Evaluation of the BackJoy Core Sitting Device on Pelvic, Lumbar Trunk, and Throacic Trunk angles and muscular activity of the Hip Flexors and Trunk Extensors during sitting.

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I. Background and Significance

This project is an initial phase of testing the human response to using the BackJoy Core sitting device (BackJoy Orthotics, Valencia, CA) during sitting (see Figure 1). The BackJoy Core sitting device is called a ‘sitting orthotic’ by the BackJoy company. It is a curved, semi-flexible, copolymer polypropylene plastic device with foam padding that is designed to be sat on, on a chair or other surface. It is claimed that this product has 3 primary benefits that improve sitting posture and reduce low back pain. They are: 1) it tilts the pelvis forward thereby improving sitting posture; 2) it ‘cups’ the gluteus muscles decreasing tightening and pain in this area; and 3) It ‘cradles’ the pelvis decreasing pressure on the lumbo-sacral joint. These claims, to date, are primarily anecdotal in nature and primarily supported by customer testimonials. In an effort to substantiate these claims with controlled, objective scientific studies, representatives from BackJoy have asked for one and possibly a series of studies to be conducted in the Biomechanics Laboratory of the Orthopedic Specialty Hospital investigating only the first claim – does sitting with the BackJoy Core product improve sitting posture.

Figure 1. Picture of the BackJoy Core sitting device and instructions on positioning.

While there is some discrepancy as to what constitutes the exact correct sitting posture in the research literature, there is general agreement that active upright posture is better than passive, ‘slumped’ posture. This is based on the assumption that during active posture, the skeletal system is optimally aligned and supported by active, force-producing tissues and stress on passive structures is reduced. Compared to upright posture, slumped posture is characterized by a posterior rotation of the pelvis and flexed pelvis, lumbar, and thoracic curvatures.

In general, muscular control of sitting posture is considered to be controlled by 2 groups of muscles. The first are those with direct attachment to the lumbar spine and provide spinal stability (i.e. lumbar multifidus, transverse abdominis, internal oblique) via direct attachment or through generating intra-abdominal pressure. The second group consists of large torque producing muscles with no direct segmental attachment to the lumbar spine and control gross trunk movements and general trunk stability (i.e. rectus abdominis, external oblique, thoracic erector spinae). When going from upright extended to slumped flexed posture, there is a significant decrease in the activation of lumbar multifidus, internal oblique, and thoracic erector spinae presumably as the lumbopelvic region becomes more dependent on its passive structures to support the position against gravity.

The overall goal of this research is to evaluate the influence that the BackJoy Core product has on sitting posture. As an initial phase to this end, this experiment will only evaluate the *acute* influence of BackJoy Core product on unsupported (no back rest) sitting posture. The specific aim of this study is to determine if sitting with the BackJoy Core product results in an improved sitting posture and postural muscle activation pattern than an individual's natural sitting.

To examine this question, we measured the thoracic trunk, lumbar trunk, pelvis and thigh orientations and muscle activation levels during sitting natural sitting with and without the BackJoy device and compare these results to intentional upright and slumped postures. In this design, each subject served as their own control for comparing variables of interest between sitting conditions.

II. Methods and Procedures

Subject Inclusion Criteria:

- Male or female between the ages of 18 to 60 years.

Subject Exclusion Criteria:

- Current (within 6 months) musculoskeletal injury of the lower extremities or back.
- Lingering symptoms of a musculoskeletal injury of the lower extremities or back.
- Known spine disorders or neurologic conditions.
- Any pain in the test postures.
- Body mass index greater than 30.
- Pregnancy

Subjects and Subject Recruitment.
Twenty three subjects were recruited for this study on a volunteer basis. The subject group consisted of 11 males and 12 females. Average age was 31±6 years; average height was 1.74 ±.11 meters; average weight was 72 ±14 kg; and average BMI was 24 ±3. Subjects were recruited from the TOSH campus and consisted of TOSH employees. All recruitment was done in person by the PI or research assistant. All subjects gave written informed consent prior to testing consistent with the Institutional Review Board at TOSH.

Experimental Protocol. The study took place in 1 visit in the Biomechanics Laboratory of TOSH scheduled at the subject's convenience. Testing was approximately 1 hour in duration. After the informed consent process, subjects' anthropometric information was recorded followed by submaximal standard contractions for EMG analysis, and then the series of sitting conditions.

