The Efficacy of an Ergonomics Education Program on Sit-Stand Workstation Usage Behaviours: A Field Intervention Study

by

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Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis including any required final revisions as accepted by my examiners.

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Abstract

Background: Much is known about the negative aspects of sitting and standing for long periods of time. In recent years there has been a shift in office furniture from non-height adjustable workstations to those that fully accommodate sitting and standing whole body postures. In the past, the integration of sit-stand desks has shown positive but also negative consequences such as pain development or minimal use of the new workstation. Outcomes depend fundamentally on the training that new users of sit-stand workstations receive. Currently, there is no standardized training program provided to users on how they should integrate their new workstations into their day to ensure optimal use of the workstation. The objective of this research study was to determine if a training program that new users of sit-stand workstations received prior to their implementation could influence the long term usage of the workstations. It was hypothesized that the type of training program that individuals received would influence how much they would use the workstation over a period of two months, would influence reports of musculoskeletal discomfort, and influence mood states.

Methods: Thirty-five adults between the ages of 23 and 64 were recruited from a University of Waterloo research centre to assess the influence of training program on the long term usage of sit-stand workstations. Participants were divided into 1 of 2 groups based on their job tasks, age and sex. A baseline period (Phase I) was collected as participants worked at their original non height adjustable workstations. Both groups received an initial training program that was an example of what is currently taught in industry. The one group then received an additional session that focused on transitioning between sitting and standing and proper sitting and standing techniques. The first four weeks after the training sessions represented the intervention phase (Phase II) of the study. During this time, those in the group who received the additional training program also received weekly meetings from the experimenter to answer any questions that the participants had regarding their workstation as well as daily reminders to rotate between sitting and standing in a 1:1 ratio. These meetings were stopped for the subsequent four weeks as this time period acted as the follow-up phase (Phase III). Desk transitions from sitting to standing were tracked using tri-axial data logging accelerometers that were securely mounted to each participants' desk (Gulf coast solutions, Waveland, Mississippi) and a measure of self-perceived sitting and standing throughout the day was taken using the Occupational Sitting and Physical Activity Questionnaire. Musculoskeletal pain score was collected on a nine point Likert scale. The Active Hip Abduction Test was collected at the beginning and end of the study to determine if any differences occurred between groups. Lastly, the Profile of Mood States questionnaire was collected to determine if any changes in mood states would occur throughout the study.

Results: There was a main effect of group ($p<0.0001$) for the number of transitions completed each day. On average, those in the group that received the additional training session based on current best practice research transitioned 6.0 (±2.1) times a day whereas those who only received a training session that is currently delivered in industry transitioned 3.2 (±1.9) times each day. There was no main effect of phase ($p=0.1161$). There was a main effect of group $p=0.0473$ and phase $p<0.0001$ for self-reported time spent sitting each day as collected via the Occupational Sitting and Physical Activity Questionnaire. There was no effect of group or time on the musculoskeletal pain reported in the lower back, buttocks, and feet region. There was an influence of phase for neck pain and right and left shoulder pain. Group influence the percentage of days that pain was reported in the right and left shoulder regions. The percentage of days that pain was

reported was higher for those who received the additional training session. Overall, those in the additional group reported sitting 6% less than those who received the industry example training. There was a main effect of group p=0.0401 and a main effect of period of p<0.0001 for self-reported time spent standing via the OSPAQ. Overall, those who received the additional training session reported standing 6% more than those who did not. Those who received the additional training session had fewer days where they did not use their workstation at all (p=0.0002). There was an influence of group on the mood state anger and depression. Those who received only the industry training session reported lower anger and depression scores by 1.3 and 1.2 respectively. Scores for confusion decreased in both groups as the study progressed (p<0.0001). There was no influence of group on the amount that participants walked each day as assessed by the Fitbit Zip (p=0.6934) and by the Occupational Sitting and Physical Activity Questionnaire (p=0.6174). There was an influence of outcome on the Active Hip Abduction Test (AHABD) on the number of days that pain occurred. Those who scored positive on the AHABD test reported more pain than those who scored negative.

Discussion: Those who received the additional training session prior to using their sit-stand workstation transitioned more often than those who only received the training session that was an example of what is currently bring completed in the industry. They also reported less time spent sitting throughout the day and more time spent standing. One of the major problems with the implementation of sit-stand workstations, as reported by industry practitioners and researchers, is the discontinued use of sit-stand workstations as time progresses. The current study found that with the delivery of a training program that was based on current best research practice in the topic of sit-stand workstation usage, there were less days where the workstation was not used at all. Behaviour change techniques, motivational interviewing approaches and hands on practice with the workstation should be incorporated into future training programs to develop sustainable habits centered around whole body posture variation.

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Chapter 1: Introduction

1.1 Introduction

In recent literature and mainstream media, researchers and journalists have highlighted the potential negative aspects of both sitting and standing for prolonged periods of time. There are risk factors that emerge in both health and musculoskeletal domains from either sitting or standing for a prolonged period of time. Recently, there has been a movement towards adopting various postures, specifically in office work places to decrease the severity of these potential risk factors. Employers are rapidly adopting sit-stand desks into their workplaces to promote employees being active at work and to vary postures while completing their occupational tasks.

A recent study conducted by Bauman and colleagues (2011) characterized the number of hours people across the world sit each day. Participants from around the world were given the International Physical Activity Questionnaire (IPAQ) to assess their level of physical activity during the International Prevalence Study (IPS). The study found that 34.9% of people in Japan, 27.6% in Taiwan, and 27.2% in Norway sat for 9-17 hours a day – the highest quintile of sitting prevalence recorded (Bauman et al., 2011). Participants from Brazil, Portugal and Columbia had the lowest percentage of their population sitting for 9-17 hours a day, 2.6%, 4.2% and 5.4% respectively (Bauman et al., 2011). These three countries' citizens reported the highest prevalence of sitting for 0-179 minutes per day at 42.8%, 50.4%, and 47.9% respectively (Bauman et al., 2011). Church and colleagues (2011) noted that there is little possibility that the number of occupations requiring light-moderate physical activity will increase. These trends highlight the importance that the sedentary nature of office jobs needs to be addressed and alternatives considered from a population perspective. Work is still being completed to determine why injury and LBP results from prolonged sitting exposure. Simply replacing sitting with standing is not a viable solution as standing for prolonged periods of time has been associated with the development of LBP (Tissot, Messing, & Stock 2009; Nelson-Wong et al. 2008; Marshall, Patel, & Callaghan 2011; Gallagher, Campbell, & Callaghan 2014). Therefore, an intervention must accommodate for both sitting and standing. A height adjustable desk that can accommodate both postures serves this purpose well.

While adjustable height workstations have been in existence for several decades, the rate at which they are being introduced into the workplace, to allow a balance between occupational sitting and standing, has seen a marked increase in the last few years. This new generation of sit-stand workstations have been shown to decrease musculoskeletal pain/discomfort (Bohr 2000; Hedge & Ray 2004; Nerhood & Thompson 1994; Davis et al. 2009) and visual discomfort (Robertson, Ciriello, & Garabet 2013) with no changes (Davis & Kotowski, 2014; Husemann, Von Mach, Borsotto, Zepf, & Scharnbacher, 2009) or slight increases (Ebara et al., 2008; Nerhood & Thompson, 1994; Pronk, Katz, Lowry, & Payfer, 2012) in subjective and objective productivity.

However, guidelines surrounding the implementation into the workplace are scarce, which in some cases has led to negative outcomes (Ebara et al., 2008). The current study was designed to assess the influence of two types of education programs when implemented prior to the adoption of sit-stand workstations. The current study investigated the differences in musculoskeletal pain, psychosocial factors, movement of the desk, and physical activity levels of employees who received a training session which represented what is currently done in the industry and a session which was created based on current best practice research.

There are many different names for a desk or piece of equipment that fall under the umbrella term of “sit-stand workstations” such as sit-stand desk/workstation, sit/stand desk/workstation, electronic height adjustable work-surface, activity permissive, or standing "hot" desk. For the duration of the current study the term "sit-stand workstation" will be used when referring to a desk or modification to a desk that allows the user to adjust their work surface vertically (either entire work surface or keyboard and monitor) to allow a transition from sitting to standing and vice versa.

1.2 Overview of Study Design

A group of office employees from the Propel Centre for Population Health Impact at the University of Waterloo changed location of their offices. With this change, the group received new personal sit-stand workstations but did not receive a new office chair. All employees that participated in the study did not have a sit-stand workstation prior to the start of the current study. The current study took place over a period of four months which was divided into three distinct phases depending on the type of workstation Propel employees were using and the type of training they received (Figure 1). Phase I acted as a baseline period lasting for 4 weeks where participants used their "original" non-height adjustable workstations. Phase I was followed by one week where no measures were taken, which allowed for the Propel Centre to change office locations and for the two types of training programs to be delivered to all participants. All employees received an industry approach to sit-stand workstation training delivered by the workstation vendor. After this training session those in the group designated to receive additional training participated in an education session which was based on current best practice research. Those in the group which received the additional session also participated in weekly meetings with M. Riddell for Phase II only. The third and final phases acted as a "Follow-up" period were M. Riddell was not present at all during the four weeks in order to assess how participants utilized their workstations with no weekly visits. At the end of Phase III those who initially received only the industry example of sit-stand workstation training received the additional education session which was based on current best practice research.

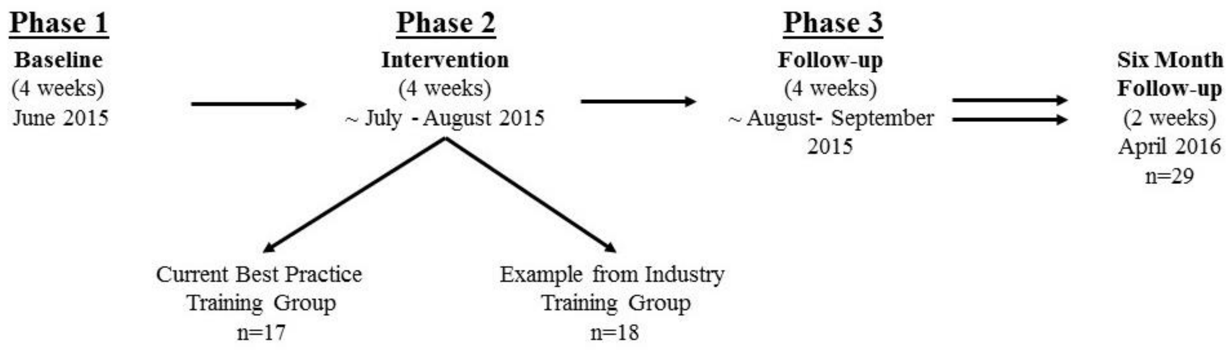

Figure 1: Overview of study design

1.3 Purpose and Hypotheses

Research Question:

> How does the type of training that people receive prior to using a new sit-stand workstation impact their behaviour, mood states, and musculoskeletal system following the education session in the first, second and sixth month after the original training session?

Purpose:

> To determine how educating sedentary office employees through ongoing ergonomic education sessions based on current research differs from the current training industry approach regarding work behaviours with sit-stand workstations.

Primary Objective:

> To investigate how an ergonomics education program with emphasis on *why* and *how* the use of a sit-stand workstation influences how new users of sit-stand workstations change their workstation height to vary whole body postures throughout the work day.

Hypotheses:

1) The type of training program that new users of sit-stand workstations receive will have an influence on individuals' behaviour at work including the number of sit stand transition.
2) Musculoskeletal pain reports by participants will improve when participants receive the additional training session.
3) There will be no influence of training program on physical activity.
4) The type of training program that individuals receive will influence their mood state score. Mood states will improve in those who received the additional training program.

5) There will be an influence of Active Hip Abduction status as determined at the beginning of the study on sit-stand workstation usage behaviour, reports of musculoskeletal pain and physical activity.

Relevant Definitions:

Active Hip Abduction Test: A clinical test used to determine if an individual is likely to develop low back pain.

Ergonomics Education: A program focused on not only providing users with the knowledge of how to move their workstation according to ergonomic principles, but also on how to modify their work environment in such a way that will not introduce musculoskeletal pain or discomfort with prolonged use.

Inactivity: when individuals' amount of moderate or vigorous physical activity fall below specified guidelines (Sedentary Behaviour Research Network, 2012).

Office: A traditional office setting where computers (either desktop or laptop) are used to process information (Brewer et al., 2006).

Sedentary behaviour: "any waking behaviour characterized by an energy expenditure ≤ 1.5 METs while in a sitting or reclining posture" (Sedentary Behaviour Research Network, 2012).

Sit-stand workstation: An entire rectangular desk surface is capable of changing height from a sitting height to a standing height to allow an individual to perform their tasks in either a sitting or a standing posture.

Sitting: The Western World's definition of sitting is used. An individual is sitting when the buttocks are seated on a seat pan high enough off of the floor that the feet are gently resting on the ground.

Training: Providing users with the knowledge of how to use their workstation.

Chapter 2: Literature Review

2.1 Negative Aspects of Sitting: Health and Musculoskeletal Pain Development

In North America, office workers spend the majority of their time in sedentary postures. Canadians spend approximately 68% (Colley et al., 2011) of their time and Americans 54.9% of their time sedentary (Matthews et al., 2008). Within this population, women are more sedentary than men in early adulthood but this trend switches with age (Matthews et al., 2008). A longitudinal study was conducted by Seguin and colleagues (2014) following a group of 92,234 women ages 50-79 from 1993-1998. Findings concluded that women who frequently reported prolonged sitting had a higher risk of all-cause mortality than less sedentary women who participated in the same study (Seguin et al., 2014).

A Canada wide study was completed by Katzmarzyk and colleagues (2009) to determine the association between all-cause mortality (such as cardiovascular disease (CVD) and cancer) and the amount individuals sat both inside and outside of the workplace. Sedentary behaviour influences a variety of metabolic factors such as bone mineral content, vascular health, metabolic dysfunction, as well as decreased levels of high-density lipoprotein cholesterol and insulin sensitivity (Tremblay, Colley, Saunders, Healy, & Owen, 2010). Prolonged sitting has been shown to be associated with increased risk of developing cardiovascular disease (CVD) especially in overweight women (Chomistek et al., 2013; Hamilton, Hamilton & Zderic 2007), Type II diabetes (Hamilton, Hamilton & Zderic 2007), and obesity (Church et al., 2011; Hamilton, Hamilton, & Zderic 2007). Lipoprotein lipase, an enzyme critical to the process of lipid metabolism, drastically decreased in an animal model when sedentary for prolonged periods (Bey & Hamilton 2003). Higher incidence of myocardial infarction was found for those in occupations that require sitting for most of their day compared to those who sit for a small portion of their day (Morris, Heady, Raffle, Roberts, & Parks, 1953). However, simply reducing the time that one spends sitting does not necessarily translate into reduced CVD risk (Chomistek et al., 2013).

Sedentary behaviour is not synonymous with absence of physical activity (Owen et al., 2011). Some people whose occupations require prolonged sitting while working may attempt to compensate for this inactive behaviour by engaging in physical activity at the beginning or end of the day. This phenomenon is known as the "Active Couch Potato" (Owen, 2010). This sedentary behaviour cannot be compensated by partaking in rigorous activity at the end of the day (Katzmarzyk et al., 2009; Owen, 2010) but instead, sedentary behaviour should be broken up with periods of light activity (Owen et al., 2011). Contrary to this school of thought is evidence that increases in time spent walking and performing vigorous exercise can reduce the risk of CVD (Manson et al., 2002).

From 1960 to 2008, there was an increase of approximately 20% in the prevalence of sedentary occupations (Church et al., 2011). Church and colleagues (2011) note that there is little possibility that the number occupations requiring light to moderate physical activity will increase, given the current trends to increasing jobs classified as sedentary or with low physical demands. These trends highlight the importance that an intervention in the workplace is needed to mitigate the health risks that are associated with sedentary behaviour.

Guidelines from the Occupational Health and Safety Council of Ontario (OHSCO) (2003) state that sitting for more than four to six hours per day is classified as a musculoskeletal disorder risk factor. Owen and colleagues (2011) recommends not sitting for more than 30 minutes continuously and to not exceed a 2-hour limit. These time periods not only highlight the length of times that may be physiologically relevant for the progression of negative health factors, but also for the development of musculoskeletal pain that is associated with maintaining postures for a prolonged period of time.

Low back pain (LBP) is one of the most common and costly musculoskeletal disorders worldwide (Lis, Black, Korn, & Nordin, 2007). De Carvalho (2015) proposed two main elements that contribute to the development of LBP when sitting for a prolonged period of time: flexion of the spine and sitting for prolonged periods of time. During prolonged sitting, posterior pelvic tilt and dissipation of the natural lumbar spine lordotic curve flattens resulting in a flexed posture (De Carvalho, 2015). This flexion of the spine also forces posterior movement of the nucleus pulposus in the disc (Alexander, Hancock, Agouris, Smith, & MacSween, 2007) . Flattening of the lumbar curve is also driven by tight muscles of the posterior thigh pulling the ishium which results in rotation of the pelvis (Keegan, 1953) when sitting in posture with a 90^0 angle trunk to thigh angle (Mandal, 1981). Sitting for prolonged periods of time has been speculated to cause muscles to contract at very low levels (as little as 2% maximal voluntary contraction) which has been shown to result in decreased oxygenation and fatigue (McGill, Hughson, & Parks 2000). Debate surrounds the thought that sitting is a causative factor for the development of LBP. Sitting is associated with an increase in spine flexion and moderate amounts of flexion while sitting may have advantages such as "even distribution of stress in the intervertebral discs, increased supply of metabolites to vulnerable regions of discs, [and] reduced loading of zygapophysial joints" (Adams et al., 2006, pg 193).

In a systematic literature review, 24 publications were included to investigate the association between sitting and LBP (Lis et al., 2007). It was reported that individuals whose occupations required sitting for more than half of a working day had a higher percentage of LBP when combined with awkward postures. An awkward posture was defined as one that an individual slouched, excess kyphosis or lordosis etc. However, controversial evidence was uncovered regarding the relationship between prolonged sitting and LBP in professions requiring sitting for most of the day (Lis et al., 2007). Sitting by itself was not associated with the development of LBP (Lis et al., 2007; Roffey, Wai, Bishop, Kwon, & Dagenais, 2010) but postures assumed while sitting have been shown to aggravate LBP (Vergara & Page, 2002) as well as sitting in a flexed posture for a prolonged period of time (Dankaerts, O'Sullivan, Burnett, & Straker, 2006). Musculoskeletal pain may also develop in the upper limb in occupations that require prolonged sitting without the opportunity to change postures (Roelofs & Straker, 2002). Other negative aspects of sitting include a decreased reach envelope for the arms to work and increased load on the lumbar spine due to the combination of spine flexion and posterior pelvis tilt (Wilks, Mortimer & Nylén, 2006).

2.2 Negative Aspects of Standing: Health and Musculoskeletal Pain Development

Although countless negative physical and health indicators have been associated with prolonged sitting and the inability to vary postures, a shift purely to standing while completing occupational tasks poses another set of risks to the human body.

Standing work can be classified into different categories based on the amount of leg movements required to complete the task (Department of Occupational Safety and Health, 2002). Little to no leg movement occurs with static activity whereas dynamic activity requires leg movement (Department of Occupational Safety and Health, 2002). The OHSCO (2003) defines standing more than 4 hours on a hard work surface as a hazard. Negative health outcomes are associated with standing for prolonged periods of time such as but not limited to carotid atherosclerosis, increased intima media thickness (IMT), venous pooling, increased heart rate (Krause et al., 2000), varicose veins (Tüchsen, Hannerz, Burr, & Krause, 2005), and chronic venous disorders (Sudoł-Szopińska, Bogdan, Szopiński, Panorska, & Kołodziejczak, 2011). An increase in IMT thickness due to prolonged standing has been shown to increase the likelihood of a myocardial infarction by 11% (Salonen & Salonen 1991).

A link between occupational prolonged standing and the development of LBP has been heavily researched for the last couple of years both as laboratory studies, reviews and field studies. Prolonged standing without the freedom to walk around or sit is associated with the development of LBP (Tissot, Messing & Stock 2009). Individuals who report LBP are not always chronic LBP developers but also asymptomatic individuals who develop LBP when they are exposed to standing for prolonged periods of time. This pain can be categorized on a 100mm visual analog scale. Any reporting above 10mm resulted in the categorization of LBP (Nelson-Wong et al., 2008; Marshall, Patel & Callaghan 2011). In transient LBP developers (PDs) start to develop pain within 30-60 minutes of exposure to prolonged standing (Nelson-Wong et al., 2008; Nelson-Wong & Callaghan 2010; Raftry & Marshall 2012; Marshall, Patel & Callaghan 2011; Gallagher, Campbell & Callaghan 2014). It is at this time where their reported pain exceeds the 10mm threshold and continues to rise throughout the duration of the study (Figure 2). Increased extension in the thoracic spine as well as less movement of the lumbar spine are characteristics of a standing provoked LBP developer. Lumbar spine angle was similar between PD and non-pain developers (NPD) (Gallagher, Campbell & Callahan 2014). Differences in muscle activity between PDs and NPDs have also been discovered. It is known that co-activation of the hip abductors occurs prior to the development of pain and that differences in co-activation patterns for the trunk muscles exist (Nelson-Wong & Callaghan 2010a).

Nelson-Wong et al. investigated the responses to a 2-hour laboratory standing protocol (Nelson-Wong, Howarth & Callaghan 2010). Forty-three asymptomatic individuals participated in this study reporting pain scores every 15 minutes. After 30 minutes of standing, participants reported clinically relevant levels of LBP resulting in the classification of 40% of participants as PDs.

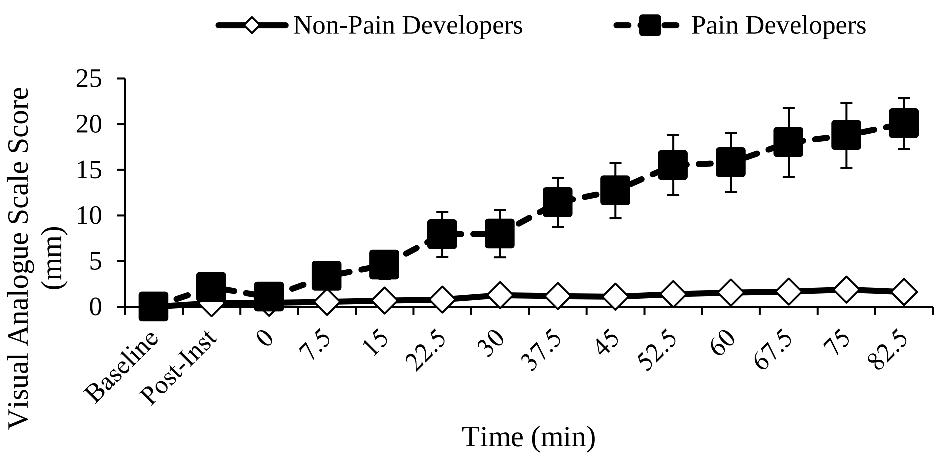

Figure 2: Low back pain discomfort as recorded from 90 minutes of prolonged standing. Adapted from Gallagher 2014.

This progression of clinically classified LBP is of great concern as a recent study has shown that this early classification is indicative of occurrences later in life. In a longitudinal study conducted by Nelson-Wong and Callaghan (2014), participants previously involved in a laboratory study were contacted each year for three years. It was found that 50% of those participants previously classified as PDs reported episodes of clinical LBP compared to those classified as NPDs (Nelson-Wong and Callaghan 2014). Therefore, participants who reported LBP during standing are at future risk for developing LBP (Nelson-Wong & Callaghan 2014). A study by Anderson and colleagues (2007) investigated the development of LBP during prolonged standing and concluded that occupational tasks requiring repetitive arm movements and prolonged standing were predictors for the development of LBP. Discomfort has been shown to develop in the feet (Jorgensen et al., 1993, Ryan 1989) and lower limbs (Hansen, Winkel & Jørgensen 1998; Roelofs & Straker 2002; Kim, Stuart-Buttle & Marras 1994) during prolonged bouts of standing.

As early as the 1980's people recognized that sitting for long periods of time negatively impacted the musculoskeletal system (Mandal, 1981). However, humans have continued to stay seated while performing much of their occupational and daily tasks. Viable interventions to decrease pain caused by prolonged standing have not been developed. After countless studies that recognize the negative impacts of prolonged sitting and standing, companies are beginning to recognize the positive effects that implementing a sit-stand workstation may have on their employees' wellbeing.

2.3 Sit-stand desks/workstations

It is clear that decreasing MSD and negative health risks cannot be achieved by simply switching the exposures from sitting to standing. Height adjustable workstations, which can accommodate both postures, such as sit-stand workstations are becoming popular across the world with companies. These two postures should be employed together in practice along with strategies for the user to ensure this intervention decreases MSD.

2.3.1 Interventions of posture change

Numerous interventions have been developed in the past in an attempt to decrease pain associated with maintaining prolonged postures such as sitting or standing. Breaks from sustained periods of sitting with periods of light activity, such as walking, have been shown to lower waist circumference, reduce basal metabolic index and improved 2-h plasma glucose levels (higher levels are associated with Type II diabetes) (Healy, 2008). Although walking regularly at a self-selected pace to break up prolonged periods of sitting has proven to be beneficial from a health perspective, walking to reduce musculoskeletal pain in regions such as the low back have been unsuccessful (De Carvalho, 2015). This intervention prescribed in a 1:20 walking to sitting ratio was unable to reduce LBP development. This intervention only provided temporary relief of LBP immediately with the walking break. Sitting has been employed as an intervention to decrease musculoskeletal pain when standing for lengthy time periods. A laboratory study by Gallagher and colleagues (2014) employed a cyclic ratio of sitting for 15 minutes for every 45 minutes stood. Employing a 1:3 ratio of standing to sitting was successful at reducing spinal shrinkage compared to those who did not sit at all (Paul & Helander, 1995). The intervention of standing and sitting in a 3:1 ratio was insufficient at reducing LBP development in those classified as PD (Gallagher et al., 2014) (Figure 3). Pain developers as compared to NPDs exhibited increased extension of the thoracic spine and less movement of the lumbar spine (Gallagher, Campbell & Callaghan 2014).

