An Evaluation of the Impact of the eQuilibrium® Almond on the Biomechanical and Comfort Responses During Prolonged Standing Work

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Prepared for:
Gordon Lamont
President,
Deltabalance Inc.
10504 Princess Elizabeth Avenue
Suite W207B
Edmonton, Alberta
T5G 3K4

Jack P. Callaghan PhD, CK, CCPE
Canada Research Chair in Spine Biomechanics and Injury Prevention
Department of Kinesiology
Faculty of Applied Health Sciences
University of Waterloo
Waterloo, Ontario, Canada N2L-3G1
Voice: (519) 888-4567 x37080
Fax: (519) 746-6776
Email: callagha@healthy.uwaterloo.ca

Acknowledgement:
The following individual contributed to the work summarized in this report:
Erika Nelson-Wong DPT, PhD Candidate

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EXECUTIVE SUMMARY:

The subsequent report presents data collected from 16 subjects (8 males, 8 females) and examines the physiological responses to prolonged standing on the eQuilibrium® (eQ) Almond compared with level ground standing. Subjects were recruited to represent individuals predisposed to developing low back pain during prolonged standing and asymptomatic controls (10 pain, 6 non-pain developers). Three different standing tasks were examined (sorting, small object assembly, and quiet standing) during 2-hours of standing on the eQ Almond and a level floor. The primary focus of the study was to assess the subjective comfort associated with using the eQ Almond and to determine to what extent the platform alters muscular activity, spine and pelvis postures during prolonged standing. The following four sub-issues were addressed: response of gender, influence of task parameters, differences in upslope and down slope standing on the eQ Almond, and the impact on symptomatic and asymptomatic low back pain sub-groupings.

Males appear to favourably respond to the eQ Almond, regardless of if they have low back pain associated with standing or not, whereas females exhibited a somewhat more variable response. All 5 of the male individuals who developed pain during level standing demonstrated a significant decrease in their subjective pain reports when using the eQ Almond and the 3 non-pain developers reported no change. Two of the 5 females who developed pain during level standing changed from the pain to non-pain group, 1 of the 8 female participants had a significant increase in discomfort when using the eQ Almond, with the remaining 5 females having no change in discomfort ranking. Overall low back discomfort scores were reduced by 43.5% for the pain development group across gender, identified in level standing, when using the eQ Almond.

The eQ Almond appears to have an influence on modifying muscle co-activation levels during standing. The pain group responded to standing on the eQ Almond by showing a marked decrease in the co-activation of the bilateral gluteus medius muscles. The gluteus medius muscle co-activation for the pain group became more similar to the profiles seen in a non-pain group during level standing. However the non-pain group responded in the other direction by having an increase in the co-activation of these muscles, although they did not have a commensurate increase in low back pain.

There were changes in both the postural and joint loading variables examined. These changes were minimal and in most cases the eQ Almond produced responses that bracketed the postures and loading magnitudes found in level standing. Variability in exposures is an accepted strategy that has been shown to be beneficial in reducing pain reporting. The eQ Almond induced variability by encouraging frequent shifts in standing position, with an average move every 84 seconds or 85 postural shifts in total over a 2-hour period. The downslope surface of the eQ Almond was preferred and 72% of the time was spent standing on the front side.

The eQ Almond introduces changes that result in beneficial reductions in low back pain during prolonged standing. These positive findings were supported in the exit survey satisfaction rating with 87.5% of all participants indicating that they would use the eQ Almond if they were in an occupational setting that required prolonged standing work.

INTRODUCTION:

It has been well established that occupations requiring prolonged periods of static standing are associated with the development of musculoskeletal disorders including low back pain (LBP) (Kim, Stuart-Buttle et al. 1994; Macfarlane, Thomas et al. 1997). A high prevalence of musculoskeletal disorders has been documented in workers across several different industries that require standing for more than 4 hours continuously (Kim, Stuart-Buttle et al. 1994). Research that has investigated the impact of ergonomic measures such as anti-fatigue mats, different flooring surfaces and shoe insoles has shown mixed results for effectiveness at alleviating or preventing musculoskeletal pain that is aggravated by prolonged standing (Kim, Stuart-Buttle et al. 1994; Hansen, Winkel et al. 1998; Orlando and King 2004).

The eQuilibrium® Almond (Deltabalance, Inc., Edmonton, Alberta, Canada) is described as an 'energy platform for standing' that is marketed as a workplace device to alleviate low back pain and fatigue associated with prolonged standing exposures.

Previous work in our lab has investigated the modulation of biomechanical factors during the development of acute low back pain during standing. This is a novel approach that utilizes a prospective design by functionally inducing low back pain in previously asymptomatic individuals. We have found that 48-64% of previously asymptomatic individuals will develop clinically significant levels of low back pain during a protocol that involves standing at a work station for a 2-hour period. This approach has allowed us to identify factors that are associated with the development of low back pain during standing by comparing the characteristics of the pain developers and non-pain developers. Furthermore, we have been able to examine the time-varying responses during the development of acute low back pain. Through identification of the factors that appear to be predisposing to development of low back pain during standing, we are also able to investigate how different interventions may impact those factors (Gregory, Brown et al. 2008; Gregory and Callaghan 2008; Nelson-Wong, Gregory et al. 2008).

The purpose of this experimental study was to provide an assessment of the subjective comfort associated with using the eQuilibrium® (eQ) Almond and to determine to what extent usage of the platform alters muscular activity, spine and pelvis postures during prolonged standing. The following four specific sub-issues were addressed: response of gender, influence of task parameters, differences in upslope and down slope standing on the eQ Almond, and the impact on symptomatic and asymptomatic low back pain sub-groupings.

METHODS:

Sixteen volunteers, 8 male and 8 female (average age 22.2 years, BMI 23.6 kg/m^2) were recruited for this study from the University of Waterloo student population. Participants had previously undergone a standing protocol as part of a larger study, and had therefore already been identified as pain developers (PD) or non-pain developers (NPD). There were 5 PD and 3 NPD participants for each gender entered into this study. Exclusion criteria included any prior lifetime history of low back pain requiring treatment by a medical doctor, chiropractor or physiotherapist or that resulted in more than 3 days off work or school, any previous hip surgery, inability to stand for greater than 4 hours, inability to answer questionnaires, and having an occupation requiring static standing during the previous 12-month period. The study protocol received approval from the University Office of Research and subjects gave informed consent before testing began.

Volunteers participated in two data collection days. On one day participants completed the 2-hour standing protocol on a level surface and on a second day of testing completed the 2-hour standing protocol while standing on the eQ Almond. Specific protocols for each testing day are detailed below.

Data Collection - Level Standing

After informed consent was obtained, participants completed a baseline measure of current pain symptoms on a 100-mm visual analogue scale (VAS) with end-point anchors of 'no-pain' and 'worst pain imaginable' for 5 different body regions (Appendix A). The VAS was chosen as it has been found to have good construct validity (Summers 2001) and reliability (Revill, Robinson et al. 1976). A licensed physiotherapist performed a standardized assessment similar to what would be done in a clinical setting with a low back pain patient. Measures included active and passive hip and lumbar range of motion, assessment of core stability as demonstrated by active straight leg raise (ASLR) (Mens, Vleeming et al. 1999) and active sidelying hip abduction (AHAbd), time to fatigue in side support (McGill, Childs et al. 1999; Hicks, Fritz et al. 2005), assessment of lumbar segmental mobility (Hicks, Fritz et al. 2003), and prone instability testing (Hicks, Fritz et al. 2003; Hicks, Fritz et al. 2005).

Muscle activation of the trunk flexors, extensors, hip extensors and abductors were monitored throughout the 2-hours of standing work. Eight pairs of disposable electromyographic (EMG) Ag-AgCl electrodes (Blue Sensor, Medicotest, Inc., Olstykke, Denmark) were affixed to the skin with a 2 cm centre-to-centre inter-electrode distance over the muscle bellies of the following bilateral muscle groups: Thoracic Erector Spinae (5 cm lateral to T_9 spinous process) (Callaghan, Gunning et al. 1998), Lumbar Erector Spinae (above and below L_1 spinous process) (Danneels, Cagnie et al. 2001), Latissimus Dorsi (upper 1/3 of a line connecting the posterior shoulder crease and L_1) (Anders, Bretschneider et al. 2005), Rectus Abdominus (1 cm above umbilicus and 2 cm lateral to midline) (Ng, Kippers et al. 1998), Internal Oblique (1 cm medial to anterior superior iliac spine (ASIS) and beneath a line joining bilateral ASIS) (Ng, Kippers et al. 1998), External Oblique (below the rib cage, along a line connecting the inferior costal margin and the contralateral pubic tubercle) (Ng, Kippers et al. 1998), Gluteus Medius (2.5 cm distal to the midpoint of the iliac crest) (Zipp 1982), and Gluteus Maximus (midway between the greater trochanter and the sacrum) (Zipp 1982). All electrode placements were also confirmed through palpation and manual resistance. Raw EMG was amplified (AMT-8, Bortec, Calgary, Canada; bandwidth = 10-1000 Hz, CMRR=115 db at 60 Hz, input impedance = 10 GΩ) and collected with a sampling frequency of 2048 Hz using a 16-bit A/D card with a ± 2.5 V range.

Maximal voluntary contractions (MVC) were collected for EMG normalization, so that all data could be expressed relative to 100% maximal exertion. Manual resistance was applied to obtain MVC's in the following positions: Beiring-Sorensen for trunk extensors (Dankaerts, O'Sullivan et al. 2004), prone hip extension for hip extensors, sidelying hip abduction for hip abductors, supine straight-leg curl up and diagonal curl-up to the left and right for trunk flexors (Dankaerts, O'Sullivan et al. 2004), and a single-arm shoulder pull-down with manual resistance applied into internal rotation and extension and the shoulder positioned in 30° of abduction (Dark, Ginn et al. 2007). 'Rest' trials were collected in supine and prone positions so that the muscle activation levels above a resting reference level could be assessed.

Participants then entered into the prolonged standing task. A height adjustable worktable was positioned in front of two in-floor force platforms (Models OR6-7 and BP900900, Advanced Mechanical Technology, Inc., Watertown, Mass.) and adjusted to a height of 5-6 cm below the wrist of the participant when the elbow as flexed to 90° (Appendix B). Participants were instructed to stand 'in their usual manner as if they were standing for an extended period' with the only stipulation being that both feet could not be on the same force platform, they could not rest their foot on the table frame, and they could not lean on the table surface with their upper extremities to support their body weight. Another baseline VAS was collected prior to the start of the 2-hour standing period.

Three different tasks were selected to simulate light occupational activities. These included a 'sorting' task, where participants were provided with an assortment of candy and instructed to sort it by type and color; a small object 'assembly' task that involved assembling and disassembling a bolt, lock-washer, flat washer, and nut; and a task termed 'boredom' where participants were asked to stand without any activity and were not interacted with by members of the research team. This was included in an attempt to assess the effect of distraction on a participant's pain ratings. Tasks were presented in a semi-random block fashion using a random number generator, with 30-minute blocks for each task. There were two blocks of boredom, and task order was a partially controlled randomized design in that two boredom blocks could not be adjacent to each other. EMG and force plate (FP) data were collected continuously for the 2-hours of standing at 2048 and 1024 Hz respectively and saved in 15-minute blocks (to maintain manageable data file sizes). At the end of each 15-minute block, participants were asked to complete a VAS for the five body regions resulting in a total of 9 pain measures over the 2-hour period.

Lower body and trunk segment positions were measured using an optoelectronic motion analysis system (Optotrak Certus, Northern Digital Inc., Waterloo, ON) at a sampling frequency of 32 Hz. Forty-six markers were placed bilaterally on each participant's body to track movement of the following segments: foot, leg, thigh, pelvis, and thorax.

Data Collection – eQuilibrium® Almond Standing

The same data collection processes were repeated for the 16 participants on a separate day at a similar time of day to the first session. There were several differences in methodology from the level standing trials aimed at quantifying the response of the participants to the eQ Almond. These differences included:

i. Passive range-of-motion measurements were taken by a licensed physiotherapist to assess ankle flexibility.

ii. Participants were then prepped for EMG electrode placement as described above with the following additional muscle groups included for platform standing: Tibialis Anterior (TA) and the lateral head of the Gastrocnemius (Gas), with electrodes placed over the muscle bellies confirmed through palpation. MVC's were collected using manually resisted ankle dorsiflexion in a supine position for TA and a reference contraction of single leg standing heel raise for Gas.

iii. A single 0.9 m square force plate was used for this data collection out of necessity to accommodate the eQ Almond. Kinetic data obtained from the FP, sampled at 1024 Hz, and the kinematic data from the motion analysis system were entered into a 3-dimensional inverse dynamic model using Visual3D software (C-Motion, Inc., Kingston, ON) to calculate forces and moments at the L_5S_1 joint during standing, and to calculate lower extremity and trunk joint angles. A standing calibration trial was collected and all joint angle data were normalized to the neutral level standing posture.

iv. The eQ Almond had markers placed on the longitudinal midline and was placed on the force platform. Prior to the 2-hour standing protocol, participants completed three 1-minute standing postures in: level standing without the eQ Almond, standing on the eQ Almond in the incline, toes-up position, and standing on the eQ Almond in the decline, toes-down position (Appendix C). The order of these postures was randomized to minimize the influence of order effects.

v. The standing table was then positioned in front of the eQ Almond. The table was fit with a pull-out tray that participants could use to position the work surface at an appropriate distance if they were standing on the back side (incline position) of the eQ Almond. The height of the table was adjusted so that the work surface was 6 cm below the wrist with the elbow positioned at 90° of flexion when the participant was standing in the decline or incline position on the eQ Almond. Participants were instructed to stand wherever they were most comfortable on the eQ Almond during the 2-hours, and to make sure they positioned the work surface to accommodate their standing position.

vi. Participants then entered into the 2-hour standing protocol on the eQ Almond. The same tasks and randomization scheme were used as in the level standing data collection. At the end of each 15-minute block, after completing the VAS, participants were asked to identify their preferred standing position on the platform.

vii. Following the 2-hour standing period, participants completed another three randomized 1-minute standing postures as before (point iv). Participants were then asked to complete an Exit Questionnaire (Appendix D) to record their opinions about the eQ Almond.

