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Effect of Posterior-Anterior Mobilization of the Thoracic Spine on Pain, Respiratory Function, and Thoracic Circumference in Patients With Chronic Low Back Pain

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Abstract

Background: Posterior-anterior (PA) vertebral mobilization, a manual therapy technique has been used for relieving pain or stiffness treating in spinal segment for in clinical practice, however evidence to gauge efficacy is yet to be synthesised.

Objects: This study aimed to investigate the effect of PA mobilization of the thoracic spine on the respiratory function in patients with low back pain (LBP).

Methods: The study participants included 30 patients with chronic LBP. They were randomly allocated to the experimental and control groups. The experimental and control groups received PA mobilization of the T1-T8 level of the thoracic spine and placebo mobilization, respectively. All patients received interventions for 35 minutes a day, five times a week, over 2-week period, respectively. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), peak expiratory flow (PEF), forced expiratory flow 25~75% ($FEF_{25\sim75\%}$), and chest wall expansion were measured before and after the intervention. Statistical analysis was performed using independent t-test and two-way analysis of variance, and Pearson's correlation analysis was used to compare the correlation between respiratory function and chest measurement.

Results: The experimental group showed significant improvements in FVC, FEV_1, PEF, $FEF_{25\sim75\%}$ ($p<.05$), and chest wall expansion ($p<.05$) compared with the control group.

Conclusion: PA mobilization of the upper thoracic spine may be beneficial for improving respiratory function parameters including FVC, FEV_1, PEF, $FEF_{25\sim75\%}$, and chest wall expansion in patients with chronic LBP.

Key Words: Low back pain; Respiratory function; Thoracic mobilization; Vital capacity.

Introduction

Low back pain (LBP) is one of the most common neuromusculoskeletal disorders, with a lifetime prevalence rate of >75% (Hanney et al, 2016). Research into the pathogenesis of chronic LBP has identified many contributing factors, including socioeconomic and psychological influences, genetic predisposition, degenerative changes, and muscle imbalance (Verkerk et al, 2012). Moreover, the medical cost of these problems is causing yearly economic losses. Patrick et al (2014) classified cases of persistent symptoms lasting longer than 3 months as chronic, and reported the importance of early treatment because of the slow recovery of chronic LBP over time.

LBP has a high correlation with respiratory function (Grimstone and Hodges, 2003; Smith et al, 2006). Respiration regulates the movement of the diaphragm through the up-and-down movement and contraction and relaxation of the muscles between

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the ribs and problems with the movement of the rib cage can cause dysfunction of these respiratory muscles (Cahalin et al, 2002). Patients with various pulmonary diseases have problems not only with the lungs but also with the respiratory muscles, and they also experience musculoskeletal disorders (Wagner, 2006). In other words, patients with LBP commonly have musculoskeletal disorders with dys-function of the respiratory muscles, and abnormal symptoms and rapid fatigue of the respiratory mus-cles are also observed during low-intensity exercise (MacIntyre, 2006).

The spine movement of patients with back pain is partially restricted and limited, particularly in terms of extension mobility of the upper thoracic spine (Mohanty and Pattnaik, 2016). Specifically, unstable lumbar spine with pain and abnormal functional movement reduces the mobility of adjacent spinal joints such as the thoracic region. And also, the thoracic spine is directly connected to the thorax and joints, the movement of the thoracic spine is inter-dependent, and the thoracic mobility is an important factor in the respiratory system. Increased chest wall mobility positively influences respiratory control, coughing ability, lung capacity, and spinal motion by inducing smooth movement and contraction of the respiratory muscle (Hodges and Gandevia, 2000). Hypomobility of the thoracic spine causes the chest to sink and limits the expansion of the circumference of the thorax during inspiration.

Decreased respiratory function is also associated with back pain because it affect the posture control ability (Ruhe et al, 2011). In particular, the dia-phragm is an important muscle in regulating the spine during postural control on inspiration (Hodges and Gandevia, 2000). In previous studies in patients with chronic LBP and chronic obstructive pulmonary disease, the proprioceptive sensations needed for pos-tural control were reduced when the inspiratory muscle was used (Janssens et al, 2010; Janssens et al, 2013). In addition, patients with chronic LBP ex-perienced greater diaphragmatic fatigue than healthy controls, and training of the inspiratory muscle in these patients improved postural control and reduced pain intensity (Janssens et al, 2010).