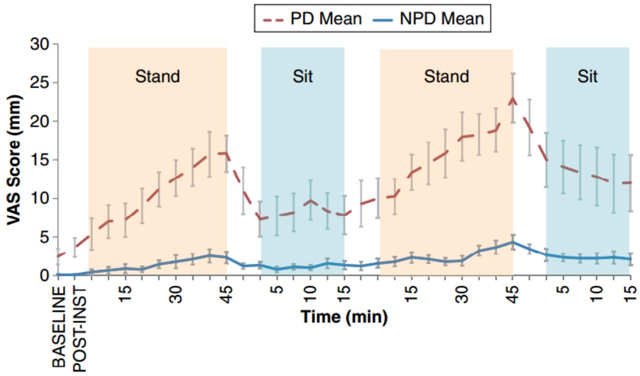

Figure 3: Pain scores continue to increase after an intervention of sitting for 15 minutes following a prolonged bout of standing (45 minutes). Taken from Gallagher et al., 2014.

Standing on sloped surfaces (both incline and decline) (Gallagher, Wong & Callaghan 2013; Nelson-Wong & Callaghan 2010), placing a foot on a rail, installing different flooring and wearing comfortable shoes (Hansen, Winkel & Jørgensen 1998; OHSCO 2003), installing anti-fatigue matting (Kim, Stuart-Buttle & Marras 1994) have also been suggested to decrease pain while standing. It was shown that an anti-fatigue matting intervention did not reduce the muscular fatigue which accumulated throughout prolonged standing (Kim, Stuart-Buttle, & Marras 1994). A systematic review by Chau and colleagues (2010) investigated the effect of workplace interventions to decrease sitting in the workplace. In total, six studies were involved comprising different types of interventions such as individualized physical activity programs, physical activity counseling, sent messages reminding participants of the benefits of eating well and active living, and the promotion of walking at work to decrease time spent sitting. Five studies reported a decrease in time spent sitting but no differences between their intervention and control group and one study reported no differences in sitting time (Chau et al., 2010). The mechanism each one of these interventions employed is attempting to modify the posture of the person in order to off-load certain tissues. However, as these interventions were implemented after pain started, they were unable to return pain scores to or below initial reports of discomfort and pain.

A study comparing reminders of when to transition from sitting to standing (alerting the user every 30 minutes) to no reminders was unable to drastically increase the use of the sit-stand workstations as it was found that participants with the reminder software moved their desk nine times per day while those with non-reminders moved their desk eight times a day (Davis et al., 2009). Dynamic movement workstations such as a treadmill desk, cycle ergometer and semi-recumbent elliptical were employed to evaluate the differences between static desk positions (sitting or standing) (Commissaris et al., 2014). It was found that walking had a negative effect while typing. In addition all dynamic movement tasks resulted in lower perceived performance and quality of telephone conversations compared to the sit condition, cognitive performance was not influenced by either task type (static or dynamic) and lastly, the perceived benefits of working while performing light-moderate physical activity was not observed in this study (Commissaris et al., 2014). The gold standard governing intervention ratio prescription is currently unknown. However, using prior research as a foundation, the optimal ratio is likely to be centered about an equal exposure to each whole body posture: a 1:1 ratio. This ratio may vary slightly either way depending to the needs of the individual. Utilizing this ratio to govern time spent sitting and standing would result in approximately 4 hours of sitting and standing throughout the day which falls under their classification of sitting and standing hazards (Occupational Health and Safety Council of Onatario, 2003). It is imperative that people begin to modify their whole body posture from the beginning of their day as either standing or sitting between 15-30 minutes is long enough to begin to induce LBP in PDs (Gallagher, 2014). For these individuals in particular, changing posture early is a necessity to prolonging the development of LBP as interventions are unable to get rid people of pain after the pain has started (De Carvalho, 2015; Gallagher, 2014).

2.3.2 Potential negative outcomes of using sit-stand workstations

Poor incorporation, as defined by simply installing sit-stand workstations in the workplace with little to no training provided to employees, of sit-stand workstation into the work environment can lead to adverse consequences. In a review article by Karakolis and Callaghan (2014), 14 articles regarding sit-stand workstations were reviewed. They noted that of the 14 articles selected only one reported negative effects of sit-stand desks. The study by Ebara and colleagues (2008) reported adverse effects on the right forearm, right wrist/hand, thighs/hips and lower legs. Participants were not educated on ergonomics prior to the study and were told to adjust their "workstation according to OSHA and ANSI/HFS guidelines" (Ebara et al., 2008, pg 499). A study by Gilson and colleagues (2012) implemented four sit-stand workstations in a workplace comprised of 25 employees. The benefits of using a sit-stand desk were described briefly to employees and they were encouraged to stand at one of the four desks as often as possible. The 'hot' desk concept fits well with employer financial constraints and the cost concerns of allocating height-adjustable desks to individuals. However, this strategy did not increase the total time spent standing in all individuals with accelerometer data showing that desk use had no overall effect on the proportion of work time spent in sedentary behaviour (Gilson, Suppini, Ryde, Brown, & Brown, 2012). No ergonomic training was provided to participants in a study conducted by (Hedge & Ray, 2004). It was found that there was a reduction in sitting time however, on average only 1.5 adjustments were made per day (Hedge & Ray, 2004). In another study with no education session, Davis and colleagues (2014) found eight transitions were seen per day and nine with the addition of reminders to alter whole body posture (Davis et al., 2009).

2.3.3 Balance between sitting and standing – movement variety

A paradigm shift has occurred in "desk-bound" occupations from always sitting to work to the alteration of whole body postures throughout the day. Due to mainstream media highlighting negative health consequences of sitting and standing, there has been a shift towards office furniture implementation that accommodates both sitting and standing postures. Balanced time between these postures (Wilks, Mortimer & Nylén 2006) and movement is crucial to prevent the development of pain, as studies have shown that after pain accumulates above clinical levels, interventions are not successful at eliminating it (De Carvalho, 2015; Gallagher et al., 2014). Differences in the compressive load at the L4/L5 spine level have been found between whole body postures such as unsupported sitting (no back rest) and standing, 1698 ± 467 N and 1076 ± 243 N respectively (Callaghan & McGill 2001). Greater differences between compressive forces may exist between standing and supported sitting postures (with a back rest). Movement after the initiation of pain has not been able to eliminate pain, therefore, proactive early and often movement variety appears to be key for the prevention of pain. Sit-stand workstations allow individuals to follow this theory with minimal disruption to their workday.

As sitting for periods longer than 30 minutes at a time have not been recommended, individuals should change postures frequently (Owen et al., 2011). Sitting should be broken up by periods of movement to vary static load distribution (Wilks, Mortimer & Nylén 2006) and light-intensity physical activity such as standing or walking (Healy et al., 2008). Walking breaks as a means to decrease sitting time resulted in decreased time spent sitting (self-reported) and increased step counts in a study conducted on 264 employees at six Spanish Universities (Puig-Ribera, Bort-Roig, et al., 2015). The program aiming to decrease sedentary behaviour by replacing it with walking (or light movement) lasted for 19 weeks. The increase in step counts (as counted via a pedometer) remained significant after the intervention had been withdrawn (Puig-Ribera, Bort-Roig, et al., 2015). In 2008, participants completed a nine hour (overnight) fast before completing an oral glucose tolerance test (Healy et al., 2008). These data provide objective evidence that light-intensity physical activity is beneficially associated with blood glucose and that sedentary time is unfavorably associated with blood glucose. These data support previous findings from studies using self-report measures, and suggest that substituting light-intensity activity for television viewing or other sedentary time may be a practical and achievable preventive strategy to reduce the risk of Type II diabetes and cardiovascular disease (Healy et al., 2008). Breaking up prolonged bouts of sitting with light activity tasks improves overall levels of physical activity. Taking breaks from prolonged bouts of sitting may also lower CVD risk (Chomistek et al., 2013). Reductions in sitting time due to increases in walking and vigorous activity reduced the risk of cardiovascular disease and associated events in women (Manson et al., 2002). The risk of CVD can be reduced for both sexes “by 30 to 50 percent with regular physical activity” (Manson et al., 2002, pg 723). Exercise is beneficial for vasculature wellbeing and has been shown to improve nitric oxide (NO) availability and vasodilator capacity (Roque, Hernanz, Salaices, & Briones, 2013). A positive relationship between participation in regular low to mid exercise intensity and improvements in cardiovascular and metabolic diseases has been shown due to the scope of vascular changes that occur (Roque et al., 2013).

2.4 A shift in the workplace

In the last 20-30 years technology has developed greatly, allowing many daily tasks to be completed at employees' desks on their computers: scheduling meeting, phone calls, emails, and document retrieval and review. Completing all of these tasks at a sitting workstation has led to a decrease in moderate work intensity and an increase in sedentary and light occupations (Church et al., 2011). Employers and companies are beginning to accept this change in the workplace and some are willing to modernize their office for employees. However, this rapid implementation has led to suboptimal integration of sit-stand workstations in the workplace.

2.4.1 Potential positive outcomes of sit-stand workstations

Musculoskeletal Pain

Potential decreases in sedentary postures and MSD is one of the many benefits of adopting a sit-stand workstation to replace a traditional sitting workstation (Husemann et al., 2009). A study on simulated office work evaluated a data entry task using 2 groups, sitting and sit-stand lasting for 5 days (Husemann et al., 2009). It was found that there was a reduction in low back discomfort in the sit-stand group (Husemann et al., 2009). A study by Roelofs and Straker (2002) evaluated discomfort and preferred posture of 30 bank tellers in 3 different conditions, "just sit", "just stand", and "sit-stand" with measures of discomfort in each. "Just stand" was found to result in more whole body discomfort than "just sit" or "sit-stand" with 70% of subjects preferring the "sit-stand" posture, 20% "just sit" and 10% "just stand" (Roelofs & Straker, 2002). The highest prevalence of lower limb discomfort was "just stand" with the least amount of MSD in the "sit-stand" posture (Roelofs & Straker, 2002). Overall, more posture variability occurred in the sit-stand condition, which authors attributed to "changing the loads" as reason for the decreased risk of MSD development. Nerhood and Thompson (1994) studied the implementation of sit-stand workstations into United Postal Service (UPS) offices as most of the work their employees performed was very sedentary. The company was motivated to improve environmental factors (lighting etc.) and physical workstation for employees which they achieved through a combination of new workstations and appropriate training (Nerhood & Thompson, 1994). After a follow-up period of nine months, MSD decreases were seen in baseline measures by 62.12% in areas such as the “thighs, lower arms/elbows, legs, upper back, buttocks, middle back, knees and feet” (Nerhood & Thompson, 1994, pg 671). Robertson and colleagues (2013) also noted favourable results with the implementation of sit-stand workstations and an education session to decrease MSDs. A study by Davis and colleagues (2014) noted significantly lower discomfort for “shoulders, hand/[wrists], lower back, and upper back” compared to conventional sitting however, no change in discomfort for the “neck, elbows, hands and wrists, hips, knees, lower legs and feet” (Davis et al., 2009, pg 885).

Productivity

Along with measures of MSD or pain with the implementation of sit-stand workstations, an effort has been made to assess productivity of new users to discover if changes occur in an employee’s work environment. Changing postures from sitting to standing allowed the employee to continue to complete their task with minimal disturbance and no reduction in efficiency in data entry (Husemann et al., 2009). One year after implementation Nerhood and Thompson (1994) reported increases in production after the implementation of their ergonomic program and no significant differences in sick days, absenteeism and late days six months and 12 months after intervention (Nerhood & Thompson, 1994). Ebara and colleagues (2008) increased work performance compared to the two other conditions (standard and high-chair). Measurements of productivity were subjectively measured over three days in Danioff and colleagues (2002); the authors noted a decrease in non-productive time directly correlating to increased productivity. Over a three day period those who stood more reported an increase in their productivity and the opposite was found for those who did not stand (Dainoff, 2002). Regular breaks due to fatigue and pain accumulation were decreased allowing individuals to remain productive at their desks as standing provided an "active work break" (Dainoff, 2002). It was also shown by another study that sit-stand workstations increased feelings of productivity with 66% of workers reporting an increase in productivity with 71% feeling more focused (Pronk et al., 2012). In a laboratory study conducted by Robertson and colleagues (2013) there was no difference in the number of faxes that the administrative assistance sent (in lab study) between an educational training session (ET) and minimally trained (MT) group. However, the quality of work from the ET group was much higher (Robertson, Ciriello, & Garabet 2013). Similarly, no change in productivity was noted by Davis and colleagues (2014) and Chau and colleagues (2016). Alkhajah and colleagues (2012) asked participants about their thoughts on how productivity was influenced using sit-stand workstations. Overall, 33% agreed it had improved their productive while 22% disagreed it has improved their productivity (Alkhajah et al., 2012).

Psychosocial and Mental Health Changes

Implementing sit-stand workstations will result in a change of the workstation environment but also has the potential to modify individuals' psychosocial wellbeing. Previous studies found that psychosocial factors, such as low job satisfaction, low job control and stress levels were predictors of lower limb pain and neck and shoulder pain, LBP (Andersen, Haahr, &

Frost 2007) as well as pain and discomfort (Demure, 2000a, 2000b). Husemann and colleagues (2009) commented that since office work is mentally demanding, standing while completing work might lead to a decrease in mental performance (Husemann et al., 2009). Pronk and colleagues (2012), reported the opposite by using surveys to assess the effect that the reduction in time spent sitting had on the mood of participants, health outcomes, and office behaviour by administering the Profile of Mood States Questionnaire (POMS) (Pronk et al., 2012). With the implementation of sit-stand workstations, participants noted improved "fatigue, vigour, tension, confusion, depression and total mood disturbance" and 75% and 33% of participants felt healthier and were less stressed out at work respectively (Pronk et al., 2012, pg 4). In the second period of this study when desks were removed, vigour and total mood disturbance returned to baseline levels and self-esteem also dropped after the removal of the devices to below baseline levels (Pronk et al., 2012). Robertson and colleagues (2013) noted that moderate and high cognitive demand tasks that participants completed in her study were completed more effectively and with better performance by the ET group. Authors concluded that the ET group "can exert control over their work environment to meet their individual needs to effectively work and minimize the occurrence of MSDs" (Robertson, Ciriello, & Garabet 2013, pg 84). A combination of both sitting and standing, versus sitting or standing, resulted in lower levels of mental concentration as indicated by critical flicker fusion frequency (Hasegawa, Inoue, Tsutsue, & Kumashiro, 2001).

The results of implementing a sit-stand workstation depend greatly on the aspects in which they are implemented: education/ training, open attitudes, management commitment, and ratio of workstations to employees. To date, studies researching the influence of desks have been completed in both the field and laboratory settings.

2.5 The influence of training on sit-stand usage

In the past, training and education have been used synonymously and interchangeably when conveying information to another person. Currently, there are no strict definitions to distinguish between the two (Robson et al., 2011). Noe and colleagues (2005) defines training as "a planned effort by a company to facilitate employees' learning of job related competencies" (pg 3). The CSA-Z412 document notes that there is a difference between education and training. They state that "education provides general knowledge and understanding about a topic" while "training…involves the systematic development of knowledge and skills required to perform a specific task or job" (CSA, 2012, pg 227). The discrepancy between definitions has become apparent in studies regarding the implementation of sit-stand workstations as varying levels of knowledge on the subject of how to use height adjustable workstations affectively, as well as why using them is important, have been described to participants/users. To date, there are no strict guidelines governing the contents or delivery mechanism for ergonomics education with regards to sit-stand workstations, although definitions have been put forward by governing bodies such as the Canadian Standards Association (CSA).

A combination of different training techniques and different outcomes measured, makes it challenging to compare studies directly to one another. Different levels of training (provided to employees) on how to use a sit-stand workstation are incorporated into studies ranging from none to minimal (those who quickly briefed participants on use of sit-stand workstation), to extensive (education with tips of how to integrate usage into their workday or on-going support throughout the initial period after installation). Of those who did not provide training (Pronk et al., 2012; Ebara et al., 2008; Hedge & Ray, 2004), an increase in discomfort was noted in one

(Ebara et al., 2008) and minimal use of the height adjustable feature of the desk in another (~1.5 times per day) (Hedge & Ray, 2004). More transitions were noted in a study by Davis and colleagues (2014) who noted eight whole body posture transitions per day and nine when a reminder told participants to move every 30 minutes. Simply implementing sit-stand workstations into a workplace did not increase ergonomic awareness of the participants, which in turn was insufficient at changing behaviours (Straker, Abbott, Heiden, Mathiassen, & Toomingas, 2013). The authors note the importance of ergonomic education, awareness and behaviour change theory for individuals to continually use their sit-stand workstations (Straker et al., 2013). Minimal training (Alkhajah et al., 2012; Gilson et al., 2012; Hasegawa et al., 2001) was associated with no change in decreasing sedentary behaviour in only one study (Gilson et al., 2012). Studies that developed extensive training programs alongside the implementation of a sit-stand workstation noted and monitored MSD levels noted decreases (Nerhood & Thompson 1994; Neuhaus et al., 2014). Additionally, individuals who were motivated, encouraged to use their sit-stand workstations, and received proper instruction utilized the transition features of their desk more than their counterparts (Wilks, Mortimer & Nylén 2006). Interventions that target varying levels of a company such as management, employees and organizations have proven to be successful in decreasing sitting time of their employees (Healy et al., 2013). Healy and colleagues (2013) successfully utilized an organizational, environmental and individual approach to integrate sit-stand workstations to decrease sitting time. A study by Robertson and colleagues (2013) assessed how an office ergonomic training program influenced new users of sit-stand workstations. Their ergonomically trained group received a 1.5-hour office ergonomic training program that incorporated knowledge-based and experiential learning. The minimally trained group received only a brief overview of the work setting. In the third block of the study included a 5-minute mandatory standing session for each 50-minutes session and in day block 4 there was 20-minutes of mandatory standing for each 50-minute session. Each of these sessions was accompanied by coaching and ergonomic reminders. In blocks three and four participants transitioned between sitting and standing an average of six and a half and seven times a day. In the block following the removal of these reminders the number of sit-stand transitions decreased to two and a half and three and a half times a day. A study by Neuhaus and colleagues (2014) implemented new sit-stand workstations in 2/3 groups involved in the study. The third group acted as a control group and did not receive any new sit-stand workstations. Of the two groups who did receive sit-stand workstations, one group received a multi-component approach which included an organizational intervention (meeting with managers), environmental interventions (new height-adjustable workstations included a brief verbal and written instructions on correct usage), and an individual intervention. The individual intervention included a 30-minute coaching session within the first two days of participants having the new workstations, emails, phone calls, an information booklet, and a self-monitoring tool. At weeks one, three, and seven participants were followed-up with via a short phone call (Neuhaus et al., 2014). The other group simply received instructions regarding correct usage of the workstations. Those who received the multi-component intervention decreased their sitting time by 19.4%(93 minutes) and those who received minimal training decreased their sitting time by 10.6% (52 minutes) (Neuhaus et al., 2014). A similar study comparing a multi-component intervention noted decreased in sitting each day of 26.0% (125 minutes) for an 8-hr workday (Healy et al., 2013). A study by Graves and colleagues (2015) gave participants sit-stand desks in the intervention group but were not told the amount of time that they needed to use the workstation. Participants were trained via representatives from Ergotron (the company who provided and installed the workstations) on the correct use of the workstations. Their control group was not given sit-stand workstations but instead were asked to sit as they usually would at their non-height adjustable workstations (Graves, Murphy, Shepherd, Cabot, & Hopkins, 2015). Reports of behaviour were made subjectively using a diary where participants were asked every 15-minutes what they were doing. Musculoskeletal pain in the neck, upper and lower back were assessed on a 10 point Likert scale ranging from one (no discomfort) to 10 (extremely uncomfortable). Participants were asked to choose from sitting, standing, walking or other. The amount of time spent in each posture was estimated by multiplying the frequency that each activity was reported by 15-minutes under the assumption that the participant had been completing the activity consistently for the past 15-minutes. Entries were only used if they were completed by participants ≥75% of the time (Graves et al., 2015).

A question that remains after the implementation of a sit-stand desk is how beneficial was their intervention at decreasing sedentary behaviours at work. Objective and subjective methods have both been used to assess decreases in time spent sitting (Alkhajah et al., 2012; Chau et al., 2014; Davis & Kotowski, 2014; Dutta, Koepp, Stovitz, Levine, & Pereira, 2014; Healy et al., 2013; Hedge & Ray, 2004; Husemann et al., 2009; Neuhaus et al., 2014; Pronk et al., 2012; Robertson et al., 2013; Straker et al., 2013). Comparing an intervention to a control group there was a 143 and 137 min/ eight hour workday differences in time spent seated for one week and three month follow-up respectively (Alkhajah et al., 2012), decreases of 66 minutes (Pronk et al., 2012), 73 minutes (Chau et al., 2014), 33-minutes without extensive training, 89min/eight-hour with extensive training (Neuhaus et al., 2014), 19-minutes over a six hour shift (cross-sectional study) (Straker et al., 2013) and an eight hour decrease over a 40 hour work week (Dutta et al., 2014) have also been reported in the literature. Difference in decreases of sitting time could have resulted from differences in training, participants, and suitability of their new sit-stand workstation.

2.6 Education and training

To the author's knowledge, an educational program incorporated in a government agency guideline or standard describing the use of sit-stand workstations in the workplace does not currently exist. If developed, this educational program should be heavily based on current research regarding the principles of ergonomics, the most optimal ratio of use, and correct workstation heights to work at when sitting or standing. The need for these guidelines is essential as many workplaces are purchasing height adjustable workstations for their employees in the hopes of decreasing the discomfort of their employees. Of the education programs mentioned in previous research studies, most mention only minimal or brief descriptions of the ergonomic principles governing use of sit-stand workstations are provided to users (Gilson et al., 2012; Alkhajah et al., 2012; Hasegawa et al., 2001; Robertson, Ciriello & Garabet, 2013). By intervening at both the individual, environmental and organizational level, as well as employing behaviour change techniques (BCTs) such as goal setting, self-monitoring, use of prompts and problem solving, Healy and colleagues (2013) successfully reduced sitting time in the workplace.

For current purposes, in order for an education/training program regarding sit-stand workstations to be classified as successful, users must continue to utilize their sit-stand workstations after the program has ended. To the author's knowledge, there have been no instances of negative outcomes resulting from training (Amick, 2015). However, the effectiveness of a training session depends on the needs of the employees, the training program, the trainer, and the environment in which it was administered.

2.6.1 Designing a Training Program

There are several different elements that contribute to a successful education/training program. Aspects such as high engagement and participation, hands on learning, teaching not only how but also why, proper length, building self-efficacy, and has management commitment will lead to a successful intervention (one that is able to accomplish its goal).

Brewer and colleagues (2006) conducted a review to answer the question: "Do office interventions among computer users have an effect on musculoskeletal or visual health?". Inconsistent findings with medium to high quality studies for the effect of ergonomic interventions were concluded. It was found by Brewer and colleagues (2006) that no studies showed negative implications of MSD or health when ergonomic interventions were employed. Many of the studies involved in this review process included multiple components of training that were included at one time. Brewer and colleagues (2006) commented that this approach may cloud outcomes of specific interventions.

A program should also be hands on, incorporate periods of active learning (Burke, 2006) and allow and encourage people to get involved and participate (Yazdani et al., 2015). These types of engaging methods of teaching comprise hands on demonstrations and active participation from the trainee with conversational feedback with the trainer and trainee working together. Active and integrative training sessions result in the decrease of negative health outcomes and greater knowledge attainment (Burke, 2006). By engaging individuals in education interventions it allows people to not only understand what they are doing but also feel responsible for the upkeep of the new principles that they learn (Burke, 2006).

In order to be effective at modifying health outcomes, the training session must also explain why the interventions mentioned are important is beneficial (Burke, 2006). People also need to understand the benefits that the intervention poses to them if they partake in and maintain the intervention (Haslam, 2002). This explanation should be delivered in a variety of ways to ensure that all participants understand the value as everyone has been shaped by their "knowledge, abilities, habits, and desires with in turn are influenced by psychological and social drivers" (Haslam, 2002, pg 242). Individuals' motivation to learn is also influenced by the feedback that they receive, their personal characteristics, the consequences of their actions, as well as their attitudes (Noe, 2005).

Noe (2005) defines self-efficacy as "employees' belief that they can successfully perform their job or learn the content of the training program" (pg 89). Noe (2005) offers suggestions to increase employees' self-efficacy such as providing information to the participants prior to the training session, describing the purpose of the training that they will take part in, demonstrating their colleagues' success, and providing feedback to the individual and re-enforcing that they are in control and have the knowledge to overcome any challenges that they may encounter (Noe, 2005). Social learning theory underlines many of the principles regarding how people learn. Self-efficacy can be increased by using several methods such as "verbal persuasion, logical verification, observation of others (modeling), and past accomplishments" (Noe, 2005, pg 110). Amick (2015) states that self-efficacy should be incorporated into training programs as a key training objective. In terms of appropriate lengths of sessions, longer training sessions were more likely to be more successful because longer training sessions were associated with more engaging training sessions (Burke, 2006). The setup of the room (chairs, tables, colours) are variables that should be considered when delivering the training program (Noe, 2005).

A training program that includes a participatory ergonomics approach in conjunction with engineering controls is likely to be successful. Training is key to participatory ergonomics, which is defined as “an approach frequently advocated for MSD prevention and has been described simply as “practical ergonomics” or a way to improve problem solving” (Yazdani et al., 2015, pg 112). A training/education program should be constructed in a standard way incorporating specific features to ensure that no aspects of a successful training program are neglected (CSA, 2012).

2.6.2 Changing Behaviour

People change their behaviour in a number of steps: pre-contemplation, contemplation, preparation, action, maintenance (Prochaska, DiClemente, & Norcross, 1992). If people are not aware a problem exists and there is no indication that they will change they are said to be in the pre-contemplation stage. People move into the contemplation phase when people are aware that a problem requires changes and are considering the change. Preparation phase comprises the intent to make a change in their behaviour but not yet successful action of that behaviour. The modification of actions in behaviour in seen in the action phase. Finally, these changes in behaviour and actions are sustained in the maintenance phase to avoid relapse (Prochaska, DiClemente, & Norcross, 1992).

