Abstract  The prevalence and incidence of musculoskeletal disorders is high with computer workers, and poor sitting posture can be considered a factor contributing to low back discomfort. In the clinical literature, maintaining a neutral spinal curvature has been considered an optimal sitting posture. This study investigated the flexion and lateral flexion of trunk movements and trunk muscle activity during computer work with and without a posture-sensing air seat device (PSASD). By sensing a certain amount of increased pressure over the baseline, posture-related visual feedback was given to participants through the PSASD. Eleven regular computer workers participated in this study. PSASD had the function of alerting the subject to their poor posture by using visual feedback. Subjects performed 20 min of computer work with and without a PSASD. Surface electromyography was used to measure the activity of the erector spine and internal abdominal oblique. Kinematic data were obtained using an electrogoniometer. The results showed that the mean of trunk flexion and lateral flexion was significantly reduced with PSASD. The activity of the erector spine and internal oblique was significantly higher with the PSASD than without. Our findings indicated that the PSASD helps to prevent habitual poor posture by maintaining an erect sitting posture during prolonged computer work. J Physiol Anthropol 30(4): 147–151, 2011 http://www.jstage.jst.go.jp/browse/jpa2 [DOI: 10.2114/jpa2.30.147]

Keywords: electrogoniometer, electromyography, poor posture, postural sensing, visual feedback

Introduction

With increasing sedentary work in the industrial arena, workers are required to spend more time in front of their computers (Balei and Aghazadeh, 2003; Watanabe et al., 2007). The prevalence and incidence of musculoskeletal disorders is high with computer workers (Watanabe et al., 2007; Aaras et al., 1997).

Studies conducted by the National Institute for Occupational Safety and Health (NIOSH) demonstrated that 20.25% of 1,000 computer workers complained of constant discomfort in the back area (Sauter et al., 1991). Although the mechanism of low back pain has not yet been clearly established (Callaghan and Dunk., 2002), some researchers have considered biomechanics, suggesting that poor sitting posture might be associated with low back pain (O’Sullivan et al., 2002; Strong et al., 2002; Lauren and Stephen, 2006). O’Sullivan reported that decreases in trunk muscle activation within a flexed-relaxed sitting posture leads to a higher load on passive structures for maintaining the posture against gravity (O’Sullivan et al., 2002). Constraint loads on passive structures may contribute to impaired reposition sense (Dolan and Green, 2006). In the clinical literature, maintaining a neutral spinal curvature with anterior rotation of the pelvis has been considered an optimal sitting posture (Strong et al., 2002; Neumann, 2002). According to this view, various ergonomic interventions have been suggested that maintain a neutral spinal alignment and prevent poor posture (Yoo et al., 2006; Bettany-Saltikov et al., 2008; Carcone and Keir, 2007). Most related studies included trunk movements in the sagittal plane, which only had the effect of preventing a flexed-relaxed posture (Yoo et al., 2006; Bettany-Saltikov et al., 2008; Carcone and Keir, 2007). Although seats that constrain lateral flexion and rotation are known risk factors for low back pain (Strong et al., 2002; Marras and Granata, 1997), scientific research relating these factors to the ergonomic chair is lacking. Feedback systems have been used for altering posture because clinical assessments of computer workers indicated the positive effects of postural correction in a previous study (Yoo et al., 2006).

Therefore, we hypothesized that proper use of a pressure-sensing feedback device with seat support might be effective for computer workers in preventing poor posture. The purpose of the current study was to determine the effects of a posture-sensing air seat device (PSASD) on the human
musculoskeletal system by assessing the kinematics of the lumbar region and trunk muscle activity during prolonged computer work.

**Methods**

**Subjects**

This study was performed on eleven healthy, sedentary workers recruited from a laboratory. Subjects were aged 20 to 27 years (23.8±5.7 years, mean±SD), and their mean heights and weights were 175.4±5.2 cm and 66.1±2.1 kg, respectively. Inclusion criteria were regular sedentary workers who used the computer at least 8 hours per day. Participants with histories of upper- or lower-extremity injuries/diseases were excluded from the study. Ethical approval was obtained from the Inje University Faculty of Health Science Human Ethics Committee, and all subjects provided written informed consent to participate prior to the commencement of the study.