Experimental Setup.
Measuring 3D Kinematics of the Trunk, Pelvis.
All sitting conditions were performed using an adjustable height platform. Lower body (thighs, pelvis) and trunk (lumbar, thoracic) kinematics were measured using an optical, passive marker motion capture system sampling at 100 Hz Motion Analysis Corporation, Santa Rosa, CA). This system tracked the positions of 19 markers placed on specific landmarks of the subject's thighs, pelvis and trunk (Figure 2). The markers were placed on the following locations: back (8), pelvis

(5), and thighs (3 each). Resulting segmental and joint kinematics were computed with Visual3D software (C-Motion Inc., Germantown, MD) and Matlab (Mathworks, Natick, MA).

Electromyography of Postural Muscles.

Surface electromyography (EMG) was recorded for the following 4 muscles bilaterally: 1) rectus femorus, erector spinae, superficial lumbar multifidus, and internal obliques. The EMG recording system consists of disposable, self-adhesive Ag/AgCl surface electrodes connected to a Noraxon TeleMyo 2400 wireless transmitter and receiver system Noraxon USA, Inc. Scottsdale, AZ.). The EMG signals are transmitted to the receiver unit of the Noraxon system where it was interfaced with the analog–to-digital conversion board of the Motion Analysis system where they were sampled at 1000 Hz, synchronously with the kinematic data. Placement of the electrodes was as follows: rectus femorus 50% on the line from the anterior superior iliac spine to the superior part of the patella); erector spinae 5 cm lateral to the T9 spinous process); superficial lumbar multifidus L5 level, parallel to a line connecting the posterior superior iliac spine and L1-L2 interspinous space); internal obliques 1 cm medial to the anterior superior iliac spine)[1-3] (See Figure 2).

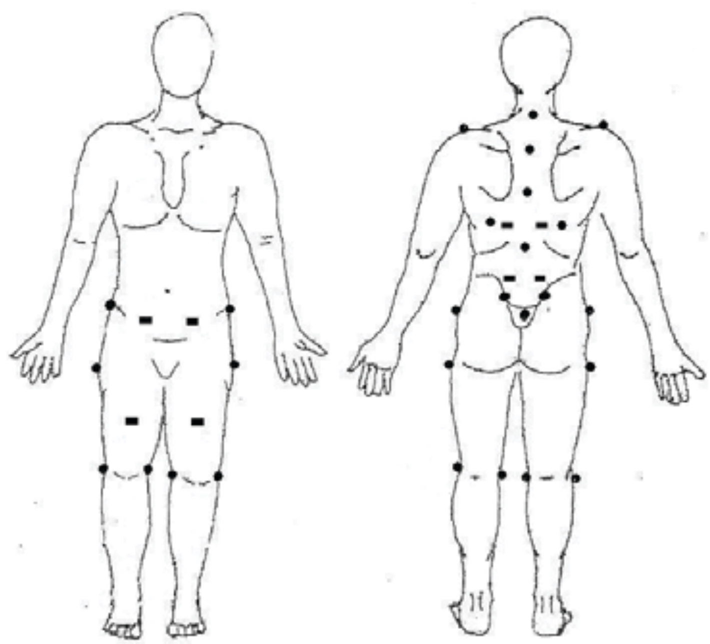

Figure 2. Placement of reflective markers (black circles) and electro-sensors (black rectangles)

Procedures.

Anthropometric measurements

Specific measurements recorded were age, height and weight.

Influence of sitting with BackJoy device on sitting posture

Subjects prepared for testing by wearing spandex or similar type of tight fitting shorts and a tight fitting top either brought from home or provided by the lab) so that the markers for the motion analysis system could be placed directly over specific anatomical landmarks at the pelvis, thighs and trunk. The procedures then began by placing the markers, placing the EMG electrodes, recording the submaximal contractions, adjusting the sitting platform for the subject, followed by the sitting conditions.

Placing EMG Electrodes: Before placing the electrodes, the skin was prepared in a standard procedure by cleaning the site with alcohol, shaving the site if it was covered with hair, then lightly abrading the skin with fine sandpaper[1-3]. Proper placement and gain settings were checked by viewing the EMG signals on the computer during the standard contractions.

Standard Submaximal Contractions: Standard submaximal isometric voluntary contractions (SMVC) served to check proper electrode placement and gain settings as well as to provide standard EMG levels by which to normalize the recorded activity levels. Submaximal contractions have been chosen over maximal contractions because they are more reliable and are closer in amplitude to the test conditions and therefore provide greater sensitivity in detecting small changes in motor activity[4]. For the hip and trunk flexors, the subject was positioned supine on an exam table and performed a crook-lying bilateral leg raise in which the heels will be held 5 cm off the table. For the trunk extensors, the subject lied prone and held the dorsum of the feet 5 cm above the table[4].