Once a training/education program has been developed, techniques should be used to advocate for the change and get people invested. Strategies such as behaviour change techniques (BCTs) have been employed to promote behaviour alteration (Abraham & Michie, 2008; Michie et al., 2011). Motivational interviewing (MI) involves listening to the patient (or participant) when speaking about an upcoming change about to occur and responding and focusing on the positive aspects that they may mention (Rollnick, Miller, & Butler, 2008). Rollnick and colleagues (2008) state that four guiding principles of MI exist: 1) resist the righting reflex, 2) to understand and explore the patient's own motivation, 3) listen with empathy, and 4) empower the patient. When speaking to people about an upcoming requirement for a change in their behaviour, maintaining a positive demeanor and focusing only on the positive comments they make about behaviour change known as "change talk" is optimal (Rollnick, Miller, & Butler, 2008) as well as not labeling individuals as "high risk" as it "medicalizes" the issue and labels people as at risk (Riekert, Ockene, & Shumaker, 2008). There are six kinds of change talk that will result in behaviour change. Integrating these communication techniques into interactions will result in the adapting their mindset to except the change, not arguing for maintenance of the status quo.

A study by Aahahl and colleagues assessed behaviour change techniques on sitting time. Behaviour change intervention was given every sixth week over six months lasting for 30-45 minutes. The intervention was based on "behavioural choice theory, incorporation individual behaviour goal-setting, self-efficacy, and motivational interviewing techniques" (Aadahl et al., 2014, pg 578). At follow up meeting goals were revisited and new ones set. Sitting time decreased for intervention (by 0.27 hours/day) compared to the control. These techniques successfully reduced sitting time in the intervention group. Additionally, peoples' attitudes toward a project also influence their outlook and their willingness to participate (Haslam, 2002). In order for a change to be successful, both the organization and the individual must be ready and willing to change. Prior to the beginning of a training program the trainer should develop goals and objectives that the session hopes to achieve as well as key take away messages (Robertson, 2003). Social cognitive theory uses "incentives, outcome expectations, and efficacy expectations" to estimate people's behaviour (Riekert, Ockene & Shumaker, 2008). A number of other factors influence peoples' behaviour such as personal characteristics, attitudes (Noe, 2005), knowledge (Haslam, 2002) self-efficacy (Riekert, Ocken & Shumaker, 2008; Razoumnikova, 2000; Noe, 2005; Wolters & Benzon, 2001) and willingness to learn (Riekert, Ockene & Shumaker, 2008).

Training is influenced by employees and managers, directors and other upper management in a company (Noe, 2005). Change management is “the process of ensuring that new interventions such as training practices are accepted and used by employees and managers” (Noe, 2005, pg 422). This process is key to the success of the training program as a whole because if the transition is not made and the training is not kept going then the training program will not be successful at modifying the behaviours of those involved (Noe, 2005). Users will continue to benefit from increased movement with the initial implementation and over time (**Error! Reference source not found.**). To lead a successful ergonomics program it needs to be i ntegrated into management and have management support and commitment (Yazdani et al., 2015).

2.7 Summary of Literature Review

Much is known about the negative aspects of sitting or standing for long periods of time. With this knowledge, an intervention was developed for the workplace that accommodated for the variation between these whole body postures. In the past, the integration of sit-stand desks has shown positive but also negative consequences when introduced into an office environment improperly. To date, no strict guidelines have been established to govern the implementation of sit-stand workstation into the workplace and the educational training session that should accompany it.

Negative Aspects of Sitting: Health and Musculoskeletal Pain Development

Sedentary behaviour influences a variety of metabolic factors such as bone mineral content, vascular health, metabolic dysfunction, as well as decreased levels of high-density lipoprotein cholesterol and insulin sensitivity (Tremblay et al., 2010). Prolonged sitting has shown to be associated with increased risk of developing cardiovascular disease (CVD) especially in overweight women (Chomistek et al., 2013; Hamilton et al., 2007), Type II diabetes (Hamilton et al., 2007), and obesity (Church et al., 2011; Hamilton et al., 2007). Lipoprotein lipase, an enzyme critical to the process of lipid metabolism, drastically decreased in a in an animal model when sedentary for prolonged periods (Bey & Hamilton, 2003). Previous studies have shown conflicting evidence both for (Dankaerts et al., 2006; Vergara & Page, 2002) and against (Lis et al., 2007; Roffey et al., 2010) the theory that LBP can develop during prolonged bouts of sitting. Although controversial evidence has been reported with respect to the development of low back pain during prolonged bouts of sitting, neglecting sitting as a potential aggravating factor for the development of LBP would be unethical and contrary to the beliefs held by workers, health & safety practitioners and clinicians.

Negative Aspects of Standing: Health and Musculoskeletal Pain Development

Negative health outcomes are associated with standing for prolonged periods of time such as but not limited to carotid atherosclerosis, increased intima media thickness, venous pooling, increased heart rate (Krause et al., 2000), varicose veins (Tüchsen et al., 2005), and chronic venous disorders (Sudoł-Szopińska et al., 2011). An increase in IMT thickness due to prolonged standing has been shown to increase the likelihood of a myocardial infarction by 11% (Salonen

& Salonen, 1991). Standing for prolonged period of time is associated with the development of LBP (Gallagher et al., 2014; Marshall et al., 2011; Erika Nelson-Wong et al., 2008; Tissot et al., 2009)**.**

A Shift in the Workplace to Sit-stand Workstations

As past research has shown, simply switching exposures from prolonged sitting to prolonged standing, or vice versa, is not a viable method to prevent the development of LBP. Instead, height adjustable workstations should be employed to allow operators to vary between these whole body postures throughout their work day. Sitting as a method of decreasing LBP generated from prolonged standing as unable to maintain a reduction in pain over a prolonged period of time when employed in a ratio of 3:1 (standing to sitting) (Gallagher et al., 2014). Walking breaks integrated in a ratio of 1:20 (walking to sitting) provided only temporary relief of LBP (De Carvalho, 2015). A 1:1 (standing to sitting) ratio between has been proposed to be used throughout a workday, as employing this ratio would result in sitting and standing times that fall below OHSCO hazards (OHSCO, 2003). It is also imperative to employ a balanced ratio as research has shown that once LBP develop during prolonged postures, employing an intervention is not enough to rid the individual of their pain (De Carvalho, 2015; Gallagher, 2014). Implementing sit-stand workstations without proper training has been shown to lead to negative outcomes (Ebara et al., 2008; Gilson et al., 2012) or minimal use of the workstation (Davis et al., 2009; Hedge & Ray, 2004).

Many positive outcomes have been associated with sit-stand workstations such as reductions in low back discomfort (Husemann et al., 2009). Another instance of installing sit-stand workstations into an office environment showed nine months after implementation decreases were seen in MSD from baseline measures by 62.12% in areas such as the "thighs, lower arms/elbows, legs, upper back, buttocks, middle back, knees and feet" (Nerhood & Thompson 1994, pg 671). Decreases in MSD were also seen in other investigations (Davis & Kotowski, 2014; Robertson et al., 2013). Measures of productivity have been assessed both subjectively and objectively. Increases in quality (Robertson et al., 2013) and productivity (Alkhajah et al., 2012; Dainoff, 2002; Ebara et al., 2008; Nerhood & Thompson, 1994; Pronk et al., 2012; Robertson et al., 2013). No changes in productivity have also been noted (Chau et al., 2016; Davis & Kotowski, 2014; Graves et al., 2015).

The influence of training on sit-stand workstation usage

There have been various studies documenting the use of sit-stand workstations in the workplace with the main goals of decreasing musculoskeletal pain and time spent sitting. The outcome of the new workstations on usage and musculoskeletal health depends greatly on how the new workstation was introduced to users. Simply implementing sit-stand workstations did not increase ergonomic awareness (Straker et al., 2013). Minimal training had no effect (Alkhajah et al., 2012; Gilson et al., 2012; Hasegawa et al., 2001) whereas training programs that included multi-level interventions were successful in decreasing sitting time (Healy et al., 2013).

Education and training

As sit-stand workstations are becoming more prevalent in modern workplaces, there is a need for organizations to provide guidelines for employers to follow when implementing sit-stand workstations to ensure safe and effective use to decrease negative health aspects of sitting and musculoskeletal pain. Currently, an educational program supported by a government agency describing the use of sit-stand workstations in the workplace does not currently exist. This education program should consist of high engagement and participation exercises (Burke, 2006; Yazdani et al., 2015), hands on learning (Burke, 2006), how to safety operate the workstation, why using the workstation is beneficial to individuals' health (Burke, 2006; Haslam, 2002), be conducted in a proper learning environment (Noe, 2005), should build individuals' self-efficacy (Aadahl et al., 2014; Noe, 2005; Riekert et al., 2008; Rollnick et al., 2008; Wolters & Benzon, 2001), have management commitment (Yazdani et al., 2015), utilize motivational interviewing techniques (Aadahl et al., 2014; Riekert et al., 2008; Rollnick et al., 2008) and behaviour change techniques (Aadahl et al., 2014; Abraham & Michie, 2008; Haslam, 2002; Healy et al., 2013; Michie et al., 2011; Neuhaus et al., 2014) to encourage users to adapt their workplace habits to incorporate and maintain alterations in whole body posture into their daily routine.

Chapter 3: Methods

3.1 Overview of methods

The University of Waterloo and the Propel Centre for Population Health Impact approached Dr. Callaghan and Ms. Riddell to partner with the Propel Centre for Population Health Impact as their workstations changed from non-height adjustable workstation to workstations that support both sitting and standing postures. All participants received new sit-stand workstations but kept the same chair they used with their previous fixed height workstation. Participants were divided into two groups. The training/ education level differed between the groups. One group only received an example of an industry approach to training/education (NFI), and the other received this training session and an example based on current best practice research (NFR). This additional training session focused on the differences in workstation configuration sitting and standing postures, how to integrate their new workstation into their work day and integrated techniques to promote frequent use of the workstation throughout a workday and in the months and years following implementation. This field study consisted of three phases. Baseline measures were taken in Phase I when the participants were still working at their original non- height adjustable desks for four weeks. This phase was followed by a one week washout period where no measures were taken. During this week new workstations were installed and the training/ education programs were delivered to participants. During the four weeks of Phase II the participants in the NFR group received weekly visits from Ms. Riddell. After the completion of Phase II, there was another week of washout to mimic the study design before the post-measures phase began. The length and measurements taken were the same in Phase III as in Phase I and II but there were no weekly meetings with participants. After the completion of Phase III the NFI group received the additional session that had been delivered to the NFR group during the first washout period (Figure 1).

3.2 Participants

Participants were recruited from the Propel Centre for Population Health Impact (PROPEL), located on the University of Waterloo's main campus. This centre comprises approximately 45 employees. Thirty-eight adults signed up to participate in the study. Two people changed jobs before the end of the Phase I, one woman left the study a few days early due to maternity leave in Phase III and another due to a change in job. In total, there were 7 male and 28 female participants. One individual was removed from analysis due to confessed self-tampering of their data. The two individuals who did not complete Phase I of the study were removed from data analysis. Participants' tasks mainly comprised of computer work, writing reports, and participating in meetings.

Table 1: Participant anthropometrics and characteristics.

	Additional training session (NFR)	Industry example training session (NFI)
n	17	18
Age (years)	38.1 (±11.2)	40.0 (±11.4)
Males	3	4
Females	14	14
Height (m)	1.7 (±0.1)	1.7 (±0.1)
Weight (kg)	75.9 (±22.9)	71.5 (±14.2)
BMI (kg/m^2)	26.7 (±6.6)	25.5 (±4.6)
Pregnant	1	1
Smokers (n)	0	1
Intake questions		
How much knowledge of sit-stand workstations do you have? (None=0, Minimal=1, Moderate=2, Lots=3)	0.8 (±0.8)	0.7 (±0.5)
On average, how many hours a day do you spend siting at your desk completing work?	5.6 (±1.6)	5.5 (±1.9)
On average, how many hours do you spend a day working on your computer?	5.8 (±1.5)	6.0 (±1.4)
On average, how many hours do you spend typing or mousing each day?	5.6 (±1.6)	5.6 (±1.1)
"I believe that using a sit-stand workstation will improve my health, decrease musculoskeletal discomfort and increase overall feelings of well-being" (scored on a scale from 1-5 1=NO 2=YES)	3.9 (±0.8)	4.0 (±0.9)

Before participants were divided into groups they were matched into pairs based on their daily tasks, sex, and age. Participants were then divided into one of two groups. Lists of those in each group were then approved by the director of PROPEL to ensure that there were no "social" conflicts between groups. Cluster randomization was done to ensure that there was as little cross-contamination between the two groups as possible. This approach is similar to a previous study (Amick et al., 2003). Note that participants were divided into groups after the completion of Phase I. They were told if they were selected to receive an additional training session (the NFR group) during the washout period between Phase I and II.

3.3 Educational training sessions: Example from industry and Best Practice Research

Prior to the start of Phase II, all participants partook in a training session representative of what is currently being taught in the industry by a representative from the company that provided the workstations. Those who were in the NFR group received an additional education session prior to the beginning of Phase II. Part of the extended education session included weekly follow up meetings for the duration of Phase II. These meetings, 10-15 minutes in length, were meant to enforce goals and objectives from the training session and provide participants the opportunity to ask questions regarding their sit-stand workstation. A decision tree (Appendix F) was used to ensure that all meetings with those in the NFR group were similar. M. Riddell visited those in the NFI group each as well but only engaged in "small talk" and asked general questions about how they enjoyed using their workstation. If during a weekly meeting someone in the NFI group asked a question about their workstation M. Riddell answered using information that was delivered to them in their initial training session by the industry representative. The individual who delivered the industry example of training wished to also meet with each person. M.

Riddell, or an undergraduate student who was assisting with data collection, was present during all of these meetings to ensure that the individual did not deliver any more information than in the original training session and to ensure that each meeting was as similar as possible. Both training sessions took place in the first washout period between Phase I and II.

3.3.1 Training session: Current example from industry approach

All participants received a 40-minute training session regarding the use of their sit-stand workstation. This information was delivered by a representative from the company responsible for providing the sit-stand workstations. The presentation began by the instructor highlighting facts about the negative influences of sedentary behaviour to participants such as "Diabetes Risk Doubles (regardless of how much you exercise), insulin Sensitivity Plunges (up to 40%)…Heart Disease Risk Soars (up to two-and-a –half times higher)". Information regarding sit-stand workstation usage was based on an article by Lisa Marshall of Men's Journal Magazine (Marshall, 2015) and personal experience. The instructor integrated anecdotal stories into the training session. Information was gained by personal communication with the instructor. One participant was asked to participate in a demonstration during the session. Due to vacation and time off, five participants did not attend this initial training session and they completed their session in the morning of their first day using the sit-stand workstation (which coincided with the first day of them having their new workstation). Training sessions were assessed as equivalent between the first and second round of this training by M. Riddell keeping a script and checklist to ensure that no information was left out of the second training session or new information added in. The following is a summary of the topics and information that was included in the training session:

- Introduction
    - What is Ergonomics?
    - What does it mean to you?
- Chair training
    - Standing and circulation
    - Introduction of how to adjust lumbar support
    - Spoke about the importance of tilting backwards in the chair often throughout the day
    - Explained to "clench your hand" and place it behind your leg to ensure that there is adequate space between the back of your chair and your legs
- Arm rests
    - Find a natural position
    - They are not for all day use
- Desk configuration (same between sitting and standing)
    - Sitting & Standing at your workstation
        - Elbows at 90 degrees
        - Keyboard should be positioned to 1 inch below the hands
        - Suggested using the palms of the hands as support
        - Make sure the wrists are always neutral
- Sitting to standing ratio
    - 20 minutes sitting, 8 minutes standing, and 2 minutes walking
- Monitors
    - Should be able to touch the monitor without leaning forwards.
    - Further adjustments to monitor made depending on vision
    - The top line of text on the monitor should fall just below your gaze angle

Adjusting monitors when there are more than two was not covered in this training session. All participants were not given the opportunity to interact 1-on-1 with the instructor or have an opportunity to adjust their workstation in the session and receive personal feedback from the instructor.

3.3.2 Additional training session: Current best practice research

This additional training session was delivered to participants the same week as the example from industry. The training session was approximately three hours in length and comprised of time for a break and for lunch.

The training session began with an icebreaker followed by an overview of the outline of the training session. The objectives of the training session were for participants to develop an understanding of ergonomic principles, understand the risk of poorly positioned tools and how to modify them, to provide users with the knowledge to adjust their workstation as needed, and to enforce the importance of why it is important to modify their whole body posture throughout their day. The goal of the session was "To decrease musculoskeletal discomfort by way of increased variability of whole body posture (sitting to standing)". Next, an explanation of some of the language used in the presentation was described. The next slides explained some of the mechanisms of injury (force, posture and repetition). The next section of the presentation discussed some of the negative health and musculoskeletal effects of prolonged sitting and provided suggestions to mitigate these risk factors in a "How do we fix it?" slide and discussion. A main suggestion and discussion point was the integration of movement throughout a work day. A recommendation was made to participants to try and vary postures approximately every 30-minutes. It was also described to participants how pain may generate in this posture to give them background information as well as mention certain postures to avoid (such as a very rounded back in sitting and ensuring their lumbar support was properly positioned). Pictures and graphs describing postures and pain development were provided to participants to visually illustrate and reinforce discussion points made throughout the presentation.

The next section of the presentation focused on standing. Similarly, to sitting, negative health and musculoskeletal effects were described to participants to allow them to become aware of the possible undesirable outcomes of prolonged standing. Graphs were shown depicting the amount of time it takes for the average person to develop low back pain in standing (if they are a pain developer in standing). As well as an explanation as to why pain may develop while standing or a prolonged period of time (greater than two hours).   It was suggested to participants to counteract pain with movement while standing such as staggering foot position, shifting weight around while standing, and being aware of their back posture. A break was given to participants before the section about rotating between sitting and standing was discussed.

The beginning of this section once again highlighted how to help prevent musculoskeletal pain development by suggesting tips such as making small movements while sitting and standing but also to make gross movements to sitting and standing whole body postures and vice versa. A discussion between what the proper ratio of sitting to standing was had. Pain development graphs of participants sitting and standing in a 1:3 or 3:1 ratio was shown as evidence before suggesting a 1:1 ratio to participants. Participants were asked to remember to "Move Early Move Often" when using their new sit-stand workstation. Considerations regarding workstation configuration were next discussed. This discussion included the proper height of the work surface while standing (at or slightly above the elbow), positioning of the monitor (and if change was necessary and if they had 1 or more monitors), keyboard and mouse placement (pushed slightly out in front), as well as footwear considerations were discussed. Four "steps" and questions to ask themselves were presented to participants to remember when transferring between a sitting and standing posture or vice versa: 1. Set your arm posture (check the height of desk or where the armrests fall), 2. Does my monitor fall at the right height for me?, 3. Do I like where my keyboard and mouse are?, and 4. Are the documents that I am using still in a good place?. A goal of moving a minimum of four times in the morning and four times in the afternoon was suggested to those in the NFR group. Participants were asked to slowly build up their time standing (five minutes first, then adding on five more). "Tips and Triggers" were offered to participants to help remember to rotate between sitting and standing throughout the day. These included, but were not limited to, taking phone calls standing up, replying to emails standing, and changing the position of the workstation when leaving the office for a meeting or going for lunch. A summary of these tips was provided to participants for personal use (Figure 5). A series of pictures with both good and poor postures and actions were presented and participants were asked to highlight what they thought was good and what could use some improvement in each picture. If poor postures were identified a discussion was had regarding what could be changed to improve the working position.

Tips and suggestions were revisited when the question "What would you tell your friend?" was posed. At this time, discussions about sitting and standing for a prolonged period were discussed as well as rotating between sitting and standing, workstation configuration, what to do if you feel pain, and habits for getting the most use out of the workstation.

After the completion of the session all participants practiced setting up a workstation in both sitting and standing on a mock workstation, which consisted of: the same workstation they were going to use at their new office, a keyboard, a mouse, a monitor, and an office chair. Differences between training sessions are highlighted in

Table 3.

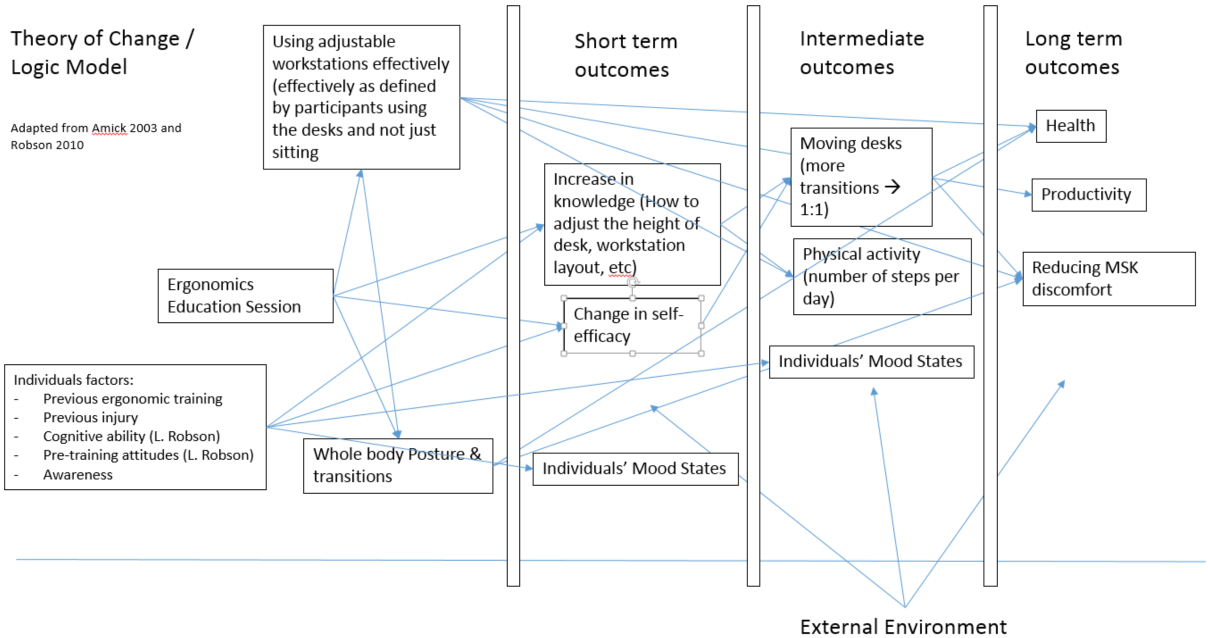

Figure 4: Theory of the proposed change model related to the integration of sit-stand workstations into the workplace in addition to an advanced ergonomic training session. Based on logic models published by Robson and colleagues (2010) and Amick and colleagues (2003).

The CSA suggestions regarding how to design training programs (

Table 2) were utilized when designing the education program that was delivered to the NFR group.

Table 2: Suggestions from the CSA on what to include in a training program.

Suggestion from CSA	How I will incorporated these suggestions into my education program
Environment should be similar to that of the actual work environment	During training sessions the chair and workstation that were installed in TechTown were used to complete the training
Should highlight the current underlying principles (i.e. good posture and reducing MSK stress)	Focused on movement throughout the day Sitting – flexion conscious Standing – extension conscious
Feedback and practice	Time was allotted to posing questions to the group and asking for their feedback as well as giving everyone a sheet that they can write down their responses A full workstation with desk, chair, keyboard, mouse and monitor arm was brought into the education room to allow participants to interact with their desk and receive feedback from M. Riddell based on their configuration in sitting and standing.
"Provide motivation to reach the outcome of the training. This can be done by focusing on the benefits of a healthy work environment"	In the "lecture" a balance between sitting and standing was emphasized along with the benefits the users could receive from both a sit and stand perspective Some negative health and MSK outcomes associated with sitting or standing for prolonged periods of time were brought into the presentation.
Use training aids such as check lists and "provide guidance throughout the learning process"	Training aids were provided in the form of business cards (Figure 5) that summarized key points from the education session tips on how to use their desk throughout the day.
Allow sufficient time for users to master the skills	This was ensured during the demo period of the education session and by meeting with participants 1-2 times a week to provide them the opportunity to ask questions about their workstation.
Clear definitions of unfamiliar content presented	During the introduction of the education session, key definitions were explained to participants
Environmental conditions	The education session mentioned on noise and lighting (glare) with respect to participants' office environment and monitors

Strategies such as behaviour change techniques (BCTs) have been employed in training sessions to promote behaviour alteration (Abraham & Michie, 2008; Michie et al., 2011; Rollnick, Miller & Butler, 2008) and in completed studies involving a change in workstation design (Healy et al., 2013; Dutta et al., 2014) and proposed studies (Dunstan et al., 2013). Suggested techniques were integrated into the research education session, as well as the follow up sessions to promote a change in behaviour from sedentary to frequently transitioning between sitting and standing (Table 4).

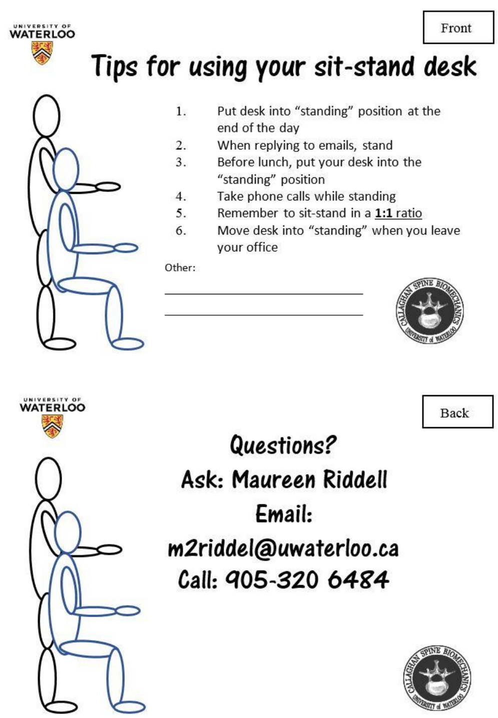

Figure 5: This small card was printed and given to those in the NFR group at the end of the training session.

Table 3: Differences between the example from industry training session and that which was based on current best practice research

Industry Approach	**Research Approach**
Length: 30 mins	Length: 2-2 ½ hours
Introduction/Description of Ergonomics	Introduction/Description of Ergonomics
How to adjust your Chair	How to adjust your Chair
Proper desk height while sitting & standing (same approach)	Proper desk height while sitting
	Proper desk height while standing
Proper monitor position - Distance and height	Proper monitor position - Distance and height (briefly) and orientation of monitors
Ratio: Sitting (20 minutes), standing (8 minutes), walking (2 minutes) **(5:2)**	Ratio: **1:1** Sitting : Standing
	Behaviour change techniques
	Motivational interviewing techniques
	Weekly Visits

Table 4: Behaviour change techniques definitions modified from Michie and colleagues (2011).

