

# Comparison of the Lumbar Flexion Angle and EMG Activity in Trunk Muscles in Individuals with and without Limited Hip Flexion Range of Motion during Visual Display Terminal Work with Cross-Legged Sitting

MIN-HYEOK KANG, PT, MSc<sup>1)</sup>, JAE-SEOP OH, PT, PhD<sup>2)\*</sup>, BYUNG-JOO PARK, PhD<sup>3)</sup>,  
TAE-HOON KIM, OT, PhD<sup>4)</sup>

<sup>1)</sup> Department of Rehabilitation Science, Graduate School, Inje University, Republic of Korea

<sup>2)</sup> Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University:  
607 Obang-dong, Gimhae-si, Gyeongsangnam-do 621-749, Republic of Korea

<sup>3)</sup> Division of Leisure and Sports Science, Dongseo University, Republic of Korea

<sup>4)</sup> Department of Occupational Therapy, Dongseo University, Republic of Korea

**Abstract.** [Purpose] The purpose of this study was to compare the lumbar flexion angle and electromyography (EMG) measurements of trunk muscle activity in individuals with and without limited hip flexion range of motion (ROM) during visual display terminal (VDT) work with cross-legged sitting. [Subjects] The 15 participants included a control group with sufficient hip flexion ROM (n = 7) and an experimental group with limited hip flexion ROM (n = 8). [Methods] All subjects performed VDT work with cross-legged sitting. The lumbar flexion angle was measured using a three-dimensional motion capture system, and the trunk muscle activity was recorded using a surface EMG system during VDT work with cross-legged sitting. The differences in trunk flexion angle and trunk muscle activity between the two groups were analyzed using independent t-tests. [Results] The lumbar flexion angle was significantly greater in the experimental group than the control group, although trunk muscle activity did not differ between the two groups. [Conclusion] These findings suggest that limited hip flexion leads to greater lumbar flexion during cross-legged sitting.

**Key words:** Cross-legged sitting, Electromyography, Lumbar flexion

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## INTRODUCTION

Desktop computer and laptop use is becoming common, and computing-related musculoskeletal symptoms are considered important health problems in university students and office workers<sup>1-4)</sup>. Previous studies have indicated that improper sitting posture during visual display terminal (VDT) work (e.g., desktop computer or laptop use) can induce musculoskeletal disorders, especially low-back pain<sup>3, 4)</sup>. Carter and Banister<sup>3)</sup> suggested that increased tension in ligaments and discs during a slumped sitting posture may lead to low-back pain.

Cross-legged sitting, a commonly adopted posture during daily living and VDT work, has been reported to induce a slumped sitting posture<sup>5, 6)</sup>. Lee et al.<sup>5)</sup> showed that the cross-legged sitting position leads to a greater slumped posture

compared with an upright sitting posture during VDT work. To prevent the unwanted slumped posture, it is crucial to identify factors that contribute to slumped posture during cross-legged sitting. Limited hip flexion range of motion (ROM) could be one possible risk factor for excessive lumbar flexion. Because the lumbar spine and hip joint are connected via the pelvis, limited hip flexion can cause greater lumbar flexion through pelvic posterior tilt during the trunk flexion-related posture<sup>7)</sup>.

Although it seems reasonable that limited hip flexion ROM leads to greater lumbar flexion during the cross-legged sitting posture, no study has investigated how hip flexion ROM influences the kinematics of the lumbar spine in the cross-legged posture during VDT work. Furthermore, previous studies have not determined whether greater lumbar flexion during VDT work with a cross-legged sitting posture changes trunk muscle activities as measured by electromyography (EMG). Only one EMG study revealed decreased EMG activity in the internal oblique (IO) muscles during the static cross-legged sitting posture compared with the static normal sitting posture<sup>8)</sup>. Thus, the aim of the present study was to compare the lumbar flexion angle and trunk muscle activity in individuals with and without lim-

\*Corresponding author. Jae-Seop Oh (E-mail: ysrehab@inje.ac.kr)

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ited hip flexion ROM during VDT work with a cross-legged sitting position.

