J. Phys. Ther. Sci. 33: 295–298, 2021

The Journal of Physical Therapy Science

Original Article

# Effect of low back pain on the muscles controlling the sitting posture

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**Abstract.** [Purpose] The purpose of the current study was to reveal the association between posture control and muscle activity by measuring the trunk and hip joint muscle activities in the upright and slump sitting positions in both the healthy participants and patients with recurrent lower back pain. [Participants and Methods] We recruited eleven patients of recurrent lower back pain and ten healthy participants. During the maintenance of the two types of posture, upright and slump, we collected the surface electromyography data. We assessed the following muscles: rectus abdominis, external oblique, thoracic erector spinae, lumbar erector spinae, internal oblique, lumbar multifidus, iliacus, serratus anterior, rectus femoris, tensor fascia latae, and gluteus maximus. We studied the differences in spinal–pelvic curvature and muscle activity between the upright and slump positions in each group. [Results] In the healthy group, comparison of the muscle activity in upright and slump positions for both the trunk (external oblique, internal oblique, lumbar erector spinae, and lumbar multifidus), and the hip muscles (iliacus and gluteus maximus) showed a significant decrease in activity in the slump position. In the group with recurrent lower back pain, although the external oblique, lumbar erector spinae and lumbar multifidus showed reduced activity in slump position, these values were smaller when compared to those in the healthy group. [Conclusion] This study aimed to clarify the relationship between posture (upright and slump) and the activity of the trunk and hip joint muscles in the healthy participants and the patients with recurrent lower back pain. The results indicated that postural changes caused by recurrent lower back pain significantly affected the activity of the muscles involved in controlling the posture.

**Key words:** Sitting posture, Muscle control, Low back pain

*(This article was submitted Nov. 9, 2020, and was accepted Dec. 29, 2020)*

## INTRODUCTION

In healthy participants, when the trunk is flexed from the standing position to the bending position, the muscle activity of the thoracolumbar extensors is lost in the final region of trunk flexion, a condition called the flexion–relaxation phenomenon (FRP). Allen[1)] first reported this phenomenon, which is now widely known. The mechanism of flexion laxity is the suppression of the stretch reflex, which is caused by the centrifugal contraction of the thoracolumbar extensor muscle group to maintain posture. The postural retention function is transferred to the passive tissues from the soft tissues, including the ligaments[2)].

In patients with nonspecific low back pain (LBP), which is considered an LBP disorder, the thoracolumbar extensor is

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hypercontracted, and the FRP disappeared[3]. Geiser et al.[4] and Mayer. et al.[5] have reported that the disappearance of the FRP is associated with the exacerbation of LBP, and we reported that the loss of the FRP can be used as an objective measure of treatment effectiveness with good sensitivity and specificity.

The slump sitting position greatly flexes the spine and spinal column in a forward bending motion, and for the muscles of the trunk, it is a typical posture for relaxation. Alternatively, it is an abnormal posture inducing back pain[6, 7]. Based on studies on slump sitting and the FRP, slump sitting may decrease lower back muscle activity. However, this posture has not been investigated in individuals with LBP. Whether slump sitting is a resting posture or a pain-inducing posture for individuals with LBP is an essential question for the sedentary demands of modern life.

Additionally, postural studies have focused only on the trunk muscles, and few have focused on the hip muscles. In clinical assessment, evaluating not only the lumbar region but also the joints such as the hip joint in patients with LBP is necessary. The need for this is obvious in terms of joint linkage, muscle linkage, and neurological linkage. For example, in the lower crossed syndrome proposed by Janda[8], hypertonicity of the thoracolumbar extensor is associated with increased muscle tone of the hip flexors, which can lead to lumbar dysfunction. Therefore, evaluating the muscle activity of the hip flexors and thoracolumbar extensors is necessary for patients with LBP.

This study reveals the association between posture and muscle control in patients with LBP. To this end, we measured trunk and hip muscle activities during upright and slump sitting positions in patients with LBP who had a loss of the FRP of the thoracolumbar extensors.

