Iran J Public Health, Vol. 51, No.9, Sep 2022, pp.2069-2077

Original Article

The Effect of a Pelvic Support Chair on Sagittal Lumbosacral Alignment in Sitting Position in Patients with Lower Back Pain

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(Received 05 Apr 2021; accepted 26 Jul 2021)

Abstract

Background: A slouched lumbar posture during sitting is risk factor for the low back pain (LBP). Various chairs have been used to maintain sagittal lumbar lordosis and sacral alignment during sitting. We aimed to demonstrate the effect of a pelvic-support chair on the lumbar lordosis and sacral tilt in patients with LBP.

Methods: We recruited 29 patients with non-specific LBP and 11 healthy subjects in South Korea from Apr 2017 to Mar 2018. The sagittal lumbosacral alignment was examined radiographically in three sitting postures: usual, erect, and sitting in a pelvic-support chair. Five angles [the lumbar lordosis, upper lumbar (ULA), lower lumbar (LLA), lumbosacral (LSA), and sacral slope (SS) angles] were compared between the subjects with LBP and healthy subjects in the three sitting conditions.

Results: There were significant differences in the lumbar lordosis, ULA, LLA, LSA, and SS according to sitting condition (P<.05). All five angles were significantly greater when participants sat erect or in a pelvic-support chair than in their usual sitting position (P<.05). ULA and SS were significantly greater when sitting erect than in a pelvic-support chair (P<.05). LLA was significantly greater in controls than in patients with LBP (P=.042).

Conclusion: The sagittal alignment of the lumbosacral region differed significantly among usual, erect, and pelvic-support chair sitting in patients with LBP and controls. Decreased lordotic curve of the lumbar spine in the usual sitting position can be changed in both patients with LBP and healthy subjects by sitting with pelvic support chair.

Keywords: Chair; Mechanical low back pain; Posture; Radiography; Spine

Introduction

Prolonged sitting and altered lumbar lordosis may be risk factors for low back pain (LBP) (1-4). Altered spine curvature is related to high mechanical loading and a forward bending posture, while sitting increases the pressure in the nucleus pulpous more than a straightened back (5, 6). A sitting posture with a flexed spine results in more lost fluid from the nucleus pulpous than an erect posture, which may contribute to insufficient nutrition of the lumbar discs (7). Hyper-lordosis during sitting induced consistently increased activation of the back extensor muscles and excessive compressive pressure in the facet joints of the spine (8, 9). Consequently, to adopt a lumbar sitting posture that reduces passive tissue strain, slight lumbar lordosis and a relaxed thorax are important to prevent and resolve LBP during seated work (10).

Studies have examined the degree of curvature of the lumbar spine according to sitting condition (11-14). Markers on the skin surface, used with motion-capture techniques or digital photogrammetry, have been used to assess spine curvature; however, these methods may be limited for determining spine curvature, as absolute angles may be underestimated due to inaccurate marker placement (13, 15, 16). Radiographic measures can provide useful information about lumbar lordosis and sacral alignment parameters, as their reliability and agreement are good (11, 12, 17). Thus, radiographic analyses may be needed to evaluate the lumbar lordotic angle under diverse sitting conditions.

Previous studies have reported the effects of various chairs on maintaining a proper lumbar lordotic curvature, with the aim of developing more comfortable seating conditions (14-16, 18-20). Using a backrest or lumbar support can help to maintain lumbar lordosis while sitting (15, 16, 18-20). These lumbar-support devices create lumbar lordotic curvature directly by supporting the lumbar spine. Another way to increase lumbar lordosis is to change the seat inclination. Using a forward-tilted seat such as a saddle-shaped chair, seat pan, or kneeling chair, can maintain greater lumbar lordosis compared to standing or a slouched sitting posture (14, 18). However, previous results showing evidence for the effects of sitting in various chairs on lumbar curvature using skin markers or via photographs did not provide data on the direct spinal curve (14, 18).

