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Comparisons for the Abnormality of Breathing Pattern, Kinesiophobia and Flexion Relaxation Phenomenon in Patients with Chronic Low Back Pain and Healthy Person during Flexion and Extension of the Trunk

Background: Most of the previous researches on the abnormality of breathing pattern have focused on the silence of functional movements owing to such abnormality, however, have not been clearly identified the relationship between the abnormal breathing pattern on one hand and kinesiophobia and flexion relaxation phenomenon (FRP) on the other hand.
Objective: To compare patients with chronic low back pain (CLBP) and healthy person in the abnormality of breathing pattern, kinesiophobia, and FRP during flexion and extension of the trunk.
Design: Case-control study.
Methods: The research subjects consisted of a group of 15 healthy adults and another group of 15 patients with CLBP. Capnography was used to measure the endtidal CO_2 ($EtCO_2$) and respiratory quotient (RQ). The muscle activity of multifidus and erector spinae of the subjects was measured during flexion and extension of the trunk to identify their FRP. The Nijmegen Questionnaire (NQ) and Tampa Scale of Kinesiophobia (TSK) were utilized to measure their breathing patterns and kinesiophobia, respectively. The Kolmogorov-Smirnov (K-S) test was conducted in order to analyze the normal distribution of the measured data. Their general characteristics were identified by the descriptive statistics and the independent t-test was performed to identify the differences between the two groups in terms of abnormality of breathing pattern, kinesiophobia, and FRP. The level of significance was set at α=.05.
Results: The patients with CLBP had significantly less $EtCO_2$ and shorter breathing hold time (BHT) than normal healthy person ($p<.05$). The patient with CLBP also had significantly greater kinesiophobia than healthy person ($p<.05$), and had less FRP than the healthy person ($p<.01$).
Conclusions: These results suggest that the CLBP had greater abnormality of breathing pattern and kinesiophobia with less FRP than healthy person.

Key words: *Breathing pattern; Kinesiophobia; FRP; Low back pain.*

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INTRODUCTION

Normal breathing also known as the diaphragm breathing involves simultaneous movement of the upper thorax, lower thorax, and abdomen. It requires appropriate use and function of the diaphragm [1]. Abnormal breathing known as the thoracic breathing, in contrast, takes place in the lower thorax [2]. Abnormality in breathing pattern can be defined as continuous and inappropriate breathing without any obvious disorder and it often occurs in chronic pain patients with abnormal musculoskeletal system [3].

The flexion relaxation phenomenon (FRP) of the lumbar refers to the silence of muscle activity (EMG) at the end point of trunk flexion [4]. With both pain and kinesiophobia, silence of the FRP occurs at the end point of trunk flexion [5]. Previous researches on the pain and function of the spine related with FRP reported that the FRP silence occurs at the erector spinae of low back pain patients and that there existed correlation between pain and function [6]. FRP has been much investigated with patients with CLBP.

Previous studies of healthy person reported that the motor function of a group with abnormal breathing pattern was more inefficient than those of a group with diaphragm breathing [7] and that abnormal breathing pattern was found in the patients with CLBP [3]. Massé-Alarie et. al. [8], in their study of the absence of FRP at the transverse abdominis, reported that absence of FRP was closely correlated with kinesiophobia. The abnormal breathing pattern of large upper chest movements is defined as continuous and inappropriate breathing without apparent abnormalities in the respiratory system, and is common in chronic pain patients with muscle skeletal abnormality [32]. The absence of FRP is due to the absence of redistribution of deep muscle (diaphragm, transverse abdominis) firing of abdomen [8]. The inappropriate co-operation of diaphragm leads to damage to the stability of lumbar, altered motor control, and dysfunctional movement patterns [33]. In chronic back pain, the absence of FRP is thought to occur due to diaphragm and dysfunction of the deep muscle of abdomen, but there is no clear evidence yet.