## PARTICIPANTS AND METHODS

Eleven healthy adults (non-LBP group) (age: 22.5 ± 9.4 years; height: 170.6 ± 9.4 cm; weight: 65.5 ± 9.5 kg) and 10 adults with recurrent low back pain (RLBP) (age: 21.5 ± 2.9 years; height: 173.5 ± 4.2 cm; weight: 65.4 ± 6.2 kg) were enrolled in this study. The participants in the non-LBP group (1) were free of neurological and orthopedic diseases within the past 6 months and (2) had the FRP in the thoracolumbar extensors. Those in the LBP group (1) had pain more than 3 months old, (2) had no lower extremity pain originating from the nerve roots and cauda equina, (3) had localized pain in the lumbosacral vertebrae, and (4) had lost the FRP in the thoracolumbar extensors. Prior to the study, we fully briefed the participants on the purpose and content of the measurements according to the Declaration of Helsinki. We obtained informed consent from all participants, and the experiment was conducted after obtaining their consent. This study received approval [Aino2015-022] regarding its purpose and experiment details prior to the experiment according to the provisions of the "Research ethics involving human subjects" as set forth by the ethics committee of Aino University.

The participants in each group were seated in a backless chair with variable seat height and their feet shoulder width apart. The height of the seat was adjusted so that the hip and knee joints were in a 90° flexed position. The upper limbs were placed in the drooping position, and the palms were placed above the knees as the basic position. The participants were instructed to gaze at an index placed at eye level in front of each participant at 2 m during the measurement. Next, each participant was asked to randomly perform two postures: (1) upright sitting and (2) slump sitting; the muscle activity and spinal–pelvic curvature angles were measured. The same examiner instructed each participant on each posture before the measurement, and each participant immediately responded to our instructions. We practiced to understand the definition of each posture thoroughly (refer to the previous studies[3, 4]): upright sitting is a state in which the pelvis is slightly tilted forward when standing up; the thoracic vertebrae were placed in a relaxed limb position. Slump sitting is defined as a relaxed thoracic limb position with the thoracic spine in a posterior tilt of the pelvis with the face up. Each limb position was held for 10 s.

Surface electromyography (EMG) was used to measure muscle activity. Disposable electrodes (Ag/AgCl) with a sensor size of 1 cm ×1 cm were used as surface electrodes. After sufficient dermal treatment, the electrodes were placed 2.0 cm apart and parallel to the fiber direction of the muscles. Based on a research[9–12], the rectus abdominis, internal oblique, external oblique, thoracic erector spinae, lumbar erector spinae, and lumbar multifidus, among the trunk muscles, and the tensor fasciae latae, sartorius, rectus femoris, iliopsoas, and upper and lower portions of the gluteus maximus, among the hip joint muscles, were chosen for measurements and as locations for electrode placement. The electrodes were placed on the right side, with the ground electrode placed on the right patella. Telemetry-type EMG (MQ16; Kissei Comtec Co., Ltd., Wada, Matsumoto, Nagano, Japan) and a piece of dedicated software (Vital Recorder 2; Kissei Comtec Co., Ltd., Wada, Matsumoto, Nagano, Japan) in a bipolar derivation at a sampling frequency of 1,000 Hz were used to record electromyograms. The EMG data obtained were subjected to filter processing (bandpass, 20–500 Hz) and root mean square smoothing processing using motion analysis software (Kine Analyzer; Kissei Comtec Co., Ltd., Wada, Matsumoto, Nagano, Japan). The muscle integral value of each muscle was calculated from the stable 5 s by normalizing the activity of each muscle in the upright sitting position.

The spinal–pelvic curvature was measured using a digital camera (EX-F1; Casio Computer Co., Ltd., Shibuya-ku, Tokyo, Japan). On the basis of a study[6, 7], we obtained sagittal plane images after attaching reflective markers with a diameter of 20 mm to the anatomical feature points (C7, Th7, Th12, L3, S2, anterior superior iliac spine (ASIS), and posterior superior iliac spine (PSIS)). The thoracic kyphosis angle (C7–Th7–Th12), lumbar lordosis angle (Th12–L3–S2), and anterior pelvic tilt angle (ASIS–PSIS) were calculated from the acquired images using ImageJ (version 1.48; National Institutes of Health, Bethesda, MD, USA).