Experimental protocols for level and eQ Almond standing data collections are shown schematically by flowchart in Figures 1 and 2. VAS collection times are highlighted in red.

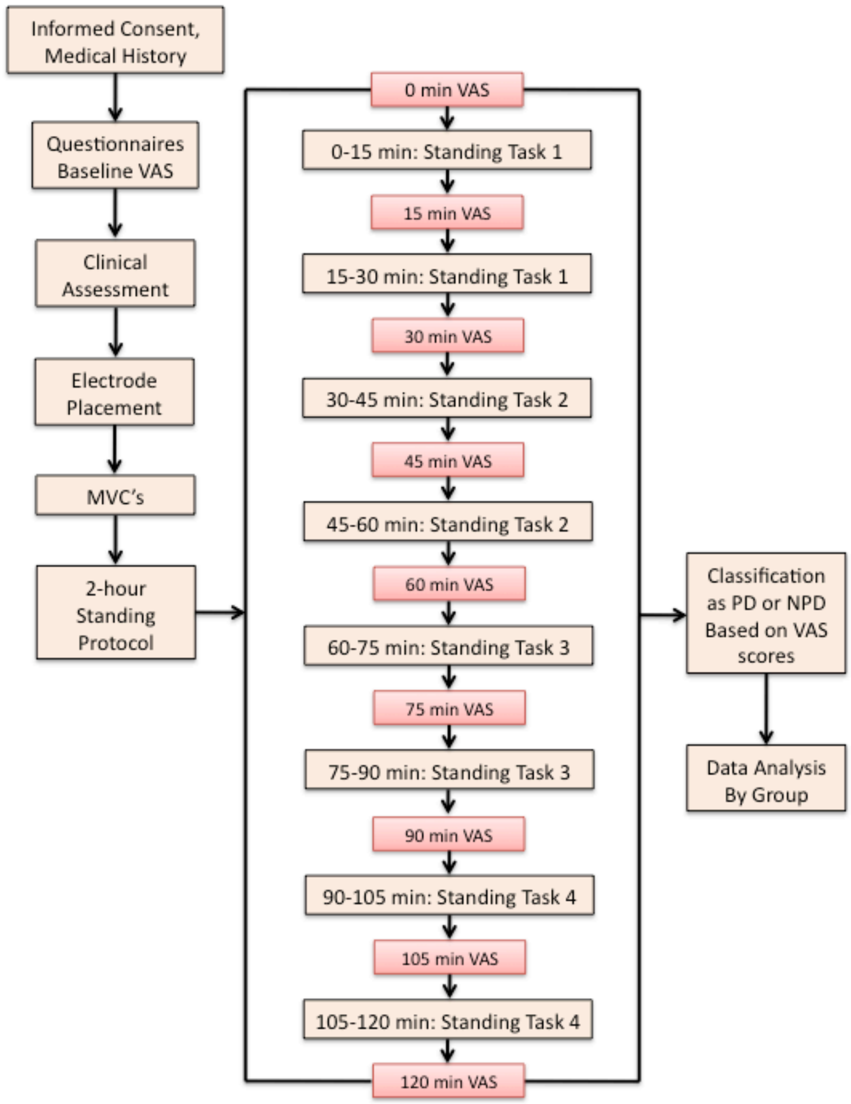

Figure 1. Level standing experimental protocol.

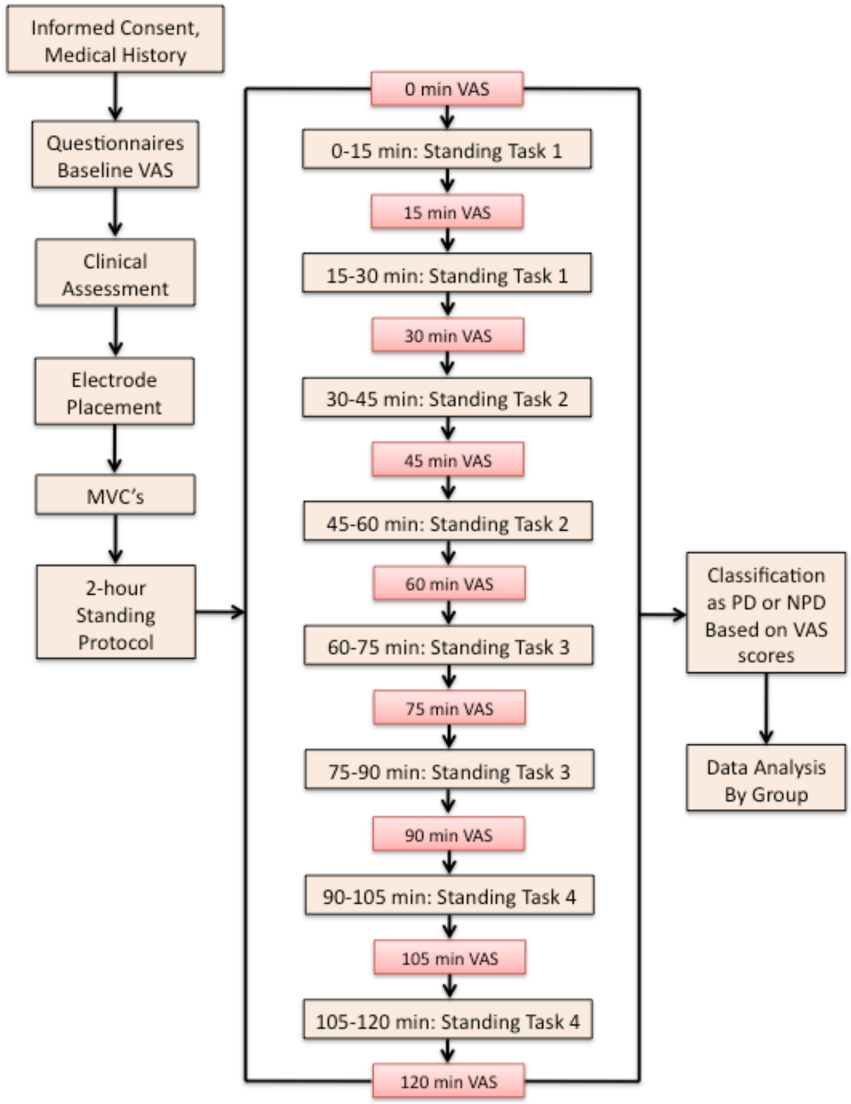

Figure 2. eQuilibrium® Almond standing experimental protocol.

Signal Post-Processing and Data Analysis

Participants were considered to be pain developers (PD) if they reported any VAS score greater than 10 mm during the 2-hour level standing period. These threshold VAS values were chosen since 9 mm has been found to be the minimum clinically significant difference in VAS, representing a small treatment effect, with greater than 20 mm differences representing a large treatment effect (Kelly 1998). The PD group could be further sub-categorized as 'responders' and 'non-responders' based upon their VAS scores during the eQ Almond standing. The 'responders' were defined as those individuals that switched from a PD group during level standing to a NPD group during eQ Almond standing using the same threshold of greater than 10 mm maximum VAS to be in the PD group. 'Non-responders' were those individuals who did not switch from a PD to a NPD group when using the eQ Almond during prolonged standing.

EMG data were filtered and processed according to our laboratory guidelines, and normalized to % MVC to represent muscle activation level.

Co-activation coefficient (CCI) (Lewek, Rudolph et al. 2004) was used to quantify muscle co-activation and was calculated for all possible muscle pairs (a total of 16 x 16 possible combinations with 120 unique comparisons). The CCI provides a quantitative measure of the degree of co-activation for a pair of muscle groups over a specified time frame. CCI was calculated over 1-minute windows for the 8 15-minute blocks and then averaged to yield 8 CCI values for the 2-hour standing period.

Marker and force platform data were used to develop a 3-dimensional inverse dynamic model with the Visual3D software (for an sample model see Figure 3). The model was used to calculate forces and moments at the L_5S_1 segment, and to determine the relative joint angles at the ankle, knee, hip, and trunk as well as the global pelvis angle. The neutral level standing position was used as a zero reference position for reporting all postural changes. Joint angles during the incline and decline standing positions on the eQ Almond are expressed as the difference in degrees from angles calculated for the neutral level standing posture. L_5S_1 forces are expressed as a percentage of the individual's body weight in order to allow for comparisons between people of different weights. L_5S_1 moments were normalized to the moment calculated during the neutral level standing position and are therefore expressed as a percentage of the neutral standing moment.

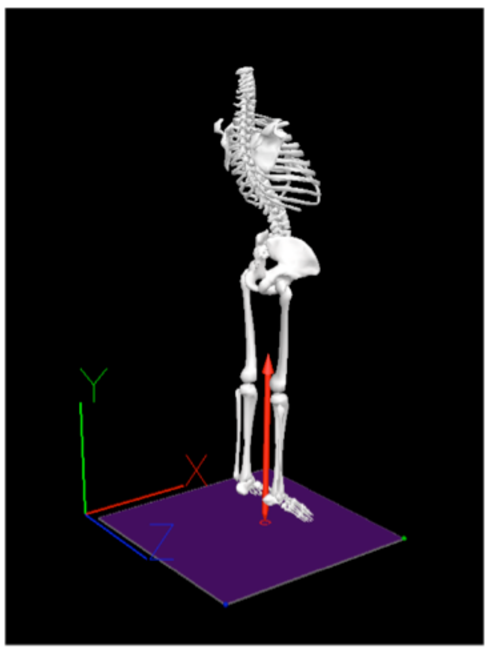

Figure 3. Example Visual3D model with participant standing in the decline position on the eQ Almond.

Marker data from the participant's feet and the eQ Almond's midline were used to determine where the participants were standing throughout the 2-hour protocol and to track the number of times they changed positions between the two surfaces (incline and decline).

Statistical Analysis

To address the purposes of the study the following factors were assessed using statistical analyses: Pain Grouping, Gender, Standing Condition (level standing versus eQ Almond) and Pain Responding Status. SPSS version 16.0 (SPSS, Inc., Chicago, IL, USA) was used for all statistical analysis. In more detail, independent t-tests were conducted to ensure equality of groups on the personal characteristics of age, body mass index (BMI), and activity level. Independent t-tests were also conducted on the Baseline VAS scores to ensure there were no group differences in pain level prior to the standing period. Range of motion measures were entered into a general linear model with between factors of gender (M/F) and group (PD/NPD). Dependent variables measured during the standing period were also entered into general linear models with between factors of gender (M/F) and group (PD/NPD) and repeated measures where appropriate. To examine differences between the responders and non-responders, measures for the PD group were also run separately with between factors of gender (M/F) and Responder Category (responder/non-responder). Pairwise comparisons were made when post-hoc tests were required. The level for significance was set at $p < 0.05$ for all statistical tests unless otherwise noted.

RESULTS:

Range of Motion Measurements

Lower extremity range of motion was not predictive of which individuals would respond during standing on the eQ Almond. There were no significant differences between known pain developers/non-developers or between responders/non-responders. There were gender differences in range-of-motion as expected and has been shown previously in the scientific literature. Range of motion measures are detailed in Appendix E.

Subjective Pain Scores During Standing

There were no significant differences in baseline VAS ratings between PD/NPD groups, responder/non-responder groups or between genders prior to the prolonged standing exposures. This indicates that all participants had a low and similar level of pain before being exposed to the standing protocol.

Ten of the 16 participants developed low back pain during standing on the level surface, with the magnitude of pain reported by the PD and NPD groups being significantly different at the $p < 0.01$ level. Figure 4 shows average VAS scores over time during level standing for the two groups.

Individuals who were categorized as PD during level standing reported an average *maximum* VAS score of 20.89 (± 3.5) mm. Individuals who were categorized as NPD during level standing reported an average *maximum* VAS score of 1.33 (± 4.5) mm (Figure 5). There were no gender differences in the VAS scores reported.

