Dual Lumbar Continuous Passive Motion Device Works Effectively for Prevention of Low Back Pain during Prolonged Sitting

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Introduction
To prevent low back pain and discomfort during prolonged sitting, an inflatable lumbar support cushion has been developed that provides lumbar continuous passive motion (CPM) (J Spinal Disord 1994). This device has a lumbar support inflating and deflating air bladder that provides a cyclical motion to the spine, periodically changing the lumbar lordosis angle. Based on results obtained from healthy volunteers, however, Aota et al showed that subjective ratings of discomfort did not differ significantly between a CPM lumbar support device and a fixed lumbar support (Spine 2007). To improve the effects in the prevention of low back pain, authors have developed a dual CPM device, in which an additional CPM cushion is located in the front portion of the seat. The primary purpose of this study was to determine whether this combination work effectively or not in the prevention of low back pain, whole body movements and pressure distribution changes in the human-seat interface during CPM were also compared with different modalities in the airbag install condition.

Materials and Methods:
A total of 23 male volunteers were recruited from a university student population (mean age: 21.2 ± 0.6 years; mean height: 172.4 ± 7.5 cm; mean weight: 67.1 ± 15.3 kg). All subjects were pain-free at the time of data collection and had not experienced low back pain for a period of six months prior to the study. All subjects gave fully informed consent.

A pneumatic device was constructed with two bladders that cyclically inflated and deflated using a pump and valve system. The dual CPM device has two synchronized bladders with two working modalities the same phase (When one bladder inflates the other inflates) and the opposite phase (When one bladder inflates the other deflates). The system is controlled by a timer and pressure feedback from the bladder. The amount of air supplied to the air bladders and cycling settings are variable through the use of a hand control to better accommodate the needs of individual users. A higher air pressure results in a greater thickness of the air bladder in the lumbar region. The bladder is 15 cm high, 37 cm wide, and approximately 8 cm thick when fully inflated, and 5 cm thick when fully deflated (Figure 1, left). The air bladders are attached to the seat with adjustable straps so it can be easily interchanged among different seat designs.

Figure 1. The dual CPM device (left) and sitting posture on the installed chair (right).

The CPM cycle rate was set at 60 seconds inflation and 60 seconds deflation. The optimal cushion pressure was set by each subject using trial and error. Each subject sat in the chair for two hours on each of eight consecutive days, testing one of the eight test modalities each day. Subjects sat in a chair for a two-hour period on each of eight consecutive days under eight test modalities (Figure 1, right). The test modalities were: (1) no lumbar support (no bladder inflation); (2) static lumbar support (a selected constant bladder inflation); (3) lumbar support CPM; (4) static seat cushion (a selected constant bladder inflation); (5) seat CPM; (6) static lumbar support cushion seat cushion (a selected constant bladder inflation); (7) dual CPM in the same phase; and (8) dual CPM in the opposite phase. The order of the eight modalities was randomized. Throughout the duration of each trial, efforts were made to induce subjects to not move. Subjects were allowed to read books. No specific instructions were given with respect to sitting posture. Immediately after the two-hour period of sitting, each subject indicated low back pain and/or lumbar discomfort, stiffness, fatigue, and buttock numbness on a 10-cm visual analog scale (VAS), where zero represented the least and ten represented the most discomfort experienced.

Whole body motion and pressure distribution of the human-seat interface of the subjects undergoing lumbar support CPM device operation were also studied. Sagittal alignment of the spine and pelvis was evaluated at following four representative airbag conditions: 1, no airbag inflation; 2, lumbar airbag inflation; 3, seat airbag inflation; and 4, dual air bags inflation.

The pressure distribution of the human-seat interface, i.e. contact areas and peak pressures at peak inflation and complete deflation were measured using the Bigmat System (Bigmat, Japan). The mean VAS scores obtained following the three test modalities and the pressure distribution during inflation were compared using the paired Student T test. P values less than 0.05 were considered to be statistically significant.

Results
The VAS scores are shown in Figure 2. Compared to the lumbar support CPM, scores were significantly high with no lumbar support (p<0.005) and significant (p<0.05) improvement in VAS scores for low back pain, lumbar stiffness, fatigue, and buttock numbness was obtained with the dual CPM device (data for stiffness, fatigue, and buttock numbness not shown).

Figure 2. VAS scores for low back pain.

On X-rays measurements, a forward rotation of the pelvic region and lumbar forced lordosis were significantly obtained during inflation of the lumbar cushion as compared to no lumbar support (data not shown). A minimal motion was observed at the head and below the knee.

Significant differences were noted between lumbar cushion inflation and seat cushion inflation periods both in contact areas (1300 ± 112 cm² at lumbar cushion inflation and 1362 ± 82 cm² at seat cushion inflation; p<0.005) and in the average pressures at the human-seat interface (2.2 ± 0.5 kPa at lumbar cushion inflation and 2.4 ± 0.5 kPa at seat cushion inflation, p<0.05).

Discussion:
The benefits of a single bladder lumbar support CPM device over static lumbar support are limited. The significant improvement in VAS scores obtained with the dual CPM may be explained by the forward rotation of the pelvis. The dual CPM may provide a comprehensive solution for occupational disability due to sitting intolerance.

Acknowledgement
This work was partly supported by 2007 JSPS grant-in-aid for scientific research (No. 19500480-0001), 2006 Strategic Research Project (No. 186) and 2008 Strategic Research Project (No. T200008) of Yokohama City University.