**Feature of the PSASD**

General seat supports used in this study were made of sponge cushions with widths and lengths of 46 and 38 cm, respectively. We modified the seat supports by placing 3 small air tubes around the seat. One of these was placed just below the coccyx to detect increasing pressure caused by the flexed-relaxed posture. The other 2 air tubes were placed on the lateral and inferior sides of both thighs to detect increasing pressure due to the forward, lateral-leaning posture. Three air tubes were inserted in the seat support, fully inflated, and independently connected with a thin tube to three pressure sensors (AP-series pressure sensor, Keyence, Japan). The pressure sensors were able to sense a certain amount of increased pressure over the baseline. To give visual feedback to each participant, pressure sensors were linked to display devices, which were covered with magnifying glasses engraved with the words “poor posture.” These were placed beside the monitor at the participants’ workspaces. To account for differences in the subjects’ weights, the baseline of the air pressure with sitting was set by each subject. Prior to the experiment, threshold of the three pressure sensors was set by measuring pressure when the subject had an excessive flexed-relaxed posture, and excessive leaning postures in both sides. The unit of measurement was set as mmHg, and the range of values was 48–65 mmHg for the posterior air tube, 24–32 mmHg for the side air tubes in neutral sitting; 56–74 mmHg for the posterior air tube in flexed relaxed sitting; and 31–46 mmHg for the side air tubes in leaning postures. The threshold values of the 3 air pressure sensors and the baseline pressure data of erect sitting are demonstrated in Table 1.

**Set-up and measurement**

Trunk movements in the sagittal and frontal planes were measured using a flexible electrogoniometer (EGM) system (M120B, Biometric, Ltd., UK), which included strain gauges that continuously measured the angle between the two end-sensor units. Sensors were placed at the L1 and S2 vertebrae to assess lumbar kinematics (Dolan and Green, 2006). Each sensor was firmly fixed with double-sided medical tape and covered by single-sided tape to minimize movement between the sensors and the underlying skin (Dolan and Green, 2006; Thoumie et al., 1998). The EGM system used in our study assessed the movements within the X- and Y-axes; the baseline was calibrated prior to the experiment in each plane at 90° using a set square. Negative values on the X-axis denoted lordotic curvatures and positive kyphotic curvatures. Positive values on the Y-axis represented right lateral flexion, while negative values represented left lateral flexion of the lumbar region. The digitalized data were obtained at a sampling rate of 1,000 Hz and analyzed using a program created with Acknowledge software (BioPac System, Santa Barbara, CA, USA).

Electromyographic (EMG) data were obtained by using a BIOPAC system (MP150 acquisition system unit, Acknowledge TM software and surface EMG electrodes). EMG signals were amplified and band-pass filtered through a 10 to 500 Hz, and the signals were acquired at a sampling rate of 1,000 Hz. Reference 5-s voluntary isometric contractions (RVICs) were measured for normalization of the EMG amplitude. Surface electrodes were placed on the right side of the following muscles: Erector spine (ES) 2 cm lateral to the midline at the L4 to L5 interspinous spaces, and the internal oblique (IO) medial to the anterior superior iliac spine.
To collect RVIC data, subjects were requested to wear a 10-lb sandbag on their right leg and take a quadruped posture. They were then asked to raise their right leg with their knee extended until the leg was parallel to the ground. The mean value of three trials for each muscle activation was taken as the RVIC. All procedures were performed by the same investigator.

Subjects performed 20 min of computer work with and without a PSASD. The absence of the PSASD eliminated visual feedback by turning off the display device. Each subject randomly performed computer work in an AB or BA order, with a 20-min interval between the tests. The same computer workstation was used by all subjects. The LCD monitor was positioned 0.8 m from the subject and at a slant angle of 20° backward. The height of a standard office chair with a back and armrest was adjusted to the subject’s popliteal level so that the hips and knees were flexed at 90°. Each subject had 5 min to adjust the work environment to their comfort preference, and all performed copy-typing work using a generalized typing program produced by Haansoft (Hangul and Computer, Korea), which displayed a famous novel on the screen. During the last 5 min of each test, EMG and EGM data were collected and analyzed with Acknowledge 4.1 software. Kinematics and muscle activity during each test were calculated as mean values for statistical analyses.

### Statistical analysis

The SPSS statistical package (version 14.0; SPSS, Chicago, IL, USA) was used to analyze the differences in trunk flexion and lateral flexion, muscle activation of ES, and IO during computer work with and without the PSASD. The Paired t-test was utilized to detect the significance of differences in collected data between the presence and absence of the PSASD. All significance levels were set at $p<0.05$.

### Results

The chair without the PSASD was associated with significantly greater mean trunk flexion and lateral flexion compared with the chair with the PSASD ($p<0.05$; Table 2). Muscle activities of both the ES and IO were significantly higher with the PSASD than without ($p<0.05$; Table 3). An example in which the PSASD corrects subject sitting posture is illustrated in Fig. 2.