Platform Adjustment: The seat height was set for each individual so the thighs were angled 10° below horizontal with the feet flat on the floor and knees flexed to 80°. Feet were positioned shoulder-width apart, and arms hung relaxed next to the thighs.

Sitting Conditions: Following the standard submaximal contractions, the following sitting conditions were performed:

1. Sitting directly on the platform (dense rubber surface)
2. Sitting on an office chair cushion
3. Sitting with the BackJoy device
4. Active upright sitting posture
5. Slumped posture

Conditions 1-3 were performed in a random order followed by 4 and 5. Subjects were instructed to view a designated target 1.5 meters ahead at their eye level. During conditions 1-2, subjects will be instructed to sit comfortably as if they were sitting in front of their computer. When sitting with the BackJoy device (condition 3), subjects were given the additional specific instructions and demonstration on positioning the device from the manufacturer. These instructions only referred to positioning the device with no cues for posture. They were then instructed to sit comfortably. To achieve active upright posture, subjects were instructed to sit as tall as possible, with their shoulder blades slightly retracted, rotate their pelvis anteriorly to obtain a neutral lordosis of the lumbar spine. They maintained this position for at least 5 seconds while data were collected. They were then asked to relax into a slumped posture by relaxing the thoracolumbar spine and rotate the pelvis posteriorly. The slumped posture was held for at least 5 seconds while data were collected.

III. Data and Statistical Analyses.

Segment and Joint Calculations. From the marker locations, the following segment and joint orientations were determined:
Segments: right, left thighs, pelvis, mid-thoracic, and upper trunk.
Joints: pelvis-mid thoracic joint, mid thoracic-upper thoracic joint

Vertebral Segment angles. Sagittal plane angles of vertebral segments were calculated. These were defined by line segments between the following pairs of markers on the vertebrae: S1-L3, L3-T8, T8-T4, T4-C7.

Muscle Activity. Activity levels were reported relative to the standard contractions and bilateral values were averaged.

In order to determine if the BackJoy device influences sitting posture, comparisons postural kinematics and muscle EMG for all subjects were made using a repeated measures ANOVA with 5 within subject factors (sitting condition). For all tests, significance was set at $p<0.05$.

IV. Results

Pelvis, Trunk Segmental Angles (Figure 3)

Upright and Slumped Conditions: For each of the segments, upright sitting showed more upright orientation than during the slumped condition. This means that the pelvis was less posteriorly rotated and the midthorax and upper thorax were less anteriorly rotated during upright sitting than during slumped sitting.

BackJoy: While sitting with the BackJoy, the orientation of all 3 segments was between and statistically different than upright and slumped sitting. While the pelvis and upper thorax were the same as the other sitting conditions, the mid thoracic segment was less flexed forward when sitting with the BackJoy than when sitting directly on the platform.

