



Original Article

Effect of chronic knee osteoarthritis on flexion-relaxation phenomenon of the erector spinae in elderly females

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Abstract. [Purpose] This study investigated the flexion-relaxation phenomenon of the erector spinae in elderly women with chronic knee osteoarthritis and determined whether the flexion-relaxation phenomenon can be used as a pain evaluation tool in such cases. [Subjects and Methods] Seventeen elderly females with chronic knee osteoarthritis and 13 healthy young females voluntarily participated in this study. They performed three postural positions in 15 s: trunk flexion, complete trunk flexion, and trunk extension, each for 5 s. While these positions were held, muscle activation of the thoracic and lumbar erector spinae were measured using surface electromyography. The flexion-relaxation rate was determined by dividing the values for trunk extension by those of complete trunk flexion and by dividing the values for trunk flexion by those of complete trunk flexion. [Results] According to our results, the flexion-relaxation phenomenon was different between healthy young and elderly females with chronic knee osteoarthritis. Specifically, there was a difference in the left thoracic erector spinae muscle, but not in the left and right lumbar erector spinae or right thoracic spinae muscle. [Conclusion] Our study demonstrated that the erector spinae muscle flexion-relaxation phenomenon can be used as a pain evaluation tool in elderly females with chronic knee osteoarthritis.

Key words: Erector spine, Flexion-relaxation phenomenon, Osteoarthritis

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INTRODUCTION

In Korea, close to 86.8% of the elderly population (aged 65 or older) has chronic degenerative disease¹⁾. Among these degenerative diseases, arthritis has the highest prevalence rate. Osteoarthritis mainly occurs in the hip joints and knee joints, which are weight-bearing joints, and most elderly persons aged 65 years or older have this disease^{1, 2)}. Osteoarthritis induces the growth of osteophytes, leading not only to pain but also to the loss of movement and often to a state of lethargy, in which the individual avoids walking¹⁾. This lethargy hinders the individual from performing functional activities, often resulting in muscle weakening and atrophy, including decrease in muscle force and motor unit activation of the muscles around the joint affected by osteoarthritis³⁾. Muscle weakening and atrophy further contribute to reduced walking and functional abilities required for daily living³⁾.

Flexion-relaxation phenomenon (FRP) refers to the appearance of muscular-electrical silence on the surface of the erector spine during complete trunk flexion⁴⁾, which could be affected by several factors, including lumbopelvic postures⁵⁾, repetition of tasks⁶⁾, and muscle fatigue⁷⁾. Leg muscle weakening caused by osteoarthritis makes it difficult to assume upright positions³⁾. Chronic osteoarthritis, therefore, often leads to stooped postures as a result of the tension experienced when assuming

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postures in which the erector spinae is elongated^{3,4}). The erector spinae muscle is a posture-maintaining muscle that is used in all daily living activities in which trunk forward-tilting and straightening motions are performed. Normal FRP of the erector spinae is an important precondition for smoothly performing the functional activities of daily living and is an important measurement variable in the evaluation of treatment effects at clinics⁸).

There are currently insufficient studies examining the effects of osteoarthritis on the FRP of the erector spinae and on how the FRP of the erector spinae observed in young adults is different from that of the elderly in whom osteoarthritis has occurred. Therefore, the present study compared the FRPs of the erector spinae occurring during (1) trunk flexion, (2) complete trunk flexion, and (3) trunk extension motions in both healthy, young females and elderly females with chronic knee osteoarthritis. In addition, data regarding whether the FRP of the erector spinae can be used as a method of evaluating the degree of pain in chronic osteoarthritis in the elderly will be presented. If the erector spinae flexion-relaxation rates can be used as a pain scale, it may assist healthcare professionals to improve elderly patients' quality of life.

SUBJECTS AND METHODS

This study was a randomized controlled trial, which included healthy adult females attending a university and elderly females aged at least 65 years diagnosed with chronic osteoarthritis in the leg, among the elderly community residing in a metropolitan area of Chungcheongnam-do in South Korea. The selection criteria for elderly subjects were as follows: those who had no orthopedic or neurologic disease affecting the leg other than chronic osteoarthritis, had not undergone surgical treatment of the leg within the last 6 months, had not experienced any fracture in the leg in the last 6 months, had corrected visual acuity not lower than 0.8 and had no blurred vision, could understand experimenters' instructions and cooperate with the experimenters, and had understood the purpose of the present study and voluntarily agreed to participate. The study was approved by the Institutional Review Board of Hanyang University, and written informed consent was obtained from all patients prior to the experiments. The general characteristics of the subjects that participated in the present study are shown in Table 1.