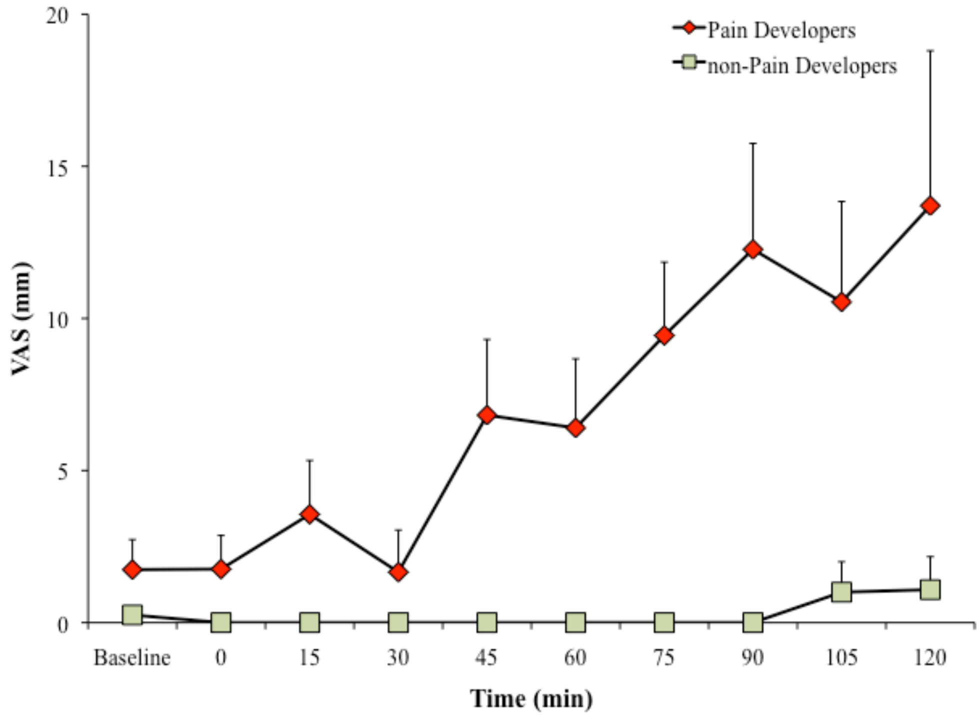

Figure 4. Average low back VAS scores at each time point over 2-hours of level standing (error bars show 1 Standard Error (SE))

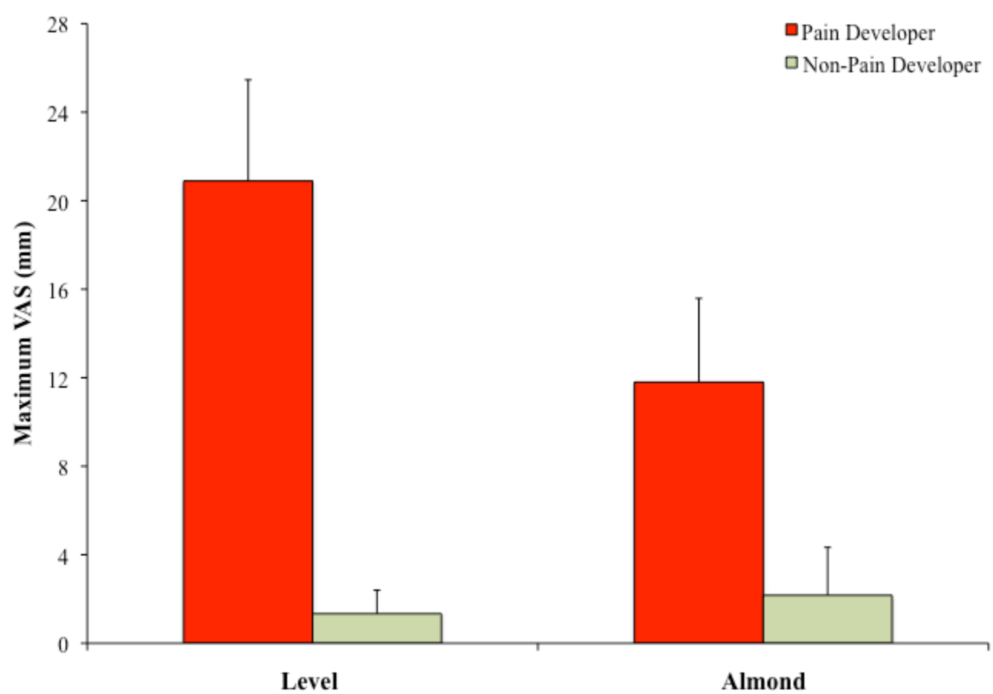

Figure 5. Maximum VAS scores (group averages with 1 SE) reported during the 2-hour standing period.

The PD group showed a significant decrease ($p < 0.01$) overall in VAS scores during eQ Almond standing (Figure 6), with no significant effect of gender. Average maximum VAS scores for the PD group decreased to 11.80 (± 3.4) mm (from 20.89 ± 3.5 mm) during eQ Almond standing.

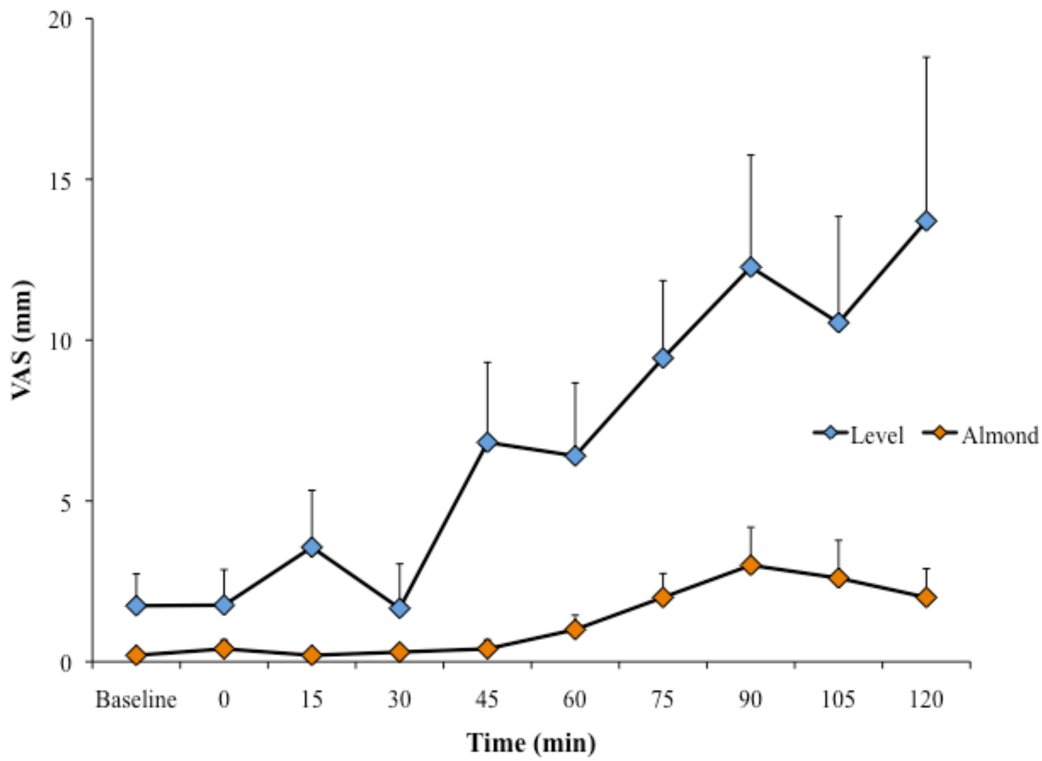

Figure 6. Comparison of low back VAS scores for PD Group between 2-hours of Level and eQuilibrium® Almond Standing

Of the 5 male PD, 3 were classified as 'responders' and 2 were classified as 'non-responders'. Of the 5 female PD, 2 were classified as 'responders' and 3 were classified as 'non-responders'. When 'responders' were examined separately, there was a significant interaction between standing surface, gender and responder category ($p < 0.01$). Male and female responders demonstrated similar decreases in maximum VAS scores from level to eQ Almond standing (average decrease of 10.3 mm, or 68.8% for males and 11.5 mm, or 74.2 % for females), while male non-responders showed a decrease in maximum VAS scores (average decrease of 45.8%, or 19.5 mm) and female non-responders showed a slight increase in maximum VAS (average increase of 4.2%, or 0.7 mm) (Figure 7).

When VAS scores from the eQ Almond standing condition were analyzed using the original threshold criteria for being a pain developer or non-developer, 6 of the 16 participants were classified as low back pain developers, with VAS scores above 10mm (Figure 8) with significant differences between groups at the $p < 0.01$ level and no differences between genders.

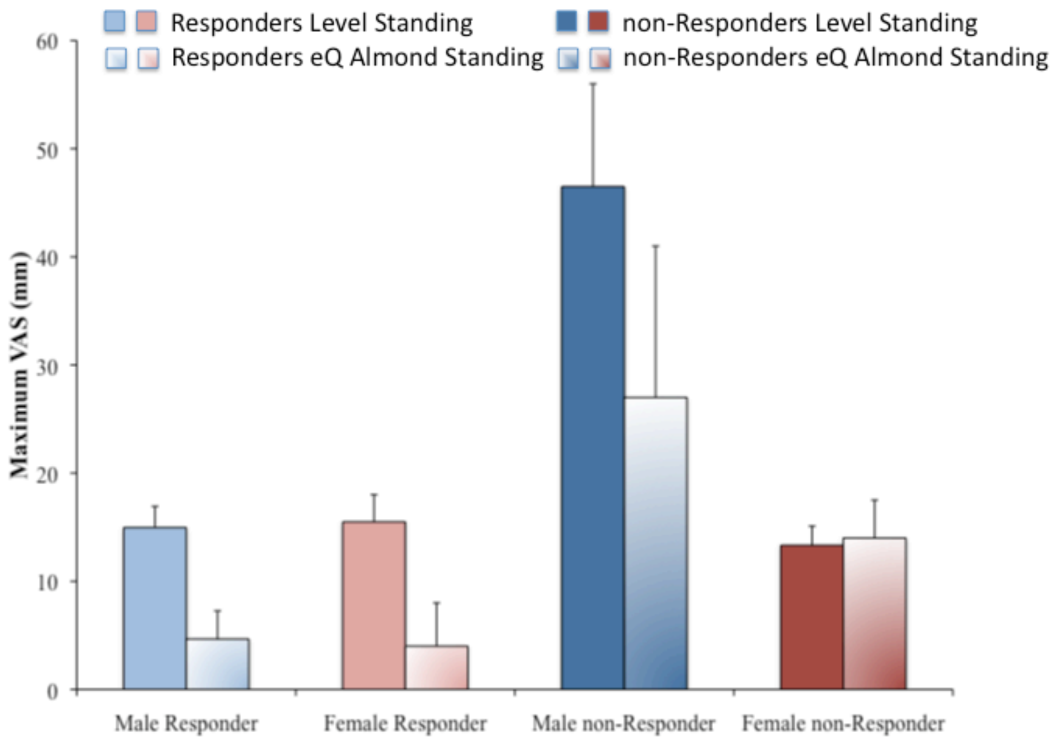

Figure 7. Comparison of maximum VAS scores during level and eQuilibrium® Almond standing by gender and responder category

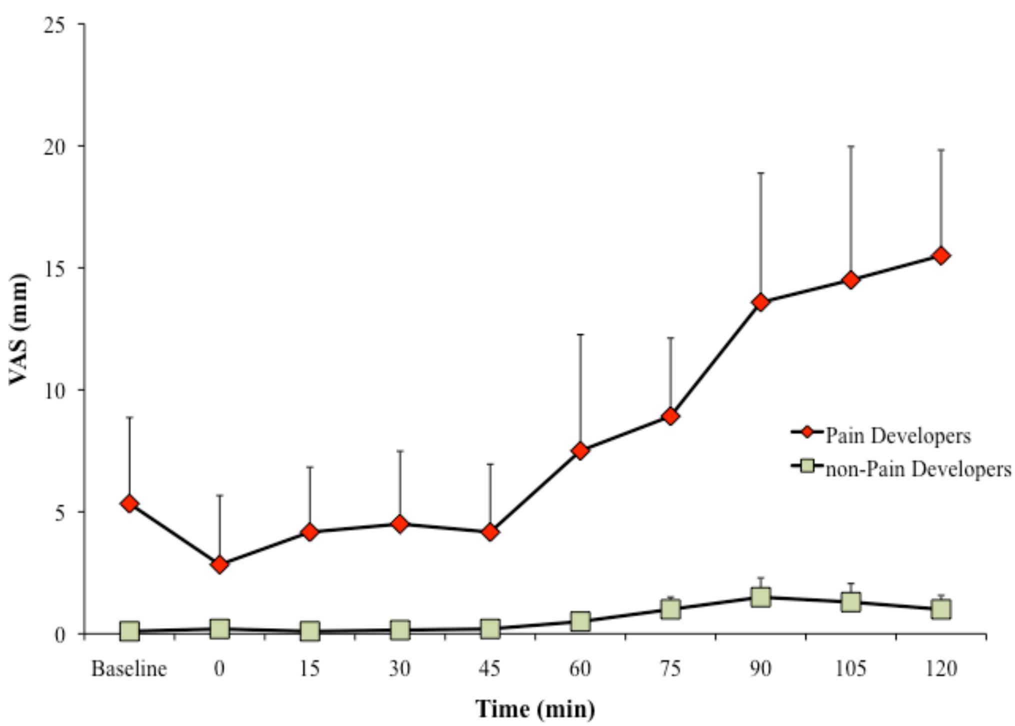

Figure 8. Low back VAS scores for all participants during eQuilibrium® Almond standing (grouped according to VAS reports during eQuilibrium® Almond condition)

Of these 6 individuals, 5 were previously classified in the PD group during level standing (and are therefore considered ‘non-responders’) and 1 female was previously classified in the NPD group during level standing. Table 1 shows individuals responses and pain group category by participant between the two standing conditions.