## SUBJECTS AND METHODS

In total, 15 university students were recruited for this study. All subjects showed right-leg dominance and performed computer work more than 20 hours per week. Measurements of the right hip flexion ROM were used to classify subjects into the experimental or control groups. According to previous findings<sup>9)</sup>, sufficient hip flexion ROM was defined as more than 120° of hip flexion, and limited hip flexion ROM was defined as ≤110° in this study. Subjects with more than 120° of right hip flexion ROM (one female, six males) were classified into the control group, and subjects with no more than 110° of right hip flexion ROM (eight males) were classified into the experimental group. Subjects were excluded if they had acute low-back pain, orthopedic damage, or lower extremity injury during the last 6 months. In addition, individuals with hip flexion ROM between 110° and 120° were also excluded in this study. The Inje University Faculty of Health Science Human Ethics Committee approved this study, and each subject signed an informed consent form before participation.

To measure hip flexion ROM, subjects were placed in the supine position on a table, and an examiner passively flexed the right hip of subjects until further hip flexion was limited by firm end feel<sup>9)</sup>. The fulcrum of a goniometer was placed on the greater trochanter, and the proximal and distal arms were aligned with the lateral midlines of the pelvis and femur, respectively.

The lumbar flexion angle was measured using eight VICON MX-T10 motion capture systems (Vicon Motion Systems Ltd., Oxford, UK) with a 100-Hz sampling rate. Three reflective markers were placed on the bilateral anterior superior iliac spines and on the midpoint between the bilateral posterior superior iliac spines for the pelvic segment. Additionally, four reflective markers were attached to the first and second lumbar spinous processes and 3 cm bilaterally from the second lumbar spinous process for the lumbar segment. The lumbar flexion angle was calculated by assessing the anterior rotation of the lumbar segment with respect to the pelvic segment using the Cardan angle<sup>10)</sup>. The trunk muscle activity of the bilateral rectus abdominis (RA), external oblique (EO), and IO muscles was recorded using a synchronized surface EMG system (Delsys Inc., Boston, MA, USA). Prior to attachment of the electrodes, skin preparation was performed by shaving the hair and cleansing with an alcohol swab. Each electrode was attached along the direction of the muscle fiber based on placements suggested by Criswell<sup>11)</sup>. EMG signals were acquired at a sampling rate of 1,000 Hz with a bandwidth of 20–450 Hz and converted into root-mean-square (RMS) data. To normalize EMG data of the trunk muscles, reference voluntary contraction (RVC) data of trunk muscles were collected when subjects were seated on a chair in a comfortable sitting posture with 90° of hip and knee flexion for 40 s. The RVC maneuver was repeated three times, and the mean value of the average muscle activity for the middle 30 s of the three

trials was used to normalize trunk muscle activity.

Prior to VDT work, a laptop (XNOTE R400, LG, Seoul, Korea) was placed on a 73-cm-high desk, and subjects sat on a height-adjustable chair without a backrest with 90° of hip and knee flexion. The examiner confirmed the 90° hip and knee flexion position using a goniometer. For VDT work with a cross-legged sitting posture, subjects were instructed to cross the right leg over the left by putting the right knee on the left knee<sup>5, 8)</sup>. Following cross-legged sitting, subjects performed typing work in which they copied some text provided on the monitor by the Korean version of Hansoft. The subjects typed for 1 min for each trial, and three test trials were conducted with 30-s rest periods between trials. The average values of the lumbar flexion angle and EMG activity of the trunk muscles for the middle 40 s of each trial were collected, and the mean values of three test trials were used for data analysis.

The subjects' characteristics (age, height, weight, hip flexion ROM), lumbar flexion angle and trunk muscle activity during VDT work with cross-legged sitting in the experimental and control groups were compared using independent *t*-tests. PASW Statistics Ver. 18.0 (SPSS, Inc., Chicago, IL, USA) was used, and the statistical significance level was set at  $p = 0.05$ .