A radiographic study found that the L5/S1 intervertebral joint was flexed by more than 60% of the total lower lumbar (from L3 to the top of the sacrum) flexion range of motion in a slouched posture in healthy subjects (21). This degree of flexion is derived by rotation of the pelvis. In this study, a "pelvic-support chair" was designed to promote lumbar lordosis by supporting the pelvis while sitting. A pelvic-support chair would facilitate a less flexed lumbar posture by anteriorly tilting the pelvis during sitting and could potentially help decrease strain on the passive spinal structures and prevent or decrease LBP.

Therefore, in the present study, we radiologically investigated the effects of sitting in a pelvic support chair on lumbar lordosis and sacral tilt. We focused on differences in lumbar lordosis and the sacral tilt angle during usual sitting, erect sitting, and sitting with pelvic support and evaluated differential postural responses between patients with LBP and healthy controls.

Materials and Methods

Participants

This study recruited 40 volunteers: 29 patients with LBP and 11 healthy controls in Jeonju-si, South Korea from Apr 2017 to Mar 2018 (Table 1).

Table 1: Characteristics of subjects

Variable	*LBP (n=29)*	*Control (n=11)*	*P*
Sex	M=14, F=15	M=6, F=5	
Age (yr)	21.28±1.19	22.09±1.51	.081
Height (cm)	165.93±7.71	165.09±8.89	.769
Weight (kg)	59.59±10.29	58.18±9.43	.696
BMI (kg/m²)	21.52±2.37	21.30±2.69	.802
Pain duration (month)	29.03±21.18	-	
VAS (mm)	55.4±17.5	-	

LBP = low back pain; BMI = Body mass index; VAS = Visual analog scale. The VAS score ranged from 0 (no pain at all) to 100 (worst possible pain)

Visual analog scale (VAS) score for measuring pain intensity were recorded for all patients with LBP. The VAS score ranged from 0 (no pain at all) to 100 (worst possible pain). The patients had complained of LBP for at least 3 months; but had no spine surgery or neurological signs (radiating pain below the lower leg or loss of sensation). Patients with LBP were excluded if they had symptoms of spondylarthrosis or disk prolapse. The healthy controls had no LBP in the previous 6 months and no history of spinal pathology or spinal surgery.

All subjects provided written informed consent after the experimental protocol had been explained to them. This study was approved by the Institutional Review Board of Jeonju University.

All subjects sat on a stool with their arms folded in front of their chests. The stool height was adjusted to ensure that the hip and knee angles were 90 degrees (11). There were three sitting conditions: usual sitting, erect sitting, and sitting with a pelvic-support chair (Fig. 1). First, the subjects were asked to sit on a stool in the same manner as they would usually sit on a chair without a backrest. For erect sitting, the subjects were asked to assume what they believed was the most proper sitting posture. Finally, they sat on the pelvic-support chair such that the posterior superior inferior spine of the pelvis was located where the backrest protruded. The pelvic-support chair is designed to incline forward when someone sits on it, inducing anterior pelvic tilt, which facilitates an erect pelvic position when sitting (Fig. 2).

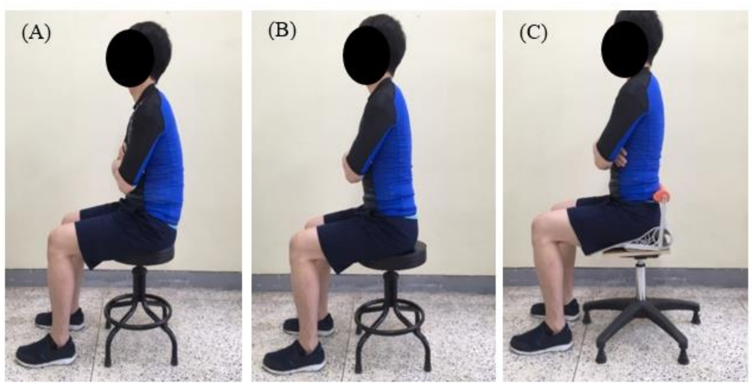

Fig. 1: Sitting coditions. (A) usual sitting, (B) erect sitting, and (C) sitting with a pelvic-support chair.

