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The Relationship Between Qualitative and Quantitative Pain Descriptors of Prolonged Standing Induced Low Back Pain

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Abstract

The purpose of this study was to determine if assessing pain symptoms could help to better define prolonged standing induced low back pain (LBP) development. Thirty-five participants (18 male & 17 female), with no prior history of LBP, preformed two-hours of standing while doing occupational tasks in random 15-minute bouts. The Visual Analogue Scale (VAS) and The Short-Form McGill Pain Questionnaire were used to assess the participant's current level of LBP in 7.5-minute increments for 120 minutes of standing. Participants were instrumented for motion capture and stood on two force plates to track lumbar spine movement and body weight shifts, respectively. Participants were either classified as pain developers (PDs) or non-pain developers (non-PDs) based on two methods, VAS and symptoms. A two-way chi-square test was used to compare pain categorization. A three-way ANOVA (time, gender, pain group) was run with lumbar spine fidgets and large body weight shifts. Pain developers on average reported pain development with the symptom method 31.3 (± 24.8) minutes before the VAS method. Eight participants (44%) changed from non-PDs with the VAS method to PDs with the symptom method (p=0.0047). Fifty-six percent of non-PDs, classified using the VAS, reported LBP symptoms during prolonged standing. Separating groups by symptom reporting did not determine differences in lumbar spine movements and body weight shifts. Clinicians, workers, and future researchers can use symptoms to help categorize pain in order to help reduce LBP due to prolonged standing.

1 Introduction

Between 40-71% of sample populations report developing low back pain (LBP) during two-hours of prolonged standing (Nelson-Wong & Callaghan 2010, Marshall et al. 2011, & Gallagher & Callaghan 2015). Individuals with no prior history of LBP who were classified as pain developers (PDs) during prolonged standing were found to be three times more likely to experience episodes of clinical LBP during the 2 years following their initial data collection than individuals classified as non-pain developers (non-PDs) (Nelson-Wong & Callaghan 2014). Clinical tests (Nelson-Wong et al. 2009) and visual analog scales (Nelson-Wong & Callaghan 2010) are typically used to assess people's potential for pain development during prolonged standing; however, qualitative reports of pain symptoms and their relationship to VAS reports have not been examined. If pain symptoms can categorize LBP development during prolonged standing, then it could be a valuable piece of information to define people who are prone to LBP during prolonged standing.

Over the last few decades, the recording of LBP has shifted from physician-based assessment to patient self-report of pain (Hagg et al. 2003). The visual analog scale (VAS) is a 100mm horizontal line where patients indicate their level of LBP from no pain to worst possible pain using a single vertical mark. The clinician records the patient's pain before treatment and during follow-up appointments in order to compare score changes to see the effect of the treatment (Hagg et al. 2003). For LBP, the VAS is responsive enough to detect pain with a minimal clinical important difference of 8mm on the 0mm-100mm scale (Hagg et al. 2003). Over a two-hour prolonged standing trial, a 10mm threshold from a baseline measure has been used to classify PDs using the

VAS. In multiple studies, using this threshold, participants clearly separated into PD and non-PD groups during two-hour prolonged standing (Gallagher et al. 2014, Gallagher et al. 2015, Nelson- Wong & Callaghan 2010, Marshal et al. 2011, & Sorenson et al. 2014, Sorenson et al. 2016). The VAS is not perfect in separating out these two groups; 17% of a sample population will be categorized in the opposite pain group during a second bout of prolonged standing performed 4 weeks later (Nelson- Wong & Callaghan 2010).

Clinicians can also ask their patients to describe their LBP from a list of common symptoms. The Short-Form McGill Pain Questionnaire is a useful instrument in measuring pain for a limited amount of time and employs qualitative and quantitative measures (Melzack 1987). A previous study determined that qualitative measures for people who were classified as PDs were similar to people that were known to have LBP, with the most common qualitative measures reported during prolonged standing being aching, stiffening, and tightness (Sorenson et al. 2014). There are modified versions of the Short-Form McGill Pain Questionnaire, one of which is going to be used in this study (Dworkin et al. 2009). No research has been done to see if pain symptom descriptors could help classify LBP during prolonged standing. Pain developers may be able to be defined earlier, or some non-PDs determined based on the VAS may still report pain symptoms that are being missed by quantitative measures only.

