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The effects of whole body vibration on static balance, spinal curvature, pain, and disability of patients with low back pain

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Abstract. [Purpose] The purpose of this study was to investigate the impact of whole body vibration (WBV) on static balance, spinal curvature, pain, and the disability of patients with chronic lower back pain. [Subjects and Methods] The subjects were of 40 patients, who were randomly assigned to WBV and control groups. Twenty-five minutes of lumbar stability training and 5 minutes of WBV were conducted for the WBV group, and 30 minutes of lumbar stability training was conducted for the control group. The training was conducted three times per week for a total of 6 weeks. Static balance, spinal curvature, pain, and disability were measured before and after the intervention. [Results] After the intervention, the WBV group showed a significant differences in static balance, spinal curvature, pain, and disability. The control group presented significant differences in pain, and disability. In the comparison of the two groups, the WBV group showed more significant improvements in the fall index and pain. [Conclusion] WBV can be recommended for the improvement of the balance ability and pain of chronic lower back pain patients.
Key words: Whole body vibration, Pain, Balance

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INTRODUCTION

Low back pain (LBP) not only induces a decline in balance but also lowers proprioception by inducing instability in the lumbar region, which is followed by weakening of the deep lumbar muscles or repetitive trauma, collectively lowering neuromuscular control capacity and coordination of the muscles. In order to resolve the problems of lower back pain, motor control of the lumbopelvic region needs to be recovered[1)]. Particularly, as the loss of priopriocеption induces neuromuscular functional dysfunction and spinal segment instability, the treatment approach for the recovery of proprioception elicits posture control ability and improvements in the quality of life of patients with LBP through improvement of muscular control, coordination of muscles, and the recovery of stability in the spinal segments[2)]. Recent studies have recommend a treatment method using WBV exercise as a method of improving pain, functional dysfunction, and the proprioception of patients with LBP[3)]. WBV is a convenient and safe method of directly stimulating the muscles and tendons, and can be applied in to various positions for pain alleviation and functional recovery of patients with chronic LBP[4)].

WBV has been reported to improve bone density, lower muscular pain and functional dysfunction[5)], and improve muscle strength[6)]. However, the study of WBV is insufficient as previous studies only examined pain, functional dysfunction, and improvement in muscle strength. Therefore, the purpose of this study was to examine the changes in balance ability, lumbar curvature, pain, and the Oswestry disability index (ODI) of patients with LBP after the application of WBV during lumbar stability training, to examine the effects of WBV on patients with chronic LBP.

SUBJECTS AND METHODS

The subject were 40 patients with LBP working in a business located in C city. Those who fully comprehended the procedure of this study and voluntarily agreed to participate were selected as subjects. This study was conducted according to the principles of the Declaration of Helsinki. Those with over 12 weeks of continuous LBP and without acute neurologic symptoms were selected. Those with tissue damage such as acute herniated nucleus pulposus, inflammation, or others, those suffering from heart disease, and those who were pregnant were excluded.

For the delivery of low frequency WBV, a Galileo 2000 (Novotec, Pforzheim, Germany) was used. It delivers vibration to both lower extremities. The range of the vibration frequency is 1–50 Hz and amplitude of the frequency can

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be controlled without restriction. In the present study, a frequency of 18 Hz, as in a previous study[7], was applied for 5 minutes. The subjects were positioned so that there was slight flexion of the knee joints and lumbar lordosis while they stood comfortably on the platform of the vibration device.

Lumbar stability training was conducted to elicit independent contractions and muscular reinforcement of the deep abdominal muscles, contraction of the deep abdominal muscles which contribute to lumbar stability in certain positions, and global muscles which perform using a pressure biofeedback unit (PBU). The lumbar stability training comprised static and dynamic stability training methods[1].

In static lumbar stability training, movements to maintain contraction of the transversus abdominis (TrA) were sufficiently performed as measured by a PBU. The subjects were educated how to perform proper contraction of TrA, and maintain the stability of the lumbar region during the exercise[8]. The training was executed in the prone and supine positions.