### Discussion

The incidence and prevalence of back pain related to prolonged computer work was caused by constant poor posture at work. Because poor postures such as flexed-relaxed or leaning posture did not require axial muscular effort to support the load of the body, it could be regarded as more comfortable. This could be why it was easy to become acclimatized to a flexed-relaxed posture which distributes the load to passive structures instead of work demanding active muscular structures. O’Sullivan et al. (2006) found that the presence of a flexion-relaxation phenomenon (FRP) when moving from an erect to a flexed-relaxed sitting posture, which indicates that poor posture of the trunk is supported by the passive paraspinal structures rather than by active muscular co-contractions. Dolan and Green (2006) suggested that proprioceptive control for the neutral zone of the spine was also influenced by degenerative change during the flexed-relaxed posture.

Maintaining upright sitting posture is an important factor for preventing and reducing posture-related low back pain (Kendall et al., 2005), which is widely known by even the general public. The assumption of the present study was that the cause of musculoskeletal problems related to sitting posture is the lack of constant cognition of one’s posture and habitual sitting in daily life. Not only devices but assessment tools and interventions for preventing an unsuitable...
The effects of a PSASD demonstrated in our study corresponds with the prevalence of scoliosis and an increase in the shearing force on the spinal column (Neumann, 2002). Our findings suggested that a chair with a PSASD has the additional advantage of preventing a leaning posture during computer work as well as reducing a flexed-relaxed seating posture.

The increase in surface EMG activities of the ES and IO with a PSASD demonstrated in our study corresponds with kinematic data, which showed less trunk flexion during computer work. It is consistent with previous studies investigating the relationship between muscle activation and sitting posture (O’Sullivan et al., 2002; O’Sullivan et al., 2006). Watanabe also reported that co-contraction of the trunk muscles stabilized the lumbopelvic region and contributed to correct lumbar curvature (Watanabe et al., 2007).

In previous work, Yoo et al. (2006) has already investigated the effect of an auditory feedback device with a proximity sensor on sitting posture during VDT work. However, usage of an auditory feedback device showed it to be distracting, and the work efficiency of seated workers was affected. In addition, the PSASD was able to warn of lateral bending posture and had the convenience of portable usage, compared with previous work which developed the form of the chair with one proximity sensor. Although we suggested that the PSASD device could result in a reduced load on the passive structures of the spine by preventing a flexed-relaxed posture, we could not determine whether the posture adjusted by the PSASD represented the ideal posture as perceived by the clinician. Recent findings revealed that there is no significant difference between subjective impressions of optimal postures and clinically recommended postures (O’Sullivan et al., 2010). We believe that asymptomatic people have the capability to reposition to an optimal posture when they become aware of poor posture. Although various ergonomic chair designs have demonstrated positive effects in many studies, it is very unlikely that every individual factor is reflected in a chair design. Therefore, voluntary posture correction with feedback, as demonstrated in our study, could serve as another ergonomic intervention resulting in repositioning to optimal posture. Although the ideal sitting posture in the clinical literature is considered to be a position in which the subject has a neutral pelvic tilt and neutral lumbar and thoracic postures, with regard to investigation of sitting postures and spinal curvature (O’Sullivan et al., 2006; Claus et al., 2009), there may be a difference between a subjectively ideal sitting posture obtained by visual feedback, as in our study, and an appreciated ideal sitting posture as perceived by the clinician (Claus et al., 2009).

The PSASD device had the advantage of preventing habitual poor posture by promoting an upright sitting posture during computer work. However, there were some limitations to our study. First, the decreased lumbar motion and static upright posture of individual workers could result in muscle fatigue of the lumbar extensors. Second, we did not measure the subjective feeling of discomfort associated with gluteal pressure and both sides of trunk muscle activation. Future research should consider these limitations and proceed as composite studies assessing discomfort and muscle fatigue accompanying lumbopelvic kinematics.

Acknowledgments This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No. 2010-0003874).

References


designed kneeling chairs are they worth it?: Comparison of sagittal lumbar curvature in two different seating postures. Stud Health Technol Inform 140: 103–106


Received: October 28, 2010
Accepted: April 13, 2011
Correspondence to: Won-gyu Yoo, 607 Obangdong, Gimhae, Gyeongsangnam-do 621–749, Republic of Korea
Phone: +82–55–320–3994
Fax: +82–55–329–1678
e-mail: won7y@inje.ac.kr