Fig. 2: Pelvic-support chair. Left: view from above, Right: view from side

Outcome Measures

Radiographs of the lumbar spine were obtained in the sagittal plane in the three sitting conditions. When the radiographs were taken, the subjects were asked to look at a target directly in front of them. The distance between the X-ray source and the participant was 100 cm. The lumbar lordosis angle (angle between the upper end plate of L1 and the upper end plate of the sacrum), upper lumbar angle (ULA; angle between the upper end plate of L1 and the upper end plate of L4), lower lumbar angle (LLA; angle between the upper end plate of L4 and the upper end plate of the sacrum), lumbosacral angle (LSA; angle between the lower end plate of L5 and the sacral end plate), and sacral slope angle (SS; the angle between the sacral plate and the horizontal plane) were measured (Fig. 3) (22). Negative values of the lumbar lordosis angle, ULA, LLA, and LSA indicated lumbar lordosis. A positive SS indicated anterior sacral tilt. All measurements were analyzed using PACS viewer (eRAD, Greenville, SC, USA).

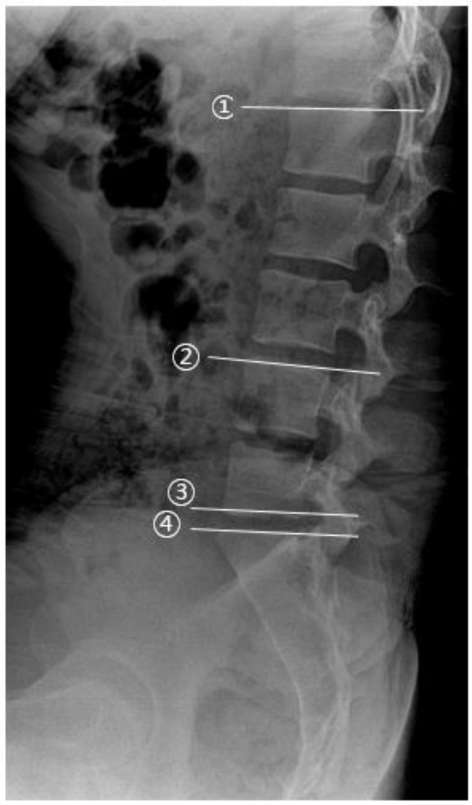

Fig. 3: Radiograph measurements of the lumbosacral region. Lumbar lordosis angle (the angle between ① and ④ lines), upper lumbar angle (between ① and ② lines), lower lumbar angle (between ② and ④ lines), lumbosacral angle (between ③ and ④), and sacral slope angle (between ④ line and the horizontal plane)

Statistical analysis

All data were analysed using SPSS 26 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $P< .05$. Independent t-tests were used to compare subject characteristics (age, height, weight, and body mass index). Repeated two-way analysis of variance was used to compare groups (patients with LBP vs. controls) and sitting conditions (usual, erect, and sitting with a pelvic-support chair). Post hoc analysis with the Bonferroni adjustment was used if main effects of the sitting conditions were found.

Results

Figure 4 presents the lumbosacral region angles (mean and standard deviation) in each sitting condition for each group. There was no significant interaction between group and sitting condition for any variable.