Table 1. Maximum VAS scores for each condition by participant

ID #	Max VAS Level (mm)	Initial Group	Max VAS Almond (mm)	Almond Group	Max VAS Change (mm)
F1	10	PD	11	PD	+1
F2	16	PD	21	PD	+5
F3	13	PD	0	NPD	-13
F4	0	NPD	0	NPD	0
F5	14	PD	10	PD	-4
F6	6.5	NPD	13	PD	+6.5
F7	18	PD	8	NPD	-10
F8	0	NPD	0	NPD	0
M1	0	NPD	0	NPD	0
M2	0	NPD	0	NPD	0
M3	18.8	PD	9	NPD	-9.8
M4	56	PD	41	PD	-15
M5	12.3	PD	5	NPD	-7.3
M6	1.5	NPD	0	NPD	-1.5
M7	13.8	PD	0	NPD	-13.8
M8	37	PD	13	PD	-24

Differences in Joint Angles and Lumbar Loading for Standing Positions on the eQuilibrium® Almond

As expected, there were postural differences in both the kinematics and kinetics of individuals when standing in the Level, Incline and Decline positions. A table of descriptive statistics for the significant postural findings is attached as Appendix F.

Significant differences ($p < 0.05$) between standing positions on the eQ Almond were observed in global pelvis and lumbosacral angles (Figure 9). The pelvis angle has increased flexion during the incline standing position and no difference from level standing in the decline position. The lumbosacral angle has increased extension during incline standing and increased flexion during decline standing. As expected, the ankle angles (Figure 10) closely follow the slope of the eQ Almond standing surface for both incline and decline positions ($p < 0.001$). Participants had increased knee extension ($p < 0.05$) during incline standing, and no significant change from level during decline standing positions (Figure 11).

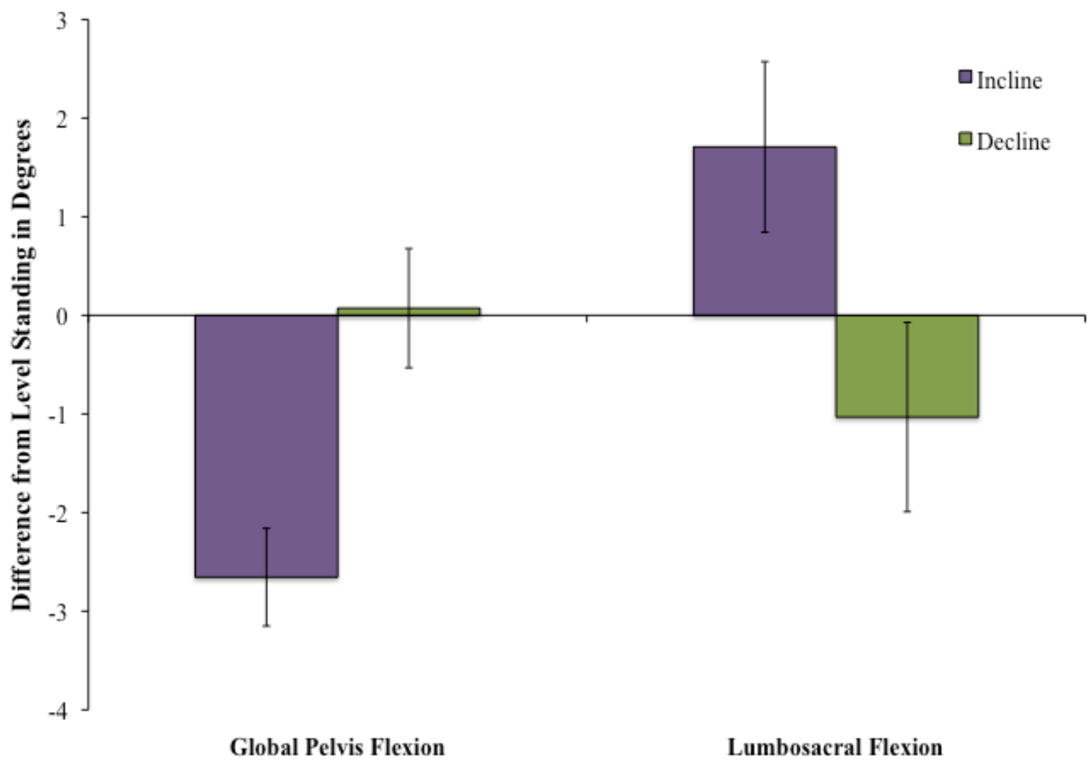

Figure 9. Differences from level standing in global pelvis and lumbosacral angles (*+ve* is in the extension direction).

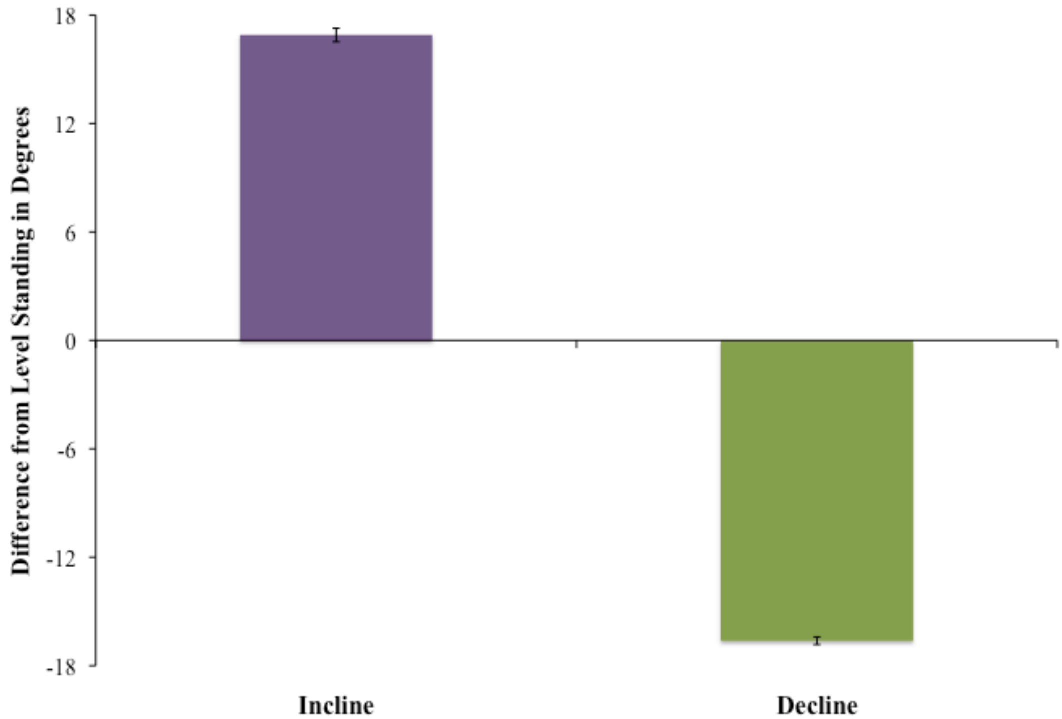

Figure 10. Differences in ankle flexion angle from level standing (+*ve* is in dorsiflexion direction).

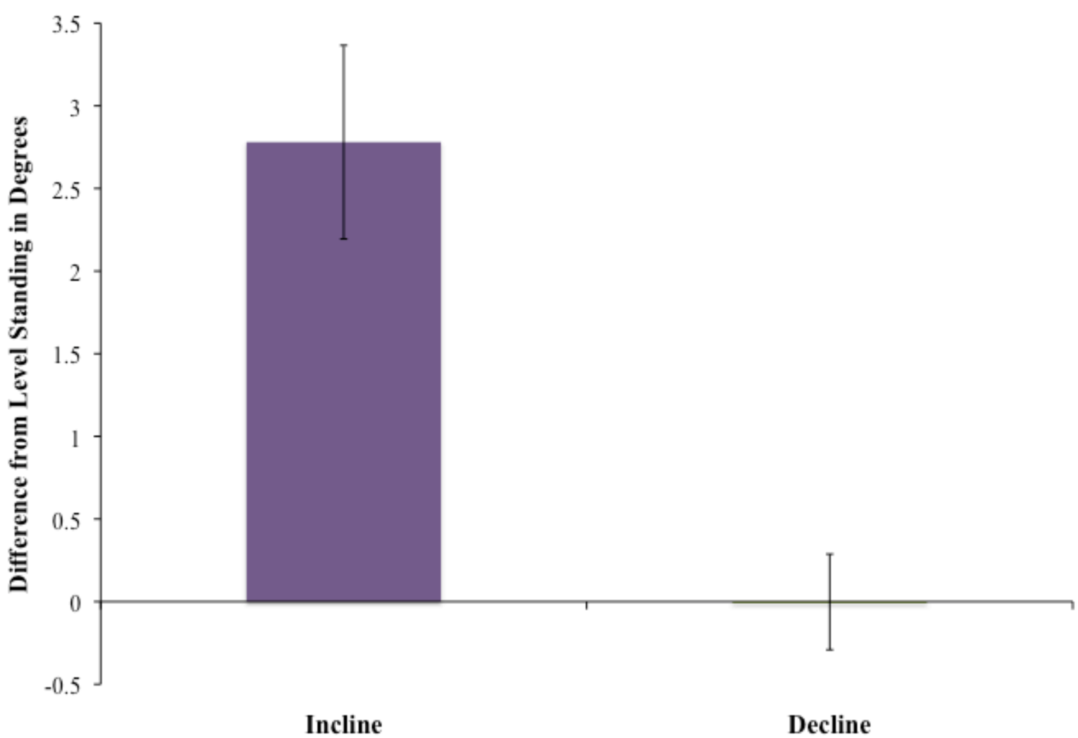

Figure 11. Differences in knee flexion/extension angle from level standing (+*ve* is in extension direction).

There was an increased L_5S_1 anterior shear in the incline standing position compared with level standing ($p < 0.05$), while anterior-posterior shear during decline standing was not different from the other 2 positions (Figure 12). Both incline and decline positions induced larger L_5S_1 compression values compared to level standing ($p < 0.05$), however there were no significant differences between the incline and decline positions (Figure 13). There were significant differences ($p < 0.05$) between all 3 positions for the calculated L_5S_1 flexion-extension moment (Figure 14). The incline position had the smallest extensor moment, while the decline position created the largest extensor moment.

Pre-Post Standing Differences in Joint Angles and Loading

There were no changes in global pelvis, ankle or knee angles for any of the 3 standing positions (level, incline and decline) between pre- and post-standing tests. Flexion-extension moment at L_5S_1 also remained unchanged. There were significant changes in lumbosacral flexion angle during incline standing only (Figure 14), and L_5S_1 compression (Figure 15) for all 3 standing positions following 2-hours of standing on the eQ Almond.

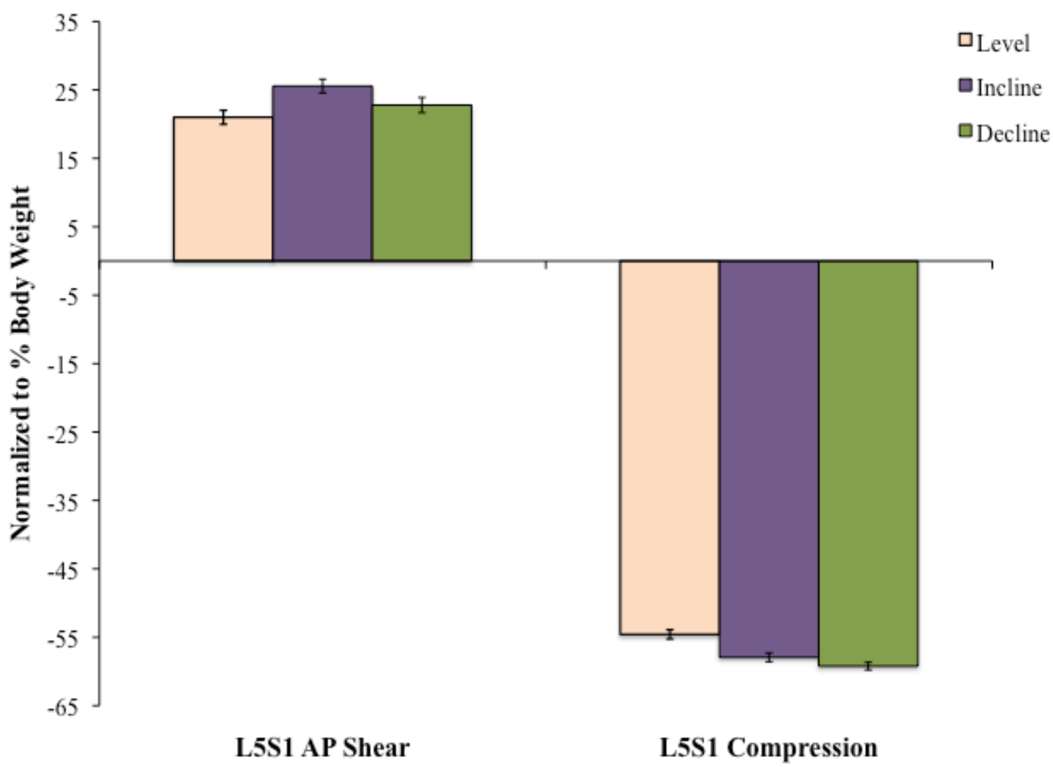

Figure 12. L_5S_1 loading differences between standing positions, normalized to participants' body weights (+*ve* is anterior shear, downward compression).

