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# Lumbar Disc Changes Associated with Prolonged Sitting

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## Abstract

**Objective—**To determine what if any changes occur to the lumbar discs in the spine after prolonged sitting with and without intermittent breaks during a four hour time period.

**Designy—**A prospective observational study

**Setting—**An academic outpatient clinic

**Methods—**The measurement of lumbar disc changes was performed on twelve subjects following an analysis of a midsagittal lumbar magnetic resonance image (MRI) scan: measuring lumbar disc height and disc diameter. Scanning and analysis were done over a two day period: day 1 at the start of the work day and four hours later after continuous sitting; at the start of work day 2 and after four hours following a change in position and stretching protocol every 15 minutes.

**Results—**For this study, we first evaluated each level of the lumbar spine for any changes after prolonged sitting for four hours over the two days. Multiple comparisons bias was eliminated by a Bonferroni correction to limit the overall experiment wise error rate to 0.05. The comparison was conducted by using a paired t-test when the normality condition was satisfied and using a Wilcoxon signed rank test when normality was not satisfied. To test for normality a Shapiro-Wilk test was used. We found that for disc height, L4-5 was significantly decreased at the end of the sitting on day 1, but not for day 2. There were no significant height changes for the other lumbar discs. Additionally, for disc diameter, there were no significant differences present for any of the discs.



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Disclosures: None

**Conclusions—**Analysis of the data shows the greatest change in disc height is at the L4-5 level after prolonged sitting without intermittent breaks. The other levels did not show significant change in their height. The findings also show the L4-5 height changes are not significant with brief positional changes every 15 minutes. Fewer changes in disc height may correlate with an improvement in low back pain and disability.

## INTRODUCTION

Low back pain is a very common condition that affects millions of Americans. It is estimated that upwards of 85% of all individuals will experience an episode of low back pain during their lifetime. [1, 2] The duration of pain may vary from a few days to decades. The pain may impact one's function and become debilitating. The disability suffered from low back pain affects individuals and society. It is estimated that low back pain costs the United States 78 billion dollars in both direct and indirect costs on a yearly basis. [3-7]

As the economy and workforce moves from a manufacturing based economy and towards a service based economy, sedentary based jobs have increased. The sedentary worker is more stationary and less active. The sedentary job typically involves the majority of the day seated in front of a computer or workstation. Multiple studies have shown that prolonged sitting can lead to increased low back pain. [8-9] The static seating position has been shown to lead to an increase in intra-discal pressure, and the increased pressures have been shown to lead to disc bulges, protrusions and potentially herniations. [10-13] Additional studies have evaluated the ensuing degenerative cascade which leads to further degenerative changes including ligamentous hypertrophy, facet arthritis and stenosis. [14-21]

The effects of prolonged sitting and potential changes in disc anatomy have also been studied. [22] Further research has also examined the effects of dynamic stimuli and different sitting postures on low back pain. [23-25]. However, very limited research has examined the changes in lumbar disc height with sitting. [26] The intent of this study is to evaluate each level of the lumbar spine for any changes with prolonged sitting for a four hour period. This time period is during the morning part of the typical sedentary eight hour work day. This four hour am period was studied since research has shown on average a 10.6% gain in disc volume overnight with bed rest and Maximal stress of the intervertebral disc is also felt to occur in the am period , with higher intradiscal pressures in the morning[27-29]. The typical four hour am portion of the work day ends with a lunch break and thus an increased likelihood of leaving the work station and seated position changing the loads on the spine, discs and supporting structures.

## METHODS

### Subjects

The study consisted of twelve volunteers. The subjects were recruited for the study with flyers. All subjects signed an informed consent form. The study was approved by the Pennsylvania State University Institutional Research Board (protocol 34347). The inclusion criteria included a sedentary job, where individuals were seated continuously for four hours at a time, more specifically the jobs were computer based with sitting at work stations for

the majority to entirety of their work day. Exclusion criteria included a history of prior lumbar surgery. None of the participants had prior clinical MRIs of their spine nor were currently obtaining treatment for back pain. All subjects completed a data collection questionnaire which included: age, sex, height, weight, years working in a sedentary job and questions to determine a history of LBP, ongoing LBP and the frequency of LBP. A total of 12 patients, eleven female and 1 male were studied, the subjects were between 23 and 66 years of age (39.83±14.33 years mean [SD]). All subjects reported an episode of low back pain in their lifetime, with six of the subjects experiencing current low back pain. Demographic data are summarized in Table 1.