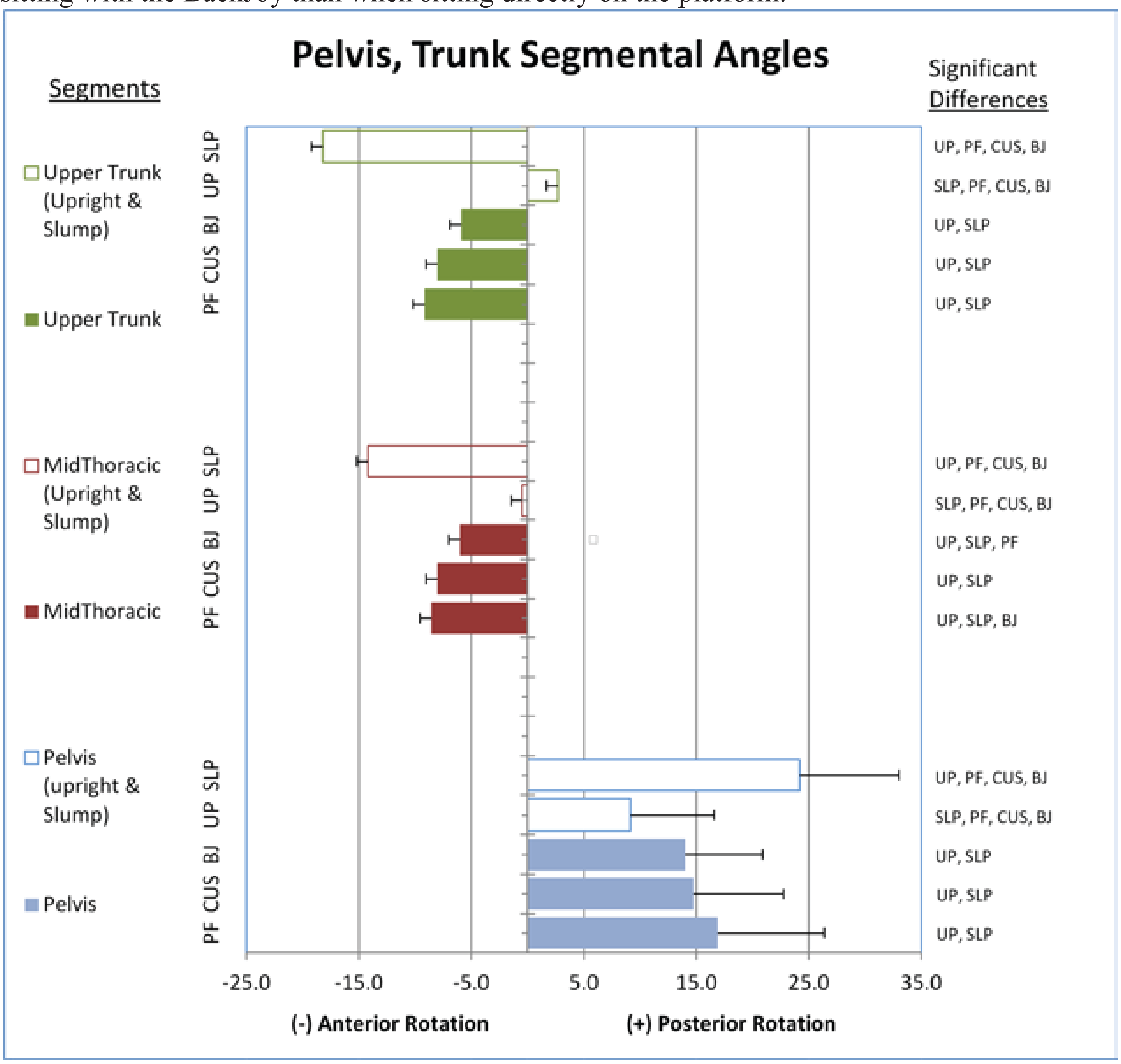

Figure3. Average pelvis, trunk segmental angles. Filled bars for each segment represent the platform, cushion, and BackJoy conditions. Unfilled bars are the upright and slumped conditions. To the right of each bar are the conditions that were significantly different ($p<0.05$).

Pelvis, Trunk Joint Angles (Figure 4)
Upright and Slumped Conditions: Both joints were less flexed (more extended) during upright sitting than during slumped.

BackJoy: The mid thoracic-upper thoracic joint was between and different than upright and slumped sitting. There were no differences for the mid thoracic-upper thoracic joint between sitting on the platform, cushion, or BackJoy. However, The pelvis-mid thor joint was less flexed (more extended) with the BackJoy than on the platform.