A third way to attempt to define PDs from non-PDs is to determine objective outcome measures of body posture or movements. Some variables that have been assessed are movements at the lumbar spine level and body weight shifting between two legs (Gallagher & Callaghan 2015). There were no differences in body weight shifts for PDs and non-PDs during two-hour prolonged standing while preforming occupational

tasks (Gallagher et al. 2011). Another study shows that non-PDs have a higher frequency of lumbar spine fidgets about the flexion/extension axis and larger body weight transfers during a two-hour prolonged occupational standing task (Gallagher & Callaghan 2015). Lumbar spine fidgets and body weight transfers could also be a pre-disposing factor for LBP during prolonged standing because these variables occurred before PDs reached a 10mm difference on the VAS (Gallagher & Callaghan 2015). Being able to properly categorize PDs and non-PDs is vital when trying to determine the objective measures in this study. If people are not properly categorized as PD or non-PD, then statistical testing will also be affected, and it will be harder to determine differences between the two groups.

The purpose of this study was to determine if assessing pain symptoms could help to better define prolonged standing induced LBP development. We hypothesized that 1) PDs would have symptoms prior to exceeding the 10mm difference on the VAS, 2) a portion of non-PDs, with a maximum VAS difference of less than 10mm, would report LBP symptoms during two-hour prolonged standing, and 3) separating the groups by pain symptom reporting would help to better determine differences in lumbar spine movements and body weight shifts between the two groups. Findings will aid clinicians in defining LBP for patients who stand for prolonged periods of time. The results can also help to educate workers with LBP on which symptoms are induced first and the amount of time they are induced during prolonged standing for training purposing to reduce LBP in the workplace.

2 Methods

2.1 Participants

Thirty-five participants, (18 male and 17 female), between 18-35 years old were recruited to participate in this study. Participants could not have had previous history of LBP that required medical intervention or time off from work longer than three days, previous lumber or hip surgery, employment in a task that required prolonged static standing during the past 12 months, and the inability to stand for at least two hours. Prior to starting the study, all participants provided written informed consent. The University of Waterloo Research Ethics Committee approved this study.

2.2 Visual Analog Scales and Pain Symptom Reporting

The VAS and symptoms from a modified version of the Short-Form McGill Pain Questionnaire (Dworkin et al. 2009) were used to assess the participant's current level of LBP at the start of the trial. For the VAS, participants were asked to indicate their level of LBP from no pain to worst possible pain using a single vertical mark on the 100mm scale and indicate on the body diagram where pain was felt. For the pain symptoms, participants were asked to check as many of the listed symptoms that they had and indicate where on the body diagram pain was felt. The choices that were used to describe the participants' current level of pain quantitatively in their low back were throbbing, shooting, stabbing, sharp, cramping, gnawing, hot-burning, aching, heavy, tender, tiring-exhausting, sickening, fearful, and cruel-punishing (Dworkin et al. 2009). The questionnaire can be found in Appendix A.

2.3 Instrumentation

Participants stood on two force plates for the entire two-hour prolonged standing task. This configuration allowed the right and left foot measurements to be analyzed separately. The participants also had iRed markers placed on anatomical landmarks so that an Optotrak Certus motion capture system (Northern Digital Inc., Waterloo, ON, CA) could track their movement. Rigid bodies were placed on the back of the individuals in order to track gross trunk (T9), upper lumbar spine (L1/L2), and pelvis (sacrum) movement and the lateral side of the heel on both feet.

2.4 Experimental Protocol

The participants underwent a 10-second standing trial in anatomical position, followed by maximum lumbar spine flexion, extension, and right/left lateral bend and axial twist for a reference point to measure their lumbar spine angles. Another VAS baseline measurement was filled out after participants were instrumented.