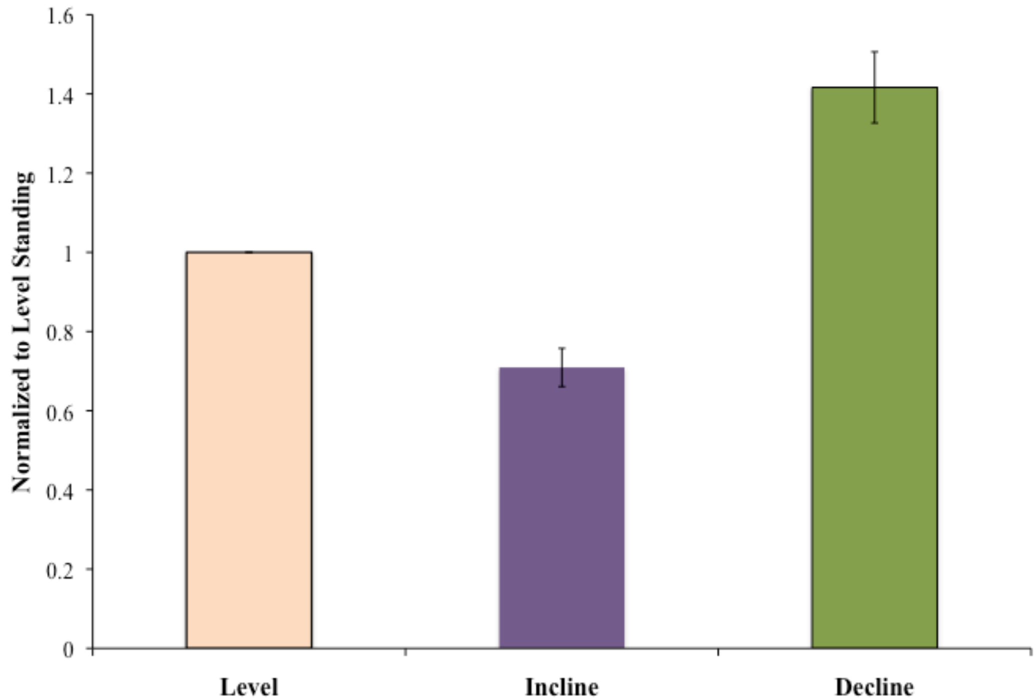

Figure 13. Differences in L_5S_1 flexion/extension moment between standing positions (+*ve* is extensor direction).

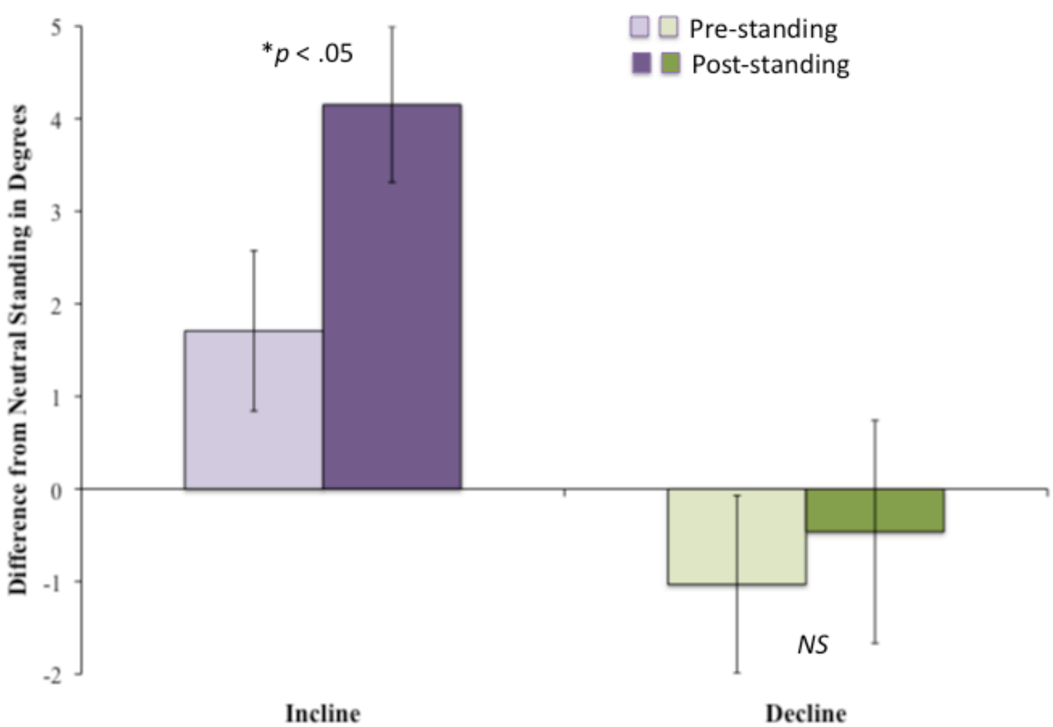

Figure 14. Pre-post standing differences in lumbosacral flexion angle. Increased lumbosacral extension in incline position after 2-hour standing, no change in decline position.

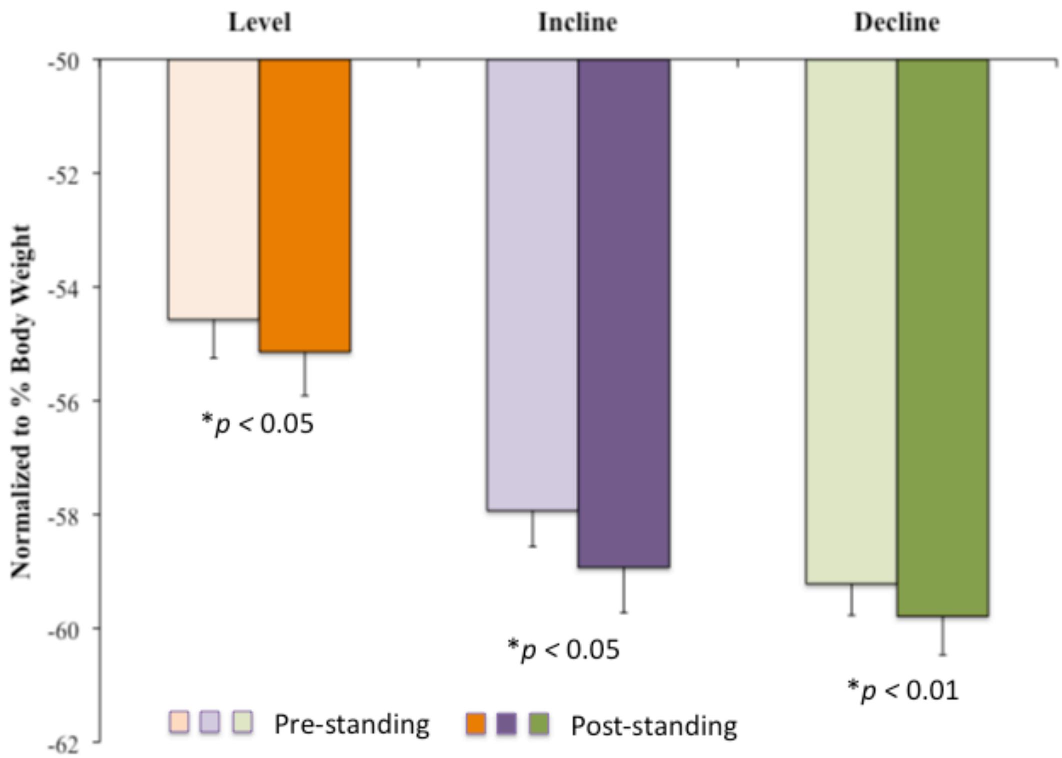

Figure 15. Pre-Post standing differences in L_5S_1 compression. Significant increase in compression in all 3 positions following 2-hours of standing.

Group Differences - Known Pain Developers versus Known non-Pain Developers

When there were no significant effects of posture and/or gender, these measures were collapsed for statistical analysis. There was a significant interaction between group and gender for L_5S_1 compression independent of position on the platform. There were no significant gender differences in lumbar compression between pain developers, however female non-pain developers had significantly lower estimates of L_5S_1 compression than male non-pain developers (Figure 16). There were group differences ($p < 0.01$) in the magnitude of estimated anterior-posterior shear at the L_5S_1 segment with the NPD group having higher anterior-posterior shear than PD (Figure 17). There were no significant differences in these measures between responders and non-responders.

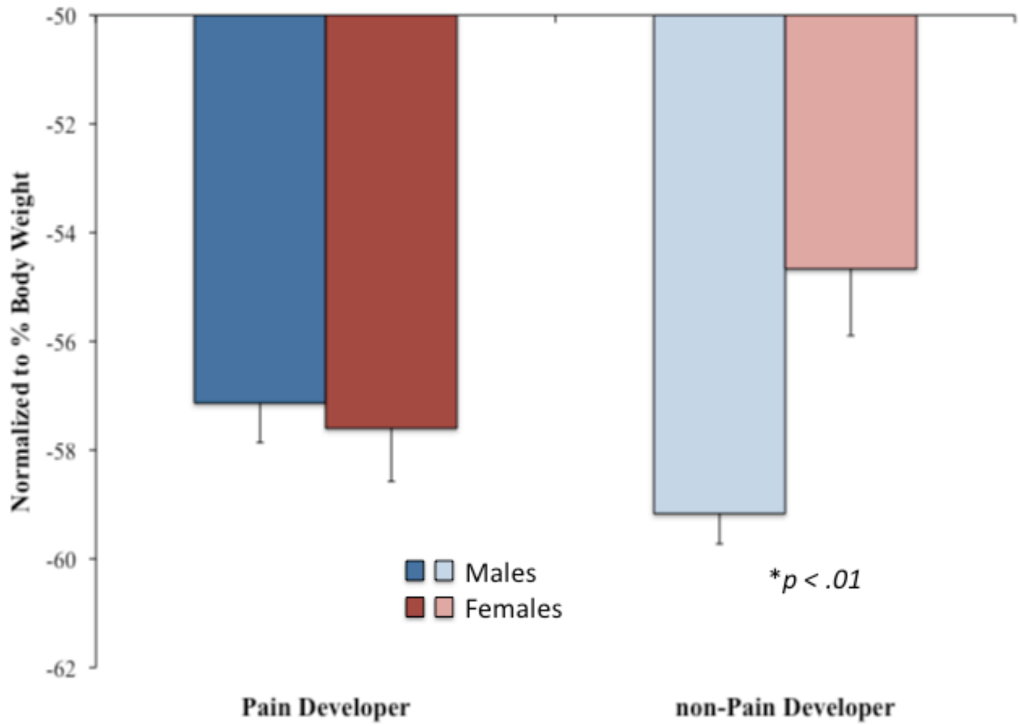

Figure 16. Gender by group differences in L_5S_1 compression (collapsed across standing position and normalized to % body weight).

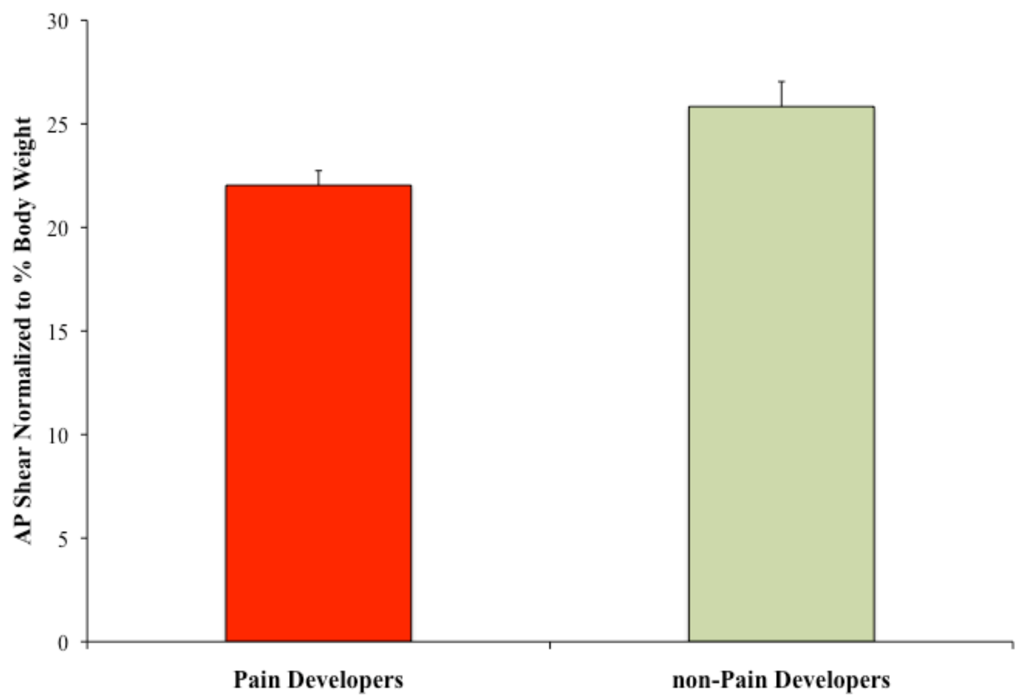

Figure 17. Group differences in AP shear (collapsed across position and gender and normalized to % body weight).