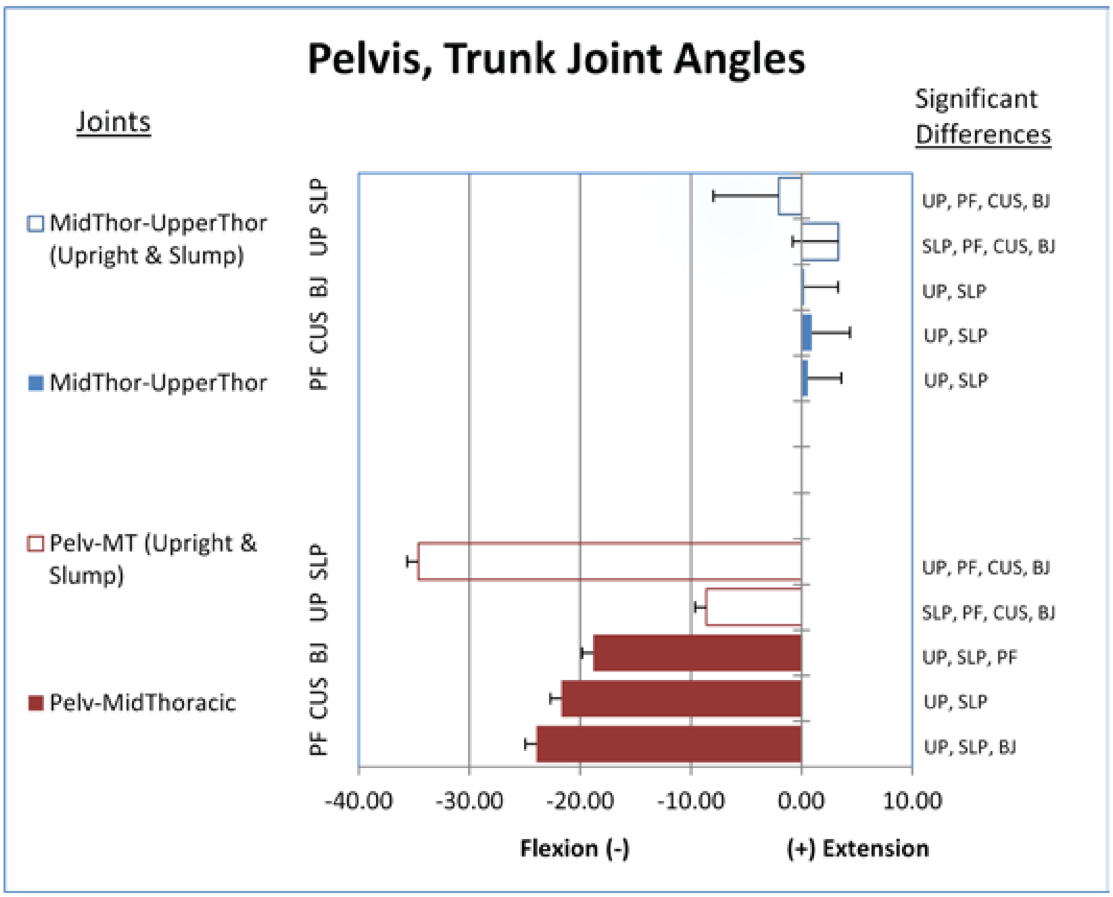

Figure 4. Average pelvis, trunk joint angles. Filled bars for each segment represent the platform, cushion, and BackJoy conditions. Unfilled bars are the upright and slumped conditions. To the right of each bar are the conditions that were significantly different ($p<0.05$).

Vertebral Segment Angles (Figure 5)

Upright and Slumped Conditions: For each segment, the upright and slumped conditions were significantly different from each other. During upright sitting, S1-L3 segment was angled forward to a greater extent and L3-T8, T8-T4, T4-T7 were angled less forward (more upright) compared to slumped sitting.

BackJoy: For the S1-L3 segment, there was no difference between the BackJoy condition and the cushion and platform conditions and these conditions were oriented the same as during the slumped condition. For the L3-T8 segment, the BackJoy condition resulted in a greater backward orientation than the cushion and platform conditions. The greater backward orientation was the same as during the upright sitting. For the upper trunk vertebral segments (T8-T4, T4-C7), there were no difference between the BackJoy condition and the cushion and platform conditions and these conditions were between and different than the upright and slumped conditions.

