Changes in Craniocervical and Trunk Flexion Angles and Gluteal Pressure during VDT Work with Continuous Cross-legged Sitting

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Abstract: Changes in Craniocervical and Trunk Flexion Angles and Gluteal Pressure during VDT Work with Continuous Cross-legged Sitting: Jung-Hoon Lee, et al. Department of Physical Therapy, Inje University Pusan Paik Hospital and Department of Physical Therapy, The Graduate School, Inje University, Republic of Korea—Objectives: This study investigated changes in craniocervical and trunk flexion angles and gluteal pressure on both sides during visual display terminal (VDT) work with continuous cross-legged sitting. Methods: The gluteal pressures of ten VDT workers, who were recruited from laboratories, were measured using a Teckscan system and videotaped using a single video camera to capture the craniocervical and trunk flexion angles during VDT work at 30 s, 10, 20 and 30 min. Results: The craniocervical angle was significantly increased at 10 and 20 min compared with the initial angle (p<0.05). The trunk flexion angle was significantly decreased at 30 s, 10, 20 and 30 min (p<0.05). The gluteal pressure of the crossed-leg side significantly increased at 30 s, 10 and 20 min (p<0.05). The gluteal pressure of the uncrossed-leg side significantly decreased at 30 s (p<0.05). Conclusion: We found that cross-legged sitting during VDT work may exert disadvantageous postural effects resulting from craniocervical and trunk flexion angles and gluteal pressure. Therefore, this posture could not be recommended during long-term VDT work. (J Occup Health 2011; 53: 350–355)

Key words: Changes in angle, Neck pain, Pelvis, Pressure, Sitting

Many office workers spend long hours sitting at their desks while doing their jobs1. Maintaining good alignment of the body in the sitting position can prevent or reduce posture-related pain2. Biomechanical studies have indicated that an incorrect sitting posture can affect posterior rotation of the pelvis, resulting in decreased lumbar lordosis and sacral inclination and increased forces at the discs3. Prolonged sitting postures in combination with poor workstation ergonomics have been significantly implicated in the development of musculoskeletal problems during visual display terminal (VDT) work4. Specifically, intensive VDT workers had frequent work-related neck problems5. In a typical VDT work week, a fixed position is maintained for a long period of time6. VDT workers usually have increased forward neck flexion compared with their relaxed sitting postures7, 8. The head and neck posture can affect the relationships between soft tissues in the cervical region9. Neck and shoulder pain has also been shown to be related to VDT work10.

Cross-legged sitting postures (i.e., sitting with one leg crossed over the other) are often used for sustained VDT work11. In previous studies, EMG measurements have indicated that the activity of both the external oblique (EO) and internal oblique (IO) is significantly decreased during cross-legged sitting, resulting in reduced muscle fatigue12, 13. In the cross-legged posture, hip flexion and adduction, which are generally required to compress the sacroiliac joint by stretching the gluteus maximus, piriformis, hamstrings, dorsal ligaments and fascia12, contribute to sacroiliac joint stability13. Therefore, crossed-legged sitting is physiologically valuable12.

However, whether continuous cross-legged sitting during VDT work is a physiologically advantageous or disadvantageous posture has yet to be clearly examined. Hence, the objectives of this study were to determine whether changes occur in craniocervical and trunk flexion
Jung-Hoon Lee, et al.: Changes in Cross-legged Sitting angles and gluteal pressure on both sides during VDT work with continuous cross-legged sitting.

Methods

Subjects and sampling procedure

The subjects were 10 asymptomatic male VDT workers aged 20 to 26 yr. They used computers for 7.2 ± 1.5 (mean ± SD) hours per day as seated workers. We performed a power analysis and calculated the sample sizes required for detection. The demographics of the subjects are shown in Table 1. The subjects were selected based on the following functional measurements and evaluations performed by an expert physical therapist: range of motion and manual muscle testing in each joint and muscle of the upper and lower extremities, pain assessment during static and dynamic movements and alignments of the head, neck, shoulder, spine and pelvis. Subjects who had a history of upper or lower extremity, spine and pelvic neuromuscular and musculoskeletal problems that could affect VDT work were excluded. Informed consent was acquired from these subjects prior to execution of the study according to the requirements of the Inje University Faculty of Health Science Human Ethics Committee.