The two hours of standing was preformed while doing light assembly and sorting tasks, such as assembling and dissembling mechanical pens, nuts, bolts, and washers and sorting cards and money into predetermined piles in random 15-minute blocks for each participant. A height adjustable table was placed 5-6cm below the participant's wrist when elbows were placed at 90 degrees. They were not allowed to lean on the table and were instructed to do the tasks within a primary reach zone with a depth of 25.4 cm from the edge of the table, width of 101.6 cm, and a diameter of 33-43 cm with respect to the shoulder joint in order to limit long reaches. Every 7.5 minutes, the participants were asked to pick words from the Short Form McGill Pain Questionnaire to

describe their current pain and mark the level of pain of the VAS, totaling to 19 entries per participant.

2.5 Data Analysis and Outcome Variables

The participant's symptoms were recorded for all 19 questionnaires. Pain development from prolonged standing was determined using two separate methods (1) pain symptom and (2) VAS method. With the pain symptom method, participants with 3 or more consecutive symptom descriptors during the two-hour prolonged standing were classified as PDs. For the VAS method, participants were classified as PDs if at any point during the two-hour prolonged standing the VAS was 10mm or greater from their baseline measurement. Pain groups were classified individually for VAS and symptom descriptors. For each participant an agreement (non-PD/ non-PD, PD/ PD) or disagreement (non-PD/ PD, PD/ non-PD) was recorded between the VAS and symptom descriptors, respectively. For PDs, time difference between VAS exceeding 10mm and first symptom descriptor were looked at to see if symptoms occurred earlier than when they reached a 10mm difference on the VAS. The number of symptoms reported per participant, the most common symptoms reported overall, max VAS, and VAS fluctuation within one participant were some other variables that were assessed to help understand LBP during prolonged standing.

Lumbar spine fidget and body weight shift frequencies were tabulated using a previously used algorithm (Gallagher & Callaghan 2015) per 15-minute periods. A combined metric of the movement patterns that involved taking the square root of the fidget and shift frequency sum of squares (Equation 1) was used to generate a

summative movement frequency outcome measure (Gallagher & Callaghan 2015):

$$Total\ movement\ estimate\ (per\ 15\ minutes)\ =\ \sqrt{(\#\ fidgets)^2\ +(\#\ shifts)^2}$$

(Equation 1)

2.6 Statistical Analysis

A two-way chi-square test was used to compare the pain categorization using the pain symptoms to those expected from the VAS scores. A three-way ANOVA with between factors of gender and pain group (PD versus non-PD) and within factor of time was run on the lumbar spine fidgets and large body weight shifts, which are biomechanical variables collected from this data set in order to see if the difference in classification yields differing results. Tukey HSD post hoc tests were run on all main effects, and simple effects were run on all interactions. The significance level for all tests was set at $p<0.05$.

3 Results

3.1 Pain Scores and Questionnaire Items

Seventeen participants (48.6%) were categorized as PDs for the VAS method. Twenty-five participants (71.4%) were categorized as PDs for the pain symptom method (Table 1). Pain scores that exceeded the 10mm threshold for the VAS method occurred on average at 42.8 (± 27.8) minutes into the two-hour prolonged standing protocol. Pain developers with at least 3 consecutive symptoms for the pain symptom method on averaged reached this threshold at 11.5 (± 22.8) minutes into the prolonged standing protocol. The average time difference between the VAS method and symptom method was 31.3 (± 24.8) minutes, with the symptom method being reported earlier for every participant (Table 2).

There was a significant difference between the number of participants who switched pain groups (p=0.0047). Eight participants changed from a non-PD with the VAS method to a PD with the symptom method (Table 1,2).

