The Change of Pelvic Tilt Angle and Backrest Pressure According to Hip Joint Angle in Healthy Adult

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Abstract
The aim of this study is to prove that the change of pelvic tilt angle and backrest pressure according to hip joint angle in healthy adult. Thirty healthy male and female adults consented to participate in this study. Subjects sat on the chair with 90°, 100° and 120° hip joint flexion while both the Pressure Sensors (PS) and Passive Makers (PM) were sticked to the subjects by an examiner. In difference between the distance values of the total axis (in distance between Superior Iliac Crest (SIC) and thigh) and the distance values of the total axis (in distance between Anterior Superior Iliac Spine (ASIS) and thigh), there was significant value (p<.01). And in difference between the thoracic pressure and the lumbar pressure, there was significant value (p<.001). Thus, in comparison with the subjects sitting down with a smaller hip joint angle, the subjects sitting down with the bigger hip joint angle can be exposed to danger complaining of low back pain.

1. Introduction
Low Back Pain (LBP) is the biggest global causes of disability worldwide1. And a musculoskeletal disorder doubted to be provoked by a chronic overuse and an acute injury2. Previous studies have proposed that physical activities in awkward postures can result in the LBP2. One of the risk factor for LBP is prolonged sitting, yet the time spent in a sitting posture is increasing steadily in modern society3,4. The best way to sit is controversial in the literature, but generally sitting is worsening factor5,6.

Increasing sitting adaptation can reduce trunk motion7. In term of trunk motion, lordosed and kyphosed sitting posture is widely discussed in various research6. Chief of both, people with LBP believes that increased lordosis come as a relief of pain9. But lordotic sitting has been related to aggravated discomfort10. For example, lordotic lumbar spine curve brings increased fatigue and discomfort on paraspinal muscle activation, and disrupts the liberty of the spine10,11.

The spine curvature is crucial factor in body posture and movement12. When the curvature changes during movement like walking and transportation of stuffs, spine is stressed12. The spine may obtain a big compressive load and it depends on a follower force pattern13. In particular, lumbar spine is pressured by upper body weight in sitting posture14.

According to an existing study, Vergara and Page9 made a subject stay in the sitting posture for a long time to create various loads on the spine, and the study showed that lordotic postures are the principal factor of the increased discomfort using rachimeter (containing a goniometer and inclinometer)9. And Patwardhan et al.13 experimented on the lumbar spine under a compressive load which is placed direction having no connection with the deficient curve (lumbar lordosis) during showing the ligamentous lumbar, and measuring a preload magnitude and range of motion. Their study reported that follower preload provides a stimulation which allows the spine to support induced compressive loads during flexion-extension activities15. Han et al.14 studied a follower load mechanism

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and muscle activation pattern around lumbar spine using electromyograph, and then their results demonstrate that muscles around spine can create compression load in the lumbar spine while standing on neutral posture\textsuperscript{16}.

These studies commonly conduct the test stays the subject’s unsupported sitting posture in lordotic lumbar spine, proposing the reasonable results about correlation between the sitting posture and lordotic spinal curvature. Until a recent study, also there are lacks of studies on the supported sitting posture for a lordotic curve researches. But, above all research results are difficult to generalize to our contemporaries because commonly chairs released in the market has a backrest.

Thus, the aim of this study is to prove that the change of pelvic tilt angle and backrest pressure according to hip joint angle in healthy adult. I hypothesize that in comparison with the subjects sitting down with a smaller hip joint angle, the subjects sitting down with the bigger hip joint angle may be exposed to danger complaining of LBP. More accurately, the various hip joint angles bring out the data containing pelvic anterior tilt and lumbar lordotic curve. Lordotic curve is estimated through the difference between thoracic and lumbar spine pressure on backrest.

2. Method

2.1 Subjects

Thirty healthy male and female adults consented to participate in this study. Exclusion criteria included any medical history of injury, postural or skeletal disorders, cardiovascular or neurological conditions which could affect normal posture, impairment of vestibular system. None of the subjects was excluded in this study. All of the participants were fully informed about the procedure and aim of current experiment. Afterward, all participants were signed up on consent form for research. This study was approved by the Institutional Review Board (IRB) of Sun Moon University.