Spinal joint mobilization in patients with LBP has been reported to help relieve pain (Savigny et al, 2009). Maitland has categorized and applied joint mobilization from grade 1 to grade 5 for the treat-ment of joint dysfunction (Banks, 2010). Cervical and thoracic joint operations can control the autonomic nervous system to regulate respiratory muscles and pulmonary function by promoting the activity of the sympathetic nerves emerging between the vagus nerves and thoracic vertebrae 1 and 5, which are the 11th cranial nerves under the control of para-sympathetic nerves (Engel and Vemulpad, 2007). Yang and Kim (2015) reported that the application of thoracic spine mobilization to patients with chronic LBP had a positive effect on pain and proprioceptive sensation. Babina et al (2016) reported improved pul-monary function in patients with chronic LBP when thoracic spine mobilization was applied, and Ito et al (1999) reported that reduction of the range of motion of the thoracic spine reduced pulmonary function, in-creased chest circumference (CC), and has been as-sociated with improved pulmonary function.

Although several reports are available on pain re-duction and motor function improvement in patients with LBP, data on respiratory ability to evaluate the effects of joint mobilization and pulmonary function are still lacking. This study aimed to investigate the effect of joint mobilization of the thoracic spine on pain and respiratory function and CC length in pa-tients with chronic LBP.

Methods

Subjects

The study subjects included 30 patients with chronic LBP. A physical therapist with 6 years of experience made the diagnosis of LBP according to the clinical assessment criteria. Medical diagnosis of

LBP was made by an orthopaedist or a physician in hospital. The inclusion criteria were subjects who had >3 months of back pain, had visual analog scale (VAS) score of >4 points, and showed positive on thoracic motility test. The exclusion criteria were cardiopulmonary system and nervous system problems, smoking, spinal fractures, and spinal joint surgery. Explanations about the procedure and stability were given to all subjects before the experiment, and informed consent was obtained from all the subjects, and this study was approved by the university ethics and institutional review board (approval number: 2018-057-01). Table 1 shows the general characteristics of the study subjects.

Instrumentation and measurement

Visual analogue scale

The visual analogue scale (VAS) is considered to be one of the best methods available for the estimation of the intensity of pain. VAS is self-report measure consisting simply of a 10 centimeter line with a statement at each end representing one dimension being measured. For pain intensity, the scale is most commonly anchored by “no pain” (score of 0) and “pain as bad as it could be” (score of 10).

Thoracic spine mobility test

Heiderscheit and Boissonnault (2008) examined the mobility of the thoracic spine using a tester’s hand in the prone position by pushing the spinous processes from the posterior to the anterior direction in the thoracic vertebrae 1~8, and Gonnella et al (1982) graded the results by using a 7-point (0-6) scale: 0 point means the movement of the segment cannot be detected in a rigid state; 1 point and 2 points, the low range of the resistance before the normal range; 3 points, the normal range; 4 points and 5 points, the normal range and a significantly reduced resistance to an increased range; and 6 points, an excessive range, meaning no ligament and capsular limitation.

Figure 1. Thoracic mobility test.

Respiratory function test

Spirobank G (Spirobank G, MIR, Rome, Italy) was used to examine the respiratory function of the subjects. Forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), peak expiratory flow (PEF), and forced expiratory flow 25~75% ($FEF_{25\sim75\%}$) were measured. Before starting the experiment, a full explanation about the method of the pulmonary function test was given to the subjects. During the respiratory function test, the subjects were in the following normal posture: seating on a chair with the legs open and the back not leaning against the back of the chair. The nose was closed using a nasal plug; the measuring instrument placed inside the mouth was held in one hand; and maximum expiration was performed after maximum inspiration. At this time, the upper body was controlled so as not to bend in a compensating motion. Measurements were taken

Table 1. General characteristics of subjects (N=30)

Parameters	Experimental group (n_1=15)	Control group (n_2=15)	t	p
Age (year)	31.0±10.6a	32.0±13.7	-.238	.814
Height (㎝)	165.3±7.7	167.0±7.7	-.590	.560
Weight (㎏)	63.6±9.6	64.6±14.2	-.225	.824

[a]mean±standard deviation.