In the present study, surface electromyography (EMG) (Trigno Wireless System, Delsys Inc., Boston, MA, USA) was used to measure the muscle activity of the healthy adult females and elderly females with chronic knee osteoarthritis while they were performing trunk flexion, complete trunk flexion, and trunk extension. The EMG signals measured by the Trigno sensor and wirelessly transmitted to the Trigno base station were analyzed using EMGworks 4.0 (Delsys Inc., Boston, MA, USA) software. All measured muscle activity values were calculated as percentages of maximal or submaximal voluntary isometric contraction values. The EMG signal-sampling rate was 1,024 Hz, and the signals were band-pass filtered within a range of 10–500 Hz.

Metronomes were used to enable the experimental subjects of the present study to perform trunk flexion, complete trunk flexion, and trunk extension for 5 s each over a total of 15 s. The beat was set to 60 bpm, and seconds were counted so that the subjects could hear and perform each motion for 5 s.

Before attaching the EMG electrodes, sweat and foreign matter in the experimental muscle regions were removed in order to minimize skin resistance. The attachment points for measuring the thoracic erector spinae were 5 cm to the left and right of the spinous process of the T9, while the attachment points for measuring the lumbar erector spinae were 2 cm to the left and right of the spinous process of the L2. The manual muscle force postures for measuring of the maximal voluntary isometric contraction (MVIC) in healthy adults and the submaximal voluntary isometric contraction in elderly persons with chronic knee osteoarthritis were determined following the method of O'Sullivan et al⁶). The values of each subject were measured 3 times for 5 s, in succession, over a total of 15 s. Measurements during the first and last seconds of each measurement period were excluded, and the maximum values during the middle 3 s were used for the quantification of the root mean square (RMS). To minimize muscle fatigue, 1 min rest was taken after each of the 3 measurement sessions. The subjects were randomly measured in the order of voluntary participation. During the measurement of the flexion-relaxation rates, three motions were performed: (a) trunk flexion, (b) complete trunk flexion, and (c) trunk extension. Posture 1 was a standing posture, posture 2 was a trunk-bending motion, and posture 3 was a maximum trunk-bending motion. In the complete trunk flexion section, the subjects were instructed to bend the trunk maximally within the range of bending with no pain before measurement. Preliminary instruction was provided to the subjects by the experimenter, who performed the motions in front of the subjects and helped the subjects practice the motions at least one time.

The flexion-relaxation rates were determined using both the values obtained by dividing the data for trunk extension by that of complete trunk flexion (c/b) and by dividing the data for trunk flexion by that of complete trunk flexion (a/b). The mean values of the three trunk flexion extension motions were used to determine the flexion-relaxation rates. The RMS values in each stage were quantified into %MVIC values. The means and standard deviations of the general characteristics of the study subjects (age, gender, height, and weight) were calculated using descriptive statistics. In the present study, the independent variable was the presence or absence of chronic knee osteoarthritis, and the dependent variable was the FRP of the erector spinae. Independent t-tests were used to examine the erector spine flexion-relaxation rates according to whether the presence or absence of chronic knee osteoarthritis. To test the statistical significance, α was set to 0.05, and the collected data were analyzed using PASW Ver. 12.0 (SPSS Inc., Chicago, IL, USA) program for Windows.

RESULTS

The effect of chronic knee osteoarthritis on the FRP of the erector spinae was first examined. The values obtained by dividing the data for trunk extension by that of complete trunk flexion were not different for the left and right lumbar erector spinae or right thoracic erector spinae; however, they were significantly different for the left thoracic erector spinae ($p < 0.05$) (Table 2). The values obtained by dividing the data for trunk flexion by that of complete trunk flexion, were not different for the left and right lumbar erector spinae and right thoracic erector spinae, but were significantly different for the left thoracic erector spinae ($p < 0.05$) (Table 3).

DISCUSSION

In the present study, the FRP of the erector spinae in elderly females with chronic knee osteoarthritis and healthy young females were measured to determine whether the erector spinae flexion-relaxation rates could act as a useful pain evaluation tool for patients with knee osteoarthritis. Although no significant differences were evident in the flexion-relaxation rates of the left and right thoracic erector spinae or right lumbar erector spinae, significant differences were shown in the flexion-relaxation rates of the left thoracic erector spinae.

