Seoul, Korea) which was used to observe the changes in bone mineral density. [Result] Although the VAS score was reduced in FEG and BEG with treatment, it was not reduced in CTG. Also, the bone mineral density was increased in FEG and BEG, while it was reduced in CTG. [Conclusion] Lumbar stabilization exercises using a ball are thought to be an effective interventional therapy for the alleviation of chronic low back pain and to increase bone mineral density of patients.

Key words: Chronic low back pain, Swiss ball exercise, Bone mineral density

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INTRODUCTION

As the development of civilization has led to decreasing levels of physical activity, chronic illnesses accompanying various symptoms and activity disorders are increasing. The representative among them is the increase in low back pain¹⁾. A person with low back pain avoids activity to reduce the pain, and this causes an increase in pain or psychological stimulus due to atrophy of the lumbar extensor and attenuation of muscle strength²⁾. O'Sullivan et al.³⁾ pointed out that the occurrence of problems in spinal stability causes the relapse of low back pain, as the core muscles of patients with low back pain are weakened compared with a normal person and the patients lack relocating ability due to the decrease in the capacity of the proprioceptive sense. This has also been proven in the study of Cooper et al.⁴⁾, in which they reported that the atrophy of muscles located in the core of patients with chronic low back pain is greatly advanced compared with patients without chronic low back pain.

Lumbar stabilization exercise is related to the capacity to control the strength of movement when the posture is unstable and consciously and unconsciously control movement to maintain a neutral spine position, a position of the spine that can best adapt to the load of the spine⁵⁾. The purpose of the lumbar stabilization exercise is to recover the capacity to control muscles and their movement, and it was recently

proposed to be an approach indispensable in the treatment of patients with low back pain⁶⁾. In particular, exercise using the Swiss ball has been proven to be not only effective for development of the upper body but also for patients suffering from low back pain and sciatica, to provide stability for the spine, to be helpful for patients with sciatica and referred pain⁷⁾, and to be even more helpful for patients who have experienced failure of discectomy than any other exercises and physical therapies⁸⁾.

Osteoporosis is a representative illness of adults and elderly women characterized by the low bone mineral density, damage in the ultrastructure of the bone, and sensitivity towards fracture⁹⁾ and causes frequent occurrence of fractures that lower quality of life due to limits on activity, decrease in self-esteem, depression, and other factors¹⁰⁾. Although osteoporosis often occurs in the elderly and women after menopause, it is a serious illness in that the importance of bone health should be recognized from adolescence, and the gravity of the negative consequences brought about by osteoporosis should not be overlooked from early stages of adulthood¹¹⁾. Although the method of maintaining maximum bone mass is uncertain, it is reported that genetic factors¹²⁾ and regular exercise have great influence¹³⁾. Generally, adequate physical activities, namely ones that exert minimum effective strain (MES), over a long period of time increase the muscle mass and change the bone mass with an impulse that accelerates during physical activities¹⁴⁾. In particular, it is reported that the resistance exercise not only prevents bone loss and increases the strength of bone but also increases the muscle mass, strengthens muscles, and

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enhances the balance of the body weakened due to aging¹⁵).

Therefore, the purpose of this study was to carry out a 16-week treatment of lumbar stabilization exercise with a ball targeting patients with chronic low back pain who do not need surgery and to look into its effects on alleviation of low back pain and bone mineral density.

SUBJECTS AND METHODS

The subjects of this study were 36 patients composed of 12 patients in the conservative treatment group (GTG), 12 patients in the floor exercise group (FEG), and 12 patients in the ball exercise group (BEG) who were diagnosed with chronic low back pain and not severe spinal disease by a physiatrist at Y hospital in Yeongju-Si, Korea, between Dec. 2010 and Apr. 2011. Patients who were suffering from back pain accompanying compression fracture, diseases such as spondylarthritis, rheumatoid arthritis, systematic disease (cancer patients), cerebral disease, and heart disease and those in which electrotherapy was contraindicated, as well as others for various reasons, were excluded as subjects. The purpose and method of this study were explained, and voluntary consent was received from all subjects. Subject characteristics are summarized in Table 2.

In CTG, hot pack, interference current (modulation depth, 100%; frequency, 80–100 Hz), and deep-heat (micro-wave, intensity: 100 W/Kg) treatment were carried out for 20, 15, and 5 minutes respectively 3 times per week for 16 weeks. In FEG, the patients performed lumbar stabilization exercise on a fixed floor, maintaining 10 seconds of equilibrium, with 3-second breaks between repetitions for 40 minutes a day, 3 times per week for 16 weeks (Table 1). In BEG, the patients received the conservative treatment and performed lumbar stabilization exercise on a ball, maintaining equilibrium for 10 seconds, with a 3-second break between repetitions for 40 minutes a day, 3 times per week for 16 weeks as (Table 1). For the ball exercise treatment, a Gymnastikball (Togu, Germany) was used, and the ball size

was determined based on the guidelines of Togu (height: ball size) (under 155 cm, 45 cm; 156–165 cm, 55 cm; 165–178 cm, 65 cm; over 178 cm, 75 cm).

