INTRODUCTION:
The whole body postural demands of seated tasks require an upright torso while still achieving a moderate amount of lumbo-sacral (LS) spine flexion (40% to 80% of maximum LS spine flexion (Callaghan and Dunk, 2002)). Given this evidence, the major factor in determining seated LS posture may be linked to the rotation of the pelvis. Gender-based differences in the LS spine and pelvic posture in sitting have been observed using external measurements of lumbar angle (Dunk and Callaghan, 2005). The purpose of this study was to examine x-ray images of the LS spine in order to determine the contribution of each lumbar intervertebral joint (IVJ) to the total LS curve in various standing and seated postures. Secondary purposes included examining any gender differences and a comparison of the IVJ angles with an external measurement of the LS curve.

METHODS:
Twenty-five healthy participants (12 males, 13 females) were recruited and a video fluoroscopy system was used to obtain sagittal images of the LS region ranging from the top of the sacrum to the top of the third lumbar vertebra in five standing and seated postures. External LS spine and pelvic posture were measured using accelerometers placed at L1, L3 and S2. Static images of the five postures were obtained using the digital radiography setting of the fluoroscope while accelerometer data were collected. The accelerometers provided inclinations relative to vertical. The top two corners of the sacrum and the four corners of all visible vertebral bodies (VB) were manually digitized four times for each x-ray image. Intervertebral angles were calculated as the angle between sagittal “mid-plane” lines of adjacent VBs (Frobin et al, 1996). The mid-plane line was determined as the line that intersected the mid-points between the two anterior and two posterior VB corners.

RESULTS & DISCUSSION:
The total standing ranges of motion (RoM) measured from x-rays for L3/Sac were similar for both males (40.6±2.7°) and females (39.2±2.7°) (Table 1). The total RoMs for each IVJ measured were not significantly different between genders (Table 1). These values correspond to IVJ RoM found previously in the literature (i.e. Pearcy et al., 1984).

Table 1: Total standing range of motion (RoM) for each of the three lower lumbo-sacral joints measured, including the RoM of the joints spanning L3 and the sacrum (L3/Sac – shaded column). Means (standard deviations)

<table>
<thead>
<tr>
<th></th>
<th>Total RoM (deg)</th>
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<tbody>
<tr>
<td></td>
<td>L3/4</td>
</tr>
<tr>
<td>FEMALE</td>
<td>12.5° (2.0)</td>
</tr>
<tr>
<td>MALE</td>
<td>12.5° (3.1)</td>
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</table>

When examining the standing mid-flexion posture and both seated postures, the external L3/Sac angle showed gender differences with males exhibiting more flexion than females. There were also differences observed in the amount of L3/Sac flexion between postures (Ranges from female to male: standing mid-flexion...
= 43.6 – 52.4°; upright sitting = 11.3 – 15.6°; slouched sitting = 18.6 – 28.3°). However, for both genders, each of the lower three IVJs approached their maximum flexion angles in the slouched sitting posture. In fact, in upright sitting, the L5/S1 joint for both genders was flexed more than 60% of its max RoM, supporting the idea that the LS curve is likely driven by rotation of the pelvis and lower IVJs in sitting (Figure 1). It follows that there could be increased loading of the passive tissues surrounding the lower LS IVJ, leading to pain generation and potential injury. While it appears that IVJ RoMs may not account for the biological variation between genders (Dunk and Callaghan, 2005), further study is required to form solid conclusions. The future development of a mathematical model to predict IVJ rotations from external measures during sitting may also improve estimates of the tissue loads surrounding the LS IVJs.

SUMMARY & CONCLUSIONS:
In upright sitting, there is evidence of a “bottom up” flexion pattern exhibited by the lower 3 LS IVJs. This is supported by observations that the L5/Sac joint achieved more than 60% of its max RoM in this posture and the next two adjacent IVJs (L4/L5 and L3/L4) achieved less of their maximum RoM. Although the external measurements obtained in this study corroborated the gender differences that have been previously documented in sitting, the IV joint angles as measured from x-rays do not explain these differences.

REFERENCES:

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Figure 1: Intervertebral joint angles normalized to their total standing range of motion (%RoM) as measured from the full flexion posture (Total RoM (deg)).