## Procedure

The participants underwent lumbar spine MRI scanning on two separate days. They had lumbar sacral MRIs performed at the start of their work days and then four hours later. All subjects worked in the same building as the MRI scanner and the scans were initiated within a few minutes after the end of the four hour sitting periods. MRI scan time was less than 15 minutes per participant. The MRI focused on the lumbar discs: L1-2, L2-3, L3-4, L4-5 and L5-S1 for analysis. The participants underwent their initial MRI scanning at the start of the work day. Day 1 protocol then had participants engage in their sedentary jobs and spend the next four hours seated; they then were reimaged with MRI scans. The Day 2 protocol consisted again of a baseline lumbar MRI at the start of the workday. The participants then again went to work, but did not sit continuous. They would arise out of the chair every fifteen minutes and engage in 5 seconds of lumbar flexion, 5 seconds of lumbar extension, 5 seconds of lumbar bending to the right and then 5 seconds of lumbar bending to the left before then returning to a seated position. The 15 minute time period was chosen given the creep response of the lumbar spine was noted to be present after a 20 minute time or prolonged full flexion. [30,31] Day 2 followed this positional change protocol and the participants were again reimaged after four hours of sitting.

All imaging was performed as follows: after changing into scrub top and pants to prevent any clothing-related image artifacts, participants were laid supine on the spine coil in the bore while images were acquired using a 3.0 Tesla MRI clinical scanner (Siemens Tim Trio, Siemens Medical Solutions USA, Malvern PA, USA). The scanner body coil was used for radio-frequency transmission; for signal reception, an 8-channel receive only spine coil (Siemens Medical Systems) was used. The MRI image acquisition parameters were as follows: T2-weighted axial and sagittal images were acquired using the turbo spin-echo with a reduced refocusing pulse. For the axial images, the spatial resolution was 0.63 mm × 0.63 mm inplane with a 4 mm slice thickness and a 5 mm slice gap; TR/TE = 4100 ms / 80 ms, refocusing flip angle = 140 degrees, bandwidth = 170 Hz/pixel, number of acquisitions=2. For the sagittal images, the spatial resolution was 0.67 mm × 0.67 mm inplane with a 3 mm slice thickness and a 3.5 mm slice gap; TR/TE = 4000 ms / 104 ms, refocusing flip angle = 120 degrees, bandwidth = 240 Hz/pixel, number of acquisitions=2. Analysis was performed using the Syngo DICOM viewer, (Siemens Medical Solutions, USA, Malvern PA, USA) using the included measurement tools.

## OUTCOME MEASURES

The MRI scans were evaluated using the Syngo DICOM viewer. T2 weighted sagittal images as previously described were evaluated. The midline sagittal image for each patient was chosen for measurements. All scans were then magnified to 1.5× their original size for measurements. Each lumbar disc was then measured for disc diameter in millimeters as shown in Figure 1. Each disc was then also measured for disc height in millimeters as shown in Figure 2. The maximal height and of each disc was measured to the edges of the annulus fibrous following a previously published technique .[32] the maximal diameter of each disc was measured in a similar manner to the edges of the annulus fibrous to maintain consistency. All measurements done on the MRI scans were blinded, as to the day and time of the scan. The data are summarized in Table 2.

## RESULTS

For this study, we first evaluated each disc level of the lumbar spine for any changes with prolonged sitting for four hours (day 1). Since there were five discs, we eliminated a multiple comparisons bias by a Bonferroni correction to limit the overall experiment wise error rate to 0.05. By dividing 0.05 (a conventional alpha level) by 5, we derived an adjusted two-tailed significance level of $p \leq 0.01$. The comparison was conducted by using paired t-test when normality condition was satisfied and Wilcoxon Signed Rank Test if normality was not satisfied. To test for normality the Shapiro-Wilk Test was used.