Degenerative arthritis develops in most people aged 65 or older, with a higher prevalence in females than in males. It frequently occurs in knee joints, which are under large weight loads¹. Lower-limb osteoarthritis is associated with foot postures and affects the dynamic alignment of the lower limbs⁹. Reilly et al.⁹ reported that patients with knee joint osteoarthritis showed changes in the ankle joint postures when compared with healthy individuals, and according to the study of Hu et al.¹⁰, foot posture and stance widths affected the load-sharing mechanism of the lumbar muscle tissues. Therefore, knee osteoarthritis was believed to affect the FRP of the lumbar erector spinae.

The FRP can act as a quantitative measure for the evaluation of changes in the neuromuscular system functions¹¹. Varying flexion-relaxation rates among patients are a useful clinical tool that can help in diagnosing chronic lower back pain in patients³. This argument is supported by strong evidence that those subjects with low back pain do not exhibit the FRP during complete trunk flexion¹². Watson et al.¹³ demonstrated the validity of measuring the FRP of the lumbar vertebrae to diagnose lower back issues and reported high specificity and sensitivity. In addition, the flexion-relaxation rates are a valuable tool for distinguishing between patients with cervical pain and those with no cervical pain, and to indicate changes in the neuromuscular control in patients with cervical pain. The flexion-relaxation rates of the cervical spine were reported to be significantly lower in patients with cervical pain¹⁴.

There have been several studies conducted on the FRP of the erector spinae. Shin et al.¹⁵ advised that the knee angles and individuals' flexibility levels affected the FRP of the lumbar muscles. They reported that in the case of subjects with high

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

	Elderly females with chronic osteoarthritis (n=17)	Healthy adult females (n=13)
Age (years), M ± SD	75.8 ± 12.0*	21.1 ± 0.8
Height (cm), M ± SD	153.5 ± 6.3	159.6 ± 3.7
Weight(kg), M ± SD	56.5 ± 8.7	52.9 ± 5.4

* $p < 0.05$

Table 2. Flexion-relaxation phenomenon (FRP) values obtained by dividing the data for trunk extension by those for complete trunk flexion from healthy adults and elderly individuals (Units: %)

Muscles	Mean ± SD	
	Elderly females with chronic osteoarthritis	Healthy adult females
Left thoracic erector spine	1.67 ± 0.61*	1.22 ± 0.45
Right thoracic erector spine	1.87 ± 0.82	2.31 ± 1.35
Left lumbar erector spine	2.35 ± 1.31	2.08 ± 1.36
Right lumbar erector spine	2.46 ± 1.03	1.85 ± 1.81

* $p < 0.05$

Table 3. Flexion-relaxation phenomenon (FRP) values obtained by dividing the data for trunk flexion by those for complete trunk flexion from healthy adults and elderly individuals (Units: %)

Muscles	Mean ± SD	
	Elderly females with chronic osteoarthritis	Healthy adult females
Left thoracic erector spine	1.47 ± 0.55*	1.12 ± 0.31
Right thoracic erector spine	1.41 ± 0.49	1.99 ± 1.43
Left lumbar erector spine	2.00 ± 1.08	2.58 ± 2.75
Right lumbar erector spine	1.76 ± 0.90	1.62 ± 1.31

* $p < 0.05$

flexibility, knee angles affected the flexion-relaxation rates when the trunk angle became 90°, and in the case of those with moderate flexibility, the foregoing reactions appeared when trunk angles were 70°–90°. They also reported that in the case of those with poor flexibility, knee angles did not affect the flexion-relaxation rates. According to the study by Hashemirad et al.¹⁶⁾, muscle activity pattern of the erector spinae varied with flexibility during trunk flexion/extension. The flexion-relaxation reactions are affected by several factors, including trunk loads, lumbosacral postures, trunk angular speed, number of task repetitions, and muscle fatigue^{6–8, 17)}. Although previous studies were actively conducted on the effects of loads, angular speed, muscle fatigue, and postures on the flexion-relaxation rates, studies on the effects of changed lumbosacral postures of patients with chronic knee osteoarthritis on the FRP of the erector spinae have been insufficient. Therefore, the present study intended to examine the differences in the FRP of the erector spinae between elderly persons with degenerative knee osteoarthritis and healthy adults. Although not clinically significance, the results showed significant differences only in the left thoracic erector spinae, but not in the left and right lumbar erector spinae or right thoracic erector spinae.

This study had limitations. First, the study sample was small and was limited to females with chronic knee osteoarthritis. Therefore, the results cannot be generalized. Second, although the same voice signals were given using a metronome during trunk flexion and extension, trunk speeds were different among individual subjects. Third, the levels of knee pain were different among individual patients with chronic knee osteoarthritis, and the effects of medication and previous treatment could not be eliminated. To further determine the FRP of the erector spinae in elderly females with chronic knee osteoarthritis, further studies that account for the limitations of the present study may be required.

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