Measures

1) The Tekscan system

The location and magnitude of gluteal peak pressure was measured by a Tekscan system (Tekscan, Inc., South Boston, MA, USA) during VDT work with continuous cross-legged sitting. The Tekscan system consisted of hardware with thin-film pressure sensors (mats) and a software program (COMFOMat research 6.20). The mats contain 1,024 individual pressure sensors. Thirty-two sensing elements are arranged in rows and columns to produce a spatial resolution of 0.46 cm². The thin-film aspect of the mats enables the inclusion of sensors without changing the characteristics of the support surface. Such factors allow precise measurements of the location and magnitude of peak pressures as well as the overall pressure-distribution patterns. The system provides a real-time pressure map of people in seats as well as measurements of pressure change, contact area and the location of the peaks of the pressure zones. The pressure sensor signals were sampled at 50 Hz.

2) Video motion-analysis system

The movement of each subject during the VDT work was videotaped using a single video camera. Six reflective markers 14 mm in diameter were placed by the same investigator on the outer canthus of the eye, the tragus of the ear, the spinous process of the seventh cervical vertebra (C7), the acromion, the spinous process of the first lumbar vertebra (L1) and the midpoint of the greater trochanter. All markers were attached on the left side of each subject’s body using double-sided tape. The craniocervical angle was defined as the angle between the line from the tragus to the outer canthus of the eye and the line from the tragus to the C7 spinous process. The trunk flexion angle was defined as the angle between two lines extending from L1 to the acromion (A) and L1 to the greater trochanter (GT).

Table 1. Demographic information of the subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>10 males</td>
</tr>
<tr>
<td>Age</td>
<td>24.5 (± 1.9) yr</td>
</tr>
<tr>
<td>Height</td>
<td>1.73 (± 0.4) m</td>
</tr>
<tr>
<td>Weight</td>
<td>66.5 (± 3.1) kg</td>
</tr>
<tr>
<td>Hours of VDT work</td>
<td>7.2 (± 1.5) h/day</td>
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Fig. 1. Summary of subject movement measurements. Craniocervical angle (CCA): the changes in angle between the line from the tragus (T) to the outer canthus (OC) of the eye and the line from the tragus to the C7 spinous process. Trunk flexion angle (TFA): the changes in angle from two lines extending from L1 to the acromion (A) and L1 to the greater trochanter (GT).
were suspended from the ceiling to provide a vertical and magnification reference. To reduce variability, all procedures were performed by the same researcher. Using a video camera for assessing postures during a long period has many advantages.

Procedure
All subjects performed VDT work for half an hour using the same computer workstation, in which the monitor was inclined backward by 20°, with their eyes 0.8 m from the monitor and the top of the display 20° below eye level. To ensure that the hips and knees were flexed at 90°, an adjustable-height table and chair without a backrest were used to set the initial sitting posture. A 5-min adjustment period was provided, during which subjects were instructed to select a workstation configuration that felt the most comfortable. The same configuration was maintained for the duration of the half-hour VDT work period. During the experimental period, all subjects performed selected keyboard typing work in the Korean version the Hansoft program. This typing work involved duplicating sentences that were presented on the monitor. All the subjects had sufficient experience with typing and could type without looking at the keyboard.

When the subjects started typing, they were asked to maintain an upright sitting posture on the mat of the Tekscan system. At 30 s after they started typing, they were asked to cross their right leg completely over the left leg such that the back of the right knee lay comfortably over the left knee for the remainder of the experimental period. During 30 min of data collection by the Tekscan system and video camera, peak gluteal pressure and kinematic data were analyzed by the COMFOMat research 6.20 and Pro-Trainer 10.1 proarams, respectively, at 30 s, 10, 20 and 30 min. A single-blinded recording method was used to ensure that results were not affected by the participant’s intentional bias.