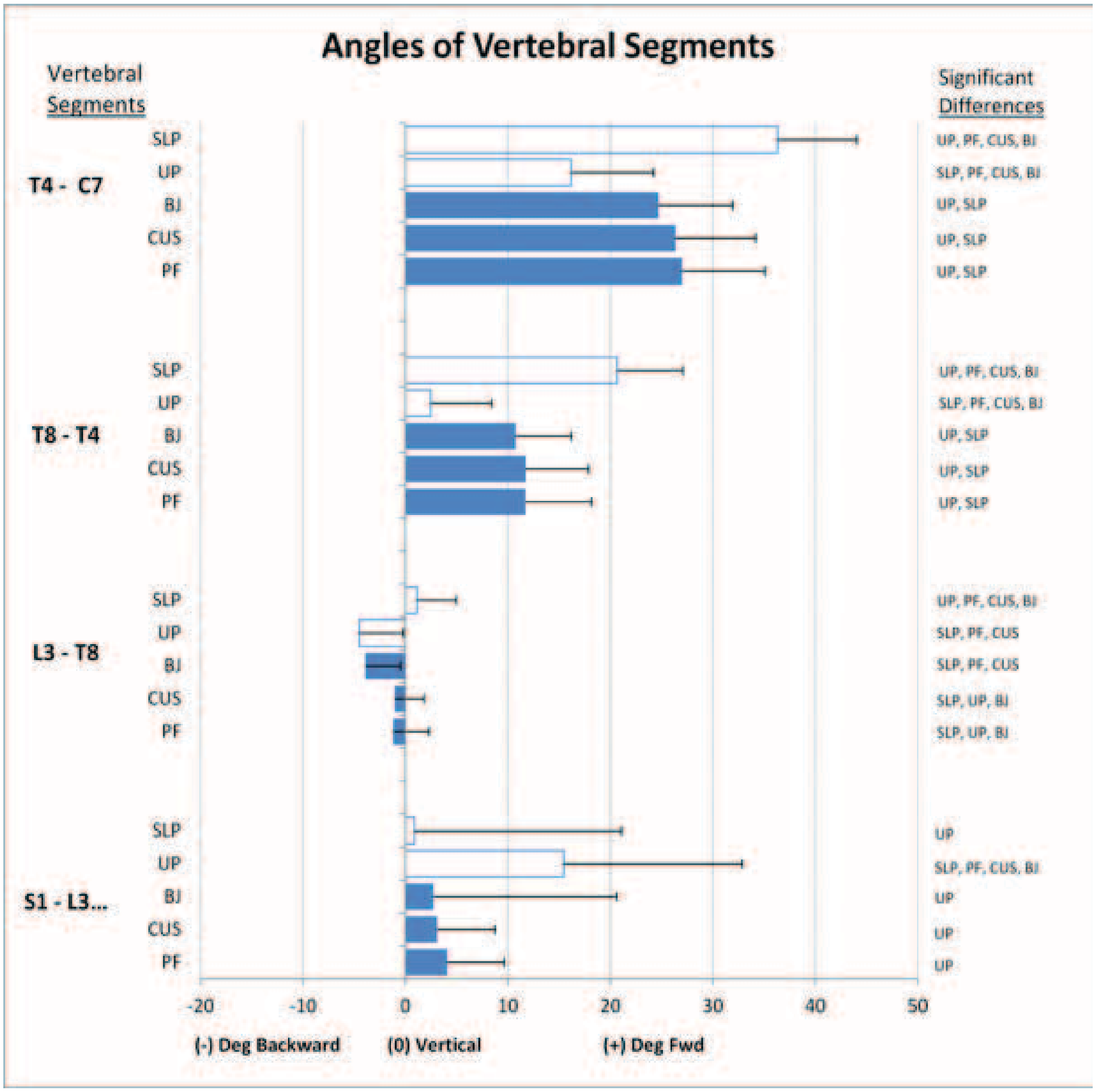

Figure 5. Average sagittal plane angles of vertebral segments defined by pairs of markers placed on the vertebrae. Filled bars for each segment represent the platform, cushion, and BackJoy conditions. Unfilled bars are the upright and slumped conditions. To the right of each bar are the conditions that were significantly different ($p<0.05$).

Muscle Activity – Anterior Muscles (Figure 6)
Upright and Slumped Conditions: For all of the muscles, active upright sitting elicited more activity than during slumped sitting.

BackJoy Anterior Muscles: There were no differences between sitting with the BackJoy and the cushion and platform conditions. Furthermore, the BackJoy, cushion, platform conditions were between and different than the upright and slumped conditions.