For the measurement of pain, a visual analogue scale (VAS) was used. For the measurement of bone mineral density, DEXXUM T (OsteoSys, Seoul, Korea) was used. This tool is able to measure lumbar vertebrae and three parts of the femur in a nonstop scan, and precise measurement data can be collected for the same part during remeasurement as it is equipped with a laser pointer. Measurement errors were minimized with standard data for Koreans and a cruciform laser pointer. A quantitative evaluation of pain and bone mineral density of lumbar vertebrae 1 to 4 was performed before the experiment, 8 weeks after the experiment, and after completion of the 16 weeks of the experiment, and 30 minutes of rest was given to the patients after exercise to minimize fatigue.

For data analysis, a one-way ANOVA was applied to analyze the characteristics of the subject using SPSS 12.0 for Windows. In order to compare the VAS and bone mineral density of each group before the experiment, 8 weeks after the experiment and after completion of the experiment, a two-way repeated ANOVA was applied, and the level of statistical significance was set as 0.05 for all analyses.

RESULTS

The VAS scores based on the intervention period are shown in Table 3. In regards to the VAS score based on the intervention period, there was a statistically significant difference ($F=145.09$, $p<0.05$), and there was also a statistically significant difference in the interaction based on the intervention period and intervention method ($F=30.42$, $p<0.05$). Validation of the scale of effect for each intervention period revealed that there was a statistically significant difference between before the intervention and after 16 weeks and between after 8 weeks and after 16 weeks ($p<0.05$). Comparison of the effect between each subject in regard to the 3

Table 1. Lumbar stabilization exercise

Floor Exercise	Ball Exercise	Amount of Exercise
Supine bridge	Supine bridge on Swiss ball	
Sit-up	Sit-up on Swiss ball	10 times/set,
Arms, legs cross-lifting	Arms, legs cross-lifting on Swiss ball	3 sets,
Side bridge	Side bridge on Swiss ball	3 times/week

Table 2. General characteristics of subject

	Sex (n)	Age (yr)	Height (cm)	Weight (kg)
CTG (n=12)	Male: 4	35.0 ± 5.9	165.4 ± 7.6	59.8 ± 7.5
	Female: 8			
FEG (n=12)	Male: 4	35.2 ± 6.6	164.8 ± 9.2	62.4 ± 10.5
	Female: 8			
BEG (n=12)	Male: 5	34.1 ± 5.9	164.7 ± 5.4	60.8 ± 7.1
	Female: 7			

(Mean ± SD)

groups showed that there were statistically significant differences ($F=11.06$, $p<0.05$) (Table 3).

The bone mineral density based on the intervention period is shown in Table 4. There were statistically significant differences in regard to the bone mineral density based on the intervention period for each lumbar vertebra (L1 ($F=36.91$, $p<0.05$), L2 ($F=20.96$, $p<0.05$), L3 ($F=8.83$, $p<0.05$), L4 ($F=5.28$, $p<0.05$)). Also, there was a statistically significant difference in regard to the interaction based on the intervention period and method (L1 ($F=20.57$, $p<0.05$), L2 ($F=13.61$, $p<0.05$), L3 ($F=12.51$, $p<0.05$), L4 ($F=12.17$, $p<0.05$)). Validation of the scale of effect for each intervention period showed that there were statistically significant differences between before the intervention and 16 weeks after the intervention and between 8 weeks and 16 weeks after the intervention in regard to lumbar vertebrae 1 to 4 ($p<0.05$). Comparison of the effect between each subject in regard to the 3 groups showed that there was no statistically significant difference for each lumbar vertebra (L1 ($F=1.03$, $p>0.05$), L2 ($F=0.64$, $p>0.05$), L3 ($F=0.26$, $p>0.05$), L4 ($F=0.29$, $p>0.05$)) (Table 4).

DISCUSSION

The purpose of this study was to look into the effects of lumbar stabilization exercise with a ball on the pain and bone mineral density of patients with chronic low back pain. As a result, the floor exercise group (FEG) and ball exercise group (BEG) displayed significant decreases in VAS scores compared with the conservative treatment group (CTG).

Table 3. Comparison of VAS score within the intervention period in each group (unit: score)

Group	Pre	8 weeks	16 weeks
CTG	5.38 ± 0.93	5.08 ± 0.67	5.00 ± 0.83
FEG*	5.46 ± 1.05	4.00 ± 0.60	3.50 ± 0.52
BEG*	5.87 ± 0.71	3.79 ± 0.50	2.42 ± 0.51

(Mean ± SD)

Although there was no significant difference among groups for the bone mineral density, it was increased in FEG and BEG and decreased in CTG.