Statistical analysis
The SPSS statistical package (version 14.0; SPSS, Chicago, IL, USA) was used to analyze significant differences in the craniocervical and trunk flexion angles and gluteal pressures on both sides during VDT work with continuous cross-legged sitting. Statistically significant differences were tested by a repeated one-way ANOVA, with the level of statistical significance set at \( p < 0.05 \). Multiple comparisons were based on Bonferroni’s correction.

Results

Craniocevical angle
The craniocervical angle was 153.5 ± 6.10° at initial upright sitting, 158.5 ± 9.02° at 30 s (i.e., the time taken to shift from the initial upright sitting posture to the cross-legged sitting posture), 162.6 ± 8.41° at 10 min, 161.7 ± 7.65° at 20 min and 160.7 ± 10.63° at 30 min. The angle was significantly increased at 10 min and 20 min compared with the initial angle (\( p < 0.05 \)). There was no significant difference for the craniocervical angle at 30 min (Fig. 2).

Trunk flexion angle
The trunk flexion angle was 123.9 ± 10.57° in the initial upright sitting posture, 111.9 ± 7.11° at 30 s after cross-legged sitting, 109.8 ± 9.83° at 10 min, 109.1 ± 8.39° at 20 min and 109.1 ± 11.78° at 30 min. The trunk flexion angle was significantly decreased at 30 s, 10, 20 and 30 min (\( p < 0.05 \); Fig. 2).

Gluteal pressure
The right gluteal pressure (crossed-leg side) was 0.53 ± 0.26 (kg/cm²) in the initial upright sitting position, 0.69 ± 0.28 (kg/cm²) at 30 s, 0.75 ± 0.27 (kg/cm²) at 10 min, 0.73 ± 0.30 (kg/cm²) at 20 min and 0.71 ± 0.30 (kg/cm²) at 30 min. The gluteal pressure of the crossed-leg side significantly increased at 30 s, 10 min and 20 min (\( p < 0.05 \)).
There was no significant difference for gluteal pressure at 30 min (Fig. 3). The left gluteal pressure (uncrossed-leg side) was 0.70 ± 0.28 (kg/cm²) in the initial upright sitting position, 0.41 ± 0.26 (kg/cm²) at 30 s, 0.58 ± 0.32 (kg/cm²) at 10 min, 0.57 ± 0.32 (kg/cm²) at 20 min and 0.59 ± 0.29 (kg/cm²) at 30 min. The gluteal pressure of the uncrossed-leg side significantly decreased at 30 s ($p$<0.05). There was no significant difference between the measured values of the gluteal pressure at 10, 20, 30 min and that of the initial sitting position (Fig. 3).

**Discussion**

This study was designed to investigate changes in craniocervical and trunk flexion angles and gluteal pressures on both sides during VDT work with continuous cross-legged sitting. The craniocervical angle gradually increased after shifting from the initial upright sitting posture to the cross-legged sitting posture. The angle was not only significantly increased at 10 min, but also showed a significant increase at 20 min. In a previous study, it was shown that VDT workers had increased forward neck flexion when compared with their relaxed sitting postures, and 13% more forward neck flexion was observed in symptomatic persons [7]. Increased forward neck flexion may increase the risk of work-related musculoskeletal problems by increasing the tension in the posture-stabilizing muscles and increasing the compressive forces on the articulations of the cervical spine [18]. Chiu et al. [19] found that approximately 60% of people with neck pain exhibited forward head postures (FHPs). Such FHPs contribute to the occurrence of chronic neck and shoulder pain [8]. This may be due to decreases in the average length of the muscle fibers, which contributes to the extensor torque of the atlanto-occipital joint [18]. Excessive FHP was correlated to the occurrence of cervicogenic headaches and chronic tension-type headaches (CTTHs) [20]. In blinded controlled studies, CTTH was correlated with active myofascial trigger points (TrPs) in the suboccipital [21], temporalis, sternocleidomastoid and upper trapezius muscles [22].