We found that for disc height in this group of participants, L4-5 was significantly decreased at the end of the sitting on day 1, but not for day 2. There was no significant height change for the remaining lumbar discs on either day 1 or day 2. For disc diameter, there were no significant results for any of the discs. The following tables provide a summary of the measurements at the start and end of each session for day 1 and day 2.

## DISCUSSION

This study was designed to evaluate the specific changes for each of the five lumbar discs with prolonged sitting. Clinically, the majority of lumbar disc degenerative changes occur at the L4-5 and L5-S1 levels [33-5]. Research has shown multiple reasons including biomechanical forces to account for the increased pressures at these discs [34-40]. The results of this study support this clinical finding. The largest change in disc height with prolonged sitting was found at the L4-5 level. Age and hours sitting were found to be significant risk factors for development of disc herniation at the L4-5 level [41]. Our findings are in agreement with such a relationship. Studies have also shown certain occupational demands including lifting and driving are important risk factors for the development of low back pain [42-44]. The findings of this study may also suggest that prolonged sitting of as little as four hours may also be a factor in increasing pressures of the L4-5 disc. These changes in pressures over a sustained time period may lead towards the disc degeneration cascade. Additionally, the study showed no significant increase in the diameter any disc. This finding perhaps may be explained by the three dimensional shape of the disc. The loss in height is noted in one plane and this can cause a slight increase in the

circumference of the disc in the lateral and posterior regions. Measurement of the diameter in the anterior to posterior direction of the disc may not reflect a large enough change in size for significance.

The disc changes in the second day following the change in position protocol showed no changes from baseline in any of the discs, including the L4-5 disc. This suggests that relieving pressure by changing positions every fifteen minutes in this group of participants resulted in no disc height changes over the same four hour period of time. Frequent positional changes could be of benefit to the sedentary workforce. Subjects did comment during day 2 following the change in position protocol that it was a challenge to stop their work and take a break from sitting.

Historically injured workers are evaluated clinically and a medically based return to work plan is formulated. Low back pain patients are frequently returned to work with limitations particularly regarding lifting and carrying duties. The government has identified certain categories with weight restrictions to define these specific classes [45]. Low back pain patients may be returned to work at a sedentary level to avoid lifting and carrying weights above 10lbs. The sedentary job may involve prolonged sitting. This study suggests that a sedentary job which may involve prolonged sitting will increase axial forces at the L4-5 level. The change in position protocol followed in this study may lessen these changes. The data from this study would advocate for brief positional changes every 15 minutes, an accommodation frequently overlooked with return to work prescriptions. Previous research has also focused on the positioning the spine with prolonged sitting and looking at changing the seated angle with back supports and comparing a relaxed sitting posture to an upright sitting posture [46,47]. This study suggests that the simple task of repositioning every 15 minutes may reduce the need for such modifications.

Limitations of this study were the small sample size and female predominance. There has been shown to be a difference in the sexes in their response to static lumbar flexion[48]. Our sample size was nearly all female. The limited study size was unable to show significance with regards to disc changes with a history of low back pain, years in a sedentary position, BMI, VAS scores and age. The small study size did not allow for correlation of disc changes with pain in the subjects. Additional studies with larger numbers of participants could evaluate these relationships further. Individuals with a history of low back pain or after a certain number of years in a sedentary position may be more susceptible to changes and deformities of the lumbar discs.

## CONCLUSION

Results from this study showed change in the L4-5 disc height after prolonged sitting of four hours. The study also showed no significant lumbar disc height changes at the L4-5 level when following the day 2 change in position protocol. Additional testing is needed to show the relationship of disc changes in regards to history of low back pain, relationship to active low back pain, years in a sedentary position, BMI and age.