2.2 Procedure

The design of this experiment was cross sectional and single blind study. And the subjects was randomly divided into three groups and allocated to different tasks, and then each group was consisted of ten subjects. Participants were fully engaged with dressing comfortable clothes. All participants received instructions to sit on a chair (width 400mm*length 400mm*height 750mm, FURSYS) having a backrest as Pressure Sensors (PS) were attached to T6 and L1. And to measure the pelvic tilt using motion capture analyzer (Qualisys system-Qualisys Medical AB 41113, Gothenburg, Sweden), Passive Makers (PM) were attached to left and right anterior superior iliac spine (ASIS), superior iliac crest (SIC), thigh. Both the PS and PM were stucked to the subjects by an examiner who practiced it repeatedly. Each joint angles was measured with digital goniometer (Authorized CE representative RMS, UK Ltd). In a first group, subjects sat on the chair with 90° hip joint flexion. Excepting hip joint angle, neck angle and knee joint angle (90°) were supervised by the examiner, and it was applied to all group. In a seconds group, subjects sat leaning back in the chair backrest with 100° hip joint flexion. In a third group, sat on the chair in the way that the seconds group did with 120° hip joint flexion. Flow diagram of subjects screening and experimental protocol were presented on Figure 1.

2.3 Measurement of Lumbar Lordotic Curve

2.3.1 Pelvic Tilt

To measure the pelvic tilt, the motion analyzer was used. And this measuring equipment was processed in 3
dimensions. Six cameras (Qualisys Oqus 300) that emit and capture infrared light reflected by spherical passive markers were used. Data were captured at a frequency of 120 Hz, using Qualisys Track Manager v2.5 acquisition software. The makers were attached to left and right ASIS following the iliac crest anteriorly to the spine at the end of the crest, SIC on the crest at the most superior and lateral point, thigh namely, the total number of makers is six. In this study, the change of pelvic tilt angle was calculated from difference between a length between SIC and thigh and length between ASIS and thigh using the following formula Figure 2.

2.3.2 The Difference between Thoracic and Lumbar Spine Pressure on Backrest
To measure the backrest pressure, the sensors were attached to T6 and L1 level. And examiner applied the sensors to the skin. The data was sent at Arduino software v1.0.5 connecting an Arduino board (Arduino Uno). This hardware was linked the metal PS using a cable, and adapted to computer as a serial port. To calibrate sensors, examiner arranged the laboratory environment.

2.4 Statistical Analysis
All statistical analysis was performed using the SPSS statistical analysis software v18.0. The mean and standard deviations of variables were calculated by descriptive statistics. One way ANOVA was used to detect differences in the difference between a length between SIC and thigh and length between ASIS and thigh during pelvic tilt and the difference between thoracic and lumbar spine pressure on backrest. A post hoc test was performed using Bonferroni correction. The significance of level was set at p<.05.

3. Result
Mean distance between SIC and thigh, and ASIS and thigh on various hip joint angle are following Table 1. In distance between SIC and thigh, X axis did showed significant value in every hip joint angle (p<.01). In Y axis, there was significant value (p<.001) which depended on hip joint angle, and there was significant value (p<.001) depend on hip joint angle in Z axis. Post hoc test result showed significant value (p<.05) on hip joint angle between 90°-120°. In distance between ASIS and thigh, X axis did showed significant value in hip joint angle (p<.05). In Y axis, there was significant value (p<.001) depend on hip joint angle, and there was significant value (p<.001) which depended on hip joint angle in Z axis. Post hoc test result showed significant value (p<.05) on hip joint angle between 90°-100°, 90°-120° in X, Y, Z axis. The distance values of the total axis in distance between ASIS and thigh was not significant (p<.05). Finally in difference between the distance values of the total axis (in distance between SIC and thigh) and the distance values of the total axis (in distance between ASIS and thigh), there was significant value (p<.01). And post hoc test result showed significant value (p<.05) on hip joint angle between 90°-120°. Mean distance between SIC and thigh, and ASIS and thigh on various hip joint angle are following Table 2. In thoracic pressure, there was significant value (p<.001), and post hoc test result showed significant value (p<.05) on hip joint angle between 90°-120°, 100°-120°. Lumbar pressure was significant value (p<.001), and post hoc test result showed significant value (p<.05) on hip joint angle between 90°-120°, 90°-100°, 100°-120°. Finally in difference between the thoracic pressure and the lumbar pressure, there was significant value (p<.001). And post hoc test result showed significant value (p<.05) on hip joint angle between 90°-120°, 90°-100°, 100°-120°.

4. Discussion
This study analyzed the change of pelvic tilt and back pressure while sitting on the chair with backrest depend on various hip joint angle. In a recent study, the researcher evaluated ideal sitting behavior and reported that movement of the trunk and pelvic was significant in sitting17. Some chair movements cause a dynamic relation of sitting impairment of physical mechanical18. Paul et al.19 investigated that the effect of adjustable simulator chair on body segments orientation using the motion capture system on the pelvic, and there was significant the effect various manipulations of the chair on pelvic tilt. Claus et al.18 researched sagittal spinal curves (thoracic, thoracolumbar, lumbar) depend on four different sitting posture (flat, long lordosis, short lordosis, slumped posture), and reported that it was difficult to divide between thoracolumbar region and lumbar region while adjust sitting posture by oneself without visual and verbal description18. In
current study, the subjects were controlled depend on three posture fixed hip joint angles in advance. Result of this study was that pelvic movement and spinal curvature in sitting on the three chair posture were significant. In contrast with Paul et al. and this study which draw a significant result using the precise control of the simulator chair and exact hip joint angles, the study of Andrew leads to no significant result. For this reason, it is considered that posture set of examiner is important when the researcher experiment about sitting posture, because it is difficult to maintain pelvic movement or spinal curve.