## RESULTS

The general characteristics of the subjects in the control group (mean age 25.1 ± 1.5 years; mean weight 62.6 ± 5.7 kg; mean height 171.9 ± 6.9 cm) and the experimental group (mean age 23.6 ± 1.5 years; mean weight 67.4 ± 4.1 kg; mean height 175.1 ± 4.5 cm) were not significantly different ( $p > 0.05$ ), except for the hip flexion ROM (123.6 ± 2.4° versus 102.5 ± 3.8°;  $p < 0.001$ ).

The lumbar flexion angle was significantly greater in the experimental group compared with the control group during VDT work with cross-legged sitting ( $p = 0.017$ ) (Table 1). However, there were no significant differences in EMG measures of trunk muscle activity between the control and experimental groups ( $p > 0.05$ ).

**Table 1.** Comparison of the lumbar flexion angle and trunk muscle activity between the two groups during visual display terminal work with cross-legged sitting

Variable	Mean ± SD	
	Control group	Experimental group
Lumbar flexion (°)	15.2 ± 7.0	23.3 ± 4.3*
Right RA activity (% RVC)	101.2 ± 5.9	100.5 ± 8.2
Right EO activity (% RVC)	98.7 ± 6.2	113.3 ± 30.4
Right IO activity (% RVC)	91.4 ± 7.9	109.4 ± 22.3
Left RA activity (% RVC)	101.3 ± 7.1	101.7 ± 8.2
Left EO activity (% RVC)	98.3 ± 5.0	115.3 ± 35.0
Left IO activity (% RVC)	99.8 ± 10.8	97.2 ± 11.3

RVC, reference voluntary contraction; RA, rectus abdominis; EO, external oblique; IO, internal oblique. \* $p < 0.05$

## DISCUSSION

In the present study, the subjects with limited hip flexion ROM showed greater lumbar flexion compared with subjects with sufficient hip flexion ROM during VDT work with cross-legged sitting; however, these differences in hip flexion ROM did not influence EMG activity in trunk muscles.

The lumbo-pelvic-hip complex is connected via a kinematic link termed the lumbo-pelvic rhythm<sup>7, 12</sup>. During forward bending, the lumbar spine is flexed anteriorly with respect to the pelvis, while the pelvis is flexed anteriorly on the femur<sup>12</sup>. When lumbar flexion is limited, greater hip flexion is required with pelvic anterior tilt throughout the lumbo-pelvic rhythm<sup>7</sup>. In other words, greater lumbar flexion is caused throughout the pelvic posterior tilt when hip flexion is limited. The results of our study imply that greater lumbar flexion compensated for insufficient hip flexion in subjects in the experimental group during VDT work with cross-legged sitting.

Despite significant differences in lumbar flexion between the experimental and control groups, EMG activity in the trunk muscles was not significantly different between the two groups. Snijders et al.<sup>8</sup> reported that the cross-legged sitting position decreased EMG activity in IO muscles due to increased stability in the sacroiliac joint. The cross-legged sitting posture is performed by the combined motion of hip flexion and adduction. Increased tension in the biceps femoris, gluteus maximus and piriformis by hip flexion and abduction influences sacroiliac joint compression and tension in the sacrotuberous ligament, which can contribute to increased stability in the sacroiliac joint<sup>13–15</sup>. Although the hip flexion angle may have been influenced by differences in hip flexion ROM in subjects in this study, sufficient hip adduction may have been possible for all subjects during VDT work with cross-legged sitting. We suggest that the sacroiliac joint compression by hip adduction during cross-legged sitting may not differ between subjects with and without limited hip flexion ROM, resulting in the absence of significant differences in EMG activity in trunk muscles between the two groups.

There are some limitations to our study. First, our study included a small sample size; therefore, it is difficult to generalize our results. Second, the subjects performed VDT work for only 1 min. However, a previous study by Lee et al.<sup>5</sup> showed that trunk kinematics were immediately changed after assuming a cross-legged sitting posture dur-

ing VDT work, and the trunk flexion angle then did not significantly change for 30 min. Based on previous findings, we consider that the kinematic data of the lumbar spine and EMG data of the trunk muscles during VDT work with cross-legged sitting for short periods may provide meaningful information for individuals who prefer cross-legged sitting.

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