Technique	**Definition of behaviour change technique**	**Incorporation into NFR education session**
Provide information on consequences of behaviour in *general*	Information about the relationship between the behaviour and its possible or likely consequences *in the general case*.	Participants were provided with information regarding why posture variation is important and how it can reduce MSD and increase overall health.
Goal setting	The person is encouraged to make a behavioural resolution (e.g. Take more exercise next week). This is directed towards encouraging people to decide to change to maintain change.	The behavioural resolution emphasized in this training session is a balance sitting and standing in a 1:1 ratio.
Action planning	Involves detailed planning of what the person will do including, as a minimum, when, in which situation and/or where to act. 'When' may describe frequency (such as how many times a day/week or duration (e.g. for how long). The exact content of action plans may or may not be described, in this case code as this technique if it is stated that the behaviour is planned contingent to a specific situation or set of situations even if exact details are not present.	During the education session participants were provided the opportunity to make a goal for themselves on how many times they will try to transition from sitting to standing to meet their goal of "x" many times per week. Goals will be set with participants of moving every 15-20 minutes between sitting and standing.
Provide instruction on how to perform the behaviour	Involves *telling* the person how to perform behaviour or preparatory behaviours, either verbally or in written form. Examples of instructions include; how to use gym equipment (without getting on and showing the participant), instruction on suitable clothing, and tips on how to take action Showing a person how to perform a behaviour without verbal instruction would be an instance of technique 22 only.	This was provided by the company installing the sit-stand workstations: instruction on how to adjust the table height.
Model/Demonstrate the behaviour	Involves *showing* the person how to perform a behaviour e.g. through physical or visual demonstrations of behavioural performance, in person or remotely.	The NFR group had the opportunity to adjust the table themselves (during the demo session) and witness how to adjust their workstations based on certain cues from their body.

Teach to use prompts/cues	The person is taught to identify environmental prompts which can be used to remind them to perform the behaviour (or to perform an alternative, incompatible behaviour in the case of behaviours to be reduced). Cues could include times of day, particular contexts or technologies such as mobile phone alerts which prompt them to perform the target behaviour.	Cues and tips were given to the NFR group such as: take phone calls standing up, when you leave at night and go for lunch place desk in standing position, transition to opposite posture before/ after snack or water break, respond to emails standing etc.
Motivational interviewing	This is a clinical method including a specific set of techniques involving prompting the person to engage in change talk in order to minimize resistance and resolve ambivalence to change (includes motivational counselling).	M. Riddell engaged in "change talk" with participants during weekly visits with participants in the NFR group.

Note: Columns one and two are directly taken from Table 3 in Michie et al., 2011.

3.4 Measures

Assessments were completed in two locations: Lyle Hallman North, and building #340 (TechTown) located in North Campus. Before the beginning of Phase II, sit-stand workstations were implemented into PROPEL's new workspace. Phase I was the baseline period of participants in their current office workstations. Participants received the education sessions during the washout phase between Phase I and II. Phase II started the first day that participants move into their new office and had the use of their sit-stand workstation. Phase III involves measures post-installation after training intervention. The study lasted for 14 weeks in total with Phases I-III each lasting for four weeks and one week of washout between each phase.
During the first two days of Phase I, the researcher, M. Riddell, met with each participant to complete the required questionnaires (Table 5) and to give each participant their Fitbit. The MPS questionnaire was completed four times a day by participants to assess musculoskeletal pain starting on day one of the study. M. Riddell worked with the information technology department to install the pain questionnaire program onto participants' computers. All initial meetings began with a brief overview of the study and the signing of the consent forms and a standardized health questionnaire will be completed by all participants (Appendix B). This study received ethics clearance from the University of Waterloo's Office of Research Ethics prior to its beginning.

3.4.1 Sit-stand workstations

Both NFR and NFI groups received a Fundamentals, EX Electric table sit-stand workstations at the beginning of Phase II (Figure 6). All participants attended an orientation session provided by a representative from the company providing the workstations. Additionally, the NFR group received the most current sit-stand workstation ergonomic education delivered by M. Riddell.

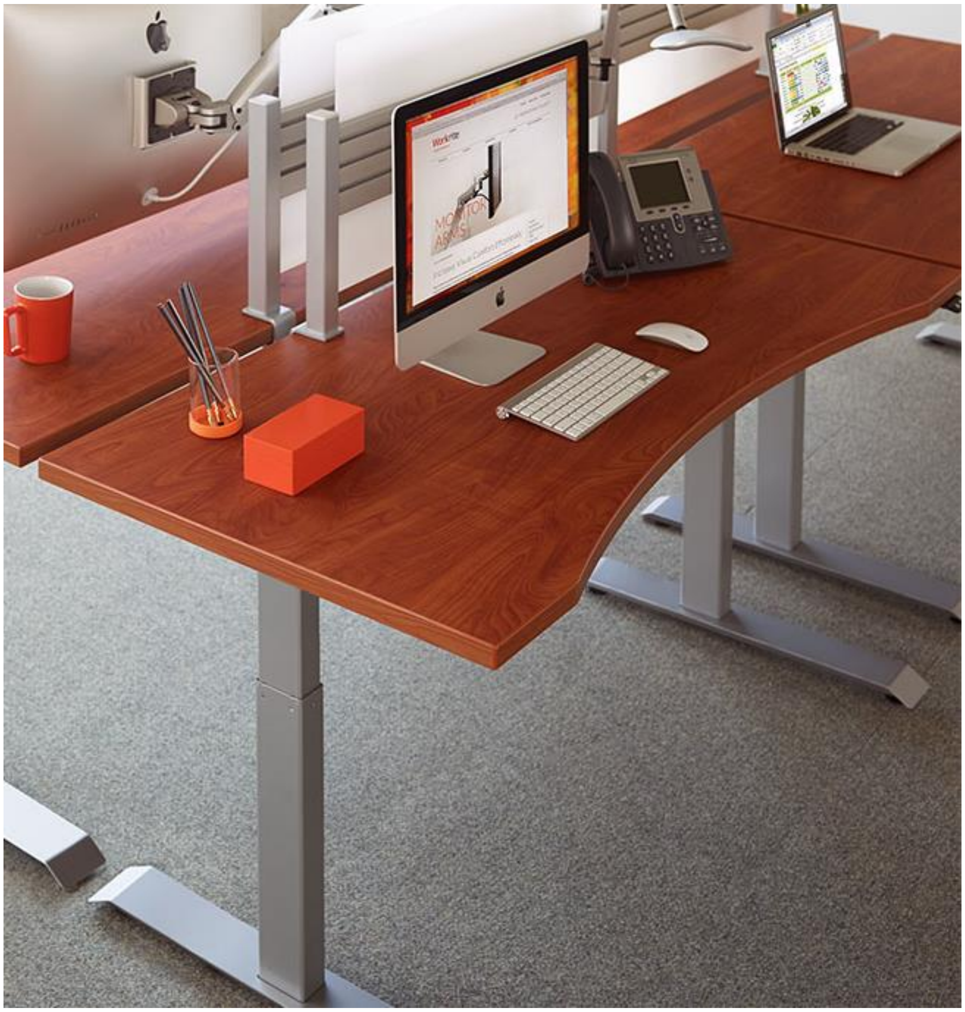

Figure 6: The Workrite Ergonomics Fundamentals EX Electric table intalled prior to the beginning of Phase II.

3.4.2 Active Hip Abduction Test

The Active Hip Abduction Test (AHABD) was designed by Nelson-Wong and colleagues (2009) to be used as a tool to aid in the identification of low back pain developers in response to occupational tasks that require standing for prolonged periods of time. The foundation of this test lies with the recent literature stating that PDs are likely to exhibit traits such as “increased bilateral gluteus medius and trunk flexor-extensor muscle co-activation” (Nelson-Wong, Flynn, & Callaghan 2009, pg 649). The AHABD test assesses the level of control that the individual completing the test has while sidelying (Nelson-Wong, Flynn, & Callaghan 2009). Participants began the test by lying on their side with their hips and feet “stacked” with no hand support on the table (Nelson-Wong, Flynn, & Callaghan 2009). Participants were instructed to “Please keep your knee straight and raise your top thigh and leg towards the ceiling, keeping them in line with your body, and try not to let your pelvis tip forwards or backwards” (Nelson-Wong, Flynn, & Callaghan 2009, pg 650).

3.4.3 Inertial Measurement Unit: Fitbit Zip

Commercial inertial measurement units (IMUs) produced by companies such as Nike, Fitbit (One and Zip) and Jawbone have recently been used in studies as a method to record steps and distance traveled by the wearer. However, the price of commercially available devices does not reflect the accuracy of the device (Ferguson, Rowlands, Olds, & Maher, 2015). When compared to research grade devices such as the AG3X ActiGraph (ActiGraph, Pensacola, FL), few devices are as accurate (Lee, Kim, & Welk, 2014). The Fitbit Zip (Fitbit Inc., San Francisco, CA) had the strongest relationship to a gold standard device used for indirect calorimetry assumptions and second lowest error percentage behind BodyMedia FIT (BodyMedia Inc., Pittsburgh, PA) (Lee, Kim & Welk, 2014) and a strong correlation to steps measured by an ActiGraph (Ferguson et al., 2015). Of seven consumer products tested against an ActiGraph and BodyMedia devices, the Fitbit Zip was one of only three devices that performed strongly (Ferguson et al., 2015).

In the current study, the Fitbit Zip was chosen to record participants' movement both inside and outside the workplace due to its high validity in measuring steps when worn on the hips (Ferguson et al., 2015), long battery life (four to six months) (Regenerant, Refills, Cartridge, & Cartridge, 2004), and cost (Lee, Kim & Welk 2014). Participants were asked to wear the Fitbit Zip everyday throughout the study and to remove the device when playing contact sports or swimming.

3.4.4 Intake Questionnaires

Meetings were scheduled with each participant during the first or second day of Phase I to allow participants time to read and sign their consent forms for participation as well as complete questionnaires required at baseline (Table 5). A standardized health questionnaire form was completed by participants, (Appendix B), Profile of Mood States (POMS) (Appendix C), and intake/job questionnaire (Appendix D). In the intake questionnaire, participants were given a questionnaire that asked to "What specific benefits do you believe you would gain by alternating between a seated and standing position?". Participants were asked to check off all that applied from the following list: Uncertain, less stressed, more comfortable, more productive, more focused, happier, energies, healthier, none of the above, and other.

3.4.5 Profile of Mood States

The Profile of Mood States (POMS) (Grove & Prapavessis, 1992) questionnaire has been used in a previous study evaluating the effect that the implementation of a sit-stand workstation has on participants' mood states (Pronk et al., 2012). A modified version of the POMS test (one with fewer adjectives and a self-esteem section) has been used in the past to determine the changes in mood states that occurs when a sit-stand workstation is introduced into the workplace (Pronk et al., 2012). This abbreviated version of the POMS with self-esteem adjectives has been evaluated for its internal consistency which ranged from 0.872 to 0.954 for fatigue anger and vigour and 0.701 to 0.766 for tension esteem and confusion and 0.664 for depression (Grove & Prapavessis, 1992). This questionnaire was completed in the form of a survey in Microsoft Excel. Participants were asked to read the list and select a radio button to describe what descriptor best represented their feeling in the past week. Caution was taken to ensure that all 40 descriptors had been filled. However, some blank responses were missed, which resulted in the removal of participants' scores at the beginning of Phase II (one participant), the end of Phase II (one participant), and the end of Phase III (two participants).

3.4.6 Musculoskeletal Pain Scale

Musculoskeletal pain for six regions in the body was assessed using an eight level ordinal scale. The musculoskeletal pain scale (MPS) assessed pain in the neck, right and left shoulders, lower back, buttocks, and feet at regular intervals throughout the day: approximately 8:30am, 12:00pm, 1:00pm, and approximately 5:00pm. Depending on the schedule of individuals these times were slightly adjusted to ensure that participants would complete four questionnaires throughout the day such as adjusting the time of the fourth measure so those who left early could complete it. In Phase II, participants in the NFR group received a reminder on the bottom of their pop-up about the optimal sit-stand workstation ratio (1:1). These reminders were removed from their pain surveys for Phase III. Those in the NFI group did not receive these additional reminders.

The 8-point Likert scale was custom made in MATLAB (R2015a, MathWorks, Natick, MA, USA). Anchors on the Likert scale were borrowed from Robertson and colleagues (2013) scale that was used to assess musculoskeletal discomfort. The program had a number of features built in it to make sure that participants completed pain assessments for each body region. After participants were finished filling out their form they could click a button to submit their pain survey “Submit”. Upon clicking this button, the program checked that all required fields had been filled out. These areas were: the time, region one (Neck), two (Left Shoulder), three (Right Shoulder), four (Lower Back), five (Buttocks), and six (Feet). Participants were not required to always have something typed in the “Additional Comments” section. If the program determined that there was missing data filled out then a comment box would pop up saying “Please check if you have completed all pain regions, and the time” (Figure 7). The “X” button in the top right corner was disabled so if participants clicked the button a message would pop up reminding participants to use the “Submit” button to submit their pain score. This prevented participants from accidentally exiting out of the program when they had filled in all the pain reports for each region but did not press “Submit”.

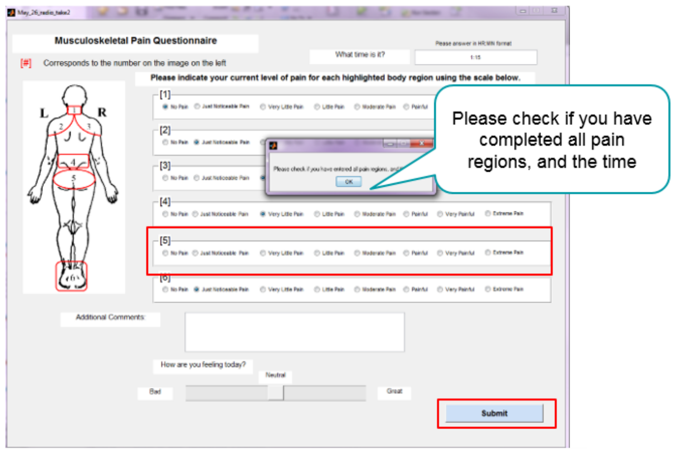

Figure 7: Error message that would pop up when participants filled out the musculoskeletal pain questionnaire and one region was accidentally left blank.

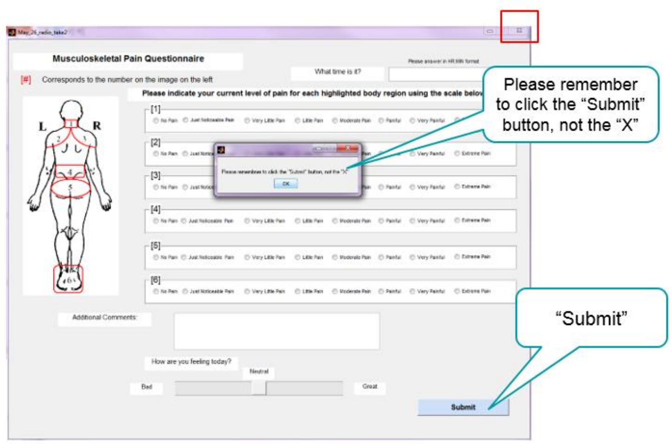

Figure 8: Example of error message that would pop up when participants tried to exit the questionnaire using the "X" button.

3.4.7 Occupational sitting and physical activity questionnaire

The Occupational Sitting and Physical Activity Questionnaire (OSPAQ) was used to collect self-reported information from participants about how much they felt they sat or stood at work. Not all studies have used a validated sedentary or physical activity questionnaire to assess sitting time pre or post intervention (Pronk et al., 2012). Pronk and colleagues (2012) assessed sitting time as a part of an intake questionnaire. Chau and colleagues (2012) validated the OSPAQ (Figure 9) tool against accelerometers to assess sitting, standing, and walking behaviours in “white collar” employees finding a difference of 22 minutes between subjective and objective measures. It was found that this questionnaire possessed excellent test-retest reliability and moderate to high validity especially for time spent sitting and standing (van Nassau, Chau, Lakerveld, Bauman, & van der Ploeg, 2015). The sample population used to validate this tool was representative of the population that will participate in the current study: mostly female, university educated, of normal weight, and worked more than 30h/week. The OSPAQ questionnaire asks participants to divide their time into four different categories of activities: sitting, standing, walking, or heavy labour or physically demanding tasks. The questionnaire was administered to participants at the beginning of Phase I, end of Phase I, end of Phase II and the end of Phase III to assess their perception of how much they are completing these activities.

Occupational Sitting and Physical Activity Questionnaire

How many hours did you work in the last 7 days?		hours
During the last 7 days, how many days were you at work?		days

Example:

Jane is an administrative officer. Her work day invovles workign on the computer at her desk, answering the phone, filing documents, photocopying, and some walking around the office. Jane would describe a typical work day in the last 7 days like this:

Sitting (including driving)	90	%
Standing	5	%
Walking	5	%
Heavy labour or physically demanding tasks	0	%
Total	100	%

How would you describe your typical work day in the last 7 days? (This involves only your work day, and does not include travel to and from work, or what you did in your leisure time)

a. Sitting (including driving)		%	
b. Standing		%	
c. Walking		%	
d. Heavy labour or physically demanding tasks		%	
Total	0	%	Make sure adds up to 100%

Score

Minutes sitting at work per week	0
Minutes sitting per workday	0
Minutes standing at work per week	0
Minutes standing per workday	0
Minutes walking at work per week	0
Minutes walking per workday	0
Minutes doing heavy labour at work per week	0
Minutes doing heavly labour per workday	0

Figure 9: Occupational Sitting and Physical Activity Questionnaire (OSPAQ)

3.4.8 Ergonomic Knowledge Test

An ergonomic knowledge questionnaire was employed to assess the current level of knowledge of the participants. The test allowed a comparison of scores pre and post training sessions as well as throughout the study to ensure that there was no cross-contamination of information that occurred between groups. The Questionnaire consisted of five different areas:

Monitor position, Keyboard and Mouse, Chair, Desk and Sit-Stand. In each section, participants were asked to either "Agree" or "Disagree" with statements provided (Appendix E). There was a third response that participants could choose if they were not sure of their answer. This questionnaire was administered to participants at the beginning of Phase I, after everyone received the training session that was representative of an example from industry, after those in the NFR group received their additional training session, at the end of Phase II, end of Phase III and to The NFI group after they received the training session that was indicative of current best practice. Correct responses of either agreeing or disagreeing with a particular statement were awarded a score of "1". If a missing field was overlooked and was not completed, the participant was given a score of "0" on that particular question. A response of "Not sure/Don't Know" was not awarded any points. Please note that this questionnaire was intended to be used as a verification tool to ensure that there was no cross-contamination of information between groups throughout the study. It was not intended as a primary assessment tool to determine participants' knowledge in the area of Ergonomics. As assessed by the Ergonomic Knowledge Assessment questionnaire there was no change in scores for the NFI group across the phases of the study (p=0.2381). Those in the NFI group scored an average of 12.1 (±2.6) after receiving the example from industry training session, 10.6 (±2.4) at the end of Phase II and 10.7 (±3.2) at the end of Phase III (Figure 10). After the additional training session was delivered to participants in the NFI group (after the completion of Phase III), Ergonomic Knowledge Scores were reassessed and compared to those in the NFR group after they received their additional training session at the beginning of Phase II. Scores out of a possible 18 marks for the NFI group were 16.1 (±2.2) and for the NFR group was 17.7 (±1.35). Although scores were similar between groups there was a significant difference between groups as assessed using an independent samples t-test (p=0.0168).

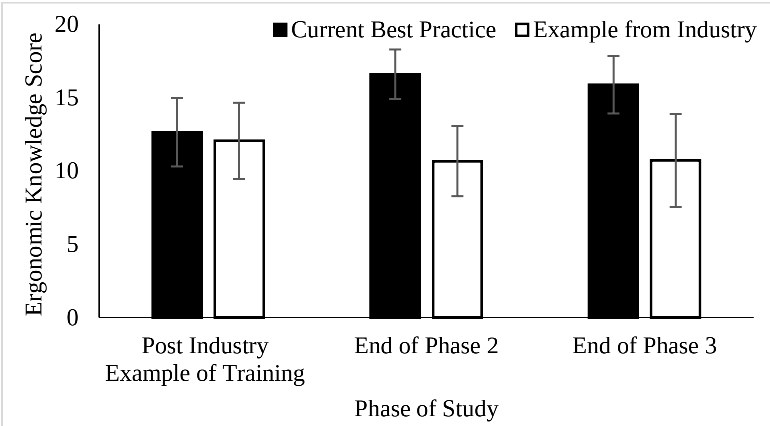

Figure 10: Ergonomic Knowledge Scores for the NFR (Current Best Practice) and NFI (Example from Industry) for different Phases of study. Post Industry Example Training are the scores from both groups initially taken when both groups received the training.

3.4.9 Accelerometers

A battery powered tri-axial accelerometer (Gulf coast solutions, Waveland, Mississippi) (Figure 11) was securely mounted to the side of each participant's desks. The accelerometer has 16bit resolution and was sampled at 12Hz and an 8BG mini-SD card logged data throughout the workday to log data throughout the day. Data was extracted from the accelerometer during weekly visits by M. Riddell.

Figure 11: Data logging tri-axial accelerometers mounted to workstations to capture movement of the sit-stand workstation.

Data was recorded for all days for participants from approximately 6:30am to 7:00pm in Phase II and III of the study with 20 working days in each phase. Additional days of collection were only added onto each phase if participants were on vacation or off due to scheduling as 11 participants worked part time and were not in the office from Monday thru Friday from 8:30 to 4:30. Days were not added on if participants were off due to illness, had all day meetings or were out of the office for part of the day due to work or personal reasons. For those part time participants, the usual number of days they worked each week were taken as their "normal" work week. For example, if someone worked 80%/ four days a week there would be a total of 16 days in each phase of the study instead of five each week which would result in a full 20 days in each Phase.

Accelerometers were secured onto the workstation using a custom jig to track workstation movement (Figure 12). Accelerometers were attached using Velcro to the metal bar. One end of the bar was attached via a pivot point to a wooden block that was taped to the stationary part of the telescopic leg of the desk. The other end of the bar was attached to the underneath of the work surface using a piece of fishing line (Red Wolf rated for 10lb). When participants' moved their desks the work surface would change height and would therefore either pull the string up (if the participant was going to standing) or reduce the tension and the weight of the bar would pull the string down (when going to sitting) (Figure 13). The change in angle of the bar would be recorded by the accelerometer reading different amounts of gravity partitioned to different axes of the accelerometer (Figure 13). Outputs from the x axis was used for analysis purposes. Post processing of the accelerometer signal will be described further in the data analysis section.

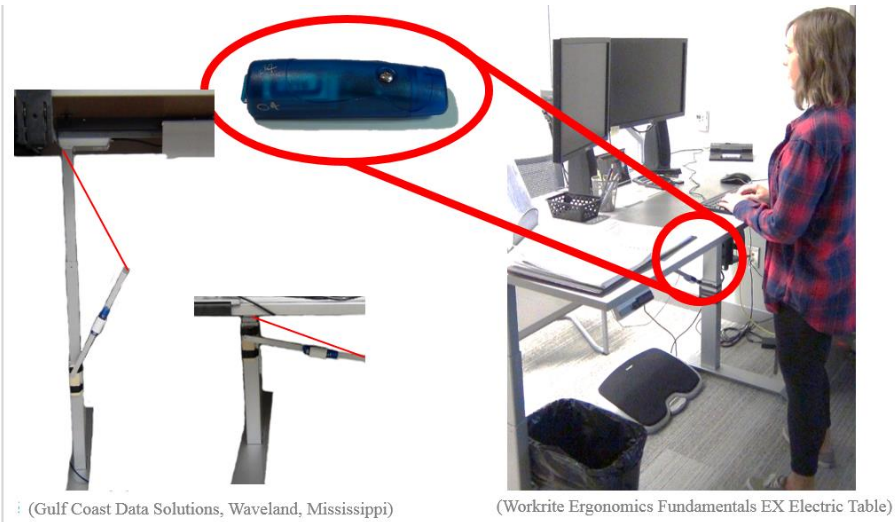

Figure 12: Custom Accelerometer jig on workstation

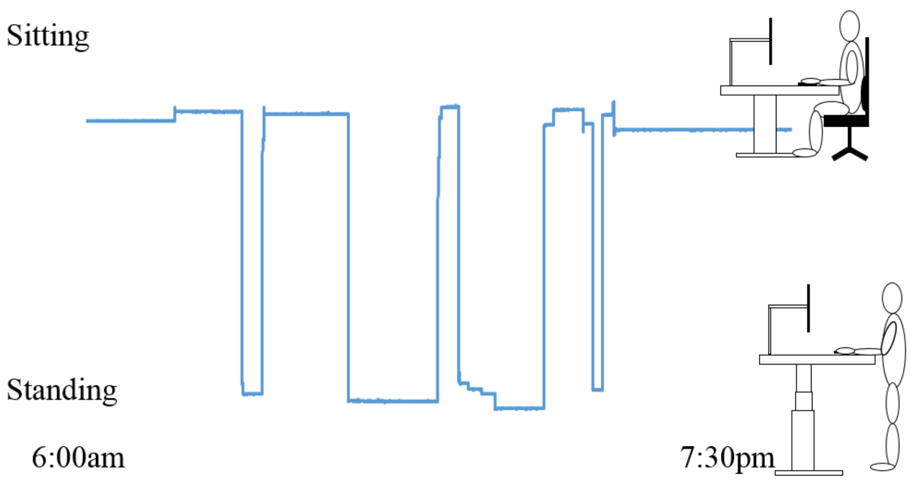

Figure 13: Sample accelerometer tracing for one day

Table 5: Questionnaires and Measures timeline breakdown.