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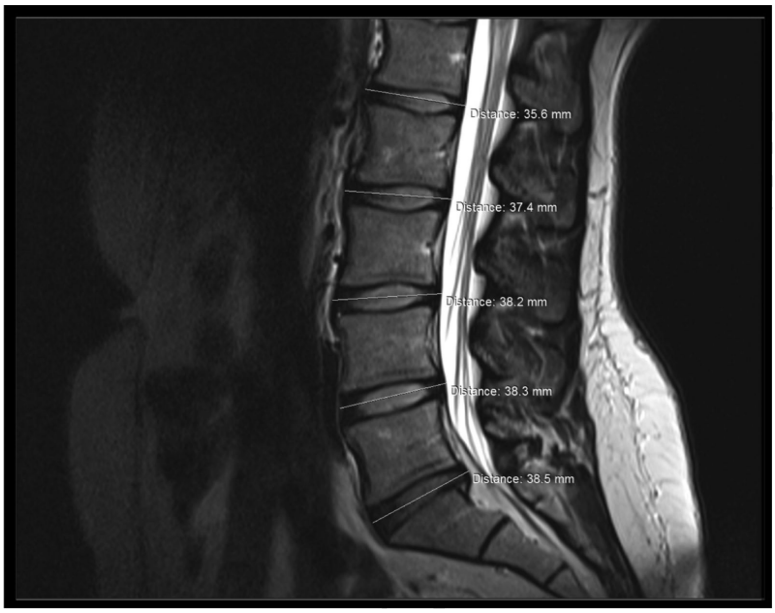


**Figure 1.**
Lumbar disc diameter measurements


**Figure 2.**
Lumbar disc height measurements

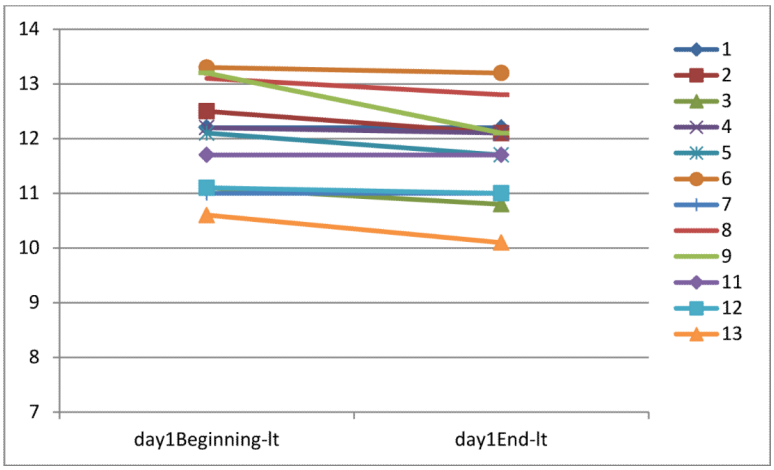


**Figure 3.**
Height of L4-5 disc at beginning and end of sitting on day 1

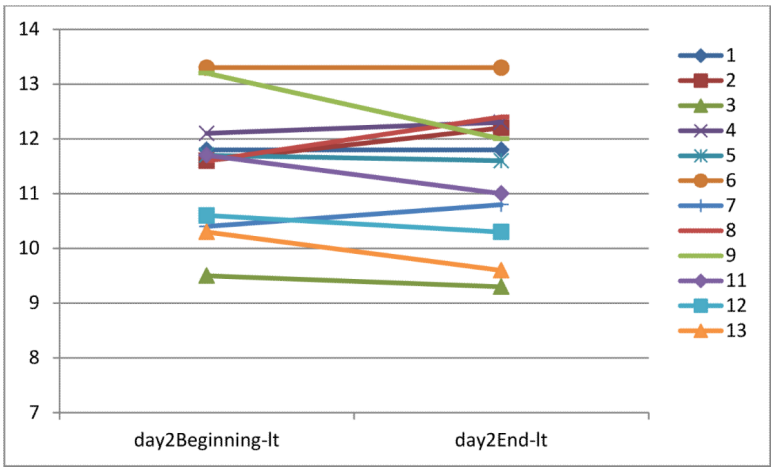


**Figure 4.**
Height of L4-5 disc at beginning and end of sitting on day 2

**Table 1**

Characteristics of participants (n=12)

| | |
|---|---|
| Mean (SD) age in years | 39.83±14.33 |
| Mean (SD) BMI in kg/m$^2$ | 26.29±9.96 |
| Prior history of LBP, number (%) | 12 (100%) |
| Current LBP, number (%) | 6 (50%) |
| Frequency of current LBP, daily- number (%) | 3(50%) |
| weekly-number (%) | 3(50%) |
| monthly-number (%) | 0(0%) |
| yearly-number (%) | 0(0%) |
| Mean (SD) number of years sedentary job (SD) in years | 14.27±10.16 |