For the supine position, the PBU was placed under the lumbar spine and the pressure was inflated to 40 mmHg after checking that subjects could comfortably breathe while holding the position. The pressure was gradually increased in 2-mmHg steps from 40 to 48 mmHg. For the prone position, PBU was placed under the navel and the pressure was increased to 70 mmHg. Then, the pressure was reduced to 60 mmHg by drawing in the abdomen under the navel toward the lumbar region. The training time was at least 10 seconds, and 5 seconds of rest was given between each maneuver in the two positions. Each maneuver was repeated in twice for each stage and repeated was a total of 10 times.

Dynamic stability training was performed using the movements of the upper and lower extremities in the side-lying and supine positions. The PBU inflated to 50 mmHg after placing it under the side, and sunjects lowered the pressure to 40 mmHg by drawing in the abdomen to the lumbar region. Then, 3 sets of motions were preformed, counting 4 times of hip joint abduction and adduction as 1 set. Five seconds rest was given between sets, and a 1-minute rest between the positions[8, 9]. The training was supervised by an experimenter to ensure the tasks were performed correctly.

For pain assessment, a 100 mm visual analogue scale (VAS) was used in order to assess the pain of subjects. VAS is an assessment method which has high reproducibility, high validity (r=0.77), and reliability (r=0.99), express the intensity of their pain[10].

The Korean Oswestry disability index (KODI) was used for the disability index. The KODI is an assessment tool that was developed as a self-administrated survey by Fairbank et al.[11] to measure the functional dysfunction of patients with LBP and it has been revised to create many versions. The discomfort and levels of disability sensed by the patients in the 10 sections of pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sexual life, social life, and traveling are indicated on a scale of 0–5 points. Then, the total sum of the responses was divided by the maximum possible value and converted to a percentage (%) by multiplying by 100%. Higher scores signify higher levels of functional dysfunction. The test-retest reliability of KODI has been presented to be high (r=0.92).

Thoracic and lumbar spinal curvature assessment were measured using 3D tomography (Backmapper, Formetric, Diers, 2011, German). For the measurement, the subjects were instructed to show their back to the camera after removing their tops and lowering their underwear so that the sacrum could be partially seen. Then, they were instructed to relax their body by standing with their feet apart at shoulder width with their arms hanging naturally by their sides. The experimenter attached stickers to the C7, sacrum apex, left posterior superior iliac spine (PSIS), right PSIS, and the right and left scapula inferior angles, which were identified by direct palpation, in order to mark the anatomical points for the analysis. The measurement was completed in 0.04 seconds, and lumbar lordosis and thoracic kyphosis were automatically computed.

Static balance assessment was measured using a Tetrax (Sunlight Medical, Ramat Gan, 2012, Israel), which performs diagnosis and examinations of posturography. The assessment of the vestibular organ, visual sense, somatic-sensory, and the central nervous system was performed, and the fall index was computed by calculating the average. Postural sway was of the center of pressure (COP) was measured by pressure sensors with subjects standing on the platform. A low fall index signifies fair balance ability.

SPSS version 18.0 was used for the statistical analysis. Descriptive statistics were used for the general characteristics of the subjects and the paired t-test was conducted for within-group comparisons of the vibration and control groups between before and after the intervention. For comparison of the groups, the independent t-test was carried out. Level of significance was chosen as 0.05.

RESULTS

There were 12 males and 8 females in the vibration group and 9 males and 11 females in the control group. The average age of the vibration group was 32.80 and that of the control group was 30.95. Weight, height and BMI of the vibration group were 70.76 kg, 170.10 cm, and 24.37 kg/m^2 respectively and those of the control group were 66.61 kg, 168.43 cm, and 23.33 kg/m^2 respectively. There were no significant differences in the general characteristics between groups. Significant differences were found after the intervention in the WBV group for the fall index, spinal balance, lordosis angle, VAS score, and ODI score ($p<0.01$), and for spinal balance, VAS scale, and ODI score in the control group ($p<0.01$). In the comparison of the groups, more significant improvements were found in the WBV group for the fall index and VAS score compared to the control group ($p<0.05$) (Table 1).