Most of the previous researches on the abnormality of breathing pattern have focused on the silence of functional movements owing to such abnormality [2, 3, 7, 8], but have not clearly identified the relationship between the abnormal breathing pattern on one hand and kinesiophobia and FRP on the other hand. Thus, the current research attempts to compare a group of CLBP patients with another group of healthy adults in their abnormality of breathing pattern, kinesiophobia, and FRP during flexion and extension of the trunk.

SUBJECTS AND METHODS

Subjects

The research subjects consisted of a group of 15 healthy person and another group of 15 CLBP patients. The group of patients with CLBP was randomly selected to meet the criteria for selection; healthy person was randomly selected as the subjects with similar age, height, and weight to the group of patients with CLBP selected to eliminate the selection error. The subjects' abnormality of breathing pattern and kinesiophobia were measured. All of the subjects were given enough explanation of the research procedure and were asked to sign a consent form to agree with the research. The participants voluntarily participated in this research, and signed an informed consent form. This study was approved by the Institutional Ethics Committee of Namseoul University (No. NSUIRB-201705-04). The criteria for selection of research subjects included the following: (i) adults whose low back pain lasted for more than 12 weeks without any spine operation, (ii) those who received medical treatments for low back pain, (iii) those who had continuous or occasional back pain after treatments, and (iv) those who agreed to the purpose and method of the current research. Participants were randomly selected. [8]. The group of healthy adults were selected with consideration of the average of age of the patient group in order to eliminate the selection error due to age difference.

Outcome Variables and Procedures

A Capnography (Capnography, Mediana, Korea) was used to measure end tidal CO_2 ($EtCO_2$) and respiratory quotient (RQ). Abnormal breathing patterns were measured and recorded with the following criteria: less than 35 mmHg of the EtCO [29], greater than 23 points of Nijmegen Questionnaire (NQ) [10], greater than 16 of RQ [2], less than 20 seconds of breath holding time (BHT) [11], and abnormal breathing pattern in the Hi-Lo evaluation [12]. The NQ consisted of a total of 16 items: 4 items for symptoms for the respiratory system and 12 items for symptoms for the whole body. Scores greater than 23 were diagnosed as abnormal breathing pattern. Tampa Scale of Kinesiophobia (TSK) was utilized to measure kineisiophobia [13]. An electromyography (Myotrace400, Noraxon, USA) was used to measure the muscle activity of the multifidus and erector spinae of the subjects during flexion and extension of the trunk. The sampling rate of the electromyographic (EMG) signal was set at 1,000Hz (1,000 samples/second) and the amplified waveform was filtered by the band pass filter of 20~500Hz. The FRP was identified by measuring the muscle activity of the multifidus and erector spinae of the subjects during flexion and extension of the trunk.

Capnography was utilized to measure the biochemical characteristics of the respiratory function [9, 14]. Capnogrpahy was used to measure the $EtCO_2$ and RQ. The subjects were asked to wear a nasal cannula and answer the questions in the NQ and TSK questionnaire. Without being conscious of their breathing, the abnormality of their breathing patterns and kinesiphobia were measured. Then, the cannula was removed to measure their breath holding time [15], and the Hi-Lo method of breathing evaluation examined diaphragm breathing and thoracic breathing [2]. After evaluation of breathing, their FRP of the multifidus and erector spinae was measured during flexion and extension of the trunk. The surface EMG signals were measured at both sides of the trunk. As for the multifidus, the EMG electrode was attached as high as the 5th lumbar vertebral spinous process between the posterior superior iliac spine (PSIS) and the first and second lumbar vertebra [8]. To measure the muscle activity of the erector spinae, the electrode was attached at 4cm external to the 3rd lumbar vertebral spinous process [16]. With the EMG electrodes attached, the subjects maintained the standing posture with the feet as wide as the pelvis. Following an auditory signal, the subjects bended forward until they reach a maximized flexion of the trunk. During EMG assessment, participants were instructed to bend forward as far as possible while keeping the knees straight, holding the flexed position for three second, then returning to the upright standing position. This movement pattern was repeated 3 times at a pace preferred by participants [8, 17]. FRP was obtained by dividing the value of the maximum muscle activity during the entire movement by the value of the maximum muscle activity for three second at the maximized flexion (Flex/FF = maximal muscle activity of 1 second during bending in standing / maximum muscle activity of 1 second in full flexion; Ext/FF = maximal muscle activity of 1 second during extension from full flexion / maximum muscle activity of 1 second in full flexion) [17, 18]. All the subjects participated in this experiment 3 times in total; 3 times a week and once a day.