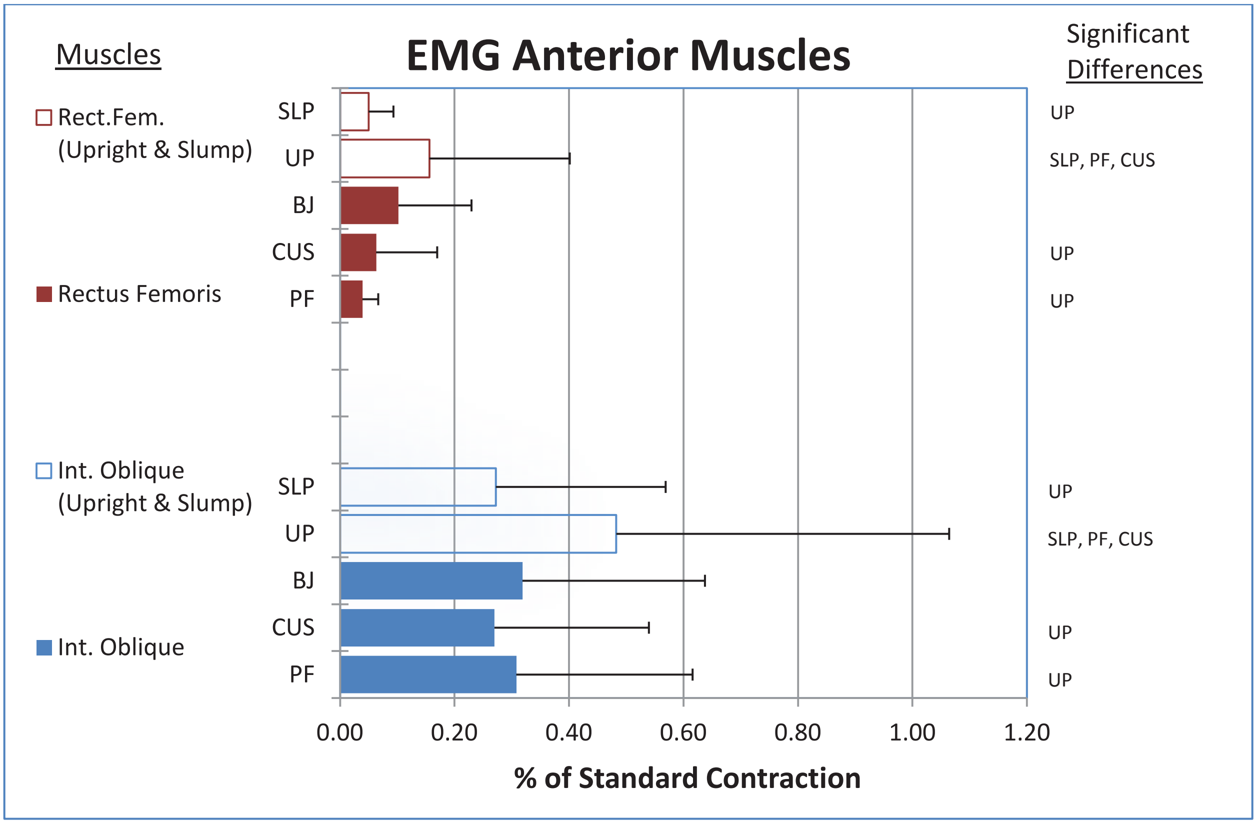

Figure 6. Average muscle activity for each of the anterior muscles. Recordings are expressed relative to the activity observed during the standard contractions. Bilateral recordings for each muscle pair were averaged. Filled bars for each segment represent the platform, cushion, and BackJoy conditions. Unfilled bars are the upright and slumped conditions. To the right of each bar are the conditions that were significantly different ($p<0.05$).

Muscle Activity – Posterior Muscles (Figure 7)
Upright and Slumped Conditions: For all of the muscles, active upright sitting elicited more activity than during slumped sitting.

BackJoy Anterior Muscles: For the erector spinae, sitting with the BackJoy not only showed less activity than the platform condition, but it was the only condition that showed less activity than upright sitting and the same amount of activity as slumped sitting. For the lumbar multifidus, while there were no differences between the BackJoy condition and the other conditions, the BackJoy condition was the only condition that showed less activity than both the upright and slumped conditions.