## Table 2

Mean values of MRI assessed disc height (mm) at the start of the work day and 4 hours later for day 1 and for day 2

| Measurement | Day 1 Start | Day 1 End | p-value* | Day 2 Start | Day 2 End | p-value* |
|---|---|---|---|---|---|---|
| | Mean(SD) | Mean(SD) | | Mean(SD) | Mean(SD) | |
| L1-2 | 8.63(1.101) | 9.40(1.19) | 0.156 | 9.29(0.75) | 9.16(0.79) | 0.572 |
| L2-3 | 10.62(1.34) | 10.64(1.12) | 0.433 | 10.51(0.97) | 10.27(1.20) | 0.347 |
| L3-4 | 11.77(1.70) | 11.68(1.82) | 0.646 | 11.40(1.51) | 11.32(1.52) | 0.459 |
| L4-5 | 12.01(0.92) | 11.73(0.88) | 0.009†‡ | 11.48(1.13) | 11.38(1.21) | 0.559 |
| L5-S1 | 11.32(1.36) | 11.27(1.53) | 0.290 | 11.05(1.47) | 11.17(1.88) | 0.553 |

MRI, magnetic resonance imaging; SD, standard deviation.

*Paired t-test comparing mean values from start to end (Wilcoxon Signed Rank test comparing median values if normality not satisfied)

†Significant at conventional unadjusted alpha level of 0.05 (two-tailed)

‡Significant at Bonferroni-adjusted alpha level of 0.01 for five simultaneous comparisons (two-tailed)

## Table 3

Mean values of MRI assessed disc diameter (mm) at the start of the work day and 4 hours later for day 1 and for day 2

| Measurement | Day 1 Start | Day 1 End | p-value* | Day 2 Start | Day 2 End | p-value* |
|---|---|---|---|---|---|---|
| | Mean(SD) | Mean(SD) | | Mean(SD) | Mean(SD) | |
| L1-2 | 35.13(1.54) | 34.81(1.89) | 0.256 | 34.67(1.24) | 34.83(2.03) | 0.715 |
| L2-3 | 36.96(1.52) | 36.93(1.87) | 0.870 | 36.83(1.72) | 36.88(1.68) | 0.386 |
| L3-4 | 37.58(1.16) | 37.38(1.48) | 0.548 | 37.45(1.29) | 37.33(0.95) | 0.669 |
| L4-5 | 38.11(1.63) | 37.95(2.14) | 0.665 | 37.13(1.62) | 37.48(1.96) | 0.059 |
| L5-S1 | 36.50(2.16) | 36.99(1.91) | 0.080 | 36.14(1.86) | 36.61(2.08) | 0.130 |

* Paired t-test comparing mean values from start to end (Wilcoxon Signed Rank test comparing median values if normality not satisfied)

## Table 4

Mean changes after the four hour session in disc height (mm) and disc diameter (mm) for day 1 and day2

| Measurement | Day 1 Change in Height | Day2 Change in Height | p-value* | Day1 Change in Diameter | Day2 Change in Diameter | p-value* |
|---|---|---|---|---|---|---|
| | Mean(SD) | Mean(SD) | | Mean(SD) | Mean(SD) | |
| L1-2 | 0.23(0.51) | 0.13(0.79) | 0.787 | 0.32(0.92) | −0.16(1.47) | 0.292 |
| L2-3 | −0.03(0.87) | 0.24(0.56) | 0.754 | 0.03(0.69) | −0.05(0.89) | 0.833 |
| L3-4 | 0.09(0.67) | 0.08(0.38) | 0.973 | 0.21(1.16) | 0.13(0.99) | 0.846 |
| L4-5 | 0.28(0.31) | 0.10(0.58) | 0.253 | 0.16(1.23) | −0.36(0.59) | 0.071 |
| L5-S1 | 0.05(0.83) | −0.12(0.66) | 0.367 | −0.49(0.88) | −0.47(0.99) | 1.000 |

To illustrate the change in disc height for L4-5 after the four hour session for day 1 and day 2, we plot the values for each subject in Fig 3 and Fig 4:

*2 sample t-test comparing mean values between the two days