Statistical Analysis

All the measured data were processed by the program of IBM SPSS Statistics version 21.0. The normal distribution of all the data was validated by the K- S (Kolmogorov- Smirnov) test and the general characteristics of the subjects were calculated by descriptive statistics. The intergroup differences in the abnormality of breathing pattern, kinesiophobia and FRP were identified by employing the independent t-test. The level of significance was set at α=.05.

RESULTS

The research subjects consisted of a group of 15 chronic low back pain (CLBP) and another group of 15 healthy adults. The ages were 45.33±9.78 (Mean±SD) years for the CLBP group and 41.27±6.63 years for the healthy group. Their heights were 163.59±6.96 cm (CLBP) and 165.63±8.63 cm (healthy Group). Their body weights were 62.00±6.81 kg (CLBP) and 65.37±7.43 kg (healthy Group). Their body mass index (BMI) were 23.11±1.41 and 23.77±1.31 kg/m2, respectively. There was no significant difference between groups in all variables ($p>.05$). The intensity of the pain (VAS) of CLBP group was 4.33±1.23.

The intergroup differences in the abnormality of breathing pattern, kinesiophobia and FRP

A statistically significant difference was found between the two groups in breathing variables, kinesiophobia, and FRP as illustrated in Table 1. As for the breathing variables, the CLBP group was significantly lower than the healthy group in $EtCO_2$ and BHT ($p<.05$). It was also found that the CLBP group felt significantly greater kinesiophobia than the healthy group ($p<.01$). FRP, in turn, was significantly lower in the CLBP group than in the healthy group ($p<.01$)(Table 1). Additionally, in terms of the breathing pattern, five (33.3%) of the healthy group showed thoracic breathing, while ten (66.7%) of healthy group showed the diaphragm breathing. The CLBP group showed a different pattern: 12 (80%) showed thoracic breathing and only 3 (20%) showed diaphragm breathing.

Table 1. The intergroup differences in the abnormality of breathing pattern, kinesiophobia and FRP

		Healthy	CLBP	t
		Mean±SD	Mean±SD	
Breathing variables	$EtCO_2$ (mmHg)	37.00±2072	31.87±3.96	4.134**
	RR (breaths/min)	16.80±2.30	17.93±4.06	−.940
	BHT (sec)	51.47±10.01	43.33±11.27	2.089*
	NQ (score)	16.80±10.48	21.67±10.64	−1.262
Kinesiophobia	TSK (score)	35.53±5.02	39.87±3.35	−2.777**
FRP	ES (Flex/FF %)	4.80±3.33	1.14±0.33	4.239**
	ES (Ext/FF %)	11.03±7.43	1.45±0.91	4.952**
	MF (Flex/FF %)	3.77±3.09	1.29±0.76	2.999**
	MF (Ext /FF %)	8.29±8.45	1.72±1.62	2.952**

SD: standard deviation, CLBP: chronic low back pain, $EtCO_2$: endtidal CO_2, RR: respiratory rate, BHT: breathing hold time, NQ: nijmegen questionnaire, TSK: tampa scale for kinesiophobia, FRP: flexion relaxation phenomenon, ES: erector spinae, MF: multifidus, Flex/FF: flexion/full flexion, Ext/FF: Extension/full flexion.
* p<.05, ** p<.01.

DISCUSSION

The silence of EMG activity reflected in FRP has been known to be observed at the end point of trunk flexion. However, it was reported that the silence does not occur with pain or fear of avoidance belief [5, 17–20]. FRP refers to the sudden onset of myoelectric silence at ES (erector spinae) during bending of the trunk from the standing position [21].