Foot Position on eQuilibrium® Almond During Standing

There were no gender differences and no differences between known pain developer/non-pain developer groups, or responder/non-responder groups in the self-selected foot position over the 2-hour period of standing. Participants, on average, showed a preference for the decline position as evidenced by the fact that they spent approximately 72% of the 2-hours in that position compared with only 28% in the incline position (Figure 18).

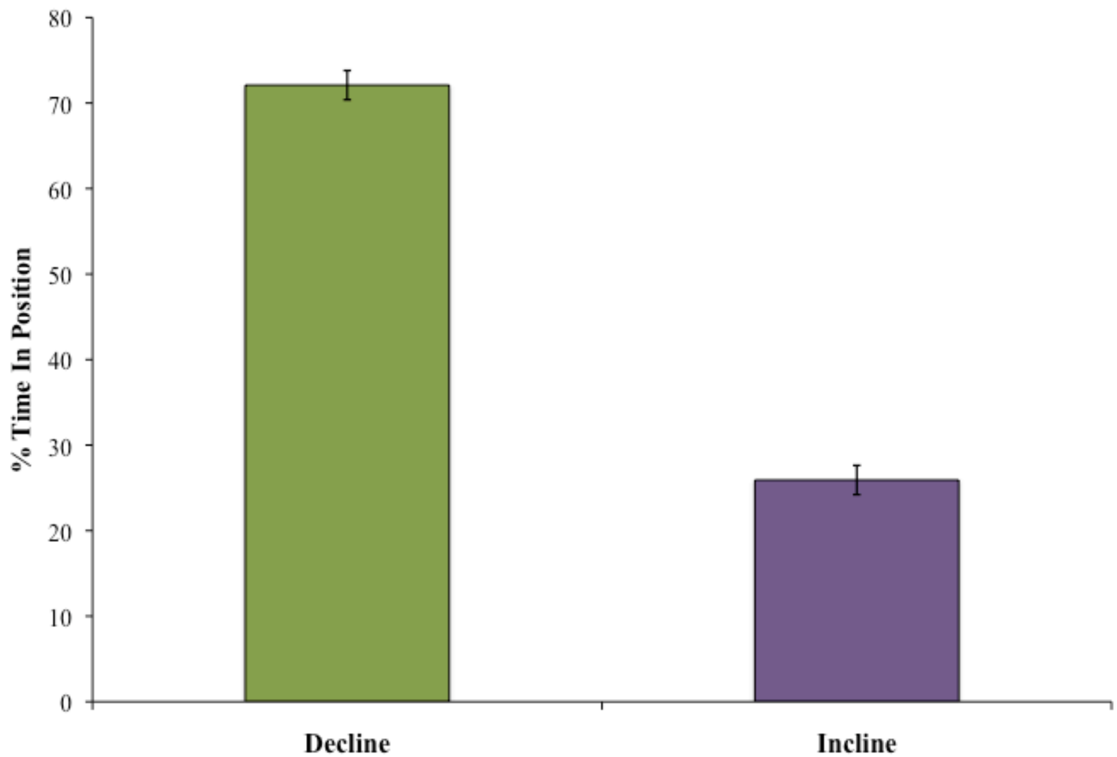

Figure 18. Participants showed a preference for the decline standing position over the 2-hours of standing on the eQ Almond.

On average, individuals changed position quite frequently over the 2-hour period of standing. Participants had an average of 85 position shifts during the 2-hours, with females changing between the incline and decline positions an average of 89 times and males changing positions an average of 80 times. There were no significant differences between genders, known pain developer/non-pain developer groups, or responder/non-responder groups in number of position shifts during the 2-hours of standing.

Muscle Co-activation Patterns During Standing

Factors that have been previously identified as being the most important predictors of low back pain development during level standing were: increased co-activation of bilateral gluteus medius and global trunk flexor/extensor muscles (Nelson-Wong, Gregory et al. 2008).

Gluteus Medius Co-activation

There was a significant interaction between group and standing condition on the 2-hour CCI average for bilateral gluteus medius ($p < 0.05$), with individuals who were categorized as PD during level standing having a decrease in co-contraction of the bilateral gluteus medius muscles during eQ Almond standing and NPD having increased co-contraction of these muscles (Figure 19). There were no significant gender differences. When the PD group was examined independently, there were no significant differences between responders and non-responders during level or eQ Almond standing.

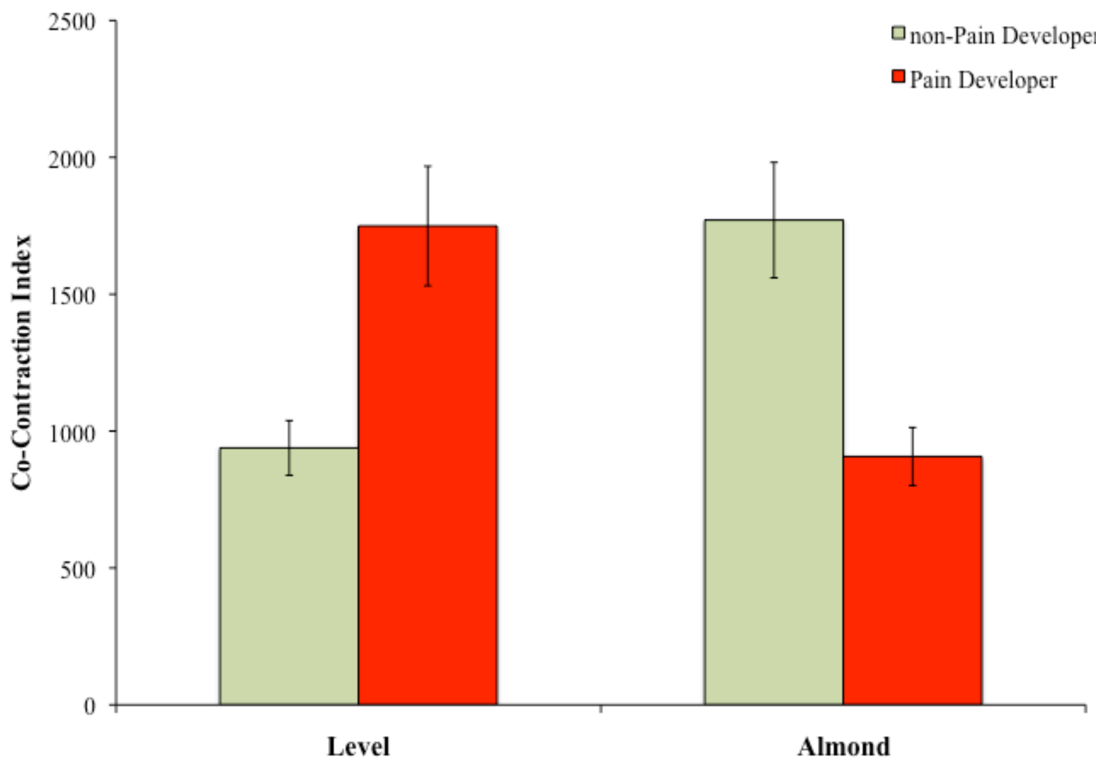

Figure 19. Different group responses in gluteus medius co-contraction with standing condition.

Trunk Flexor-Extensor Co-activation

When the CCI values for trunk flexors and extensors were collapsed into a single global measure, there were no significant differences found between standing conditions by group or by gender. However, when muscle pairs were examined independently, there were significant group differences for the CCI measure of the left lumbar erector spinae (LLES) and left external oblique

(LEO) pair ($p < 0.01$) and the right lumbar erector spinae (RLES) and right external oblique (REO) pair ($p < 0.05$). There were no significant gender differences. When the PD group was examined independently, there were no significant differences between responders and non-responders in any of the trunk flexor/extensor muscle pairs during level or eQ Almond standing. The non-pain developers had higher CCI for LLES-LEO during eQ Almond standing ($p < 0.05$) while the pain developers had no change (Figure 20).

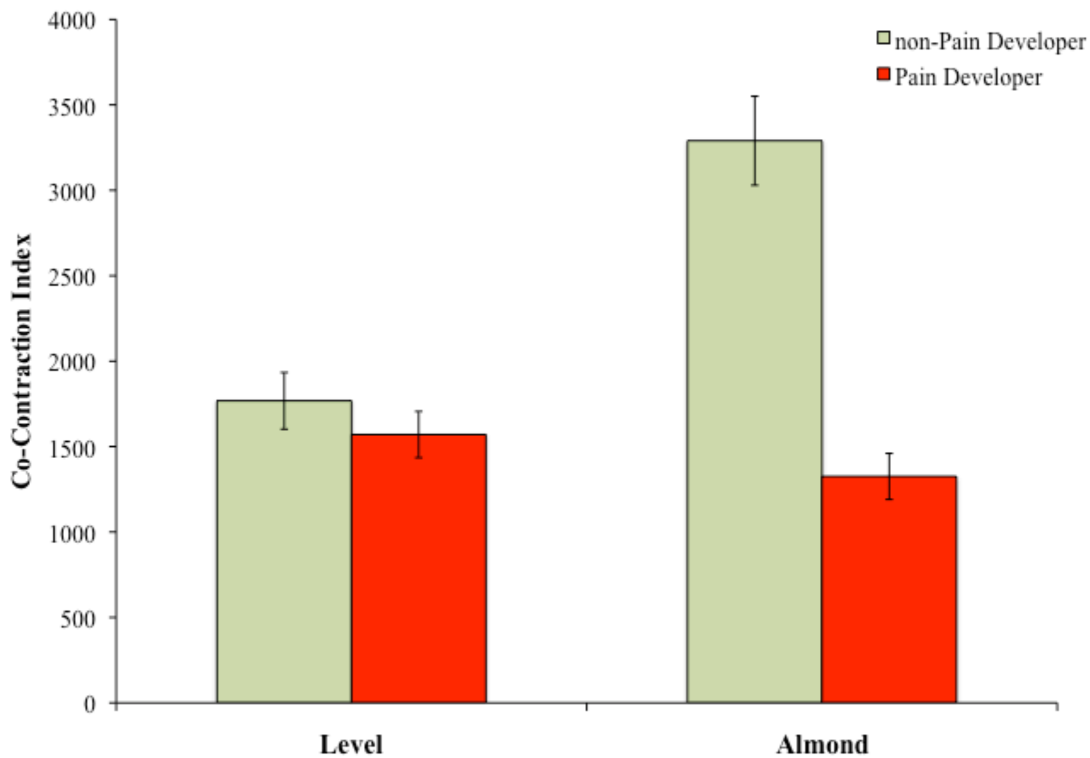

Figure 20. Co-contraction Index for LLES-LEO muscle pair between standing conditions.

A similar pattern was seen in the RLES-LEO muscle pair, with the non-pain developers again having increased co-contraction of this muscle group during eQ Almond standing ($p < .05$) and the pain developers showing no change between the standing conditions (Figure 21).