Questionnaire/ Measure	Administration Technique	Time Point	Who Completes?
PHASE I: BASELINE MEAUSRES (Everyone n= 35)			
Health questionnaire	In person by M. Riddell	Baseline – Day 1	Everyone
Intake/ Job questionnaire	In person by M. Riddell	Baseline – Day 1	Everyone
Active Hip Abduction Test	In person by M. Riddell	Baseline – Day 1	Everyone
Occupational sitting time and physical activity questionnaire	In person by M. Riddell	Baseline – Day 1	Everyone
Profile of Mood State Questionnaire	In person by M. Riddell	Baseline – Day 1	Everyone
MPS questionnaire	On computer	Baseline (4wk) – Daily*	Everyone
Baseline Ergonomic knowledge test	In person by M. Riddell	Baseline – Day 1	Everyone
Daily count of step counts	Fitbit Zip	Daily – inside and outside of work	Everyone
Occupational sitting time and physical activity questionnaire	In person by M. Riddell	Last day of Phase I	Everyone
Profile of Mood State Questionnaire	In person by M. Riddell	Last day of Phase I	Everyone
MOVE/ NEW WORKSTATION INSTALLATION			
PHASE II: PARTICIPANTS DIVIDED INTO 2 GROUPS (NFR n= 17, NFI n= 18)			
Health questionnaire	In person by M. Riddell	Baseline – Day 1	Everyone
Profile of Mood State Questionnaire	In person by M. Riddell	Intervention block – Day 1	Everyone
Ergonomic knowledge	Individually completed on test	After ergonomics education session	NFR group
MPS questionnaire with reminders	On Computer	Intervention block (4wk) – Daily*	NFR group

MPS questionnaire	On computer	Intervention block (4wk) – Daily*	NFI group
Daily count of step counts	Fitbit Zip	Daily – inside and outside of work	Everyone
Desk movement	Desk mounted tri-axial accelerometers	Daily	Everyone
Occupational sitting time and physical activity questionnaire	In person by M. Riddell	Last day of Phase II	Everyone
Profile of Mood State Questionnaire	In person by M. Riddell	Last day of Phase II	Everyone
1 WEEK WASHOUT PERIOD			
PHASE III: POST-MEASURES (Everyone n= 35)			
Health questionnaire and Intake/Job questionnaire	In person by M. Riddell to ensure no major changes had occurred	Intervention block – Day 1	Everyone
Ergonomic knowledge	Individually completed	End of Post Measures	Everyone
MPS questionnaire	On computer	Post Measures (4wk) – Daily*	Everyone
Daily count of step counts	Fitbit Zip	Daily – inside and outside of work	Everyone
Desk movement	Desk mounted tri-axial accelerometers	Daily*	Everyone
Occupational sitting time and physical activity questionnaire	In person by M. Riddell	Last day of Phase III	Everyone
Profile of Mood State Questionnaire	In person by M. Riddell	Last day of Phase III	Everyone

Note: Daily* Whole body MPS will be assessed throughout the day at 8:30am, 12:00pm, 1:00pm, and 5:00pm (first thing in the morning, before and after lunch, and at the end of the day before participants went home)

3.5 Six-Month Follow-Up

Two weeks after the completion of the study, the additional training session was taught to those in the NFI group. There was no refresher training session for those in the NFR group. This follow-up was completed approximately six months following the delivery of the additional training program to the NFI group (April 2016). The same presentation was delivered along with the hands-on demonstration period. Data for the number of sit-stand transitions made each day were collected for two weeks without participant's knowledge. Participants were blinded to when this follow-up session occurred. After the completion of these two weeks the POMS and OSPAQ questionnaires were completed by participants.

3.6 Data analysis

Thirty-five participants were included in the analysis portion of this study. One participant was removed from analysis due to intentional manipulation of their data. Please note that there is one-day missing from Phase I due to a national holiday (Canada Day). It was not possible to append another day onto the end of Phase I to make up for the missing day as the 5^{th} week was needed to complete the training sessions and to move offices to another building off-campus. There are 20 days in Phase II and III of the study for those who worked 100% of the time during the week. Those who only worked part time have a condensed number of days in each Phase of the study. In Phase II and III there was more flexibility with time that would allow for collection of more days to make up for days that participants were not in the office due to vacation days or holidays. Please note that days were only appended on to the length of the study if participants were not at work due to vacation days or if they were not schedule to work (those working 80%). Days were not added onto the end of the day if participants reported being sick or at meetings for the majority of their day.

M. Riddell met with participants during the first two days of the study (June 8th and 9th) in order to collect complete an initial interview with participants where initial surveys were completed and Fitbit Zip devices were distributed. The musculoskeletal GUI was remotely installed on participants' computers as to allow the reporting of pain beginning on Monday June 8th. Due to complications in this process, musculoskeletal pain not collected on Monday June 8th for participants. Musculoskeletal pain collection began Tuesday June 9th.

3.6.1 Active Hip Abduction Test

The AHABD test was completed once on each side of the participant (Nelson-Wong, Flynn, & Callaghan, 2009). After the completion of the test on one side M. Riddell scored the participant based on the AHABD scoring criteria (Table 6). The protocol was then completed on the other leg and the scores recorded. A score of two or higher, as scored by the researcher, was used to classify participants as likely to develop LBP while standing for prolonged periods of time and will therefore classify participants as a positive "P" test (Nelson-Wong, Flynn, & Callaghan, 2009). A score of zero or one categorized participants as a having a negative test "N". These participants were deemed "unlikely" to develop LBP while standing.

Table 6: Scoring cues for the examiner to assign a score to each leg of a participant who completes the Active Hip Abduction Test. (Table is taken from Nelson-Wong, Flynn & Callaghan, 2009).

Test score assigned to each lower limb	Cues for Examiner (M. Riddell)
0 = No loss of pelvis frontal plane	- Participant smoothly and easily performs the movement. - Lower extremities, pelvis, trunk and shoulders remain aligned in the frontal plane.
1 = Minimal loss of pelvis frontal plane	- Participant may demonstrate a slight wobble at initiation of the movement, but quickly regains control. - Movement may be performed with noticeable effort or with a slight ratcheting of the moving limb.
2 = Moderate loss of pelvis frontal plane	- Participant has a noticeable wobble, tipping of the pelvis, rotation of the shoulders or trunk, hip flexion, and/or internal rotation of the abducting limb. - Movement may be performed too rapidly, and participant may or may not be able to regain control of the movement once it has been lost.
3 = Severe loss of pelvis frontal plane	- Participant demonstrates the same patterns as in a test score of 2, with greater severity. - Participant is unable to regain control of the movement and may have to use a hand or arm on the table to maintain balance.

3.6.2 Inertial Measurement Unit: Fitbit Zip

The number of steps that each participant took each day was recorded using the Fitbit Zip device. Each participant was given a wireless dongle to allow the Fitbit Zip to automatically sync step data to participants' individual profiles when the dongle and the Fitbit Zip were within 6m of each other. Each participant had a unique online profile (synced with the Fitbit Zip via a unique code), for the data to be uploaded daily. The participants did not have access to this information until they completed the study. The face of the Fitbit Zip, which displays the distance and number of steps walked each day, was covered with a piece of black electrical tape to ensure that the participants did not have any feedback as to how many steps they were taking each day.

Steps from Fitbit data were organized into the specific day of data corresponding to a particular day of each phase. A score of "0" occurred when the Fitbit Zip was not worn by the participant but the logger was still recording data. These "0"'s were deleted so not to skew the day as the average of each phase was taken for analysis and replaced with "." to represent missing data. Missing days when the Fitbit was unsuccessfully synced and data were lost was also coded as missing ("."). In total, participants wore their Fitbit Zips to work 80.27% of the time in the study. Missing days of data for each group and phase have been provided (Table 7). In Phase III two participants from the NFI group did not have any data and one participant in the research did not have any data.

Table 7: Summary of the days missed wearing the Fitbit device for each phase and group.

	Phase I		Phase II		Phase III	
	Total days missed	Percentage of days missed	Total days missed	Percentage of days missed	Total days missed	Percentage of days missed
NFR	18	5.26%	48	13.33%	101	28.06%
NFI	57	16.66%	89	24.72%	118	32.78%
Total	75	21.93%	137	38.06%	219	60.83%

Note: This table includes only those who participated until the completion of Phase I as to allow division of participants into groups. Phase I had only 19 working days instead of 20 due to Canada Day.

3.6.3 Profile of Mood States Questionnaire

The Profiles of Mood States Questionnaire (POMS) was administered by M. Riddell at four time points throughout the study: Beginning of Phase I, end of Phase I, end of Phase II, and the end of Phase III. Subjects were asked to assign a number on a scale from one to five to describe their relationship toward a type of feeling that was presented. Participants were instructed as in Pronk and colleagues (2012) “The following list describes feelings people have. Please read each one carefully and select the answer that best describes your feelings in the past week” (Pronk et al., 2012) (Appendix C). Participants chose descriptors of “Not at all”, “A little”, “Moderately”, “Quite a bit”, and “Extremely”. A numeric scale was assigned to each scaling factor ranging from 0 to 4: Not at all=0, A little=1, Moderately=2, Quite a bit=3, Extremely=4. The 40 feelings presented were grouped into seven different categories: tension, depression, fatigue, confusion, anger, vigour, or self-esteem. The scores for each feeling were summed to result in score for each category. To determine the total mood disturbance (TMD) the following equation was used:

$$TMD = [(tension + depression + fatigue + confusion + anger) - (vigour + self\text{-}esteem)] + 100$$

As a constant of 100 is added to the score, higher scores will give a stronger indication of mood disturbance than a lower score (Grove & Prapavessis, 1992; Pronk et al., 2012).

3.6.4 Musculoskeletal Pain Scale

Pain was recorded for each body region four times a day. Pain that was felt in six specific regions of the body were assessed using a custom made MATLAB graphic user interface (GUI) that was installed on participants’ computers. The six highlighted regions of the body were assessed: neck, right shoulder, left shoulder, lower back, buttocks, and feet (right and left combined). Feelings of pain were reported on a Likert scale by clicking off a box to indicate that pain is felt that reflects the descriptor (Appendix A). The scale had eight evenly placed boxes labeled “No Pain”, “Just Noticeable Pain”, “Very Little Pain”, “Little Pain”, “Moderate Pain”, “Painful”, “Very Painful”, and “Extreme Pain”. These words were matched with numbers from 0 (No Pain) to 8 (Extreme Pain). The max pain that was reported for each region of the body was extracted and used for data analysis. Participants were asked to note ratings of pain due to outside occurrences (i.e. Pain from playing sports) in the comments section of the GUI to allow M. Riddell to remove these reports from the musculoskeletal reports for the specific region. During processing, any pain reports that the participant had deemed was clearly unrelated to their workstation (such as pain in shoulder due to lifting weights, or “got hit in ankle with softball last night”) was removed from the data set. Any score above “0/No Pain” indicated to M. Riddell that the individual experienced some level of pain throughout the day. Another analysis was performed to determine if Group, AHABD status or Time had an influence on the number of days that participants reported pain in each phase of the study.

3.6.5 Occupational Sitting and Physical Activity Questionnaire

The OSPAQ was administered by M. Riddell to all participants involved in the study at various time points (Table 5) to assess their subjective opinion on how much time they spent sitting, standing, walking or completing physically demanding tasks at work for a typical workday. Participants were then asked to assign percentages to four categories (sitting, standing, walking, and heavy labour or physically demanding tasks) that comprise a typical workday (Figure 9). The percent of their day that participants’ reported spending in a particular posture was assessed at four different time points throughout the three-month period: at the beginning of Phase I, the end of Phase I, the end of Phase II and the end of Phase III.

3.6.6 Accelerometers/ desk movement

The number of whole body transitions made each day was recorded using data logging accelerometers (Figure 10). Any change in position greater than 15 seconds was recorded as a change in whole body posture and a transition was added to participants' total count. This duration was chosen in order to exclude quick movements of the accelerometer that may have been caused by people kicking it with their foot, or nudging it while moving boxes that were close to the jig. Data collected by the accelerometer at 12Hz from 7:30am to 7:30pm each day to ensure that movement of the sit-stand workstations as assessed while still preserving battery life of the accelerometers. Transitions between sitting and standing were extracted from the accelerometer tracing by any differences in tilt of the accelerometer. The number of transitions that were made were recorded on a daily basis for each participant and were analyzed for Phase II and Phase III.

3.6.7 Weekly meetings with participants in Phase II

M. Riddell met with participants approximately one to two times each week. These were quick meetings (<10 minutes) and followed a strict decision tree to guide conversations with participants (Appendix F). Over the course of Phase II participants met with M. Riddell an average of 5.2 (±1.2) times (

Table 8).

Table 8: Number of weekly meetings with participants in Phase II for those in the group that received the additional training program based on current best practice research.

Subject Number	Frequency of meeting in Phase II
1	5
2	5
3	4
4	3
5	6
6	8
7	7
8	6
9	4
10	6
11	5
12	5
13	4
14	5
15	6
16	5
17	4

3.6.8 Six-Month Follow-Up

This follow-up was completed approximately six months following the completion of Phase III (April 2016). Those who originally only received only the industry example of training participated in a training session at the end of Phase III where they received the training session based on current best practice research. Of the 35 participants who completed the study, six participants were not included in the six-month follow-up. Two of the five participants did not participate in the six-month follow-up because they were on maternity leave, one changed offices, one changed jobs, and two did not participate in the make-up training session. Data are still being collected from six participants due to technical difficulties while collecting data from the accelerometers in the original six-month follow-up. Please note that the participant that manipulated their data was not included in the six-month follow-up. Data from participants are not taken from the exactly the same two weeks due to issues with the accelerometers. Data from the first consecutive 10 days were used for analysis.

Three participants' data for the POMS questionnaire were not included in the analysis because one participant was very sick for three days before they took the questionnaire and two participants were on vacation. Analysis was not completed on the "heavy labour and physically demanding tasks" component of the OSPAQ questionnaire because only one participant reported spending 5% of their time completing "heavy labour and physically demanding tasks" where all the other participants reported 0%. Measures that were taken during the original study but not in the follow-up period are: daily measures of musculoskeletal pain scores, daily steps (Fitbit Zip), the ergonomic knowledge assessment, and the active hip abduction test was not re-done.

3.7 Statistics

Hypotheses were tested using the statistical software SAS 9.3 (The SAS Institute, Cary NC, USA). People were semi-randomly divided as into either the NFI or NFR group and matched based on their daily tasks, sex, age and a social aspect. Groups were not balanced based on their AHABD test score and did not have even proportions of males and females. Where applicable, between factors of group, and pain classification from AHABD test and a within factor of time was incorporated into a three-way general linear model (Table 9). Normality was tested for variables by analyzing the skewness and kurtosis of data, histograms and the Shapiro-Wilk test. There were no violations of normality. Bonferroni corrections for multiple comparisons were made where appropriate. These p-values were used to accept or reject the null hypothesis. P-values are presented in the results section below.

Table 9: Factors used to complete statistical analyses.

Factor	Type	Factor Levels
Group	Between	NFR: Current best practice research training program NFI: Example from industry training program
Time	Within	Phase: Phase I/2/3
	Within	Week: Week1/2/3/4/5/6/7/8/9/10/11/12
***Active Hip Abduction Test Score**	Between	Positive Negative

*Note: This was not included as a between factor because not all participants completed this test at the beginning of the study.

Statistical analyses are presented for hypotheses separately as the inclusion of between factors depended on the specific hypothesis. Note that three participants did not complete the AHABD test at the beginning of Phase I and are therefore not included in analyses that used AHABD as a factor (total n=32). All 35 participants were included in the analyses where AHABD status was not included as a factor. Gender was not analyzed as a factor due to small sample sizes (three males in the NFR group and 4 males in the NFI group) (only 1 participant in 2 categories). Similar studies investigating the usage of sit-stand workstation usage did not include gender as a factor in their statistical model (Pronk et al., 2012; Robertson et al., 2013).

Statistical models used to answer hypotheses #1-4

Individual two way general linear models with a between factor of group and a within factor of time (three phases) were used to assess the following variables: daily step counts, total POMS score, individual mood state scores, self-reported sitting throughout the day, self-reported standing throughout the day, self-reported walking throughout the day, self-reported heavy labour throughout the day, daily frequency of sit-stand transitions, number of days where the sit-stand workstation was not used at all, and the days where musculoskeletal pain was reported for each pain region. Sit-stand transitions were assessed in five day increments to determine if there was an effect of week on the daily sit-stand transitions. These data were entered in to a 2-way general linear model with a between factor of group and a within factor of time (12 weeks).

Statistical models used to answer hypothesis #5

Differences between groups at the beginning and end of the study were determined by using a Fisher's exact test. Differences within each group from the beginning to end of the study were be determined by using two McNemar tests. Three way general linear models with between factors of group, AHABD status and a within factor of phase were completed to analyze daily step counts, and sit-stand transitions. The number of days where the workstation was not used at all was assessed using this model. Self-reported measures of sitting, standing, walking and heavy labour or physically demanding tasks were also analyzed using this approach. The percentage of days that participants reported pain above a score of one was also analyzed in the model presented above.

Six-month follow up

Measures of sit-stand transitions, self-reported amounts of sitting, standing, walking, and mood states were re-collected six-months after each participant had completed the initial 3-month collection. Measurements from the six-month follow-up and Phase III were compared using a 2-way general linear model with a between factor of group and a within factor of time. Analyses which included the investigation to determine if there was still an influence of AHABD status (transitions and self-reported measures of sitting, standing, walking and heavy labour) were entered into a 3-way general linear model with between factors of group and AHABD status and a within factor of time.

Chapter 4: Results

Results will be presented in two parts. First, results where the AHABD test score was not used as a factor will be presented. This analysis includes data from all participants. Chapter 4.2 includes the results where the AHABD test score was used as a between factor. Only data from those who completed the AHABD test was included in this part of the analysis. A table summarizing findings by group can be found at the beginning of Chapter 4 (

Table 10).

Two previously cited surveys and one clinical test was completed to assess individuals' mood states and self-reported sitting standing and walking at work, and to assess trunk control. The abbreviated version of the Profile of Mood States (POMS), with self-esteem adjectives, has been evaluated for its internal consistency which ranged from 0.872 to 0.954 for fatigue anger and vigour and 0.701 to 0.766 for tension esteem and confusion and 0.664 for depression (Grove & Prapavessis, 1992). The Occupational Sitting and Physical Activity Questionnaire (OSPAQ) test-retest intraclass correlation coefficients ranged from 0.73 to 0.90 for walking, sitting, and standing and Spearman correlations for the OSPAQ was high (r=0.65) (Chau, Van Der Ploeg, Dunn, Kurko, & Bauman, 2012). The AHABD test demonstrated interrater reliability was 0.59 (95% CI:0.43,0.76) when they scored individuals as either positive or negative on the test (Davis, Bridge, Miller, & Nelson-Wong, 2011). Experience level of scorers was not significantly correlated with the outcome accuracy of individual scores (Davis et al., 2011).

Table 10: Summary table of all outcome variables by group.

		Current best practice research training program	Example from Industry training program
Fitbit Zip	Daily Step Counts	6725.09(3974.14)	2405.37 (2096.05)
Data logging accelerometer	Frequency of sit-stand transitions each day	6.03 (3.39)	3.24 (2.76)
Occupational Sitting and Physical Activity Questionnaire	Sitting	67.58 (20.27)	73.13 (21.59)
	Standing	25.63 (20.43)	19.59 (20.48)
	Walking	7.24 (5.64)	7.33 (7.32)
Profile of Mood States Questionnaire	Vigour	10.58 (3.97)	11.78 (4.13)
	Tension	5.45 (4.06)	5.43 (3.10)
	Self-Esteem	7.22 (2.11)	7.22 (2.04)
	Fatigue	6.71 (4.81)	6.75 (4.02)
	Depression	3.13 (3.80)	1.90 (3.08)
	Confusion	4.40 (2.84)	4.14 (2.27)
	Anger	4.99 (3.75)	3.58 (3.51)
Musculoskeletal Pain Scores	Lower Back	0.34 (0.74)	0.38 (0.77)
	Buttocks	0.22 (0.61)	0.27 (0.71)
	Feet	0.25 (0.57)	0.24 (0.65)
	Left Shoulder	0.38 (0.76)	0.18 (0.54)
	Right Shoulder	0.18 (0.54)	0.51 (1.02)
	Neck	0.51 (1.02)	0.25 (0.63)

Note: The mean (standard deviation) are reported for each variable.

4.1 Results without Active Hip Abduction Test as a factor

4.1.1 Fitbit Zip: Daily Step Counts

There was no main effect of group p=0.6934. The NFR group had an average of 6697.5 (±4059.6) steps a day while the NFI group had an average of 6585.2 (±3424.8). There was a main effect of period p <0.0001 (Figure 14). In Phase I participants stepped each day on average 7405 (±4342.5), in Phase II 6448 (±3490.7) and in Phase III 5943 (±3077). Differences were seen in Phase I vs Phase II *p*=0.0001 and in Phase I vs Phase III *p* <0.0001 but not between Phase II and Phase III *p*=0.1604.

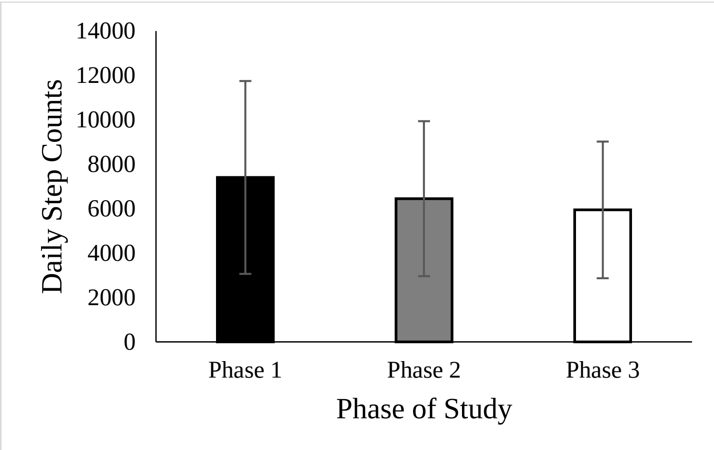

Figure 14: Daily steps as recorded via the Fitbit Zip for different phases of the study.

4.1.2 Profile of Mood States Questionnaire

There was no interaction of group*period (p=0.9061) or main effect of group (*p*=0.1788) or period (*p*=0.5007) for total POMS score. Those in the in the NFR group had a mean score of 107.0 (± 18.8) and the NFI group had a mean score of 102.9 (±15.3). When collapsed by group, participants scored 108.4 (± 19.3), at the end of Phase I 103.0 (±18.2), at the end of Phase II 105.4 (±16.7), and at the end of Phase III 102.7 (± 14.0).

There was no interaction between group and phase (*p*=0. 8278) for the mood state anger but there was a main effect of group (*p*=0.0313). There was no main effect of phase (*p*=0.8847). Those in the NFR group had a mean mood state anger score of 4.9 (±3.74) and those in the NFI group had a mean score of 3.6 (±3.5) (Figure 15). When collapsed by group there was a mean score in the initial meeting for anger of 4.6 (±3.7), at the end of Phase I of 4.2 (±4.3), at the end of Phase II of 3.9 (±2.8), and at the end of Phase III of 4.3 (±3.9).

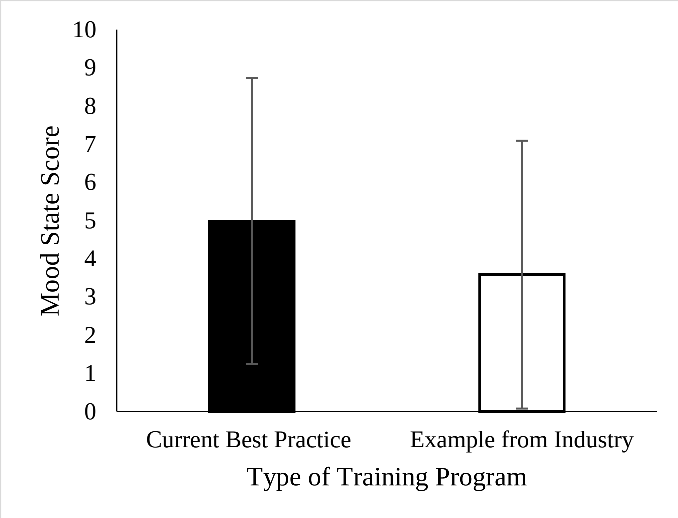

Figure 15: Profile of Mood State (POMS) score for anger.

There was no interaction between group and phase (*p*=0.9575) for the mood state confusion. There a main effect of phase (*p*<0.0001) but there was no main effect of group (*p*=0.5247). In the initial meeting at the beginning of the study there was an average of 6.1 (±2.4), at the end of Phase I 3.6 (±2.3), at the end of Phase II 3.9 (± 2.3), and at the end of Phase III 3.5 (±2.4) (Figure 16). Those in the NFR group reported a mean score of 4.4 (±2.8), and those in the NFI group a mean of 4.1 (±2.3).

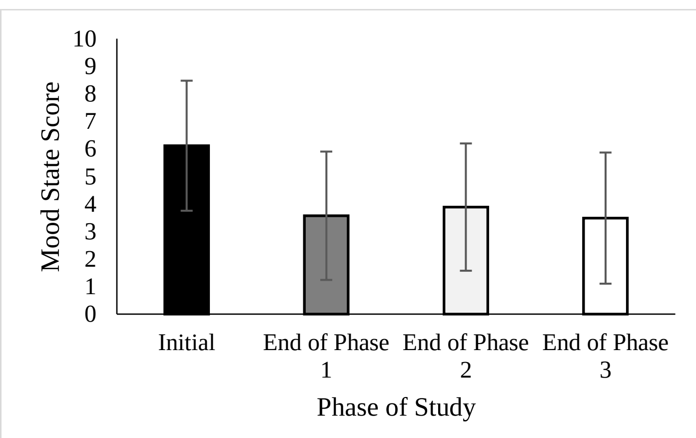

Figure 16: Profile of Mood State (POMS) score for confusion.

There was no interaction between group and phase (*p*=0. 9109) for the mood state depression. There was a main effect of group (*p*=0.0451) but there was no main effect of phase (*p*=0.5218). Those in the NFR group reported higher mood state values for depression 3.1 (±3.8) compared to those in the NFI group who reported a mean score of 1.9 (±3.1) (Figure 17). When collapsed by group there was a mean score in the initial meeting for anger of 3.2 (±4.3), at the end of Phase I of 2.5 (±3.7), at the end of Phase II of 2.2 (±2.9), and at the end of Phase III of 2.1 (±2.9).