Table 1. Frequency of Non- PDs and PDs between VAS method and pain symptom method

		VAS		
	Count	PD	Non-PD	Total
Symptoms	PD	17	8	25
	Non-PD	0	10	10
	Total	17	18	35

Table 2. Time of VAS versus Symptom reporting for all participants

Participant	VAS	Pain Quality	Time VAS	Time Symptom	Difference
SCP	non-PD	non-PD	N/A	N/A	N/A
LAM	non-PD	non-PD	N/A	N/A	N/A
TXQ	non-PD	non-PD	N/A	N/A	N/A
RLH	non-PD	non-PD	N/A	N/A	N/A
TTL	non-PD	non-PD	N/A	N/A	N/A
CTH	non-PD	non-PD	N/A	N/A	N/A
MUT	non-PD	non-PD	N/A	N/A	N/A
RLI	non-PD	non-PD	N/A	N/A	N/A
SQC	non-PD	non-PD	N/A	N/A	N/A
YNF	non-PD	non-PD	N/A	N/A	N/A
UNQ	non-PD	PD	N/A	0 min	N/A
GXY	non-PD	PD	N/A	22.5 min	N/A
JOH	non-PD	PD	N/A	52.5 min	N/A
IJM	non-PD	PD	N/A	60 min	N/A
MYJ	non-PD	PD	N/A	52.5 min	N/A
BJR	non-PD	PD	N/A	30 min	N/A
NNI	non-PD	PD	N/A	7.5 min	N/A
ADP	non-PD	PD	N/A	82.5 min	N/A
GFH	PD	PD	15 min	15 min	0 min
JMG	PD	PD	30 min	22.5 min	7.5 min
NWS	PD	PD	0 min	0 min	0 min
NHA	PD	PD	7.5 min	0 min	7.5 min
UBO	PD	PD	37.5 min	22.5 min	15 min
XRT	PD	PD	7.5 min	0 min	7.5 min
RTW	PD	PD	75 min	52.5 min	22.5 min
UJW	PD	PD	22.5 min	0 min	22.5 min
KZG	PD	PD	45 min	15 min	30 min
PFM	PD	PD	22.5 min	0 min	22.5 min
KCF	PD	PD	45 min	7.5 min	37.5 min
MSP	PD	PD	60 min	7.5 min	52.5 min
JXL	PD	PD	75 min	22.5 min	52.5 min
ADF	PD	PD	60 min	7.5 min	52.5 min
NPB	PD	PD	75 min	15 min	60 min
MQO	PD	PD	60 min	0 min	60 min
BLZ	PD	PD	90 min	7.5 min	82.5 min
Average			42.8 min	11.5 min	31.3 min

3.2 Body Weight Shifts

When participants were categorized into one of the three pain groups (non-PD, symptom PDs, PDs), a main effect of time was found for large body weight shifts (p= 0.0035). In the first 45 minutes there was an increase in large (≥ 30% body weight) body weight shifts independent of pain group. At 15 minutes, 30 minutes, and 45 minutes into the two-hour prolonged standing, there was an average of 19.2 (±1 9.2), 38.4 (± 32.8), and 45.6 (± 36.5) body weight shifts per 15 minutes.