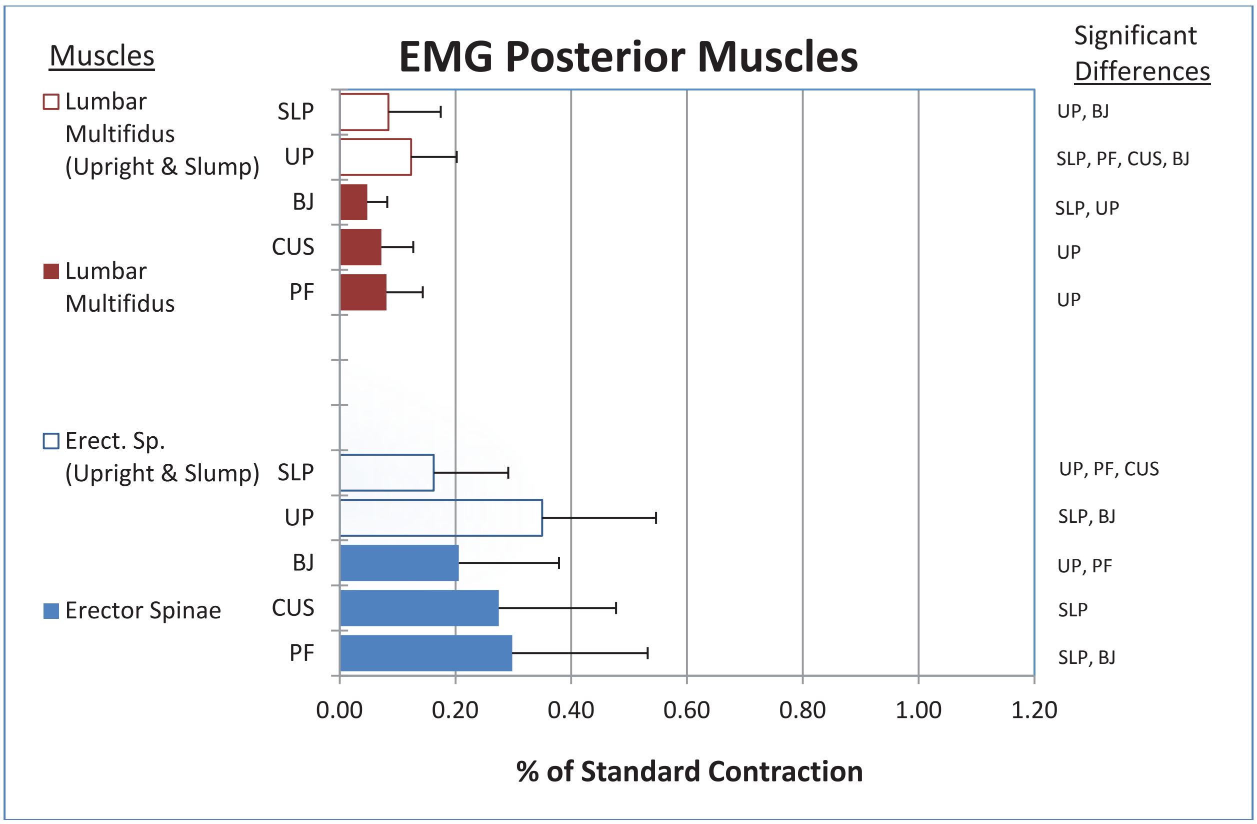

Figure 7. Average muscle activity for each of the posterior muscles. Recordings are expressed relative to the activity observed during the standard contractions. Bilateral recordings for each muscle pair were averaged. Filled bars for each segment represent the platform, cushion, and BackJoy conditions. Unfilled bars are the upright and slumped conditions. To the right of each bar are the conditions that were significantly different ($p<0.05$).

V Discussion and Summary

The present study evaluated the acute postural response to sitting with the BackJoy Core sitting device. To this end, subjects assumed a comfortable, unsupported sitting posture while sitting with the BackJoy, sitting on an office chair cushion, and sitting directly on a firm platform surface. These conditions were compared to intentional active upright sitting and intentional slumped sitting. While the BackJoy device had no effect on the pelvis or upper trunk, there was a significant influence on the upper lumbar and lower thoracic areas of the trunk consistent with improved posture. Specifically, with the BackJoy, the mid thoracic segment showed less anterior rotation than on the Platform (Figure 3). This is also evident in the joint angle formed between the pelvis and mid thoracic segments (Figure 4) where this joint angle was less flexed forward than sitting on the platform. This is also consistent the greater backward orientation of the vertebral segment formed between L3 and T8 while sitting with the BackJoy compared to the platform and cushion (Figure 5). In each of these cases, the less anterior rotation of the mid thoracic segment, less flexion of the pelvis-mid thoracic joint and the greater backward orientation of the L3-T8 segment are all in the direction of, or consistent with, the active upright posture conditions.

Muscle activity of key postural muscles was also evaluated during the sitting conditions. For all muscles, active upright sitting elicited significantly more activity than during slumped sitting. There were no differences in muscle activity observed between the BackJoy, platform and cushion conditions for the anterior postural muscles. There were, however, significant changes in muscle activity for the posterior muscles. Specifically, for the erector spinae, sitting with the BackJoy elicited less activity than sitting on the platform and the BackJoy condition was the only one to show activity as low as during the relaxed slumped condition. Similarly, sitting with the BackJoy was the only condition to elicit less activity than during the slumped condition for the lumbar multifidus.

In summary, when subjects sit with the BackJoy Core sitting device, there is an improvement in the posture of the lumbar-thoracic region of the trunk. Interestingly, this is done with less effort from key posterior postural muscles.

It is important to note the key limitations of this study and the scope. The current study evaluated the immediate (less than one minute) postural response in a subject population that consisted of healthy, young individuals free of any back pain and injury. It is unknown if the results would be similar in older individuals, individuals with back pain and injury, or overweight individuals. It is also unknown if the same postural responses would appear with prolonged sitting.

VI. References

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