The trunk flexion angle was significantly decreased immediately after shifting from the initial upright sitting posture to the cross-legged sitting posture, and a significantly decreased degree was observed at 10, 20 and 30 min. When the legs were crossed, the trunk flexion angle was decreased with an accompanying reduction of the range of motion in hip flexion and increased pelvic rotation in the lumbar area [23]. Additionally, prolonged flexion during sitting was found to result in redistribution of the nucleus within the annulus [24]. These factors may collectively cause disc degeneration, herniation or ruptures, potentially leading to lower back pain. Additionally, Snijders et al. [13] reported a relaxation phenomenon in IO muscles during cross-legged sitting when compared with supported upright sitting. It was proposed that reduction of IO muscle activity during cross-legged sitting may strengthen the passive system stability in the sacroiliac joints [13]. In the case of end-range spine flexion, the postural muscle activity decreases, as the lumbo pelvic region depends on passive structures to maintain body position in response to gravity [25]. It has been suggested that these findings may be closely related to decreases in lumbo pelvic stabilizing muscle activity and the adoption of passive postures [26]. Decreases in trunk muscle activity were shown to result in increased load on the lumbar discs and ligaments [27]. This may cause more strain, instability or injury in the lumbo pelvic region [27]. When lumbar muscle activity does not increase and thoracic activation levels decrease, passive tissues (ligaments, lumbodorsal fascia, etc.) of the spine may support the load moment [27]. Numerous free nerve endings act as pain receptors in ligaments of the lumbar spine [28]. Load added to the ligaments of the lumbar spine for a long duration may affect the lumbar spine [29], stimulate pain receptors and eventually become a source of low back pain in seated workers [27].

The gluteal pressure on the crossed-leg side significantly increased at 30 s, 10 and 20 min. The gluteal pressure on the uncrossed-leg side was significantly decreased at 30 s. In other words, the imbalance of the gluteal pressure between the right and left legs was found immediately after the leg was crossed, and at 30 min, the gluteal pressure pattern was opposite to the initial pattern. During sitting, the upper body weight is transferred mainly to the ischial tuberosities [30]. The interfacial pressure on the gluteal area and lower back is dependent on sitting posture [11, 32] and body positioning [31]. The decreased activity of the muscles that are involved in positioning has been shown to increase the load on the bones and ligaments [33]. Therefore, decreases in EO and IO activity may result in additional and abnormal pressures on the ligaments and on the bone of the ischial tuberosities. These may significantly increase the gluteal pressure on the ipsilateral (crossed-leg) side. The increased pressures on the ischial tuberosities may be closely related to elevated spinal loads [30]. Furthermore, the metabolite accumulation due to the static load may accelerate disc herniation and degeneration [30].

When the subjects crossed their legs, the PSIS rotated backward, with the femur flexing by more than 90° on the right (crossed-leg) side [32]. As posterior tilt of the ilium shortens the hamstring muscles and lengthens the rectus femoris muscles, pelvic asymmetry may affect the lengths of muscles around the pelvis [30]. Pelvic asymmetry in the sagittal plane by iliac rotation asymmetry often leads to sacroiliac joint dysfunction and results in misalignment of the innominate bones [30]. Pelvic asymmetry may alter body mechanics, increase strain on soft tissues and bones and contribute to musculoskeletal problems [31]. In addition, functional compensation for pelvic asymmetry changes
the trunk\(^{36}\).

This study had a few limitations. First, it is difficult to standardize the postural changes because the sample size was small, the subjects were simply described as Korean men in their 20 s and only short-term response was examined. Second, changes in the craniocervical and trunk flexion angles during VDT work with continuous cross-legged sitting were not directly measured in 3-D motion. Third, all the subjects were asked to cross their right legs, and they were not asked to the crossed leg that felt most comfortable. Fourth, the study did not separately evaluate the effects of continuous cross-legged sitting and VDT work on working posture. Further studies are required to evaluate all of these issues.

**Conclusion**

We found that cross-legged sitting during VDT work may exert disadvantageous postural effects resulting from craniocervical and trunk flexion angles and gluteal pressure. Therefore, this posture could not be recommended during long-term VDT work.

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**References**