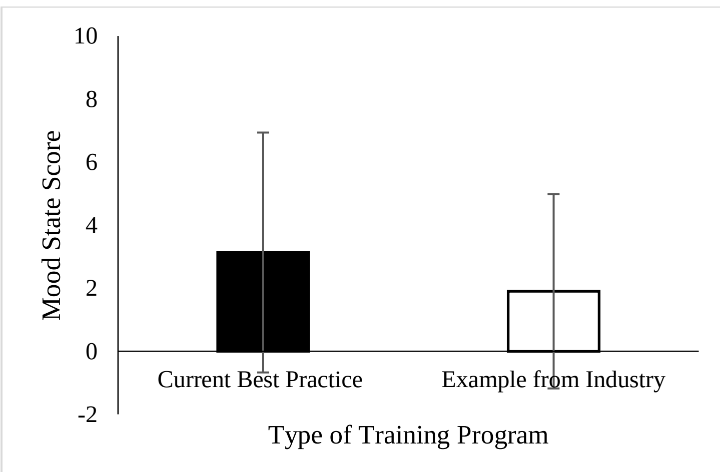

Figure 17: Profile of Mood State (POMS) score for depression.

There was no interaction between group and phase (*p*=0.7657) for the mood state fatigue. There was no main effect of group (*p*=0.9677) or phase (*p*=0.7636). Those in the NFR group reported a mean fatigue score of 6.7 (±4.3) and those in the NFI group a mean score of 6.7 (±4.5). Fatigue scores were similar across phase of study with the mean score in the initial meeting begin 7.4 (±4.9), at the end of Phase I 6.5 (±4.7), at the end of Phase II 6.6 (±4.3), and at the end of Phase III 6.3 (±3.7).

There was no interaction between group and phase (*p*=0.3642) for the mood state self-esteem. There was no main effect of group (*p*=0.9963) or phase (*p*=0.2772). Those in the NFR group reported a mean self-esteem score of 7.4 (±1.9) and those in the NFI group a mean score of 7.1 (±2.2). Self-esteem scores were similar across phase of study with the mean score in the initial meeting begin 7.6(±1.8), at the end of Phase I 7.3 (±2.2), at the end of Phase II 6.6 (±2.1), and at the end of Phase III 7.3 (±2.1).

There was no interaction between group and phase (*p*=0.5755) for the mood state tension. There was no main effect of group (*p*=0.9935) or phase (*p*=0.8241). Those in the NFR group reported a mean tension score of 5.4 (±3.4) and those in the NFI group a mean score of 5.5 (±3.78). Tension scores were similar across phase of study with the mean score in the initial meeting begin 5.6 (±4.3), at the end of Phase I 5.0 (±3.3), at the end of Phase II 5.7 (±3.5), and at the end of Phase III 5.2 (±3.2).

There was no interaction between group and phase (*p*=0.9427) for the mood state vigour. There was no main effect of group (*p*=0.0982) or phase (*p*=0.7913). Those in the NFR group reported a mean vigour score of 11.4 (±4.4) and those in the NFI group a mean score of 11.1 (±3.8). Vigour scores were similar across phase of study with the mean score in the initial meeting begin 11.1 (±3.5), at the end of Phase I1.6 (±4.6), at the end of Phase II 10.7 (±4.4), and at the end of Phase III 11.5 (±3.8).

4.1.3 Musculoskeletal Pain Score

There was no main effect of group *p*=0.6512 or phase *p*=0.6337 for the lower back region. Those in the NFI group reported on average 26.1% (±29.9) of days with pain and those in the NFR group reported fewer days with having low back pain 23.6% (±25.1). In Phase I participants reported 28.5% (±26.6) days with pain, 22.4% (±26.8) in Phase II, and 23.8% (±29.6) days in Phase III.

There was no main effect of group p=0.7659 or phase p=0.4446 for the buttocks region. Those in the NFI group reported a higher average 17.4% (±30.8) of days with pain and those in the NFR group reported an average of 15.9% (±21.6) days with pain. In Phase I participants reported 21.5% (±27.1) days with pain, 14.7% (±26.8) in Phase II, and 13.8% (±26.8) days in Phase III.

There was no main effect of group for neck pain p=0.4713. Those in the NFR group reported on average 27.0% (±35.1) of days with pain and those in the NFI group reported an average of 22.4% (±31.5) days with pain. There was a main effect of phase for neck pain p=0.0413. For both groups, the percentage of days with pain decreased with the implementation of their new workstation. The percentage of days reporting neck pain decreased from 36.1% (±37.4) in Phase I to 21.1% (±29.4) in Phase II and decreased again in Phase III to 16.6 % (±29.8) (Figure 18).

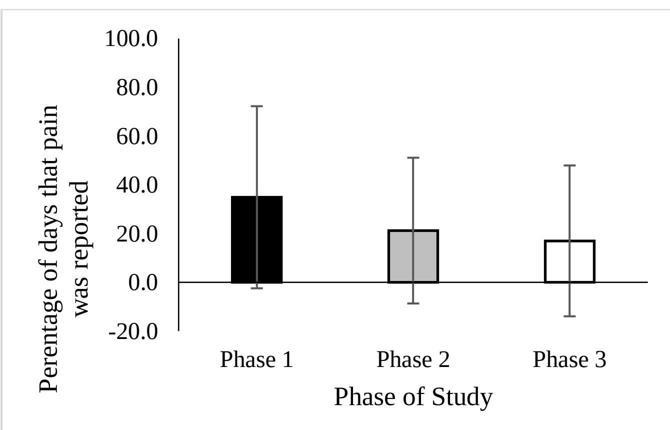

Figure 18: Average number of days in each phase where neck pain was reported. Note: this is the number of days were participants reported a maximum score greater than 0 on the musculoskeletal pain survey.

There was no main effect of group p=0.4586 or phase p=0.3529 for pain in the feet. Those in the NFI group reported on average 15.1% (±25.2) of days with pain and those in the

NFR group reported an average of 18.8% (±25.5) days with pain. In Phase I participants reported 14.0% (±21.4) days with pain, 21.5% (±28.7) in Phase II, and 14.8% (±26.2) days in Phase III.

There was a main effect of group *p*=0.0295 and there was a main effect of period *p*=0.0118 for pain in the left shoulder. Those in the NFI group reported on average having pain in their left shoulder 14.3% (±22.2) percent of the time while the NFR reported more days of having pain in their left shoulder: 27.8% (±35.9) percent of the time (Figure 19). The number of days that participants reported pain in their left shoulder decreased as the study went on. In Phase I 36.1% (±32.5), in Phase II 16.7% (±28.1), and in Phase III 13.3% (± 26.1) (Figure 20).

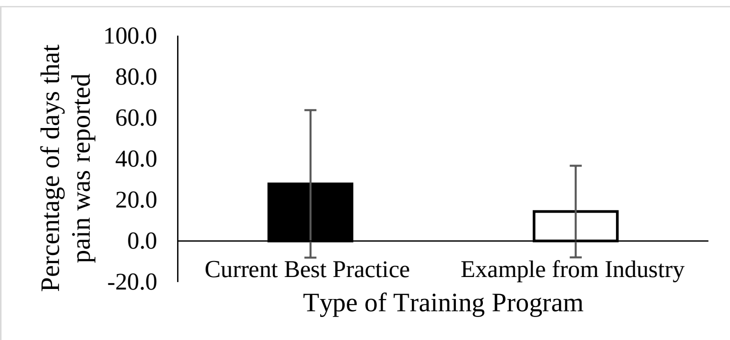

Figure 19: Average number of days that pain was reported in the left shoulder region depending on the type of training program that participants received. Note: this is the number of days were participants reported a maximum score greater than 0 on the musculoskeletal pain survey.

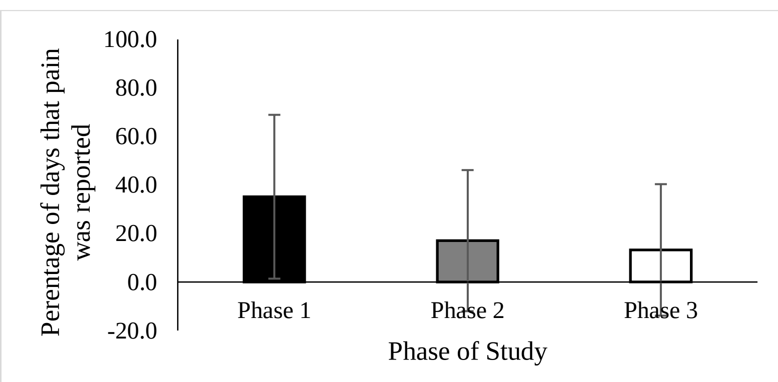

Figure 20: Average number of days that pain was reported in the left shoulder region for each Phase of study. Note: this is the number of days were participants reported a maximum score greater than 0 on the musculoskeletal pain survey.

There was a main effect of group p=0.0404 and there was a main effect of phase p=0.0024 for pain reports in the right shoulder. Those in the NFI group reported a lower number of days having pain in their right shoulder 15.9% (±22.3) percent of the time while the NFI reported having pain in their right shoulder 27.8% (±35.7) percent of the time (Figure 21). The number of days that participants reported pain in their right shoulder decreased as the study progressed for both groups. Reports were highest in Phase I at 36.1% (±32.5), decrease in Phase II to 16.5% (±27.6), and decreased further in Phase III to 13.3% (± 26.1) (Figure 22).

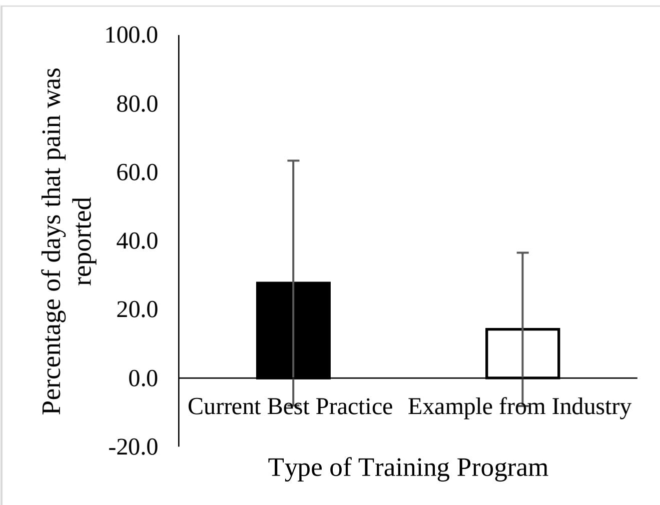

Figure 21: Average number of days were pain was reported in the right shoulder. Data is presented separately for each group.

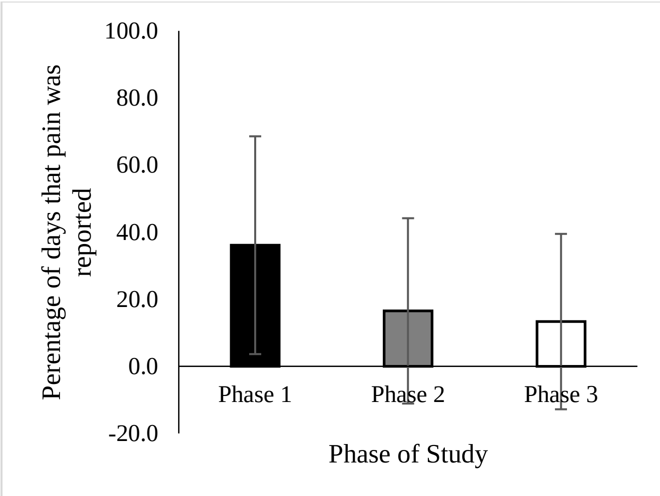

Figure 22: Average number of days were pain was reported in the right shoulder. Data is reported for each Phase of the current study.

4.1.4 Occupational Sitting and Physical Activity Questionnaire

There was no interaction between group and phase p=0.2016 for self-reported time spent sitting. There was a main effect of group p=0.0473. Those in the NFR group reported sitting for 67.2% of their day (± 20.4) while those in the NFI group reported sitting for a higher percentage of their day at 73.1% (±21.6) (Figure 23). There was a main effect of phase p<0.0001. The highest amounts of self-reported sitting throughout the day was seen in the initial and End of Phase I collections 84.1% (±17.4) and 79.9% (±91.4) respectively. Amounts of self-reported sitting was lower at the end of Phase II and 3 as reports were 57.6% (±16.4) and 59.6% (±17.5) respectively (Figure 24). The report at the initial meeting was not significantly different from the end of Phase I (p=1.000) and the End of Phase II was not significantly different than the end of Phase II (p=1.000). All other comparisons were significantly different from one another at p<0.0001.

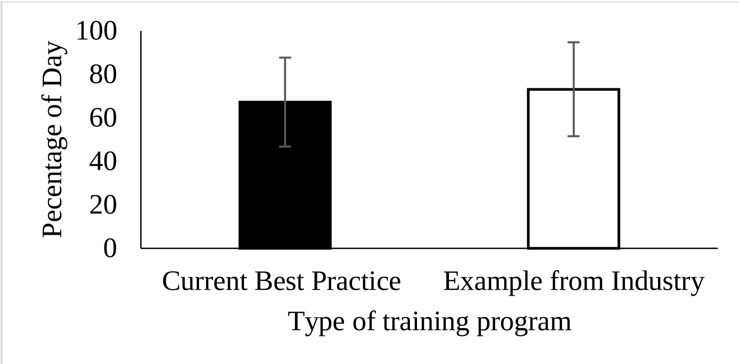

Figure 23: Self-reported percentage of workday spent sitting given the type of training program that individuals received.

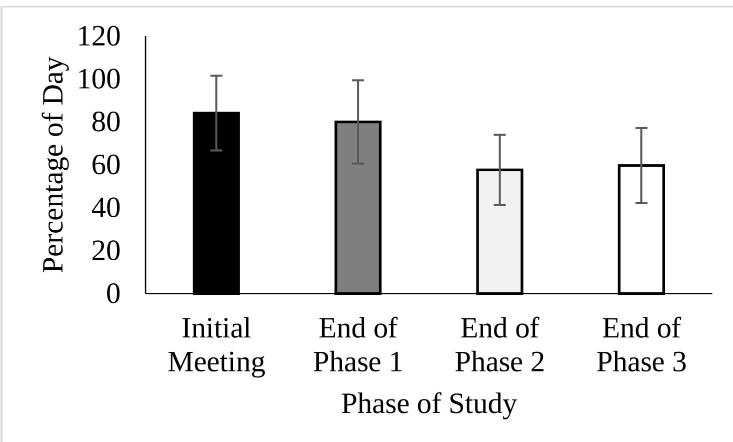

Figure 24: Self-reported percentage of day spent sitting in a typical workday in each Phase of the current study.

There was a main effect of group p=0.0401 those in the NFR group reported standing for a higher amount of time at an average of 25.6% (±20.4) compared to the NFI group who reported standing 19.6% (±20.5) of the day (Figure 25). There was a main effect of phase p<0.0001. There was an increase in self-reports of standing from data collected in Phase I to the end of Phase II and 3. Initially, participants reported standing 9.8% (±17.9), and 11.7% (±17.6) at the end of Phase I. Standing increased in Phase II and 3 to 35.1% (±15.8) and 33.3% (±16.8) respectively (Figure 26).

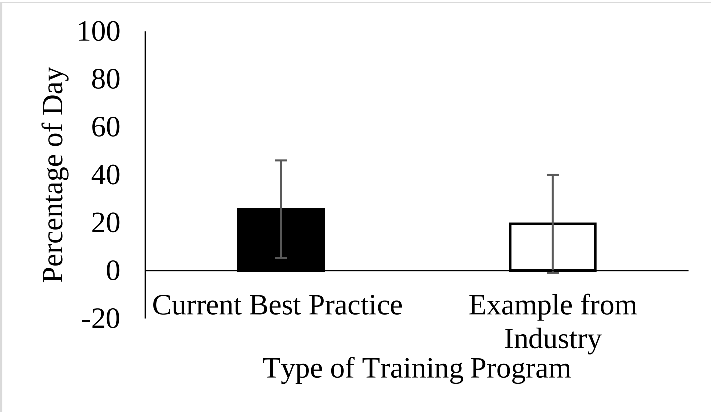

Figure 25: Self-reported amounts of percentage of day spend standing in a typical workday for each group.

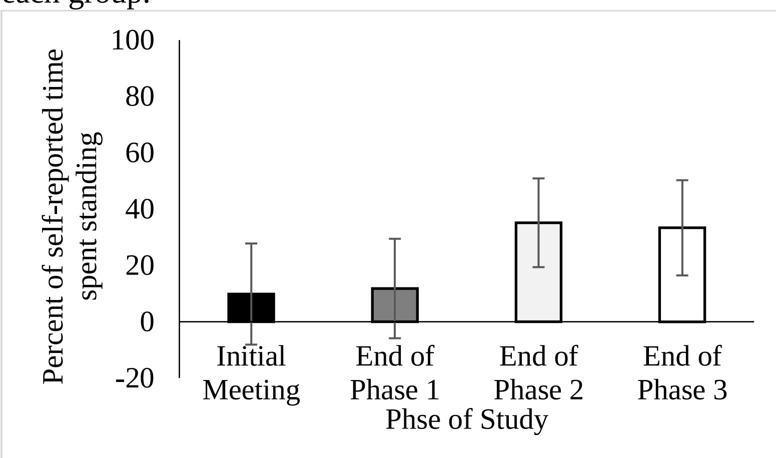

Figure 26: Self-reported amount of standing in the different phases of the study.

There was no main effect of group p=0.9442 or phase p=0.6657 for self-reported walking. On average, those in the NFR group spent 7.2 (±5.6) and those in the NFI group spent 7.3 (±9.0) percent of their day walking. Participants reported walking 6.1% (±4.85), 8.4% (±10.8), 7.4% (±6.7), and 7.3% (±6.4) of their day in the Initial Meeting, end of Phase I, end of Phase II, and end of Phase III respectively.

4.1.5 Frequency of sit-stand transitions each day

There was an interaction between group and period p=0.0386 for the frequency of sit-stand transitions made each day. In Phase II, those in the NFR group transitioned 6.6 (±3.4) times a day while those in the NFI group transitioned 3.4 (±2.5) times a day. In Phase III, the number of transitions each day decreased in the NFR group from 6.5 to 5.5 (±3.2) times a day while those in the NFI group stayed relatively constant at 3.1 (±3.0) times a day (Figure 27).

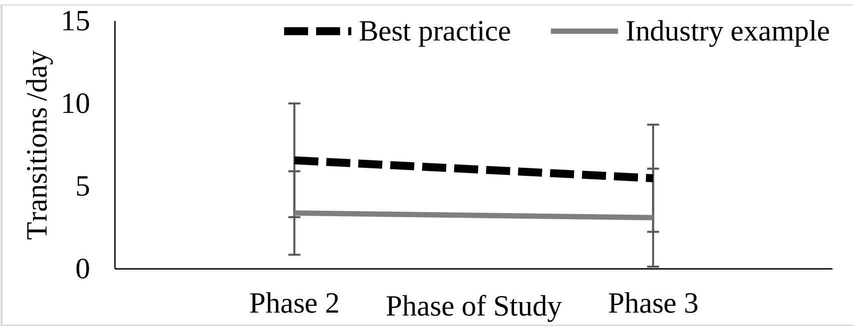

Figure 27: Number of sit-stand transitions made each day in Phase II and Phase III

An analysis was also completed to determine if there would be any changes each week. There was an interaction between group and week p=0.0059. Transitions from sitting to standing and vice versa stayed relatively constant for those in the NFI group (Table 11). In the NFR group we see an increase from week 5 to 6 and then a steady decline in the amount each day until week 12 (Figure 28).

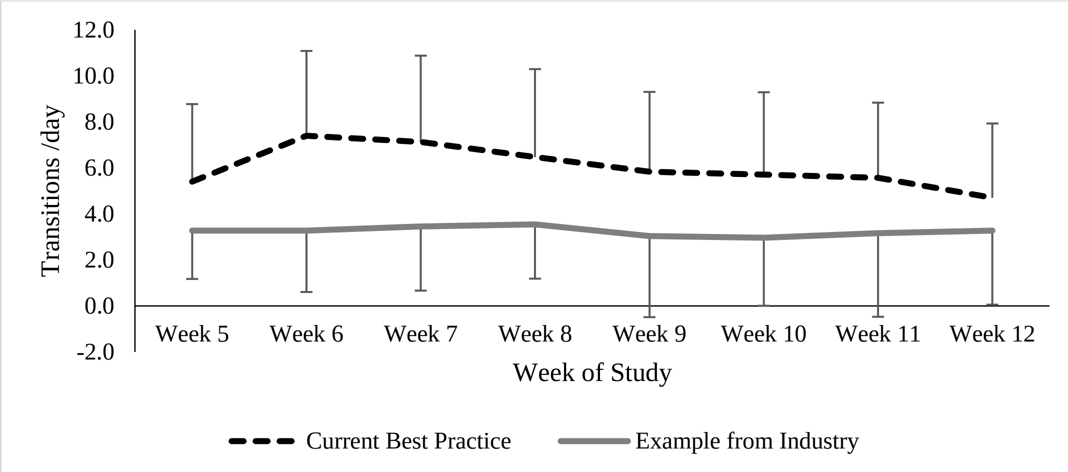

Figure 28: Number of sit-stand transitions made each day in Phase II (week 5-8) and in Phase III (week 9-12).

Table 11: Number of sit-stand transitions made each day in Phase II (week 5-8) and in Phase III (week 9-12).

		Week 5	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**	**Week 11**	**Week 12**
Current Best Practice	Mean	5.4	7.4	7.1	6.5	5.8	5.7	5.6	4.7
	Standard Deviation	3.4	3.7	3.8	3.8	3.5	3.6	3.3	3.2
Example from Industry	Mean	3.3	3.3	3.5	3.5	3.0	3.0	3.2	3.3
	Standard Deviation	2.1	2.7	2.8	2.4	3.5	3.0	3.6	3.2

4.1.6 Number of days where the workstation was not moved at all

There was a main effect of group p=0.0002 for the number of days where the workstation was not used at all. Those who received the training session based on current best practice research had 0.7 (±1.0) days on average where participants did not move their workstation whereas those who only received the industry example training program had on average 3.5 (±3.7) days were they did not move their workstation (Figure 29).

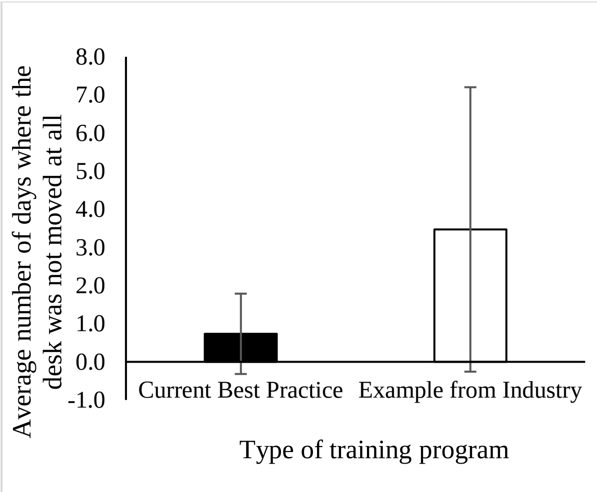

Figure 29: Number of days where the sit-stand workstation was not moved at all between sitting and standing.

4.2 Results including outcome of the Active Hip Abduction Test as a factor

Only when there was a main effect or interaction of or including AHABD status are the results presented in the following section. All redundant results will not be re-presented in this section.

There was no difference in the rate of positive scores on the AHABD test at the beginning of the study between the NFR (12) and NFI (10) group p=0.4578. There was no difference in the rate of positive scorers on the AHABD test at the end of the study for those in the NFR (four) group compared to the NFI (five) group p=0.7043. There was a difference in the number of positive scores on the AHABD test when the beginning of the study was compared to the end of the study p=0.0215 (Figure 30). At the beginning of the study 12 participants scored positive and at the end only four participants scored positive. There was no difference in the occurrence of positive tests at the beginning of the study (10) to the end of the study (five) for the NFI group p=0.2188. One individuals' score worsened in each group at the end compared to the beginning.

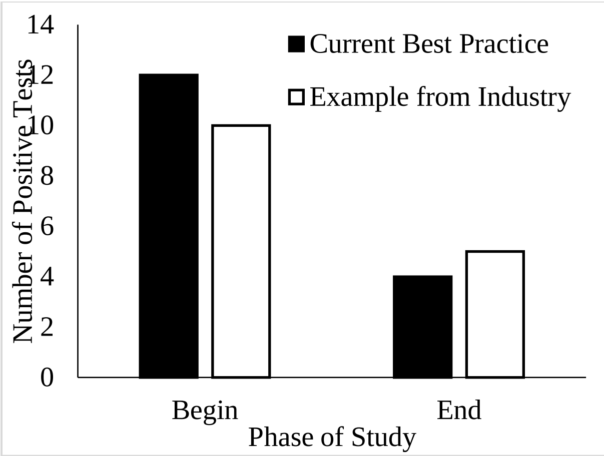

Figure 30: The number of positive scorers on the Active Hip Abduction Test at the beginning and end of the study for both the NFR and NFI group.

4.2.1 Fitbit Zip: Daily Step Counts

There was an interaction between group and AHABD status $p<0.0001$ for daily step counts (Figure 31). Those who scored positive on the AHABD test and were in the NFR group stepped on average 5935.7 (±3500.0), and in the NFI group 6815.8 (±3528.9). Those who scored negative on the AHABD test and were in the NFR group moved 8177.2 (± 4643.9) and in the NFI group moved 7212.1 (±3386.8). There was also a main effect of period $p<0.0001$ (Figure 32). In Phase I participants stepped each day on average 7593.1 (±4339.5), in Phase II 6644.5 (±3553.9) and in Phase III 6033.6 (±3132.9).

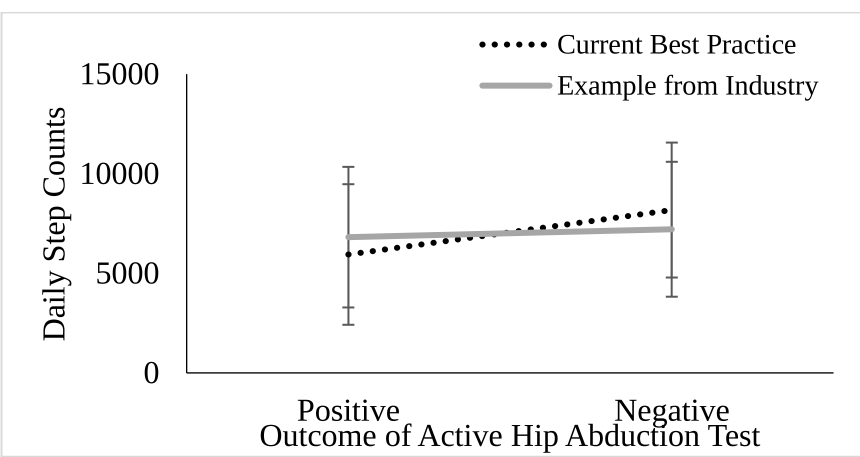

Figure 31: Interaction between type of training and outcome of AHABD test.