Lumbar stabilization refers to internal stabilization achieved by isometric contraction of the abdominal and lumbar muscles to maintain stability¹⁶. It has also been referred to in the literature as core strengthening, motor control training, and dynamic stabilization¹⁷. O'Sullivan et al.¹⁸ reported that among the effects of lumbar stabilization exercise on the alleviation of pain and improvement in function of patients with low back pain, special exercises concerning the stability of the trunk are more effective in alleviating pain and improving function of patients with chronic spondylolisthesis, spondylolysis, and degenerative disc compared with conservative treatment. In particular, the Swiss ball exercise is one of the dynamic lumbar stabilization exercises, and its main principle is to reduce low back pain by comprehensively improving muscle strength, endurance, balance, and flexibility of the trunk and the reflexes, cognitive sense, balance, and proprioceptive sense while the individual leans their body on the ball¹⁹. In the study of Saal²⁰, a treatment success rate of 87% was displayed when 52 patients with herniated discs were treated with dynamic lumbar stabilization exercise, and 92% of patients returned to work. The VAS was used to measure the degree of pain in this study as well. The results of this study were in agreement with the preceding studies in that the VAS scores of FEG and BEG were significantly decreased compared with CTG. It can be considered that the lumbar stabilization exercise reduces pain by reducing the stimulus delivered to pain-sensitive tissues such as ligaments and joint capsules through reduction of the load on the lumbar vertebra as a result of enhancing the muscle function of the stabilizer muscles and core abdominal muscles that contribute to positional control of the trunk.

According to the report of Malina²¹, physical composition continually changes from infancy to adulthood, constant physical activities have a positive influence on physical composition, and an effective exercise program can prevent bone loss in the lumbar vertebra and femur

Table 4. Comparison of BMD within the intervention period in each group (unit: g/cm²)

Group	Lumbar	Pre	8 weeks	16 weeks	Rate of change (%) 16 weeks-Pre
CTG	L1	0.972 ± 0.114	0.967 ± 0.112	0.962 ± 0.112	-1.03
	L2	1.065 ± 0.090	1.061 ± 0.090	1.057 ± 0.090	-0.75
	L3	1.142 ± 0.106	1.138 ± 0.110	1.129 ± 0.110	-1.14
	L4	1.118 ± 0.116	1.112 ± 0.118	1.088 ± 0.121	-2.68
FEG	L1	1.022 ± 0.119	1.026 ± 0.118	1.031 ± 0.118	0.88
	L2	1.108 ± 0.137	1.112 ± 0.136	1.119 ± 0.134	0.99
	L3	1.159 ± 0.120	1.160 ± 0.120	1.166 ± 0.118	0.60
	L4	1.121 ± 0.106	1.123 ± 0.106	1.137 ± 0.104	1.43
BEG	L1	1.012 ± 0.123	1.016 ± 0.123	1.051 ± 0.112	3.85
	L2	1.100 ± 0.137	1.102 ± 0.137	1.118 ± 0.137	1.64
	L3	1.124 ± 0.130	1.125 ± 0.129	1.138 ± 0.130	1.25
	L4	1.116 ± 0.119	1.138 ± 0.106	1.166 ± 0.105	4.48

(Mean ± SD)

neck of women before and after menopause or increase the bone mass by 1% per year²²⁾. Rhodes et al.²³⁾ reported that the bone mineral density of the femur and lumbar vertebra increased after resistance training for 52 weeks and that of the control group decreased, and Lohman et al.²⁴⁾ also reported an increase in bone mineral density after execution of 18 months of muscle strength exercise. Furthermore, the study of Krølner et al.²⁵⁾ reported that the bone mineral density of the lumbar vertebra increased about 3.5% in 50- to 72 year-old women who carried out regular training for 8 months and that that of women who did not receive training decreased about 2.7%. In addition, several studies have reported positive correlations between general physical activity, structured exercise, and back strength or bone mineral density²⁶⁻²⁹⁾. In this study, examination of the effects of lumbar stabilization exercise on bone mineral density revealed significant results with regard to measurements in FEG and BEG based on the intervention period. Although there were no significant differences in the comparison among groups, bone mineral density was reduced by 1.4% in CTG and increased by 0.96% and 2.81% in FEG and BEG respectively. It can be considered that there was no significant difference because this study was conducted for only 16 weeks, which is a relatively a short period of time compared with previous studies. However, the fact that the average age of the subjects for this study was in the mid 30's and that it included men contributed to enhancing the rate of increase of bone mineral density in BEG regardless of the study being carried out for a short period of time.

Considering the above results, it can be said that the lumbar stabilization exercise on a ball is effective for alleviating low back pain and produces a higher rate of increase of bone mineral density compared with lumbar stabilization exercise on the floor. As it suggests that the lumbar stabilization exercise on a ball has a positive influence on the increase in bone mineral density, regular and long-term lumbar stabilization exercise would be very helpful for patients who are suffering from osteopenia and osteoporosis.

Limitations of this study include a small sample size and the fact that it did not control for lifestyle influences on bone mineral density. Therefore, future studies need to be conducted without these limitations.

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