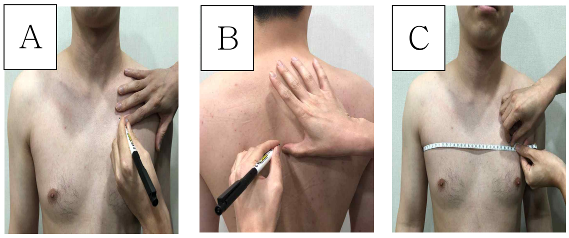

Figure 2. Chest measurement.

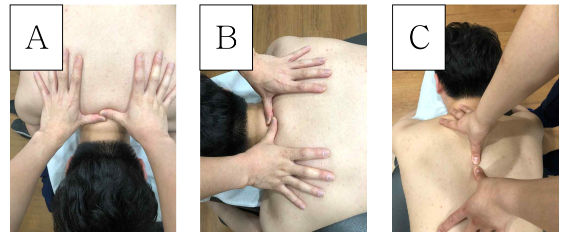

Figure 3. Upper and middle thoracic spine mobilization (A: upper thoracic spine superior view, B: upper thoracic spine lateral view, C: middle thoracic spine superior view).

three times consecutively, and the mean value was used in the analysis.

Chest measurement

Before and after intervention, the CC was measured at the time of maximum inspiration. According to the study by Bockenhauer et al (2007), the point in the 3rd intercostal region to the mid-clavicular line (Figure 2, A) and the point at the 5th spinous processes from the thoracic spine (Figure 2, B) were marked, and the circumference was measured where the two points meet (Figure 2, C).

Intervention

The experimental group was treated for chronic LBP by performing Maitland grade 3 on thoracic spine vertebrae 1~8 (Figure 3). The control group was also treated for chronic LBP by applying Maitland grade 1 on thoracic spine vertebrae 1~8. Both groups received interventions for 35 minutes a day, five times a week, over 2-week period, respectively. Grade 3 mobilization was applied to the experimental group to obtain the range of motion of the normal joint by imparting a large vibration to the hypomobility region and stretching the connective tissue of the joint or the joint capsule. Grade 1 mobilization refers to a small amount of vibration at the beginning of the range of motion of the joint to control pain or muscle spasm.

Statistical analysis

The general characteristics of the subjects such as age, height, and weight, were used in the independent t-test. Two-way analysis of variance with interindividual factors was used to compare respiratory function and CC length before and after the experiment in the experimental and control groups. The Bonferroni post-hoc test was performed when the effect within the individual was significant. Pearson's correlation analysis was used to compare the correlation of respiratory function and CC length. The collected data were analyzed using the statistical program SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA), and the correlation between lung function and CC was set at $p<.01$. A p value of $<.05$ was considered statistically significant.

Results

In the VAS, the group effect was not significant ($F=1.746$, $p=.197$), and the time effect was significant ($F=259.288$, $p<.001$). The interaction effect was significant ($F=6.137$ $p=.020$) (Table 2).

In the FVC, the group effect was not significant

Table 2. Comparisons visual analog scale in both groups

Variable	Test	Experimental (n_1=15)	Control (n_2=15)	Group effect F(1,28)	Group effect p	Time effect F(1,28)	Time effect p	Interaction effect F(1,28)	Interaction effect p
VAS[a]	Pre	4.93±0.79[b]	5.00±0.75	1.746	.197	259.288	<.001	6.137	.020
	Post	2.93±0.70	3.53±7.43						

[a]visual analog scale, [b]mean±standard deviation.