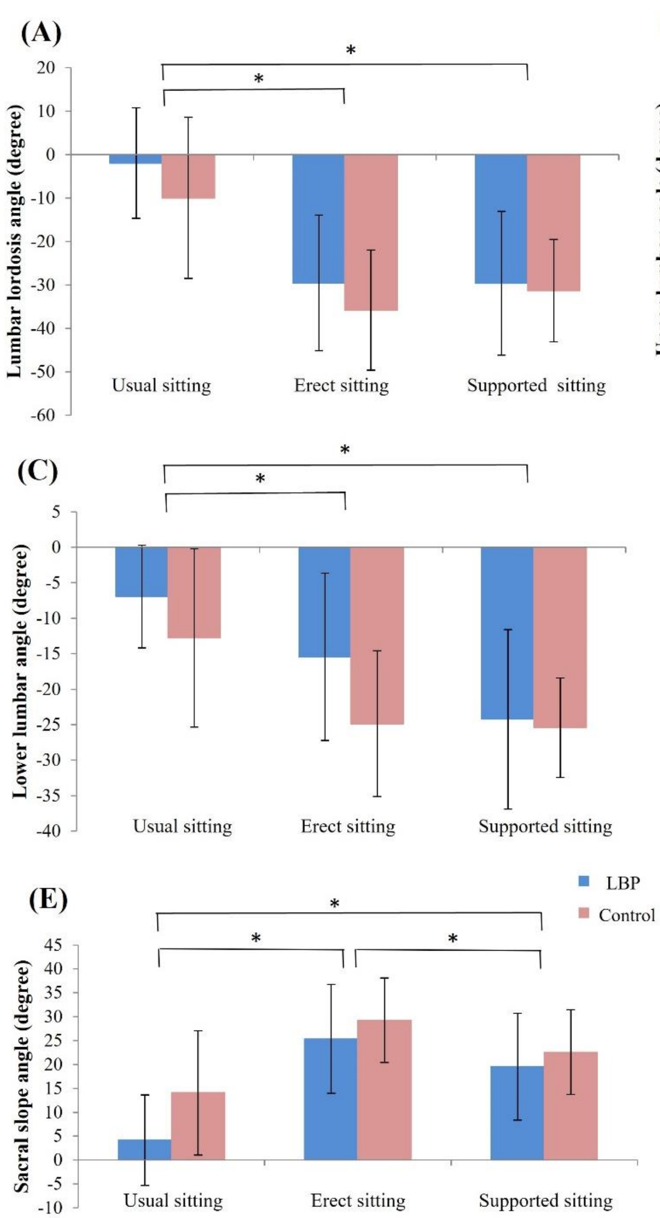

Fig. 4: Lumbar lordosis (A), upper lumbar (B), lower lumbar (C), lumbosacral (D), and sacral slope (E) angle for each sitting conditions in LBP and controls (**P*<.05, significant difference in main effect for sitting condition)

There was a significant main effect of the sitting conditions on the lumbar lordosis angle (F=53.761; *P*<.001), ULA (F=56.989; *P*<.001), LLA (F=20.933; *P*<.001), LSA (F=7.996; *P*=.001), and SS (F= 42.415; *P*<.001). The lumbar lordosis, ULA, LLA, LSA, and SS in the usual sitting position were significantly lower than in erect sitting or sitting with pelvic support (*P*<.05). ULA and SS were significantly greater when erect sitting than in a pelvic-support chair (*P*=.003 and *P*=.002, respectively). There was also significant main effect of groups on the LLA (F=4.439; *P*=.042). LLA was significantly greater in controls than in patients with LBP (Fig. 5).

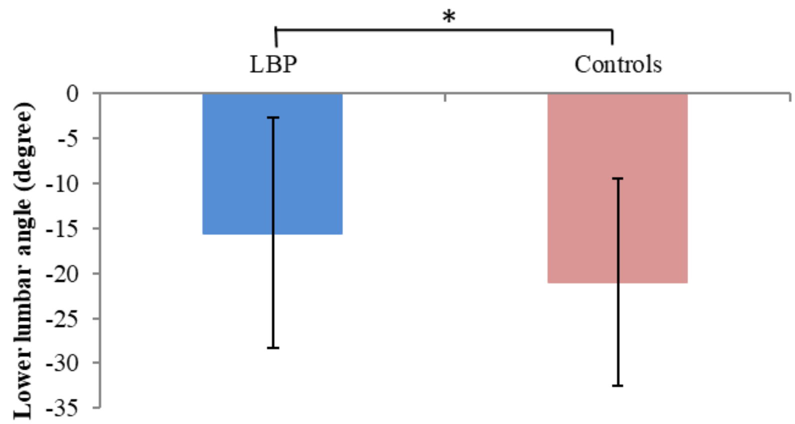

Fig. 5: Main effect of the lower lumbar angle between LBP and controls (* $P < .05$, significant difference for group)

Discussion

This study examined the angle of the lumbosacral region during sitting with a pelvic-support chair and demonstrated the effects of sitting conditions (usual, erect sitting, and sitting with pelvic support) on the lumbosacral region in patients with LBP and controls. In our study, a pelvic-support chair induced lumbar lordosis by supporting the posterior pelvic region in a forward position. There are differences in sagittal lumbar lordosis and the sacral tilt angle among sitting conditions; both significantly increased in erect sitting and sitting with pelvic support compared to the usual sitting position. Patients with LBP showed significantly lower lordotic angle in the lower lumbar spine while sitting compared to the control group. To date, few studies have used radiographic techniques to examine lumbar lordotic and sacral angles during sitting with a pelvic-support chair in patients with LBP. This study demonstrated the effects of a pelvic-support chair on the angle of the lumbosacral region in a seated posture.