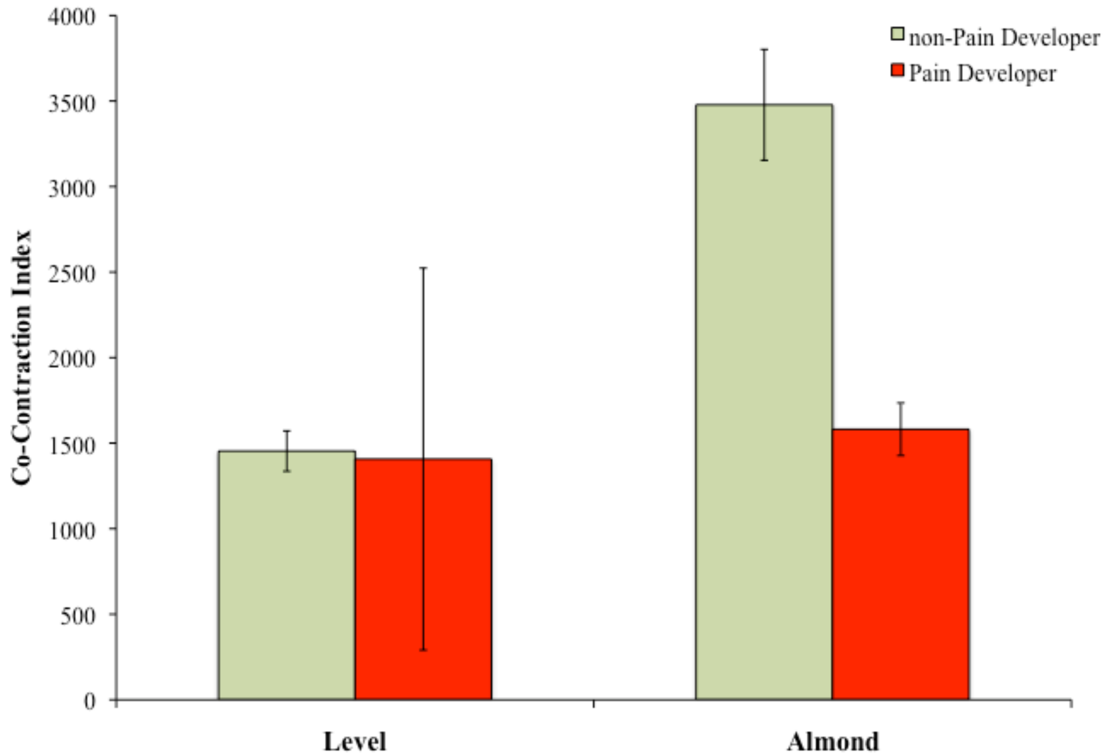

Figure 21. Co-contraction Index for RLES-LEO between standing conditions.

Exit Questionnaires

All 16 exit questionnaires are attached in Appendix G. In general, participants rated the eQ Almond favorably, with 14 of the 16 participants indicating they would use the eQ Almond for greater than 50% of the time if they worked in an occupation that required standing. Two of the 16 participants (1 female, 1 male) indicated they would choose not to use the eQ Almond in a work environment at all. Surprisingly, those 2 participants were PD and classified as 'responders' with decreased low back VAS scores when standing on the eQ Almond.

Some of the common statements from the questionnaires are summarized here:

- "The toes-up position was good for stretching out my feet and legs… but hyper-extended my knees"
- "The variation in positions was the best aspect of the platform… I liked being able to alternate positions."
- "The toes-up position would be better if the slope was not so steep."

Several people also indicated they would like to have a level surface option and asked if that could be built into the design of the platform.

DISCUSSION:

Male pain developers showed a definite decrease in low back pain as reported by VAS during standing on the eQ Almond. All 5 of the male individuals who developed pain during level standing had a significant decrease in their subjective pain reports. Female pain developers showed a less favorable subjective response to the eQ Almond. Of the 5 female individuals who developed pain during level standing, 2 had a decrease in their subjective pain reports while 3 had no change or a slight increase in their pain reports when standing on the eQ Almond. One previous female non-pain developer actually became classified as a pain developer during standing on the eQ Almond. It should also be noted that for the 5 other non-pain developers in level standing (3 male and 2 females), the levels of discomfort remained at the same or lower levels of discomfort when using the eQ Almond.

The 2 male 'non-responders', whose maximum VAS scores remained above 10 mm, still had a clinically meaningful decrease in pain, while the 3 female 'non-responders' had essentially no meaningful change between the 2 standing conditions. The male non-responders were also the 2 individuals who reported the highest level of LBP during level standing, so they might be considered to have been more severe LBP developers. It must also be noted that when the PD group is further subdivided into responder and non-responder categories, the sample sizes are very small, so findings related to responder category may have limited generalizability to different populations.

This leads us to believe that there are both a gender and a pain developing profile influence on the subjective response to the eQ Almond as an intervention for low back pain, and this should be a consideration when recommending this device for people in the workplace. Males appear to more favourably respond to the eQ Almond, regardless of if they have low back pain associated with standing or not, whereas females exhibited a more variable response. Five of the 8 female participants had no change or an increase in discomfort when using the eQ Almond with only 2 changing pain classification group from a pain to non-pain developer when standing.

There were no differences in the range of motion measures between groups, however in the incline position, male participants were standing at an average of 82.5% of their available dorsi-flexion range of motion while females were standing at an average of 78.6% of their available range. The incline position also had a tendency to induce a knee extension position beyond the knee angle adopted in level standing. Participants spent a greater amount of time in the decline position during the 2-hour standing period. A common remark from the participants was that they enjoyed being able to 'stretch their calf muscles' when standing in the incline position although they found it to be 'uncomfortable on their knees' when they were in that position for an extended amount of time (Appendix G – subjective comments).

There was an increase in lumbosacral extension angle during incline standing with a commensurate increase in estimated L_5S_1 anterior shear and compression forces when compared with level standing. Shear and compression force at L_5S_1 were not different between the incline and decline positions. Interestingly, the NPD group had higher estimated shear forces at L_5S_1 (191 ± 13 for NPD versus 155 ± 6 N) and males in the NPD group (-540 ± 7.3 N for male NPD versus -438 ± 11.4 N for PD males) had higher compression estimates. While these values were significantly different, they are a rather small percentage of body weight (on the order of 5-10%) and small magnitudes (approximately 40 N range for shear and 100 N range for compression) from a clinically meaningful perspective and are unlikely to be contributory to low back pain development.

Furthermore, when a comparison is made to established tolerance limits for the lumbar spine, 500 N for shear (McGill, Norman et al. 1998) and 3400 N for compression (Waters, Putz-Anderson et al. 1993), these loads and changes in magnitudes are not on the order that would cause any concern for damage or injury to the spine.

There were larger differences in the estimated lumbar flexion-extension moment between the standing positions, with the decline standing position creating an extensor moment approximately 1.4 times that in level standing and the incline position reducing extensor moment to approximately 0.6 of that in level standing. This has an influence on the amount of muscle activity that is necessary to balance the moment to maintain static equilibrium in standing. The average magnitude of the estimated extensor moment was 21.1 ± 3.2 N-m in level standing, 15.3 ± 2.9 N-m in the incline position and 27.1 ± 3.1 N-m in the decline position. The differences between postures are on the order of approximately 6 N-m, and are very low when compared to the population 50% percentile trunk extensor strength limits of 234 N-m for males and 184 N-m for females (Chaffin, Andersson et al. 2006).

Exposure to a prolonged period of standing on the eQ Almond over 2-hours did result in some postural changes with participants having an increase in lumbosacral extension in the incline position only. Because there was no change in the global pelvis angle, this difference must be driven by an adjustment of the thorax position on the pelvis. L_5S_1 compression estimates significantly increased in all 3 positions following the 2-hours of standing, although again the magnitudes of these increases were extremely small, (on the order of 5-6 N), and would not be considered to be clinically relevant or of a concern in a task exposure risk assessment.

Previous work in our lab has linked increased muscle co-activation in the early stages of prolonged standing with development of LBP (Nelson-Wong, Gregory et al. 2008). The eQ Almond appears to have an influence on modifying muscle co-activation levels during standing. The PD group responded to standing on the eQ Almond by showing a marked decrease in the co-activation of the bilateral gluteus medius muscles. The gluteus medius muscle co-activation profile for the PD group in eQ Almond standing became more similar to the profiles seen in NPD groups during level standing. However the NPD group responded in the other direction by having an increase in the co-activation of these muscles, which was on the same order of the values seen in the PD group during level standing, although they did not also have a commensurate increase in low back pain. There was no change in the trunk flexor-extensor co-activation in the PD group, however the NPD group again responded with an increase in co-activation of these muscles.

While muscle co-activation during standing has been associated with susceptibility to pain development it may be that it is a marker for some other, as yet unexplained, mechanism. Standing on the eQ Almond surface did modulate this muscle activation pattern, however the finding of increased muscle co-activation in the NPD group (to PD levels) without increased pain, is intriguing and requires further study as a potential pathway to pain development. This is also of potential concern if there is a direct response between these co-activation patterns and pain development as the NPD group exhibited a pattern that would be indicative of identifying high risk individuals for developing low back pain in level standing.

CONCLUSIONS:

There was a positive effect of reduced low back pain during standing for pain developers when the eQ Almond was compared to standing on a level surface. Over 2-hour periods of standing exposure the eQ Almond reduced perceived discomfort, primarily for male users. The effect of the eQ Almond was seen in the reduced discomfort scores for the lower back with the pain development group identified in level standing reducing their perceived discomfort by 43.5% on average when using the eQ Almond. There were corresponding changes in the postural and joint loading variables examined. The joint loading changes were minimal and in most cases the eQ Almond resulted in changes in joint position and joint loading that bracketed the postures and loading magnitudes found in level standing. In other words, the incline and decline surfaces resulted in higher magnitudes for one direction compared to level standing and lower magnitudes than level standing for the other surface. The only variable that was consistently increased by both surfaces of the eQ Almond was joint compression, which was higher when standing on the eQ Almond compared to level standing. These changes were of a very small magnitude and are of no concern when compared to risk of injury threshold limit values. The eQ Almond creates a favourable postural variability in both pelvic and lumbar spine angles. The incline surface resulted in flexion or anterior rotation of the pelvis and a corresponding increase in lumbar spine extension. The decline surface created the opposite postural shift with extension or posterior rotation of the pelvis and an increase in flexion of the lumbar spine. These motions were on the order of 1 to 2 degrees and would be classified as small postural adjustments. Similar small changes in muscular activation profiles have been shown to be beneficial in reducing pain reporting in assembly workers (Veiersted, Westgaard et al. 1990) and in prolonged seated exposures less frequent lumbar and pelvis postural adjustments were associated with higher low back discomfort (Vergara and Page 2000; Vergara and Page 2002). The variability in posture is supported by the finding that participants tended to alter position on the eQ Almond on average once every 84 seconds, or 85 postural shifts in total over a 2-hour period. The decline or downslope surface was preferred and 72% of the total time was spent standing on the front side of the eQ Almond. The eQ Almond appears to introduce changes in standing style that result in beneficial reductions in low back pain during prolonged standing exposures. These findings were most prevalent in the male sample of participants examined in this study. The positive outcomes were supported in the satisfaction rating of the participants, with 87.5% indicating that they would use the eQ Almond if they were in an occupational setting that required prolonged standing work.

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APPENDIX A: Subjective Pain Scale

VISUAL ANALOGUE SCALE FOR PAIN/DISCOMFORT

Please place a mark on the line to indicate the CURRENT level of pain/discomfort in each body region.

HEAD/NECK

No Pain/Discomfort at all | Worst Pain/Discomfort imaginable

UPPER BACK/SHOULDERS

No Pain/Discomfort at all | Worst Pain/Discomfort imaginable

LOW BACK

No Pain/Discomfort at all | Worst Pain/Discomfort imaginable

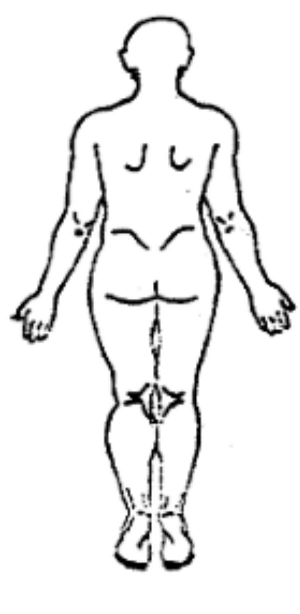
KNEES

No Pain/Discomfort at all | Worst Pain/Discomfort imaginable

FEET

No Pain/Discomfort at all | Worst Pain/Discomfort imaginable

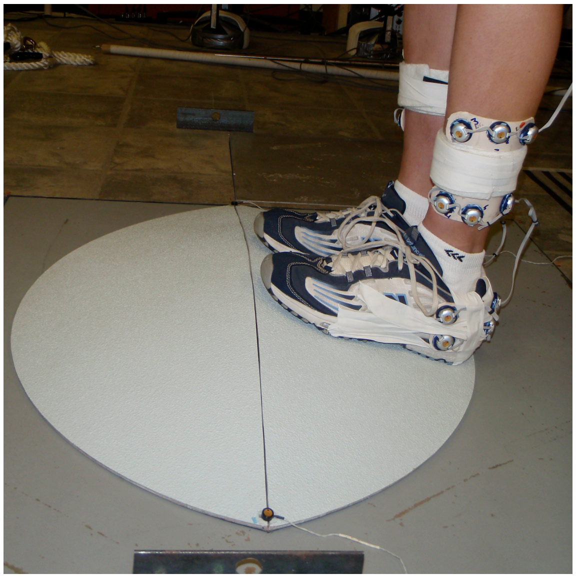
Please mark the location of your pain/discomfort on the body chart.