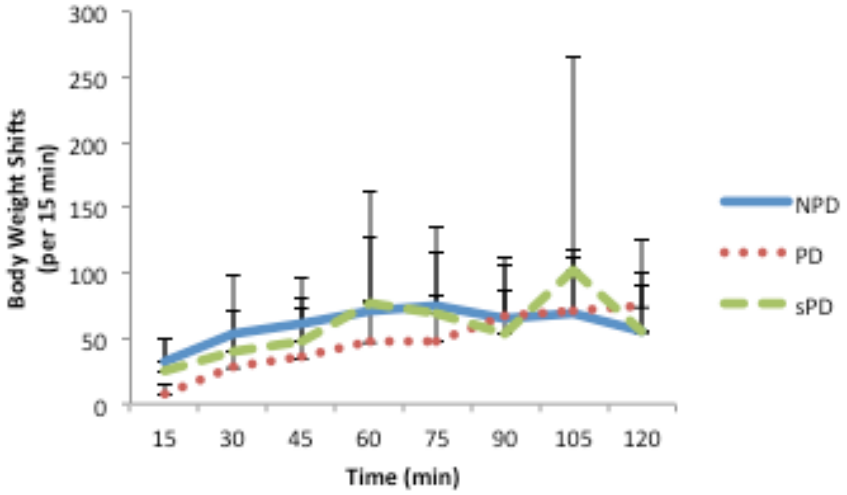

Figure 1. Average frequency of large (≥ 30%) body weight shifts per 15 minutes during the 120-minute prolonged standing trial for non-PD, PD, and sPD pain groups.

A main effect of time was found for 10-29% body weight shifts (p<0.0001). The first 15 minutes differed from the rest of the two-hour prolonged standing in relation to 10-29% body weight shifts. In the first 15 minutes of prolonged standing participants had an average of 52.1 (± 43.4) body weight shifts, and there was an increase for all three groups.

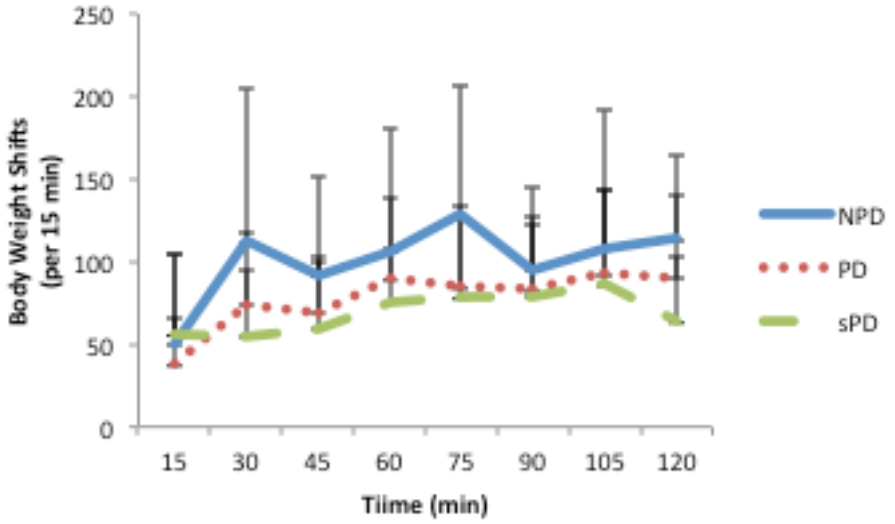

Figure 2. Average frequency of small (10-29%) body weight shifts per 15 minutes during the 120-minute prolonged standing trial for non-PD, PD, and sPD pain groups.

3.3 Lumbar Spine Fidgets

There were no significant differences for the within variable of time (p=0.80) and between variables of pain group (p=0.46) and gender (p=0.77) for lumbar spine fidgets (Figure 3). Over the two-hour protocol participants were fairly consistent in the amount of fidgets per minute. The average number of fidgets for all participants was 10 (± 4.8) fidgets per 15 minutes.