Table 3. Comparison of respiratory function between two groups

Variable	Test	Experimental (n_1=15)	Control (n_2=15)	Group effect F(1,28)	Group effect p	Time effect F(1,28)	Time effect p	Interaction effect F(1,28)	Interaction effect p
FVC[a]	Pre	3.42±.88[b]	3.50±.88	.002	.962	37.105	<.001	13.417	.001
	Post	3.58±.93	3.54±.89						
FEV_1[c]	Pre	2.80±.85	3.03±.80	.158	.694	25.212	<.001	12.406	.001
	Post	3.06±.79	3.07±.81						
PEF[d]	Pre	5.76±2.28	6.41±1.90	.045	.834	18.322	<.001	13.938	.001
	Post	6.81±2.06	6.48±1.91						
$FEF_{25\sim75\%}$[e]	Pre	3.46±1.14	3.52±.81	.043	.837	15.385	.001	7.608	.010
	Post	3.79±1.07	3.58±.84						

[a]forced vital capacity, [b]mean±standard deviation, [c]forced expiratory volume 1 second, [d]peak expiratory flow, [e]forced expiratory flow 25~75%.

(F=.002, p=.962), while the time effect (F=37.105, p<.001) and the interaction effect (F=13.417, p=.001) were significant, respectively. In the FEV_1, the group effect was not significant (F=.158, p=.694), while the time effect (F=25.212, p<.001) and the interaction effect (F=12.406, p=.001) were significant, respectively. In the PEF, the group effect was not significant (F=.045, p=.834), while the time effect (F=18.322, p<.001) and the interaction effect (F=13.938, p=.001) were significant, respectively. In the $FEF_{25\sim75\%}$, the group effect was not significant (F=.043, p=.837), while the time effect (F=15.385, p=.001) and the interaction effect (F=7.608, p=.010) were significant, respectively (Table 3).

In the CC, the group effect was not significant (F=.014, p=.908), while the time effect (F=362.577, p<.001) and the interaction effect (F=63.959, p<.001) were significant, respectively (Table 4).

The correlation coefficients between respiratory function and CC were positively correlated with FVC=.735 (p<.01), FEV_1=.612 (p<.01) and PEF=.507 (Table 5).

Discussion

Although improvement in pain and respiratory function in patients with back pain is important for the normal movement of the vertebrae through postural control, studies applying appropriate intervention to the thoracic region directly associated with respiratory function are limited. In this study, we evaluated pain, respiratory function, and CC length by applying Posterior-Anterior mobilization to the thoracic region in patients with LBP. We also investigated the correlation between respiratory function and CC length. As a result, a positive effect on pain, respiratory function, and CC length and a moderate correlation among respiratory function parameters such as FVC, FEV_1, and PEF, except for $FEF_{25\sim75\%}$, were found.

The LBP group included people who had recurrent back pain in clinical field and had not improved with nonoperative treatments. In participants with LBP, we observed a reduction of pain specifically improvements in VAS (from 5 to 3) after the intervention. Our findings are consistent with those of Ko et al

Table 4. Comparisons chest circumference between in both groups

Variable	Test	Experimental (n_1=15)	Control (n_2=15)	Group effect F(1,28)	Group effect p	Time effect F(1,28)	Time effect p	Interaction effect F(1,28)	Interaction effect p
CC[a] (㎝)	Pre	93.96±4.72[b]	94.82±8.46	.014	.908	362.577	<.001	63.959	<.001
	Post	95.86±4.82	95.59±8.50						

[a]chest circumference, [b]mean±standard deviation.

Table 5. Correlation between respiratory function and chest circumference

Variable	FEV1[a]	PEF[b]	$FEF_{25\sim75\%}$[c]	CC[d]
FVC[e]	.914	.835	.568	.735
FEV_1		.918	.687	.612
PEF			.813	.507
$FEF_{25\sim75\%}$				.316

[a]forced expiratory volume 1 second, [b]peak expiratory flow, [c]forced expiratory flow 25~75%, [d]chest circumference, [e]forced vital capacity.

(2009), who showed that engaging in thoracic mobilization like PA mobilization with lumbar stabilization reduced the oswestry disability index cores of patients with chronic LBP. Kaltenborn et al (1993) reported that unstable lumbar spine stability reduces the mobility of adjacent spinal joints such as the thoracic part. The results of this study suggest that the lumbar spine can be treated by increasing the mobility of the thoracic spine with reduced motility, and that the side effects are less severe than the direct treatment of the painful lumbar spine (Singer and Giles, 1990).