Overall lumbar lordotic angle (lumbar lordosis, ULA, LLA, and LSA) and anteriorly SS were significantly increased in erect and sitting with pelvic-support chair compared with that in usual sitting. A prolonged flexed sitting posture contributes to increasing the intervertebral disc pressure (5, 23) and cervical lordosis and pelvic tilt (24) while sitting. Less activity of the back muscles (i.e., the lumbar multifidus, iliocostalis lumborum, and thoracic erector spinae) is required with a flexed lumbar posture (8, 19, 25); however, it can induce more stress on the articular and ligamentous structures. Although we did not assess muscle activity in the lumbar region during sitting, a pelvic support chair may induce passive anterior pelvic tilt, which would contribute to an increased lumbar lordotic angle, thus requiring less effort to maintain a lumbar posture compared to active erect sitting.

This study demonstrated that the LLA was significantly decreased in patients with LBP compared with that in controls. Previous studies have found an association between sitting in an awkward posture (e.g., trunk flexed or a bent posture) and presence or severity of LBP, although whether there is a strong association between sitting itself and LBP remains unknown (2, 8, 26, 27). Decreased lumbar lordosis has been considered as an important factor in the development of LBP during prolonged sitting with flattening of the lumbar spine (2, 8, 26, 27). It is difficult to determine a cause-and-effect relationship between decreased lordosis, measured based on LLA, and LBP, as a flexed lower lumbar spine may lead to strain on passive tissues that are already vulnerable in patients with LBP.

People who spend a lot of time sitting are more likely to develop LBP (1, 3, 4). People tend to flex their lumbar spine while sitting for long periods and have difficulty maintaining the optimal lumbar curve while sitting. In addition, increased back muscle activation is required to maintain an erect sitting posture and the constant muscle activity may induce muscle fatigue (28). LBP and referred pain were reduced when patients with LBP sat with a lordotic posture using a lumbar roll (29). Maintaining the lordotic curve while sitting led to centralization of the pain (30). In this study, the pelvic-support chair might induce to maintain an erect pelvic position and to maintain the lumbar lordotic curve with less active effort. Therefore, a pelvic-support chair is recommended as an external support to maintain the lumbosacral curve in people with and without LBP.

There are several limitations to this study. First, this study evaluated the immediate sitting posture of the lumbosacral region in three sitting conditions. This did not reflect the typical sitting postures of the subjects and we cannot determine the effects of prolonged sitting conditions on lumbosacral posture. A future study should examine the lumbosacral posture after a prolonged period of sitting. Second, this study focused on the lumbosacral region in the three sitting conditions and did not consider the effects on the thoracic and cervical curves. The spinal curve from the cervical region to the sacrum is influenced by the sitting posture (31). Thoracolumbar pain was related to a slumped sitting posture (3). Therefore, future investigations should examine the effect of sitting posture on the spinal curve from the cervical region to the sacrum.

Conclusion

This study compared the differences in the alignment of the lumbosacral region in three different sitting conditions (usual, erect, and sitting with pelvic support) between patients with LBP and healthy controls. The lumbar lordosis, ULA, LLA, and SS were significantly increased while sitting with pelvic support and during erect sitting compared with those in the usual sitting posture of patients with LBP and healthy controls. In addition, LLA was significantly decreased in patients with LBP than controls. Therefore, using a pelvic-support chair can maintain the lumbar lordotic curve while sitting in patients with LBP and healthy people.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

The authors would like to thank the participants who participated in our study for their help.

Financial source

The study has received no funding.

Conflict of interest

There is no conflict of interest within the study.

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