DISCUSSION

The application of WBV was effective for the recovery of the static balance of patients with chronic LBP in this study. WBV was reported to activate mechanotransduction similar to exercise in a previous study[12]. For subjects who suffer from loss of proprioception and balance ability, the application of WBV has been reported to increase the muscle

Table 1. Comparison of whole body vibration within and between groups (N=40)

		Vibration group (n=20)	Control group (n=20)
FI	Pre	30.59 (14.97)	23.40 (12.73)
	Post	12.80 (10.39)†**	21.69 (12.68)‡*
KA	Pre	44.50 (9.61)	43.05 (8.61)
	Post	44.80 (4.96)	42.85 (7.48)
LA	Pre	28.75 (8.90)	28.55 (5.74)
	Post	32.05 (7.86)†**	30.55 (6.92)
VAS	Pre	5.60 (1.60)	5.25 (1.12)
	Post	2.70 (1.26)†**	3.50 (0.76)†**‡*
ODI	Pre	17.85 (11.09)	15.30 (7.57)
	Post	12.45 (6.06)†**	12.80 (5.67)†**

Values are expressed as mean(SD), FI: fall index, KA: kyphotic angle, LA: lordotic angle, VAS: visual analogue scale, ODI: oswestry disability index

†within group comparison, ‡between group comparison, *p<0.05, **p<0.01

strength around the lumbar region by activating the mechanoreceptors of contractile and non-contractile tissues in the lumbo-pelvic region and to assist the recovery of proprioception through the improvement of muscle coordination[13]. A previous study also suggested that vibration stimulation in the standing position has a positive effect on postural balance ability[14]. After applying diverse vibration stimulation (10, 60, 120 Hz) to healthy elderly females, there was improvement in proprioception of their knee joints[15], and the application of WBV to healthy elderly persons was reported to have enhanced their balance ability and reduced their fall index scores[16]. Richardson et al.[1] reported that lumbar stability training reduced pain and the disability index scores and enhanced the balance ability through activating the deep abdomen muscles strength and enhancing the coordination of the muscles. There was a statistically significant change in the balance index after lumbar stability training in this study, similar to the results of previous studies. As noted above, previous studies have reported that lumbar stability training and WBV improve the balance ability and helps the recovery of proprioception, muscle strength, and muscle coordination.

Due to the limitation of function by pain, a flat back is induced in patients with LBP, and reducting of lumbar lordosis. Arokoski et al.[8] reported that lumbar stability training for patients with LBP changes the lumbar structure by fostering the lumbar stability and the activation of the deep abdomen muscles. Furthermore it reduces pain, which restricts in function, and ODI. The results of this study are similar to the findings of previous studies, showing significant increases in lumbar lordosis after the intervention in both the vibration and control group.

The application of WBV in this study was effective at alleviating the pain of patients with chronic LBP. WBV stimulates receptors Pacinian corpuscle and Meissner corpuscles which endure the vibration and stimulates interneurons within the spinal cord by delivering signals through myelinated fiber A-beta fiber. Also, it suppresses the pain transmitted by C-fiber or A-delta fiber[17]. WBV reduces pain and ODI score through recovery of functional dysfunction caused by back pain with the activation of muscular contractions through stimulation of the somato-sensory system, thereby restoring nerve roots control ability[18]. Lumbar stability training has been reported to reduce pain and ODI scores through positive effects on functional movement by fostering stability of the spinal segments and recovery of nerve root control ability, improving postural balance, and recovering a flexibility of posture and movement[19]. Moreover, lumbar stability training in this study was also effective at decreasing pain and ODI scores, and it was more effective at alleviating pain when cinducted with WBV compared to sole application of lumbar stability training. Furthermore, Rittweger et al.[7] reported that a combination of the Mckenzie Exercise and vibration treatment for 12 weeks was effective at alleviating pain and recovering the function of patients with chronic LBP. The results of this study show there were a significant decreases in pain and ODI scores after the administration of lumbar stability training and WBV for patients with chronic LBP, and these results are in agreement with the results of previous studies.

Limitations of this study include the inability to generalize the results due to small the number of subjects partcipating in this study and the absence of data on the WBV administration times that optimize the treatment effect. Lastly, there was no control of the subjects except during the intervention periods. The verification of the effects of WBV should be carried out in future studies after addressing the limitations of this study.

In conclusion, for positive effects on static balance and pain of patients with chronic LBP, WBV should be applied together with lumbar stability training for more significant effects than the application of lumbar stability training alone. Therefore, we suggest the combination of lumbar stability training and WBV to enhance in balance ability and decrease the lumbar pain of patients with chronic LBP.

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