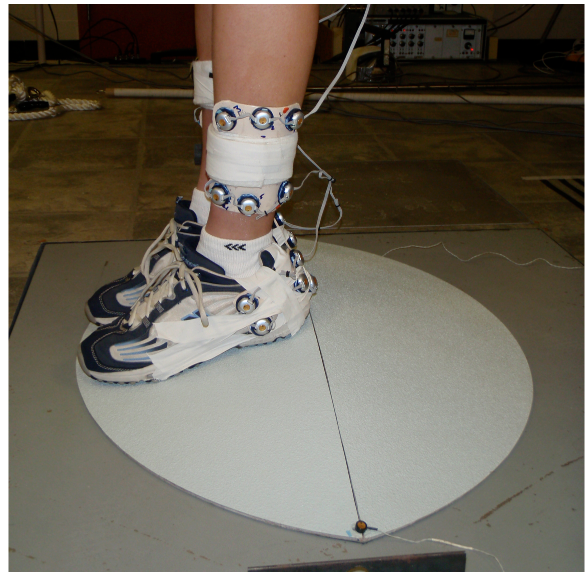
BACK

APPENDIX B: Experimental Set-Up For Level Standing

APPENDIX C: Standing Positions



A : Incline Position



B : Decline Position

C : Level Standing

APPENDIX D : Exit Questionnaire

DELTABALANCE EQ ALMOND QUESTIONNAIRE PART 1 SUBJECT CODE:_________

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Do you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) _________________

2. Do you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) _________________

3. Do you like the platform?
   (0 = not at all, 100 = very much) _________________

4. How much would you want to use this platform at work for standing tasks?
   (0 = never, 100 = all of the time) _________________

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up _________________

   Toes Down _________________

6. Please rate your overall discomfort level for the 2-hour standing period on the 0-10 scale

   Without the platform _________________

   With the platform _________________

Please feel free to add any additional comments that you may have:

____

____

____

____

____

Thank you for your time!!

APPENDIX E: Range Of Motion Measures

Measurement	Males		Females	
	Mean (°)	Std. Error (°)	Mean (°)	Std. Error (°)
Left Hip Flexion	124.25	1.925	128.88	1.695
Right Hip Flexion	123.00	2.179	126.50	2.212
Left Prone Hip Extension	15.50	1.592	20.75	1.521
Right Prone Hip Extension	14.87	1.856	23.12	2.083
Left Prone Knee Flexion	133.38	2.535	138.50	1.439
Right Prone Knee Flexion	131.25	2.210	138.25	2.085
Left Hip Internal Rotation	35.00	2.435	46.38	3.364
Right Hip Internal Rotation	38.00	2.405	44.62	3.029
Left Hip External Rotation	43.88	2.973	42.12	4.311
Right Hip External Rotation	40.75	3.416	43.50	4.551
Left Straight Leg Raise	66.75	1.810	79.38	3.535
Right Straight Leg Raise	63.50	2.322	76.12	3.114
Left Popliteal Angle	46.38	2.803	53.38	4.399
Right Popliteal Angle	45.75	2.839	56.62	3.784
Left Plantar Flexion	51.12	4.357	52.50	1.871
Right Plantar Flexion	44.00	4.301	55.25	1.386
Left Dorsi -flexion Supine	19.38	4.247	23.25	1.820
Right Dorsi-flexion Supine	21.38	4.472	21.25	2.077
Left Dorsi-flexion Weight Bearing	40.75	1.830	34.88	2.553
Right Dorsi-flexion Weight Bearing	38.25	1.590	35.62	3.099
Left Ankle Neutral Weight Bearing	1.13	.693	2.88	1.156
Right Ankle Neutral Weight Bearing	.62	1.690	2.62	1.535

APPENDIX F: Statistics Summary

Note - Angle data expressed as difference from neutral standing in degrees	**Mean**	**SE**
Global Pelvis Flexion Angle (°)	+*ve* = Extension	
Incline	-2.65 [a, b]	0.495
Decline	0.072 [c]	0.604
Lumbosacral Angle Flexion Angle (°)	+*ve* = Extension	
Incline	1.71 [b]	0.86
Decline	-1.03 [a, c]	0.96
Left Ankle Dorsi/Plantar Flexion Angle (°)	+*ve* = dorsiflexion	
Incline	16.6 [a, b]	0.48
Decline	-16.6 [a, c]	0.29
Right Ankle Dorsi/Plantar Flexion Angle (°)	+*ve* = dorsiflexion	
Incline	17.2 [a, b]	0.58
Decline	-16.6 [a, c]	0.32
Left Knee Flexion/Extension Angle (°)	+*ve* = Extension	
Incline	2.37 [a, b]	0.68
Decline	-0.22 [c]	0.39
Right Knee Flexion/Extension Angle (°)	+*ve* = Extension	
Incline	3.2 [a, b]	0.97
Decline	0.22 [c]	0.44
L5S1 AP Shear – *normalized to % Body Weight*	+*ve* = anterior	
Level	21.0 [c]	1.04
Incline	25.5 [a]	0.99
Decline	22.8 [*NS*]	1.12
L5S1 Compression – *normalized to % Body Weight*	+*ve* = upwards	
Level	-54.5 [b, c]	0.66
Incline	-58.0 [a]	0.62
Decline	-59.0 [a]	0.65
L5S1 Flexion/Extension Moment – *normalized to Level Standing Value*	+*ve* = extensor	
Level	1.0 [b, c]	
Incline	0.71 [a, b]	0.048
Decline	1.142 [a, c]	0.09

a. = Different from Level Standing at the $p \leq .05$ level

b. = Different from Decline Standing at the $p \leq .05$ level

c. = Different from Incline Standing at the $p \leq .05$ level

NS = Not significantly Different From Other Positions

APPENDIX G : Exit Questionnaire Responses

DELTABALANCE EQ1 QUESTIONNAIRE

SUBJECT CODE: PF-F1

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 75

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 50

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 75

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 85

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up @ Work

   Toes Down @ Rest

   Alternating [illegible]

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 7

   With the platform 5

We would appreciate any additional comments that you may have about the standing platform:

- Need an option for flat footed standing as a break from dorsi/plantar flexion!
- Is it large feet friendly? My ladies size 9 just fits on the board in flexed positions!

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-F2

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? 20
   (0 = very uncomfortable, 100 = very comfortable)
2. Did you like the choice of standing positions on the platform? 5
   (0 = not at all, 100 = very much)
3. Did you like using the platform? 20
   (0 = not at all, 100 = very much)
4. How much would you use this platform if you had a job that required prolonged standing? 50
   (0 = never, 100 = all of the time)
5. What position did you find to be the most comfortable for you to stand in?

   Toes Up _____

   Toes Down _____

   Alternating ✓ or on middle

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 1

   With the platform 3

We would appreciate any additional comments that you may have about the standing platform:

liked being able to change positions
didn't like platform - found feet got alot more sore
+ soreness ↑ instead of remaining constand like
on level ground.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-F3

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 45

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 30

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 0

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 0

5. What position did you find to be the most comfortable for you to stand in?

Toes Up	
Toes Down	
Alternating	✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

Without the platform	0
With the platform	7

We would appreciate any additional comments that you may have about the standing platform:

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE

SUBJECT CODE: F4

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 60

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 75

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 60

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 60

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   Toes Down ______

   Alternating ✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 1

   With the platform 1

We would appreciate any additional comments that you may have about the standing platform:

→ perhaps including a flat surface on the platform would be beneficial.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE

SUBJECT CODE: PF-F5

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? (0 = very uncomfortable, 100 = very comfortable) 50
2. Did you like the choice of standing positions on the platform? (0 = not at all, 100 = very much) 50
3. Did you like using the platform? (0 = not at all, 100 = very much) 50
4. How much would you use this platform if you had a job that required prolonged standing? (0 = never, 100 = all of the time) 50
5. What position did you find to be the most comfortable for you to stand in?

Toes Up	
Toes Down	✓
Alternating	

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

Without the platform	2
With the platform	5

We would appreciate any additional comments that you may have about the standing platform:

In toes up my knees were hyperextended. Thus, toes down was more comfortable at 1st, However, after about 1 hour my low back was becoming stiff (from being hyperextended). The platform was good (comfortable) for a short time, but after about 1 hour I would have preferred to stand on flat ground due to back discomfort.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE

SUBJECT CODE: PF-F6

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 75

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 80

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 80

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 60

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   Toes Down ✓

   Alternating ______

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 2

   With the platform 1

We would appreciate any additional comments that you may have about the standing platform:

When performing tasks it is more difficult to adjust to balance on the platform, almost as if you must make a conscious effort. Slanted dowawards (toes down) did relieve foot discomfort and lower leg cramp. Difficult to balance toes up position with tasks

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-F7

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 80

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 80

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 85

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 85

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   – Toes Down and Middle alternating ______

   Alternating ______

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform I don't remember but

   With the platform I liked platform. (2)

We would appreciate any additional comments that you may have about the standing platform:

I felt like I was getting blisters on my toes when I was standing toes down. Toes down was much more comfortable but my toe joints were hurting after 2hrs. I liked how you can stretch and alternate toes up/down in the middle.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-F8

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 75.

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 100

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 70

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 90

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   Toes Down ______

   Alternating ✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 1

   With the platform 0.1

We would appreciate any additional comments that you may have about the standing platform:

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: M1

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) ____50________

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) ____70____

3. Did you like using the platform?
   (0 = not at all, 100 = very much) ____60______

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) ____50________

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ________________

   Toes Down ___More than toes up______

   Alternating ______X_______

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform ___7_______

   With the platform ___5_______

We would appreciate any additional comments that you may have about the standing platform:

_____Did not like to stand all the way toes up – half-way toes up (towards the top) was better (less stretch)_.____

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-M2

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 50

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 50

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 50

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 100

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up 30%

   Toes Down 70%

   Alternating ✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 2

   With the platform 0.5

We would appreciate any additional comments that you may have about the standing platform:

I found the toes up position was good for stretching out my feet and legs, but the toes down position was more comfortable to perform the task.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-M3

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? (0 = very uncomfortable, 100 = very comfortable) 25
2. Did you like the choice of standing positions on the platform? (0 = not at all, 100 = very much) 40
3. Did you like using the platform? (0 = not at all, 100 = very much) 50
4. How much would you use this platform if you had a job that required prolonged standing? (0 = never, 100 = all of the time) 75
5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   Toes Down ✓

   Alternating ______

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 5

   With the platform 2

We would appreciate any additional comments that you may have about the standing platform:

I believe that the comfort level would have increased the comfort of the platform. Most likely would have prefered toes up if the slope wasn't so steep.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-M4

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? (0 = very uncomfortable, 100 = very comfortable) 70
2. Did you like the choice of standing positions on the platform? (0 = not at all, 100 = very much) 100
3. Did you like using the platform? (0 = not at all, 100 = very much) 100
4. How much would you use this platform if you had a job that required prolonged standing? (0 = never, 100 = all of the time) 100
5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ____

   Toes Down ~~✓~~

   Alternating ✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 8

   With the platform 4

We would appreciate any additional comments that you may have about the standing platform:

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-M5

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? (0 = very uncomfortable, 100 = very comfortable) 30
2. Did you like the choice of standing positions on the platform? (0 = not at all, 100 = very much) 25
3. Did you like using the platform? (0 = not at all, 100 = very much) 0
4. How much would you use this platform if you had a job that required prolonged standing? (0 = never, 100 = all of the time) ______
5. What position did you find to be the most comfortable for you to stand in?

Toes Up	
Toes Down	
Alternating	✓

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

Without the platform	4
With the platform	6

We would appreciate any additional comments that you may have about the standing platform:

It was very uncomfortable, although the shifting helped. There was pressure on my feet, but after the initial 'shock', it lessened. Seems like a learned position

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE

SUBJECT CODE: PF-M6

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 85

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 90

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 70

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 70

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up ______

   Toes Down 2nd Best

   Alternating Best

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 2

   With the platform 2 - 3

We would appreciate any additional comments that you may have about the standing platform:

None.

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-M7

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform?
   (0 = very uncomfortable, 100 = very comfortable) 95

2. Did you like the choice of standing positions on the platform?
   (0 = not at all, 100 = very much) 90

3. Did you like using the platform?
   (0 = not at all, 100 = very much) 90

4. How much would you use this platform if you had a job that required prolonged standing?
   (0 = never, 100 = all of the time) 85

5. What position did you find to be the most comfortable for you to stand in?

   Toes Up X

   Toes Down ____

   Alternating ____

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

   Without the platform 7

   With the platform 9

We would appreciate any additional comments that you may have about the standing platform:

Can the platform be made to flatten?

Thank you for your time!!

DELTABALANCE EQ1 QUESTIONNAIRE SUBJECT CODE: PF-18

For the following questions, please consider the platform you were standing on. Answer all questions according to the indicated scale.

1. Did you feel comfortable standing on the platform? (0 = very uncomfortable, 100 = very comfortable) 80
2. Did you like the choice of standing positions on the platform? (0 = not at all, 100 = very much) 85
3. Did you like using the platform? (0 = not at all, 100 = very much) 85
4. How much would you use this platform if you had a job that required prolonged standing? (0 = never, 100 = all of the time) 75
5. What position did you find to be the most comfortable for you to stand in?

Toes Up	
Toes Down	✓
Alternating	✓

mostly toes down, but short times in toes up for relief.

6. Please rate your overall discomfort level for the 2-hour standing period on the same 0-10 scale you have been using (0 = no discomfort, 10 = worst discomfort imaginable)

Without the platform	~~4~~ 6
With the platform	8

We would appreciate any additional comments that you may have about the standing platform:

The variation in position was the best aspect of the platform. Cycling through positions really relieved discomfort or fatigue I had in any given position.

Thank you for your time!!