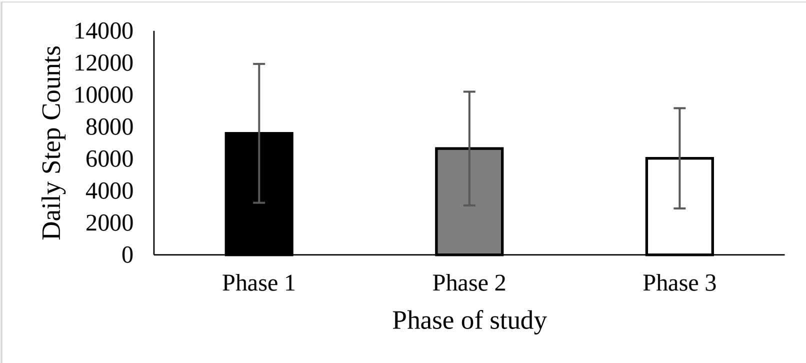

Figure 32: Step counts main effect of period for those who completed AHABD

4.2.2 Musculoskeletal Pain Score

There was no main effect of group *p*=0.8301 or phase *p*=0.8340 for the lower back region. There was a main effect of AHABD status *p*=0.0177. Those in the NFI group reported on average 24.3% (±30.1) of days with pain and those in the NFR group reported fewer days with having low back pain 23.6% (±25.1). In Phase I participants reported 26.9% (±27.1) days with pain, 22.0% (±26.7) in Phase II, and 22.9% (±29.0) days in Phase III. Those who scored positive on the AHABD test at the beginning of the study reported pain in their lower back region 29.5% (±29.8) percent of days while those who scored negative on the AHABD test reported 14.7% (±20.1) days of pain (Figure 33).

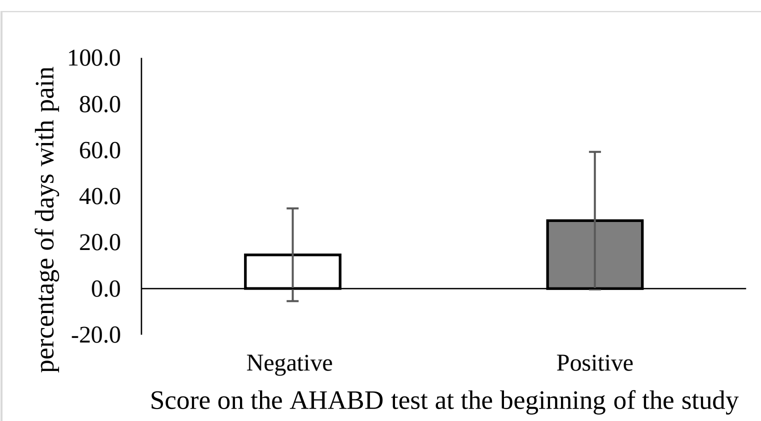

Figure 33: Percentage of days that pain in the low back region was reported for those who scored either positive or negative on the AHABD test at the beginning of the study.

There was no main effect of group *p*=0.6454, phase *p*=0.4595 or AHABD status *p*=0.7931 on the number of days where pain was reported in the buttocks region. There was no main effect of group *p*=0.3449 or phase *p*=0.4178 or AHABD status *p*=0.6273 for pain reported in the feet.

4.2.3 Occupational Sitting and Physical Activity Questionnaire

A main effect of phase for self-reported amount of time sitting was found ($p<0.0001$) which is consistent with findings when AHABD was excluded as a between factor. There was no main effect of group *p*=0.1709 or AHABD on self-reported time spent sitting *p*=0.8580. There was an interaction between group and time *p*=0.0408 for self-reported amount standing. No main effect AHABD status *p*=0.1935.

There was a main effect of AHABD status on the amount of walking that participants reported walking on average each day *p*=0.0149. Those who scored positive on the AHABD test reported walking 8.9 (±9.1) percent of their day which is approximately ~4% more than those who scored negative on the AHABD test who reported walking only 5.4 (±3.7) percent of their day (Figure 34).

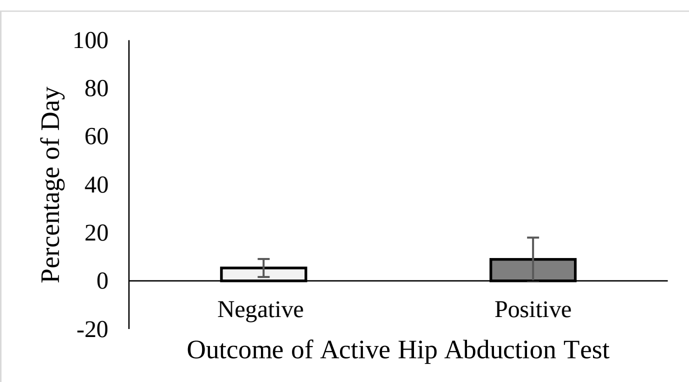

Figure 34: Self-reported amounts of walking throughout the day for those who scored either positive or negative on the AHABD test.

4.2.4 Frequency of sit-stand transitions each day

There was a three-way interaction between group, period and AHABD status p=0.0262 for the frequency of sit-stand transitions made each day. Within the NFR group, those who scored either positive or negative on the AHABD test acted differently in Phase II and 3 of the study. In Phase II, those who scored positive or negative on the AHABD test transitioned between sitting and standing 6.8 (±3.5) and 6.1 (±3.4) times a day (Figure 35). In Phase III those who scored positive on the AHABD test decreased the number of transitions between sitting and standing to 5.1 (±3.3) and those who scored negative on the test stayed at 6.2 (±3.0) transition a day.

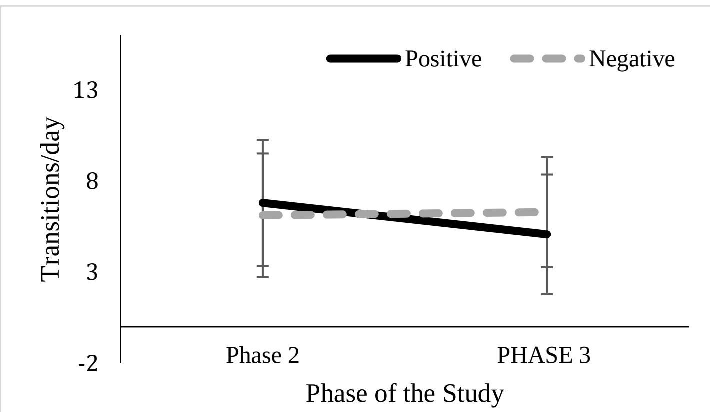

Figure 35: Graph one of the 3-way interaction between group, phase, and AHABD (NFR group). This graph represents the number of transitions made each day in Phase II and 3 of the study for those who scored positive or negative on the AHABD test who received the Current Best Practice training session.

Within the NFI group, those who scored negative on the AHABD test moved on average 1 more time a day than those who scored positive on the AHABD test. Positive scorers on the AHABD test transitioned between sitting and standing 2.6 (±2.1) times in Phase II and 2.2 (±2.4) times a day in Phase III (Figure 36). Those who scored negative on the AHABD test transitioned about 3.4 (±2.8) times a day in Phase II and 3.3 (±3.0) times a day in Phase III.

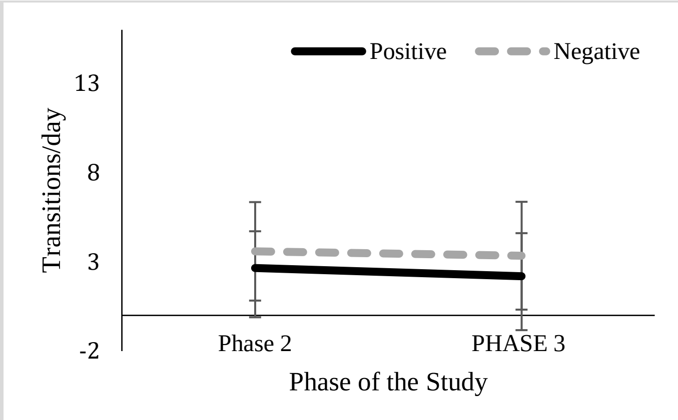

Figure 36: Graph two of the 3-way interaction between group*phase*AHABD (NFI group). This graph represents the number of transitions made each day in Phase II and 3 of the study for those who scored positive or negative on the AHABD test in the group who only received the industry training example.

The following analysis was conducted to determine if week of study influenced the frequency of sit-stand transitions. There was an interaction between AHABD status and week *p*=0.0475 (Figure 37). There was an interaction between group and AHABD *p*=0.0429. Those who were in the NFR group and scored positive and negative on the AHABD test moved 5.9 (±2.5) and 6.2 (±3.2) times a day respectively. Those who were in the NFI group and scored positive and negative on the AHABD test transitioned between sitting and standing 2.4 (±2.3) and 3.5 (±2.9) times a day respectively (Figure 38).

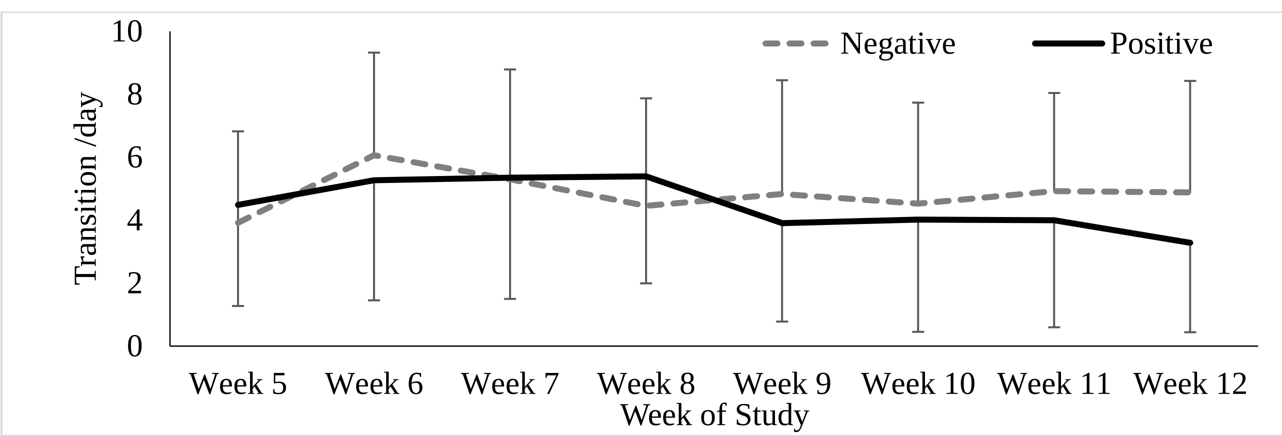

Figure 37: Transitions for positive and negative scorers on the AHABD test over 8 weeks.

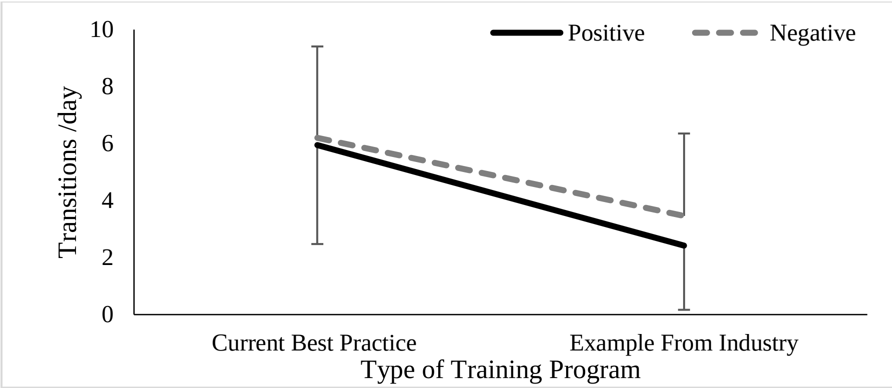

Figure 38: Sit-stand transitions made each day for those in the Current Best practice group versus those in the Example from Industry group if scored either positive or negative on the AHABD test.

4.2.5 Number of days where the workstation was not moved at all

There was a main effect of group p=0.0002 on the number of days where the sit-stand workstation was not used at all. There was no main effect of AHABD status p=0.7349. There was no main effect of phase p=0.4995. Those who scored negative on the AHABD test had average 2.2 (±3.8) days where they did not move their workstation. Similarly, those who scored positive on the AHABD test had 2.3 (±2.7) days where they did not move their workstation at all.

4.3 Six Month Follow-Up

Data for the number of sit-stand transitions made each day are presented for the statistical model that included group, time, and AHABD status. Results from only group by time are excluded in order to not present redundant data.

4.3.1 Profile of Mood States Questionnaire

There was no main effect of group *p*=0.4838 or period *p*=0.5952 for the mood state anger. The NFR group had an average score of 3.8 (±3.0) and the NFI a score of 4.5 (±3.5). At the end of Phase III there was an average of 3.9 (±2.9) and at the end of the six-month follow-up the score was 4.3 (±3.6).

There was no main effect of group *p*=0.8655 or main effect of period *p*=0.9665 for the mood state vigour. The NFR group had an average score of 11.4 (±3.5) and the NFI a score of 11.2 (±4.3). At the end of Phase III there was an average of 11.3 (±3.3) and at the end of the six-month follow-up the score was 11.3 (±4.4).

There was no main effect of group *p* =0.0224 or period *p*=0.7160 for the mood state tension. The NFR group had an average score of 4.1 (±3.4) and the NFI a score of 6.5 (±3.6) (Figure 39). At the end of Phase III there was an average of 5.0 (±3.3) and at the end of the six-month follow-up the score was 5.4 (±4.1).

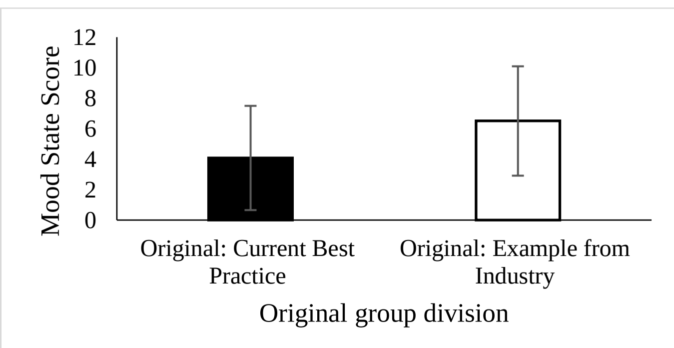

Figure 39: Profile of mood state score: Tension comparing scores between groups.

There was no main effect of group *p*=0.4969 or main effect of period *p*=0.5235 for the mood state self-esteem. The NFR group had an average score of 7.2 (±1.9) and the NFI a score of 6.8 (±2.1). At the end of Phase III there was an average of 7.2 (±1.9) and at the end of the six-month follow-up the score was 6.8 (±2.0).

There was no main effect of group p=0.7647 or main effect of period p=0.5775 for the mood state confusion. The NFR group had an average score of 3.6 (±2.8) and the NFI a score of 3.8 (±2.3). At the end of Phase III there was an average of 3.5 (±2.5) and at the end of the six-month follow-up the score was 3.9 (±2.6).

There was no main effect of group p=0.8120 or main effect of period p=0.4318 for the mood state depression. The NFR group had an average score of 2.7 (±4.1) and the NFI a score of 2.5 (±3.3). At the end of Phase III there was an average of 2.2 (±3.3) and at the end of the six-month follow-up the score was 3.0 (±4.2).

There was no main effect of group p=0.0813 or period p=0.4220 for the mood state fatigue. The NFR group had an average score of 5.2 (±3.1) and the NFI a score of 7.2 (±4.4). At the end of Phase III there was an average of 5.7 (±3.4) and at the end of the six-month follow-up the score was 6.6 (±4.3).

4.3.2 Occupational Sitting Time and Physical Activity Questionnaire

There was a main effect of group p=0.0127 but no main effect of period p=0.2880 for self-reports of sitting at the six-month follow-up. Those in the original NFR group reported that they sat for 55.3% (±15.3) of the day while those in the NFI group reported sitting for 67.5% (±18.0) of their day (Figure 40). At the end of Phase III participants reporting sitting for 59.2 (±18.7) percent of their time and 64.0 (±17.7) at the time of the six-month follow-up.

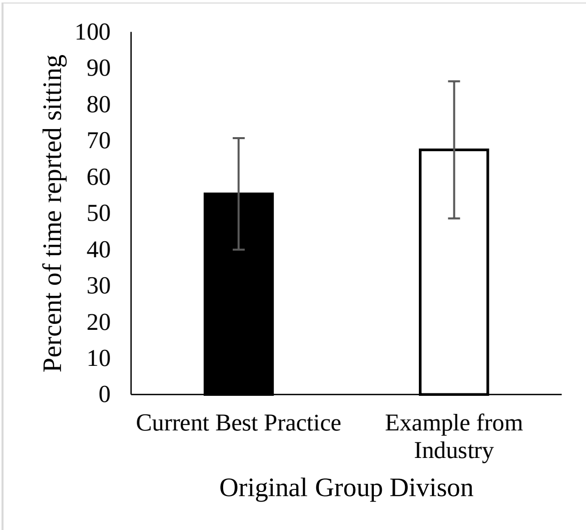

Figure 40: Amount of participants’ day reported sitting. Time points included in this graph are the reports at the end of Phase III and at the six-month follow-up.

There was a main effect of group p=0.0134 for the self-reported amount of standing. Those in the NFR group reported standing for 35.9 (±15.6) of their day while those in the NFI group reported standing for 24.6 (±17.1). There is no difference in period (p=0.1666) for self-reported amounts of standing throughout the workday. At the end of Phase III, participants reported that they perceived that they stood for 33.0% (±18.2) of their day. This percentage dropped for the six-month follow-up to 27.1 (±15.9) percent of their day.

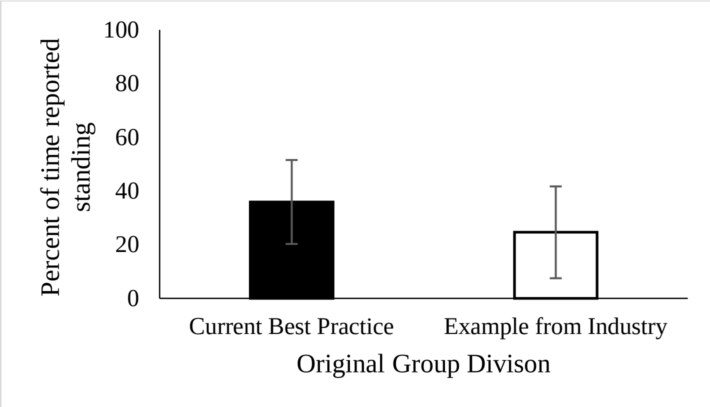

Figure 41: Self-reported percentage of their day spent standing compared from the end of Phase III to the six-month follow-up.

There was no main effect of group for self-reported walking *p*=0.6174. Those in the NFR group reported walking 8.6 (±6.0) percent of their day while those in the NFI group reported walking for 7.7 (±6.9) percent of their day. There was no difference in period of time for self-reported amounts of walking throughout the day *p*=0.6385. At the end of Phase III participants reported walking 7.8% (±6.8) of their day and at the six-month follow-up they reported walking 8.6 (±6.2) percent of their day.

When group by time by AHABD status was run for the six-month follow-up, it was found that there was no influence of the AHABD test on the amount of self-reported amounts of sitting (*p*=0.4501), standing (*p*=0.3394), and walking (*p*=0.7676).

4.3.3 Transitions at six-month follow-up and the influence of AHABD status

There was an interaction between group and period *p*<0.0001. There was a main effect of AHABD *p*=0.0034. At the end of Phase III those in the NFR transitioned an average of 5.7 (±3.4) times a day and those in the NFI group transitioned 2.2 (±2.4) times a day. As assessed in the six-month follow-up, those in the NFR group transitioned 2.3 (±2.2) times a day and those in the NFI group also transitioned 2.3 (±2.4) (Figure 42: Transitions /day comparing the end of Phase III to the collection at the six-month follow-up (analyzed by running 3-way GLM with repeated factors of group, time and AHABD status).Figure 42). Those who scored positive on the AHABD test transitioned between sitting and standing 4.2 (±3.0) times a day. Those who scored positive on the AHABD test transitioned fewer times a day at an average of 2.9 (±3.1) (Figure 43).

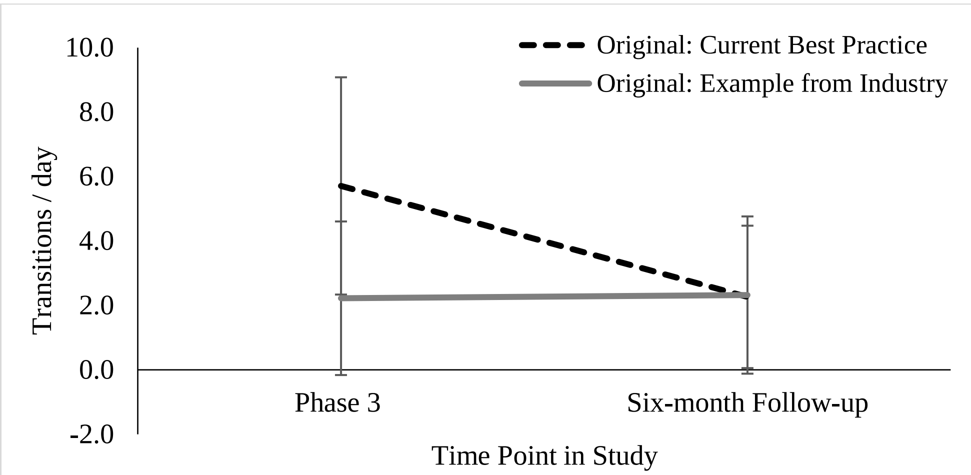

Figure 42: Transitions /day comparing the end of Phase III to the collection at the six-month follow-up (analyzed by running 3-way GLM with repeated factors of group, time and AHABD status).

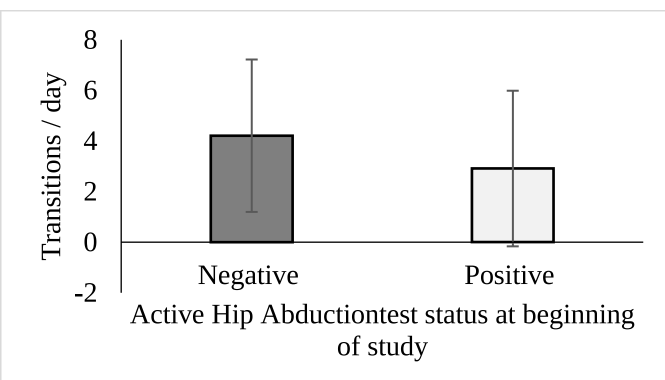

Figure 43: Transitions made each day (at the end of Phase III and six-month follow-up) for individuals who scored either negative or positive on the AHABD test at the beginning of the study.

4.4 Intake questionnaires

At the beginning of the study participants were asked “What specific benefits do you believe you would gain by alternating between a seated and standing position?”. Participants were asked to check off all that applied from the following list: Uncertain, less stressed, more comfortable, more productive, more focused, happier, energies, healthier, none of the above, and other (Table 12). Participants were asked again at the end of Phase III “What benefits do you think you have gained by alternating between a sitting and standing position?”.

Table 12: Number of people in each group who reported benefits that they thought they would have experienced at the beginning of the study and that they did experience at the end.

Phase of Study	N	Group	Uncertain	Less Stressed	More Comfortable	More Productive	More focused	Happier	Energized	Healthier	None of above	Other
Beginning	2	N/A	0	1	2	2	2	1	2	1	0	0
	18	NFI	5	1	11	0	3	3	6	15	1	0
	17	NFR	5	0	10	6	8	0	6	15	0	0
	35	ALL	10	2	23	8	13	4	14	31	1	0
End	18	NFI	2	3	16	9	7	7	9	8	1	0
	17	NFR	1	2	15	6	6	6	7	7	0	2
	35	ALL	3	5	31	15	13	13	16	15	1	2

Note: Those in group N/A were not allotted to a group as they did not complete Phase I of the study.

Two participants noted that “other” at the end of the study and reported that: “I find I’m no longer comfortable sitting for extended period of time, have the urge to get up and move” and “feeling privileged and proud to have this ‘luxury’”. At the end of the study both groups decreased in their reporting that they were “uncertain” about any benefits they would receive and less people reported being healthier at the end of the study compared to the beginning. More people in the NFI group reported that they were more productive and more focused. There was no change in the number of people reporting increased productivity from the beginning to end and the number of people who reported being more focused decreased. Those in both the NFI and NFR group noted that they were less stressed, more comfortable, happier, and more energized. One person in the NFI group reported having no benefits at all from alternating between a seated and standing position.

Chapter 5: Discussion

The purpose of this field investigation was to determine how the type of training/education program that new users of sit-stand workstations received influenced their work behaviour in the first, second, and sixth months following the implementation of sit-stand workstations. Results from the initial collection period and six-month follow-up are presented first. As not all participants completed the Active Hip Abduction Test (AHABD) results when AHABD status was run as a between factor will be discussed separately.

Those in the NFR group transitioned almost double the number of the NFI group. The NFR group moved their desk 6.6 (±3.4) times a day and the NFI group 3.4 (±2.5) times a day. Both groups' frequency of sit-stand transitions each day dropped in the six-month follow-up as compared to Phase III. At the six-month follow-up both groups transitioned 2.3 times a day whereas in Phase III the NFR group transitioned 5.5 (±3.2) times a day and the NFI 3.1 (±3.0) times a day. As assessed by the OSPAQ, there were lower reports of sitting (6% lower) and higher amounts of standing (6% higher) for those in the NFR group. There was no influence of group or phase on the amount of self-reported walking that each person reported doing each day. At the six-month follow-up the NFR group reported standing 11% more and sitting less 12% than the NFI group. There was no influence of group on heavy labour or physically demanding tasks. The amount of musculoskeletal pain decreased for the neck region in Phase II and 3 of the study compared to Phase I. Unexpectedly, there was an increase in the amount of right and left shoulder pain for those in the NFR group. Overall, reports of right and left shoulder pain decreased as the study progressed. There was no difference between groups for the daily amount of step counts. There was a decrease in the number of steps counts as recorded by the Fitbit Zip as the study progressed. Both negative and positive scorers on the AHABD test transitioned and stood more than the NFI group and the NFR stood more than the NFI. Negative scorers on the AHABD test walked more than positive score according to Fitbit. But self-reported walking told the opposite story that people who scored negative on the AHABD walked 5.4% of their day while those who scored positive walked 8.9% of their day. AHABD status had an influence on pain reporting in the low back region with positive scorers reporting more pain.