Although improvement in respiratory function should be included in the field of rehabilitation and physical therapy for improving the pain control and exercise capacity of patients with back pain, concrete intervention methods are lacking. This study suggests that the use of joint mobilization indirectly applied to the thoracic region rather than to the lumbar region could solve the difficulties of patients with back pain, because direct intervention is difficult owing to pain in the lumbar region and the ability to control the abnormal movement, and can be introduced as an intervention method. In addition, considering the anatomical structure of the thoracic region, mobilization in only the PA direction was applied to the thoracic vertebrae 1~8 region. Therefore, various intervention methods may be considered in combination with the functional movement of the thoracic region. In this study, the FVC, FEV_1, PEF, and $FEF_{25\sim75\%}$ were measured using the most common and easily used method of spirometry, to evaluate respiratory function. For the CC measurement, the point in the 3rd intercostal region to the mid-clavicular line and the point at the 5th spinous processes from the thoracic spine were marked, and the circumference was measured where the two points meet, by using a tapeline (Bockenhauer et al, 2007).

Compared with the control group, all respiratory function parameters were improved in the experimental group. FVC was improved by about 5% in the experimental group after the intervention, but by only about 1% in the control group. FVC is the total amount of air that can be blown out of the lungs during forced exhalation after maximum inhalation and is generally considered normal when it is >80% of the predicted value (Lima et al, 2011). FEV1 increased by approximately 9% after the intervention in the experimental group, but increased by only approximately 1% in the control group. FEV1 is the maximum amount of air that can be released within 1 second and is an indicator of whether the large airway has been shut down. The PEF increased by approximately 5% after the intervention in the experimental group but increased by only approximately 1% in the control group. PEF is the maximum flow rate generated during forceful exhalation, and reflects the bronchial condition.

Moreover, the CC was further improved in the experimental group compared with the control group. This may be due to the mechanical advantage of PA mobilization applied to the thoracic spine. In particular, passive external forces, such as joint motion, expand the ribcage during breathing, and smooth movements of the associated connective tissues appear to enhance the mobility of the thoracic joints. The increase in the length of the thoracic cavity seems to have a positive effect on the respiratory function, leading to minimization of cardiopulmonary pressures and improvement in function by expansion of the thoracic cavity (Hussain and Pardy, 1985). In a previous study supporting this finding, it was suggested that restricting the movement of the chest could decrease the values of respiratory function parameters such as FVC and FEV_1 (Gonzalez et al, 1999). Brenner et al (2007) reported that direct joint mobilization of the thoracic spine contributes to respiratory function by increasing the mobility of the muscles and joints between the ribs constituting the thorax. These results suggest that the joint mobilization applied to the thoracic spine relaxes the surrounding joints and soft tissues, and aids in thoracic expansion.

The correlation analysis of respiratory function and CC length showed the greatest correlation between FVC and CC ($r=.735$, $p<.01$). According to Cline et al (1999), the increase in thoracic mobility is associated with an increase in the length of the CC due to an increase in the optimal length of the inspiratory muscle. The positive correlations between FEV_1 and CC ($r=.612$, $p<.01$) were also similar, and Ozgocmen et al (2002) showed that the increase in CC length correlated with maximal exhalation pressure. The positive correlation between PEF and CC ($r=.507$, $p<.01$) also suggests that force generation by the inspiratory muscle should precede the increase in the maximum expiratory flow (Tzelepis et al, 1997). Increased CC may be considered to improve aerobic flow by optimizing the inspiratory muscle function.

This study has some limitations, including the sample recruitment, because we only included patients with LBP, and the use of a universal and easy-to-use measurement instrument, mainly focusing on expiratory function, to measure respiratory function. In future studies, a high-function breathing apparatus capable of measuring the inspiratory capacity of a number of patients with LBP should be used to overcome these limitations.

Conclusion

The purpose of this study was to investigate the effects of PA joint mobilization on pain, respiratory function, and CC length in 30 patients with LBP, as well as to investigate the correlation between respiratory function and CC length. Joint mobilization applied to the thoracic spine improved pain, respiratory function, and CC length. A moderate correlation among respiratory function parameters such as FVC, FEV_1, and PEF, except for $FEF_{25\sim75\%}$, was found. Therefore, we would like to recommend indirect PA joint mobilization in the thoracic region to improve the pain and respiratory function of patients with back pain with difficulty in posture control.

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