To compare the muscle activity and spinal–pelvic curvature between the groups, the LBP and non-LBP groups were examined using the corresponding t-test. Statistics were then analyzed using Statistical Package for the Social Sciences (version 21; IBM Corp., Armonk, NY, USA). All p values <0.05 were used to denote statistical significance.

## RESULTS

The mean and standard deviation (SD) of the spinal–pelvic curvature and pelvic angles (in degrees) and normalized trunk muscle activity (as a percentage of upright sitting) compared with that of the sitting postures are shown in Tables 1 and 2, respectively. Significant differences in the spinal–pelvic curvature and pelvic angle ($p<0.05$) were found between the two sitting postures. During the slump sitting position, both groups had significantly greater thoracic flexion ($p<0.05$), lesser lumbar extension ($p<0.05$), and lesser anterior pelvic tilt ($p<0.05$) than during the upright sitting position. No significant difference was observed between the groups ($p>0.05$).

Regarding the trunk muscle activities in the non-LBP group, slump sitting was associated with significantly lesser muscle activities of the external oblique ($p<0.05$), internal oblique ($p<0.05$), thoracic erector spinae ($p<0.05$), lumbar erector spinae ($p<0.05$), and lumbar multifidus ($p<0.05$) than upright sitting. Additionally, for the hip muscle activities, slump sitting was associated with significantly lesser hip muscle activities of the iliopsoas ($p<0.05$) and upper portion of the gluteus maximus ($p<0.05$) than upright sitting. The muscle activities of the rectus abdominis, tensor fasciae latae, sartorius, and lower portion of the gluteus maximus were insignificantly different between the two sitting postures ($p>0.05$). Next, regarding the trunk muscle activities in the RLBP group, slump sitting was associated with significantly lesser muscle activities of the external oblique ($p<0.05$), lumbar erector spinae ($p<0.05$), and lumbar multifidus ($p<0.05$) than upright sitting. For the hip muscle activities, the muscle activities of the rectus abdominis, tensor fasciae latae, sartorius, iliopsoas, and upper and lower portions of the gluteus maximus were insignificantly different between the two sitting postures ($p>0.05$).

## DISCUSSION

This study clearly revealed that patients with and without LBP showed different trunk and hip muscle activation patterns during sitting. The participants with RLBP had significantly more trunk muscle activities during slump sitting than those without LBP. Additionally, in the LBP group, no change in the hip muscle activity was observed during upright and slump sitting. Postural muscle relaxation could not be facilitated in LBP regardless of the spinal–pelvic curvature. This suggests that slump sitting is not a relaxing posture for patients with RLBP. These findings support the hypothesis that hip muscle control is necessary for postural muscle control.

An interesting finding of this study was that the same degree of the spinal–pelvic curvature was observed during slump sitting in patients with and without RLBP, despite the different muscle activities. Commonly adopted relaxed sitting postures are often passive in nature with a predisposition toward slump sitting. It was considered that the postures rely on the passive

**Table 1.** Comparison of joint angle (°) in the thoracic, lumbar, and pelvic curvatures and anterior pelvic tilt

| | | Thoracic kyphosis | Lumber lordosis | Anterior pelvic tilt |
|---|---|---|---|---|
| RLBP | UP | 159.3 ± 6.0 | 181.0 ± 11.1 | 2.0 ± 8.4 |
| | SL | 147.6 ± 7.6* | 163.6 ± 10.8* | 22.1 ± 9.8* |
| non-RLBP | UP | 153.8 ± 5.0 | 177.0 ± 14.4 | 4.8 ± 4.8 |
| | SL | 146.5 ± 5.5* | 164.2 ± 7.5* | 26.6 ± 8.5* |

Mean ± SD, *p<0.05.
UP: upright sitting; SL: slump sitting.