The current research aims to examine the differences between patients with CLBP and healthy adults in their FRP and breathing pattern disorder (BPD) during flexion and extension of the trunk. Of the healthy group, five subjects (33.3%) showed the thoracic breathing and ten (66.7%) had the diaphragm breathing. The CLBP group, in contrast, were clearly different: twelve (80%) showed the thoracic breathing and only three (20%) showed the diaphragm breathing. The trunk flexion and extension is related with the movement of the muscles controlling the pressure in the abdominal cavity: erector spinae, multifidus, transverse abdominis, diaphragm, and pelvic floor muscles [22–24, 31, 32]. The diaphragm assist to control the pressure inside the abdominal cavity and performs an important role for the stability of the spine [22–24]. In addition, the diaphragm is crucial for both postures and breathing [25]. CLBP in patients might have promoted psychological anxiety over trunk flexion and extension which may lead to isometric contraction of the upper limbs, lower limbs, and trunk. Such reactionary contractions may have reduced the diaphragm activity and corresponding compensatory thoracic breathing patterns [26]. As for breathing variables, the CLBP group showed less $EtCO_2$ and shorter BHT. The normal range of $EtCO_2$ is 35mmHg ~ 40mmHg and less than 35mmHg is considered abnormal breathing pattern [27]. This study found that $EtCO_2$ of the CLBP group was 31.87±3.96mmHg and their BHT was 43.33±11.27 seconds, which was significantly shorter than that of the healthy group. This abnormality of the breathing pattern can be attributable to lack of normal diaphragm breathing during the movement of flexion and extension [26]. However, it is still unclear that the abnormality of breathing pattern results in low back pain or vice versa. The controversy on the relationship between low back pain and breathing seems to wait for further detailed studies.

Kinesiophobia was felt more by the CLBP group than the healthy group. Kinesiophobia is defined as the fear of painful injury or risk of recurring damage in performing physical movement or activity [28]. CLBP and fear of movement are associated with an overactivation of paravertebral muscles during forward bending. This impairs spine motor control and contributes to pain perpetuation [8]. It can be assumed that the patients with CLBP possessed anxiety over recurrence of low back pain while performing flexion

and extension of the trunk, which led to a greater level of kinesiophobia than the healthy group.

It was found that the CLBP group had significantly less FRP than the healthy group, which is consistent with the result of previous studies that EMG silence occurred to low back pain patients [29]. The reduced EMG activity of the erector spinae and multifidus during the healthy group's flexion of the trunk is attributable to the power transition from the spine's active system of muscle to the passive system of ligament [30, 31]. However, in the case of the patients with CLBP, such reduction of the EMG activity was not manifested since the active system of the erector spinae and multifidus was maintained until the complete flexion of the trunk due to their fear of flexion. Thus, it can be assumed that the CLBP group's continuous maintenance of the active force results from their pain and kinesiophobia [5, 8, 31].

The present research found that the CLBP group exhibited a greater level of abnormality in the breathing pattern, greater kinesiophobia, and less FRP than the healthy group. The results of the current study are expected to be used as helpful baseline data for providing exercises and respiratory practices of the patients with CLBP. Limitations of this study were conducted with a group of subjects whose ages were in the 40's and thus it is not easy to generalize the research results for all ages. Moreover, their pain intensity (VAS) were 4.33±1.23 and it might be true that different pain intensity would lead to different research results. It might be suggested that further researches should take a variety of age groups and pain intensity into consideration. The researchers have tried to control any possible extraneous variables, but it was not possible to control the subjects' activities of daily living.

CONCLUSION

In conclusion, the present research found that the CLBP group exhibited a greater level of abnormality in the breathing pattern, greater kinesiophobia, and less FRP than the healthy group. The results of the current study are expected to be used as helpful baseline data for providing exercises and respiratory practices of the patients with CLBP.

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