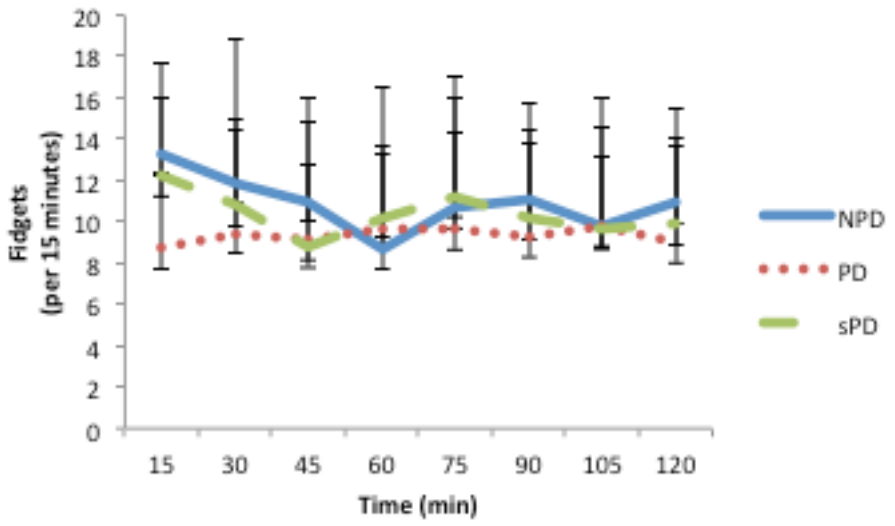

Figure 3. Average frequency of lumbar spine fidgets per 15 minutes of the 120-minute prolonged standing trail for non-PD, PD, and sPD pain groups.

3.4 Total Movement Estimate

There were no significant differences for the within variable of time (p=0.90) and between variables of pain group (p=0.44) and gender (p=0.82) for total movement estimate. Over the two-hour protocol participants were consistent in the number of total movements per minute. For all participants, the average total movement estimate was 11.5 (± 4.5) per 15 minutes.

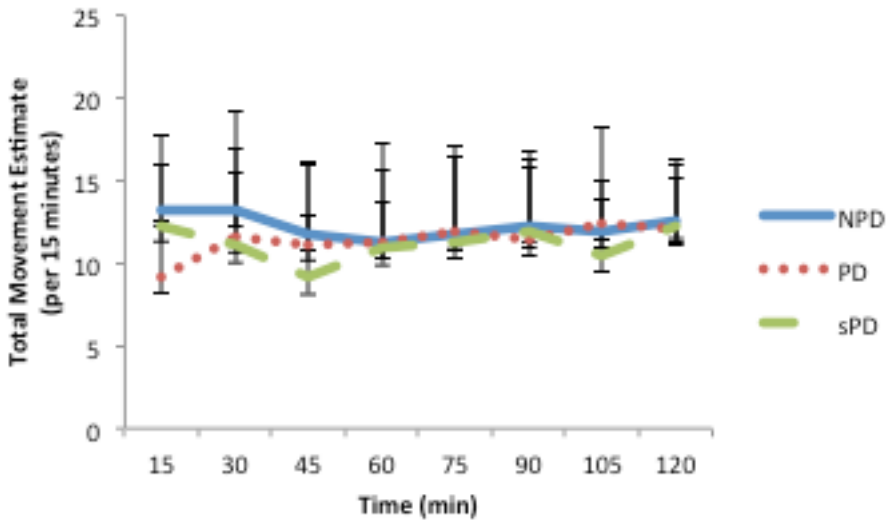

Figure 4. Average total movement estimate that combined sagittal lumbar spine fidgets and shift measures per 15 minutes of the 120-minute prolonged standing trail for non-PD, PD, and sPD pain groups.

4 Discussions

The purpose of this study was to investigate differences in quantitative versus qualitative measures of defining prolonged standing induced LBP development. The first hypothesis, that PDs would develop symptoms before they reached a 10mm difference on the VAS was supported. Of the participants that remained in the PD pain group for both methods, 100% (17/17) were categorized as pain developers with the symptom method prior to when they were categorized as a PD for the VAS method. The second hypothesis that a portion of non-PDs, with a VAS difference of less than 10mm, would report LBP symptoms during two-hour prolonged standing was also supported. Of the 18 participants classified as non-PDs based on the VAS, eight (44%) changed to PDs based on symptom descriptors. The third hypothesis that separating groups by pain symptom reporting would help to better determine differences in lumbar spine movements and body weight shifts between the two groups was not supported. Even with the refined grouping of participants, pain group and gender continued to show no differences based on the symptom method of defining pain groups.