Precise hip joint angles should be defined by regarding the effect of different tasks in sitting posture\textsuperscript{20}. Shibata\textsuperscript{21} investigated the effects of hip joint angles by backrest inclination (0°, 10°, 30°) in vertical axis on power absorption through seats using biodynamic response parameter, and else study evaluated that change of axial stiffness in region between the buttocks and the thighs upon the various sitting posture in the same principal with above study. Both proposed that the more hip joint angles increase, the more risk of LBP decrease\textsuperscript{21,22}. This study likes the two researches in that hip joint angles were changed in each group and set (90°, 100°, 120°) by examiner. But current study showed that the subject sitting apple down with the bigger hip joint angle were exposed to risk of LBP. Result of this study is different from above two researches. The reason why this study places emphasis on lordotic curve depend on various hip joint angle while the backrest was controlled, in contrast with other studies which overlook the spinal curve by touching back to backrest continuously.

When hip joint angle changes, pelvic tilt measured angle between ASIS-PSIS line and horizontal line also changes. For example, hip flexion cause pelvic posterior tilt, hip extension cause pelvic anterior tilt\textsuperscript{23}. To measure pelvic tilt, Virginie et al.\textsuperscript{25} used retrospective radiographic analysis and Harvey et al.\textsuperscript{23} utilizes protractor device, and Nik et al.\textsuperscript{24} used Textile-based Micro electro mechanical system accelerometer\textsuperscript{23–25}. However, this study sticked to use motion capture system, although many method measured pelvic tilt like above researches, in order to

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<tr>
<th>Table 1. The change of pelvic tilt according to each hip joint angle (Units : mm)</th>
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<td>Distance between SIC and thigh (A)</td>
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<tr>
<td>X</td>
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<td>Total</td>
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<th>Distance between ASIS and thigh (B)</th>
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<tr>
<td>X</td>
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<tr>
<td>Y</td>
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<tr>
<td>Z</td>
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| (A)-(B)                           | 42.50±8.25             | 38.65±6.40             |

All values are *mean ± standard deviation (SD)\textsuperscript{, a} \textsuperscript{P}<.05, **P<.01, ***P<.001


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<th>Table 2. The change of back pressure according to each hip joint angle (Units : index)</th>
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<td>Thoracic pressure (C)</td>
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<td>90°</td>
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<td>100°</td>
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<td>120°</td>
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| Lumbar pressure (D)                          |
| 1393.20±45.62\textsuperscript{a} |
| 1347.20±74.12\textsuperscript{a} |
| 1562.30±77.91\textsuperscript{a} |

| (C)-(D)                     | -63.30±53.35  |
| (C)-(D)                     | 107.40±70.76  |
| (C)-(D)                     | 604.60±178.43 |

All values are *mean ± standard deviation (SD)\textsuperscript{, a} \textsuperscript{P}<.05, **P<.01, ***P<.001
test objectively. In current study, PSIS is not recognized because of backrest. Therefore, the pelvic tilt means difference value app lengths between SIC and thigh and length between ASIS and thigh using the formula in this study.

Along with change of pelvic tilt, spine curvature is also crucial factor in dynamic sitting posture14. O’Sullivan et al26 investigated effects of various sitting posture on spine curve using the Spinal Position Monitoring Device (SPMD). And the study reported that pain-free subjects can be adjusted in a neutral lumbar sitting posture. This study used the pressure sensor to measure the spinal curve unlike above study using the SPMD. The sensors were attached to T6 and L1 level because the PS can contact with backrest well in that location. In present study, when hip joint angle was 120°, thoracic spine pressure is bigger than lumbar spine pressure; it means that lordotic curve was bigger. On the contrary, when hip joint angle was 90°, there was no difference between thoracic pressure and lumbar pressure. It means that lordotic curve was not bigger and may be the better sitting posture. And this study examined in case of healthy adults, whereas above research inspected in case of both healthy adults and adult with LBP group. If this study was designed in case of both subjects, in this way, it is considered that the result can be proved difference between two subject groups.

In the limit of this study, the small number of subjects was studied, so it is hard to generalize the results. And as mentioned above, result of this study is limited in healthy adult. For clinical application, the future research needs to investigate that the change of pelvic tilt angle and backrest pressure according to hip joint angle in adult with LBP.

5. References