**Table 2.** Comparison of the muscle activity (percentage of upright sitting) in 12 hip/trunk muscles

| Trunk | RA | EO | IO | TES | LES | LM |
|---|---|---|---|---|---|---|
| RLBP | 116.5 ± 49.0 | 82.1 ± 45.0 | 52.0 ± 24.7* | 77.0 ± 39.3 | 66.8 ± 33.4* | 86.0 ± 16.4* |
| non-RLBP | 111.8 ± 26.7 | 62.7 ± 20.5* | 47.9 ± 20.4* | 46.7 ± 15.2* | 24.0 ± 12.9* | 29.0 ± 15.8* |
| Hip Joint | GMU | GML | IL | TFL | SA | RF |
| RLBP | 105.3 ± 38.2 | 101.3 ± 21.6 | 92.1 ± 39.5 | 84.6 ± 31.1 | 141.8 ± 126.2 | 112.1 ± 79.7 |
| non-RLBP | 88.1 ± 11.4* | 92.2 ± 14.4 | 47.5 ± 28.6* | 91.2 ± 29.4 | 92.2 ± 51.4 | 75.4 ± 45.1 |

Mean ± SD, *p<0.05.
RA: rectus abdominis; EO: external oblique; IO: internal oblique; TES: thoracic erector spinae; LES: lumbar erector spinae; LM: lumbar multifidus; GMU: upper portions of the gluteus maximus; GML: lower portions of the gluteus maximus; IL: iliopsoas; TFL: tensor fasciae latae; SA: sartorius; RF: rectus femoris.

lumbopelvic structures for the maintenance of the position against gravity. Consequently, muscle activity is diminished.

This study showed that slump sitting was associated with reduced muscular activation of the thoracic erector spinae, lumbar erector spinae, lumbar multifidus, external oblique, internal oblique, upper portions of the gluteus maximus, and iliopsoas in the non-LBP group. Conversely, in the LBP group, the muscle activities of the thoracic erector spinae, external oblique, upper portions of the gluteus maximus, and iliopsoas did not differ between the two sitting postures. Additionally, during slump sitting, the LBP group had more trunk muscle activities than the non-LBP group. A reduction in the EMG activity of the erector spinae during slump sitting has been reported consistently in the literature, indicating a “flexion relaxation” response of the back muscles[3, 6, 7]. Postural muscle activity decreases as the lumbopelvic region becomes dependent on its passive structures to maintain the position against gravity at end-range spine flexion.

Normally, the activity of the dorsal muscles is reduced during forward flexion because of the FRP of the spinal column. The FRP of the participants with RLBP in this study had disappeared. Solomonow et al.[13] has reported that postural maintenance in trunk flexion caused the activation of the supraspinatus ligament and vertebral body, which in turn caused abnormal muscle activity. Therefore, in the LBP group, organic changes in the supraspinatus ligament and intervertebral joint capsule may have occurred, which may have led to the development of the following problems. The reflexive muscle activity in the thoracolumbar spinal erector muscle group may be caused by the activation of the thoracolumbar spine.

In the non-LBP group, the lower gluteus maximus muscle did not change its function, but the activity of the upper gluteus maximus muscle mildly reduced and the activity of the iliopsoas muscle greatly reduced. Therefore, the posterior tilt of the pelvis is accompanied by an increase in the activity of the posteriorly inclined muscles or a decrease in the activity of the anteriorly inclined muscles, or both are required. Slump sitting is a comfortable or relaxing posture, thus ideally reducing the activity of the muscle groups on both sides of the tilt. In fact, in patients without LBP, the lower gluteus maximus muscle does not change its function, but the activity of the upper gluteus maximus muscle mildly decreased and the activity of the iliopsoas muscle greatly reduced. Note that the iliopsoas and upper gluteus maximus were associated with control of the pelvic girdle. In studies on the hip muscles, the gluteus maximus[14] and iliopsoas[15] were associated with LBP. These studies suggested that the gluteus maximus and iliopsoas were an important factor in understanding the postural control in individuals with LBP.

This study involved participants with LBP who had FRP disappearance. However, because the number of participants was small, future investigations involving more participants, including patients without LBP, are necessary. Additionally, because this study was conducted only in the seated position, examining the trunk and hip muscle control in the standing passive position as well is necessary.

These findings suggest that slump sitting is a pain-inducing position rather than a relaxing position for patients with RLBP. Because of the high activity of the erector spinae and the stress of non-contractile elements, the lumbar pelvic girdle of the participants with RLBP during slump sitting is suggested to be subjected to significant forces.

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