Previous research on LBP during prolonged standing and pain symptom reporting used 5 similar symptoms (stabbing, cramping, burning, aching, and sensitive) out of 14 symptoms used in this study (Sorenson et al. 2015). The current study used the modified version of the Short-form McGill Questionnaire (Dworkin et al. 2009), where as Sorenson et al. used the original study (Melzack 1987). Aching, stiffening, and tightness were the most frequent symptoms reported during prolonged standing for the previous study (Sorenson et al. 2015). The most reported symptoms from the modified version of the Short Form McGill Questionnaire in our study during prolonged

standing were aching and cramping. Future studies should be done to determine the impact of differences in symptom choices on pain group classification during prolonged standing induced LBP.

The eight participants who switched groups averaged a max VAS of 4.9 mm, while the ten participants that remained non-PDs had a max VAS of 1.9 mm. Pain symptoms were more inclusive for defining PDs. Other quantitative measures such as the Oswestry Disability Index, the General Function Score, and the Zung Depression Scale have also been used to measure LBP; however, the VAS is the most responsive (Hagg et al. 2003). It is reasonable to suggest that similar results for these quantitative scales would occur in comparison to the VAS.

Participants who indicated symptoms throughout the two-hour prolonged standing and did not hit a 10mm difference from baseline on the VAS could be interesting to look further into. Continued exposure overtime in participants that did not develop pain may attribute to worse pain in the future. Individuals who were classified as PDs based on the VAS were found to be three times more likely to experience episodes of clinical LBP two years following data collection compared to those placed in the non-PD group (Nelson-Wong & Callaghan 2014). Symptom PDs could be on the same path as those individuals and could have more LBP with continued exposure to long periods of constrained standing.

The success of determining objective measures that can predict or assist with determining risk factors related to prolonged standing induced LBP depend on our ability to classify people into the proper pain group. When objective measures were statistically analyzed using three pain groups (PDs who stayed the same, non-PDs who

stayed the same, and non-PDs that switched to PD) instead of two, there were no differences in body movements that would indicate why individuals get classified in a certain pain group for the symptom reporting method. Other objective measures, such as postural variables, could be looked at in the future to see if pain categorization assists with assessing these measures.

A limitation to this study would be the young age of the participants, whom ranged from 18-35 years old. The results may not be generalizable to older populations; however, most of the individuals who report developing LBP during prolonged standing are younger in age (Tissot et al. 2009, Anderson et al. 2007).

5 Conclusions

Categorization of participants with LBP development during prolonged standing using a qualitative measure of pain provided differing results than when a quantitative measure was used. All PDs reported pain symptoms prior to exceeding a 10mm difference on the VAS (100%). Fifty-six percent of non-PDs reported LBP symptoms during two-hours of prolonged standing. Separating pain groups by symptom reporting did not help to determine differences in lumbar spine movements and body weight shifts. Clinicians should consider these findings to aid in defining LBP for patients who stand for prolonged periods of time. Knowing the symptoms are commonly induced during prolonged standing and the amount of time in which they develop can help in educating and training workers appropriately so their LBP can be reduced. Future studies should look at the repeatability of symptom reports since it is unknown if participants would have the same symptoms or amount of symptoms in a second bout of prolonged standing.

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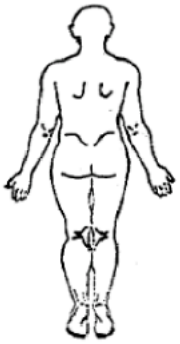
Appendix A: Questionnaire used to assess low back pain development

VISUAL ANALOG SCALE FOR PAIN

Please place a mark on the line to indicate the CURRENT level of pain in your LOW BACK

No Pain — Worst Pain Imaginable

Please mark the location of your pain on the body chart



BACK

Please check the words that you would use to describe your CURRENT level of pain in your LOW BACK*

- ☐ throbbing
- ☐ shooting
- ☐ stabbing
- ☐ sharp
- ☐ cramping
- ☐ gnawing
- ☐ hot-burning
- ☐ aching
- ☐ heavy
- ☐ tender
- ☐ tiring-exhausting
- ☐ sickening
- ☐ fearful
- ☐ cruel-punishing

*Melzack, 1987.