Hypothesis 1: The type of training program that new users of sit-stand workstations receive will have an influence on individuals' behaviour at work?

This hypothesis was accepted. Self-reported amounts of sitting and standing throughout the day was assessed in the current study by using the Occupational Sitting and Physical Activity Questionnaire (OSPAQ). Dutta and colleagues (2014) trained their participant similarly to the current study. Participants received sit-stand workstation and were asked to replace 50% of their time with standing. They reported an increase in standing time of 39% and a decrease in sitting of 40% as assessed by the OSPAQ (Dutta et al., 2014). The current study found a 22.4% decrease in sitting and a 23.3% increase in standing which aligns with that reported by Alkhajah and colleagues (2012) who reported a 27% decrease in sitting time. Graves and colleagues (2015) collected subjective reports of minutes spent sitting, standing and walking each day by reporting behaviours in a diary. These reports are similar to what the current study found across an eight-week period. Graves and colleagues (2015) reported that participants *sat* in their baseline, four-week measure and eight-week measure for 80.4%, 62.3%, and 67.1% of their day. The current study found that reports of sitting also decreased over time as participants reported sitting for 80.1% of their day in baseline, 57.6% in Phase II and 59.6% at the end of Phase III. Differences between the studies emerge when self-reported *standing* amounts are compared.

Graves and colleagues (2015) reported standing 8.5% in baseline, 29.4% at four weeks and 8.8% at 8 weeks whereas the participants in the current study maintained the amount of standing reported in Phase II of the study (35.1%) in Phase III (33.3%) increasing from11.8% at baseline (Figure 25: Self-reported amounts of percentage of day spend standing in a typical workday for each group.Figure 26). These reports are higher than reported by Chau (2016) by approximately 5% at maximum and are maintained at a steadier rate than Chau (2016) in which a decrease in the 19week follow-up was noted.

Although reports of sitting decreased, it is not necessarily replaced by sustained periods of light activity such as standing as reported by Graves and colleagues (2015). The behaviour change techniques, hands-on demonstration period, and weekly meeting were likely to have contributed to the increased amounts of self-reported standing throughout the day for participants in the current study. A measure of sit-stand transitions is also helpful to understand postural transitions participants are making throughout the day.

Robertson and colleagues (2013) employed a training intervention that began with an ergonomic education session followed by a 15-day assessment period. The first three days acted a baseline period then participants received reminders to sit and stand on days 4-6, had 5 minutes of mandatory standing for every 50 minutes on days 7-9, followed by 20-minutes of mandatory standing to every 50-minute session for days 10-12, and the last 3 days (13-15) had no ergonomic reminders. Participants stood between 6.5 and 7 times a day in days 7-12 but decreased to 2.5-3.5 times a day in days 13-15 (Robertson et al., 2013). The current study also found decreases in the amount of sit-stand transitions made as the NFR group transitioned on average 6.6 (±3.4) times a day while participants had weekly meetings with M. Riddell and daily reminders to move throughout the day (Phase II). These initial findings are more frequent than was reported by Dainoff and colleagues (2002) who reported 2.5 transitions/day. On average, findings from the current study were lower than reported by Davis and colleagues (2014) who reported 8 postural transitions for those who did not receive reminders throughout their shift and 9 transitions for those who did.

Studies that included a multi-component approach to decreasing sitting time and increasing standing time and sit-stand transitions generally reported the same amount of sit-stand transitions as recorded per hour of an 8-hour workday (Danquah et al., 2016; Healy et al., 2013; Neuhaus et al., 2014). These studies tracked movement of participants throughout the day, not specifically sit-stand transitions at the workstation. In the current study, the daily number of sit-stand transitions decreased from 6.6 (±3.4) when these weekly meetings occurred to 5.5 (±3.2) times a day one month after weekly meetings and reminders had ceased. Healy and colleagues (2013) reported 5.7 (1.6) movements per hour in the baseline phase and 7.2 (2.3) transitions per hour of workplace sitting in the follow-up phase for the intervention group. Neuhaus and colleagues (2014) reported 5.1, 4.9, and 4.2 sit-stand movements per hour of sitting for the multi-component, workstation-only and control group respectively. A similar multi-component approach was implemented with people who already had sit-stand workstations in a study by Danquah and colleagues (2016). They reported participants making six-seven sit-stand movements every hour for both the intervention and control group in the initial and follow-up phases. These studies assessed movement using the activPAL3 (Healy et al., 2013; Neuhaus et al., 2014) or ActiGraph (Danquah et al., 2016) that was affixed to participants' thighs. Although this device was monitoring when participants transitioned between sit-stand and vice versa, these measurements would have been influenced by factors such as sitting and standing in meetings, bathroom breaks, lunch breaks etc. and do not necessarily account for movements of the sit-stand workstation itself. Findings in the current study are expected to be lower than reports from these studies as the current study measures sit-stand workstation transitions using an objective desk mounted accelerometer.

Recall that participants in the NFI group received the additional training session at the end of Phase III and both groups were assessed for a two week period, six-months following the completion of the study. Although there are limitations in interpreting this data (as no initial re-testing of the NFI group was conducted after the training program was delivered) participants in the original NFR group transitioned on average 2.3 (±2.2) times a day in the six-month follow-up phase whereas those in the original NFI group transitioned 2.4 (±2.4) times a day. The minimum number of movements recorded for both groups was 0/day and the maximum number was 10/day for the original NFI group and 8 for the original NFR group. According to the OSPAQ questionnaire, those in the original NFR group still reported sitting less and standing more throughout their days. As expected, there is no difference between groups for the self-reported amount of walking of each group in the six-month follow-up. It is not possible to speculate on how many sit-stand transitions would have been made by the NFI group in the six-month follow-up (as they received the additional training session) but other studies have noted that sit-stand workstations are rarely used over time (Danquah et al., 2016). This is consistent with personal conversations had with industry ergonomists and other researchers. Those who originally received the NFR training session significantly decreased the use of the workstations over time (from 5.7 to 2.3 times/day). This decrease is not due to change in health or job duties and tasks as verified in the exit interview with participants. Possible explanations may be due to participants having a busy week, participation in a lot of meetings, that they feel they are moving their workstation enough to support their personal needs, or simply that they tolerate sitting and prefer to work in that posture. Another reason may be because participants have made changes throughout their entire workday by implementing more movement into their daily routine so they are getting the postural benefits of moving throughout the day. However, the step count in the 12-week study phase would not support this statement and step counts at six-month follow-up were not measured so it is not possible to say for sure.

Hypothesis 2: Musculoskeletal pain reports by participants will improve with the additional training session that participants receive.

This hypothesis was rejected. The number of days that participants reported pain above a score of “0” counted and divided by the total number of pain (in each phase) that participants filled out surveys yielding a percentage of how many days in each phase participants had reported pain. The percentage of days that pain was reported decreased from 36.1% (±37.4) in Phase I to 21.1% (±29.4) in Phase II and decreased again in Phase III to 16.6 % (±29.8) for both groups (Figure 18). Overall, the configuration of everyone’s workstation improved at the new office. In the previous office space participants’ computers were configured awkwardly such as offset in the corner from where their keyboard and mouse were. Overall, pain in the right and left shoulder decreased as well as the study progressed (Figure 20 and Figure 22).

Unexpectedly, there was an influence of group illustrating that those in the group who received current best practice information regarding workstation configuration, reported higher amounts of pain in the right and left shoulder regions than those who received only the example of what is currently being done in the industry (Figure 19 and Figure 21). This does not align with previous studies who have noted reductions in musculoskeletal pain (Davis & Kotowski, 2014; Husemann et al., 2009; Nerhood & Thompson, 1994; Pronk et al., 2012; Robertson et al., 2013; Roelofs & Straker, 2002). Musculoskeletal pain was reported by Ebara and colleagues

(2008) while in the sit-stand workstation in the right forearm, right wrist/hand, and right and left lower legs.

These increases in the amount of pain may be caused by M. Riddell meeting with participants weekly in Phase II of the study and encouraging participants to record any amounts of pain that they felt. Another reason may be due to the type of instruction that was provided to participants in terms of how to set their workstation up while in standing. Participants were encouraged to bring their desk up to a height that would allow them to rest their arms on their desk while working and to be mindful of the position of their arms relative to the workstation. In the situation where their workstation was lower than suggested, participants may have compensated by using their shoulder musculature to bring their arms up to a better height which in turn may have increased the amount of discomfort experienced. There were 3 participants in the NFR group who reported pain in their shoulders consistently throughout the study. One body region that was not captured on the MPS were the wrists. Two participants in the NFI group reported experiencing pain in their wrists at the new workstation. Some participants also noted pain in their knees. These increases in the NFR group may also be associated with the increased time they spent standing.

Due to the reports of MSK pain reported by participants, little was shown from direct measures of pain. Daily reports on the MPS are shown for each region (Appendix G) which includes reports from all participants. Both the left and right foot are merged together to create the region “feet”. Scores for the feet pain are very low in Phase I of the study. Only four participants reported feet pain above “1” which is just noticeable pain. One participant who did not report pain in their feet did in Phase II and III of the study. Overall, the amount of feet pain seemed to increase for participants in Phase II and Phase III compared to Phase I. Reports of back pain increase in in Phase II and III compared to Phase I for both groups. These reports of LBP are likely linked to those individuals' outcomes on the AHABD test. Reports of pain in the buttocks region seemed to increase for a few people over the course of the study. This trajectory was unexpected as in Phase II and III participants would have the opportunity to stand and alleviate pain in the buttocks by standing. Participants did not receive new chairs along with the implementation of their sit-stand workstation which eliminates the chair as the reason for these increases. The participants reporting pain in their buttocks region were from both the NFR and NFI group. Max pain reports neck pain tended to decrease form Phase I to Phase II and then increase again in Phase III. In Phase I most participants worked at computer that was situated in a corner of a desk and shared an office with other people. Higher reports of neck pain may be due to neck rotation throughout the day as well as "cradling" a telephone between the neck and shoulder while taking a call to decrease disturbance to their officemates. Pain reports in the left shoulder decreased for most individuals in Phase II compared to Phase I. Different participants seemed to increase the reports of pain in Phase III compared to II. Some of these participants were from the NFR group. This would align with results from the number of days that people reported experiencing pain. Pain reports in the right shoulder seemed to follow the same trajectory as that in the left shoulder. Overall participants tended to report low amounts of pain in the right shoulder. These reports of pain decreased in Phase II compared to Phase I. Graves and colleagues (2015) collected musculoskeletal pain data on a 10-point Likert scale with anchors of no pain to extremely uncomfortable. No differences between groups (training and height adjustable workstations and no training non-height adjustable workstations) was reported (Graves et al., 2015).

Hypothesis 3: There will be no influence of training program on physical activity

This hypothesis was accepted. In the current study there was no difference in walking throughout the day between groups, for objective or subjective reports, even though those who received the industry training session were asked to use the ratio 20-minutes sitting, eight-minutes standing, and two-minutes walking. Over the course of the entire study the NFR group had an average of 6697.5 (±4059.6) steps a day while the NFI group had an average of 6585.2 (±3424.8). No changes in daily step counts may be due to the fact that is isn't possible for those in the NFI group to move around this much throughout their day as participants in both groups were "desk bound" for the majority of the day.

Overall, the amount of daily step counts decreased as the current study progressed from 7405 (±4342.5) in Phase I, 6448 (±3490.7) in Phase II and 5943 (±3077) in Phase III (Figure 14). This is in agreement with what was self-reported via the OSPAQ. Self-reported amount of walking decreased as the study progress decreasing ~1% in Phase II and III compared to Phase I. Chau and colleagues (2016) found similar results in that there were no significant changes in self-reported walking depending on the type of intervention they received. Discussions with participants during the exit interview revealed that the layout of their new office spaces may also play a factor. Numerous participants noted that at their previous office location teams were spread out between two floors and in their new office teams are placed in the same hallways most of the time with offices facing each other. Of the 35 participants, only two had offices on the first floor of the building.

There is likely a tradeoff between increased physical activity during the workday and transitioning between sitting and standing. Puig-Ribera and colleagues (2015a) aimed to decrease sedentary behaviour by replacing it with walking throughout the day. They were successful at increasing step counts in those who were in the intervention group from 8862 (±2475) at baseline and maintained an increase in follow-up phase of 9786 (±3205) steps a day. With this increase in steps/day there was also a decrease in the amount of time that participants self-reported sitting a day. This study did not include measures of productivity but a follow-up study did. Healy and colleagues (2013) reported that their intervention and control groups stepped approximately the same amount 1997 (±678) in baseline and 2019 (±645) in follow-up for their intervention group and 1924 (±549) and 2038 (±531) for their control group in the baseline and follow-up phases respectively. They reported that individuals with higher amounts of physical activity throughout the week was inversely correlated with productivity as assessed by the Work Limitations Questionnaire (WLQ) (as physical activity increased so did measures of productivity) (Puig-Ribera, Martínez-Lemos, et al., 2015). The WLQ was developed by Lerner and colleagues (2001) as a psychometric questionnaire to assess the impact of chronic health problems have on "the degree to which chronic health problems interfere with ability to perform job roles" using four scales: time, physical, mental-interpersonal and output demands) (Lerner et al., 2001 pg, 78-79). Puig-Ribera and colleagues (2015) noted that the "Physical Scale" was removed from WLQ that they used. This measure of productivity may not be the best way to assess productivity of employees. Future work should assess the influence of high amounts of walking throughout the day with an analysis tool better suited to their uses.

Future considerations for employers to make regarding which intervention to implement in a workplace (reductions in sitting via walking or standing at a standing workstation) would likely include the productivity of their employees in each of these new environments with the caveat that decreases in sitting time due to increases in walking around the office or outside would in some way influence employees' productivity.

Hypothesis 4: The type of training program that individuals receive will improve their overall measures of mood state.

This hypothesis was rejected. The Profile of Mood States (POMS) Questionnaire was collected in order to assess if changes in work behaviours (as brought about by the implementation of sit-stand workstations) could influence mood states of the new users. Pronk and colleagues (2012) compared participants' POMS scores for those who did not receive a sit-stand workstation (control group) and who received a sit-stand workstation but then it was removed. When participants received the height adjustable workstations, it was reported that this group reported significant improvements in the mood state scores fatigue, tension, confusion, depression and overall total mood disturbance. The current study found that there were no differences in total mood state score, self-esteem, tension, fatigue and vigour with the implementation of sit-stand workstations for between types of training sessions. Differences were noted for the mood states anger, depression, and confusion. Reports were higher for both anger (Figure 15) and depression (Figure 17) for the group that received the additional training session. Self-reports of depression may have increased if the participants felt as if they were responsible for the outcomes of the study or if they were not transitioning between sitting and standing regularly throughout the day and felt that their workstation may be taken away from them at the end of the study. As noted by Burke (2006) behaviour change programs can also result in participants feeling responsible for their actions. Reports of confusion changed over time for both groups as both reported scores between 1.6 and 7.2 at the initial meeting and increased when participants started Phase II compared to Phase I. This increase is likely due to participants receiving their new workstations, trying to integrate them into their workday, and adjusting to the new office space. Another factor that may have contributed to this confusion (for the NFR group) was that the industry representative (who delivered the industry example of sit-stand workstation training) stopped by sporadically one day and reinforced some key points from his training session on everyone. M. Riddell did revisit each participant after this happened, but this may have still contributed to some confusion.

Mood states were assessed again at the six-month follow-up where there was only an effect in the mood state tension found. Reports of *tension* were different between groups with a higher amount in the group who initially only received the example of an industry training session at the beginning of Phase II. It is unknown as to why *tension* would have been different at this time.

Hypothesis 5: There will be an influence of Active Hip Abduction status as determined at the beginning of the study on sit-stand workstation usage behaviour, reports of musculoskeletal pain and physical activity?

It was concluded that there was an influence of AHABD status on workstation usage behaviour, musculoskeletal pain and physical activity. Although M. Riddell did not randomize participants into groups at the beginning of the study based on their AHABD score, there was no significant difference in the rate of positive scorers between groups. It was expected that the number of participants who would score positive on the AHABD test would be roughly equal between groups. This aligns with previous work that states that approximately 40-70% of the population will develop low back pain as a result of prolonged standing (Marshall et al., 2011; E Nelson-Wong & Callaghan, 2010; Raftry & Marshall, 2012). A study conducted by Nelson-Wong and Callaghan (2010a) showed improvements in pain scores (as assessed by a visual analog scale) in response to a four-week long intervention program which focused on strengthening trunk musculature. Participants in the NFR group of the current study showed improvements in the AHABD scores at the end of the study whereas those in the NFI group did not. This change may have been brought about by the NFR group standing more throughout the day (Figure 25), and taking frequent postural breaks from sitting and standing in both Phase II and III. Previous work has shown that erect standing postures are more active than slumped sitting (Sullivan et al., 2002). Assuming that participants sit in a "slumped" seated posture for the majority of the day, standing may have allowed for greater use of trunk musculature. Over a period of two months this may have allowed participants to increase trunk musculature control which could have resulted in a change in AHABD scores for the NFR group.

There is an association between AHABD status and group for the daily step counts. Those in the NFI group had the same number of steps if they were categorized as either positive or negative on the AHABD test whereas those in the NFR group responded differently (Figure 31). Positive scorers on the AHABD test moved less than negative scorers. There was also an influence of Phase of study which will be discussed below.

The number of days that participants reported pain (any selection on the MPS greater than ≥one) was assessed for each body region. It was found that the only region that was influenced by AHABD status was the low back region. Recall a positive test on the AHABD test would indicate that participants are likely to generate pain while standing. Results from the current study support findings from Nelson-Wong and Callaghan (2010) that positive scorers are more likely to generate LBP during standing and the support for the use of the AHABD tool as a screening tool to predict those who are at risk of developing low back pain while standing for a prolonged period of time. This pain did not prevent participants from standing at their workstation throughout the day as there was no effect of AHABD status on the self-reported amount of either sitting or standing at their workstation throughout the day. There was an influence of AHABD status on the amount of self-reported walking that participants reported throughout the day but the opposite was seen in objective measurements of step counts. On the OSPAQ positive scorers reported walking 8.9 (±9.1) percent of their day compared to negative scorers who walking 5.4 (±3.7) whereas an interaction was seen between AHABD status and group (Figure 34).

The number of sit-stand transitions /day may have been influenced by score on the AHABD test. Both positive and negative scorers on the AHABD test in the NFR group transitioned at a higher frequency than those in the NFI group. Within those who received the additional training session, positive scorers dropped from 6.8 (±3.5) transitions a day in Phase II to 5.1 (±3.3) times in Phase III (Figure 35). During Phase II these individuals would have been receiving weekly meetings with M. Riddell which may have prompted those who would have otherwise avoided standing (due to the risk of pain development) to stand. When these weekly meetings stopped in Phase III it can be seen that these individuals choose to not transition between sitting and standing as much throughout the day. This may be because they are actively avoiding the amount of their day that they spend in standing (their "pain developing posture"). For those in the group who only received the industry example of training, those who scored positive on the AHABD test transitioned approximately one time fewer/day in both Phase II and III (Figure 36). Overall, those who scored negative on the AHABD test transitioned more frequently each day than those who scored negative. This is true for both groups. The initial meetings between participants in NFR group and M. Riddell may have provided enough encouragement for positive AHABD people to stand when they initially received their workstation to develop lasting changes for their trunk control even though their transitions decreased in Phase III (by one) (Figure 35).

At the six-month follow-up it can be seen that the effect of group is no longer present (Figure 38) but there is still an effect of AHABD status (Figure 43). Those who scored positive on the AHABD test transitioned between sitting and standing 4.2 (±3.0) times a day. Those who scored positive on the AHABD test transitioned fewer times a day at an average of 2.9 (±3.1). Even without the influence of group (now both groups have the same training session), we will see that there is an influence on AHABD status on the number of sit-stand transitions that people make each day. With further investigation, the AHABD test could be used to identify who would be a "good" candidate to receive a sit-stand workstation. Those who scored negative would highlight to practitioners that individuals may need more attention to ensure that they are using their workstation throughout the day with reduced risk of developing MSK pain.

Exit Interview and Questionnaire

At the beginning and end of the current study participants completed a questionnaire asking them to report that they think they will or have had any benefits from using their sit-stand workstation. At the beginning of the study Summary from benefits questionnaire only two participants noted that they believed that they would be less stressed (one of these people dropped out of the study before the end of Phase I). At the end of the study five people in total reported being less stressed. At the end of the current study 43% of participants reported feeling more productive and 37% more focused compared to 66% and 71% from Pronk and colleagues (2012). Reports of increased productivity from the current study more closely aligned with that reported by Alkhajah and colleagues (2012) at 33%. Recent studies have shown that using a sit-stand workstation does not decrease productivity, but instead it stays generally the same (Chau et al., 2016; Dutta et al., 2014; Ebara et al., 2008; Graves et al., 2015; Husemann et al., 2009;

Nerhood & Thompson, 1994) which agrees with findings from a published literature review (Karakolis & Callaghan, 2014). Robertson and colleagues (2013) noted that participants tended to switch whole body postures after the completion of a task. Participants in the study conducted by Graves and colleagues (2015) reported that they did not like standing and seeing everyone in their office and suggested that a screen moves up with the work surface to limit distractions in the office while standing.

Upon completion of the study, an exit interview was conducted with each participant. In this semi-structured interview, most participants stated that if they didn't use their workstation at all one day it was likely because they didn't feel well or if they were very busy and had to get something done for a deadline. The question "Would you have liked more, less, or the same amount of training/education about how to use your workstation?" This question was not answered by one individual in the NFR group. Fourteen participants reported wanting more information, zero wanted less and 20 wanted the same. All participants who wanted more training and three who wanted the same amount of training were from the NFI group. These numbers may be higher than what would typically be seen in a study of its kind as participants in the current study are researchers and would be more inclined to know "what they were missing". Participants who reported that they wanted more training requested information regarding using the pre-programmed heights on the desk, a follow-up session, the correct set-up of the workstation, or more specific information regarding the literature. Most participants commented that the use of the workstation was task dependent when they initially started using the workstation but it decreased over time. The majority of the participants noted that using their workstation was more so based on how busy they were.

Limitations

Although this study was novel and has contributed to this area of literature, there are some limitations to the current study. One limitation is that there was not true segregation between groups as participants worked very close to each other. Participants noted in the exit interview that even though everyone had their own office, the motor was very loud and could be heard from across the hall if doors were open. This inevitably would have "triggered" participants to change postures upon hearing their colleagues adjusting theirs. Between the different phases of the study there was no change in the knowledge that participants had in the NFI group, but that isn't to say that their usage of the workstation was not influenced by those around them in the other group. Participants also changed office locations at the beginning of Phase II which would have altered participants' normal daily routines. The number of daily sit-stand transitions was not collected for the NFI group after they received the additional training session which disables the ability to compare changes in whole-body transitions after they received the additional training session.

The current study adds to existing literature as it is the first to objectively measure movement of the sit-stand workstations and not the individual user. The study also collected data for three-months in the initial study and for three weeks after a follow-up period of six months.

Current and future training programs

Future training programs should incorporate a hands-on demonstration period to allow each individual one-on-one time with an educator to review workstation configuration in both sitting and standing postures. This time also allows the new user to ask questions specific to tasks that they complete on a day to day basis and to receive personalized feedback. Participants noted that the exercise where they were asked to point out it was helpful and that they benefited from the discussion. One participant noted that they thought the training session was very dry and wasn't sure how it could be improved given the subject matter. As the current study noted higher amounts of pain in the right and left shoulders, future training sessions should focus on the delivery of the training program when explaining workstation configuration in sitting and standing.

Future training sessions should spend less time discussing why prolonged sitting and standing is not optimal and more time on how participants can integrate their new workstation in to their workday and how to recognize when to change postures. This could be via individuals knowing their own bodies and when pain development is likely to occur as well as what to use as triggers to know when to change whole body posture.

If using a device similar to a Fitbit Zip, it is suggested that a bright colour is chosen to prevent participants losing them by them falling off and not noticing, forgetting to wear them because they were left in another pair of pants, or inadvertently washed in the laundry or worn while participating in water activities. It is suggested that future recordings of musculoskeletal pain are recorded on a continuous scale (with a sliding bar) in order for participants to report feelings of pain more freely. Future studies should continue to combine objective and subjective measures of sit-stand transitions and sitting and standing throughout the day to allow the best understanding of how individuals are using their workstations.

Chapter 6: Conclusions

Those who received the training program based on current best practice research spent less time sitting and more time standing than those who only received an example of what is currently being taught in industry.

Those who originally received the training program that was based on current best practice research reported standing more and sitting less than the other group at the six-month follow-up.

There was no increase in physical activity (as assessed by the Fitbit Zip) with the implementation of sit-stand workstations.

Those who scored positive on the Active Hip Abduction test reported more low back pain than those who did not.

Those who received the training program prior to the implementation of sit-stand workstation had fewer days where they did not transition between sitting and standing at all.

Future research should continue to investigate the postures to recommend to users of sit-stand workstations when standing and working. The mental and cognitive nature of tasks should be considered.

6.1 Contributions/ Impact

The current study provided objective data about the number of sit-stand transitions that users of sit-stand workstations make each day. This is a relatively simple technique and should be employed in future studies.

This study was the first to utilize the Active Hip Abduction test to determine what or if it had a relationship between how people use their sit-stand workstations.

The two groups of participants were very similar in terms of their age, and the tasks that they completed on a day to day basis, which allowed for a more direct comparison between groups.

This was the first study to conduct an objective measurement of sit-stand transitions six months after the completion of the study. The blinding of participants to this collection allowed a more in depth look into how workstations are used in industry on a day to day basis.

The development of the training program can lend itself to material that can accompany future training sessions to new users of sit-stand workstations. Findings can be used to direct the development of guidelines for use by practitioners, researchers, and the public.

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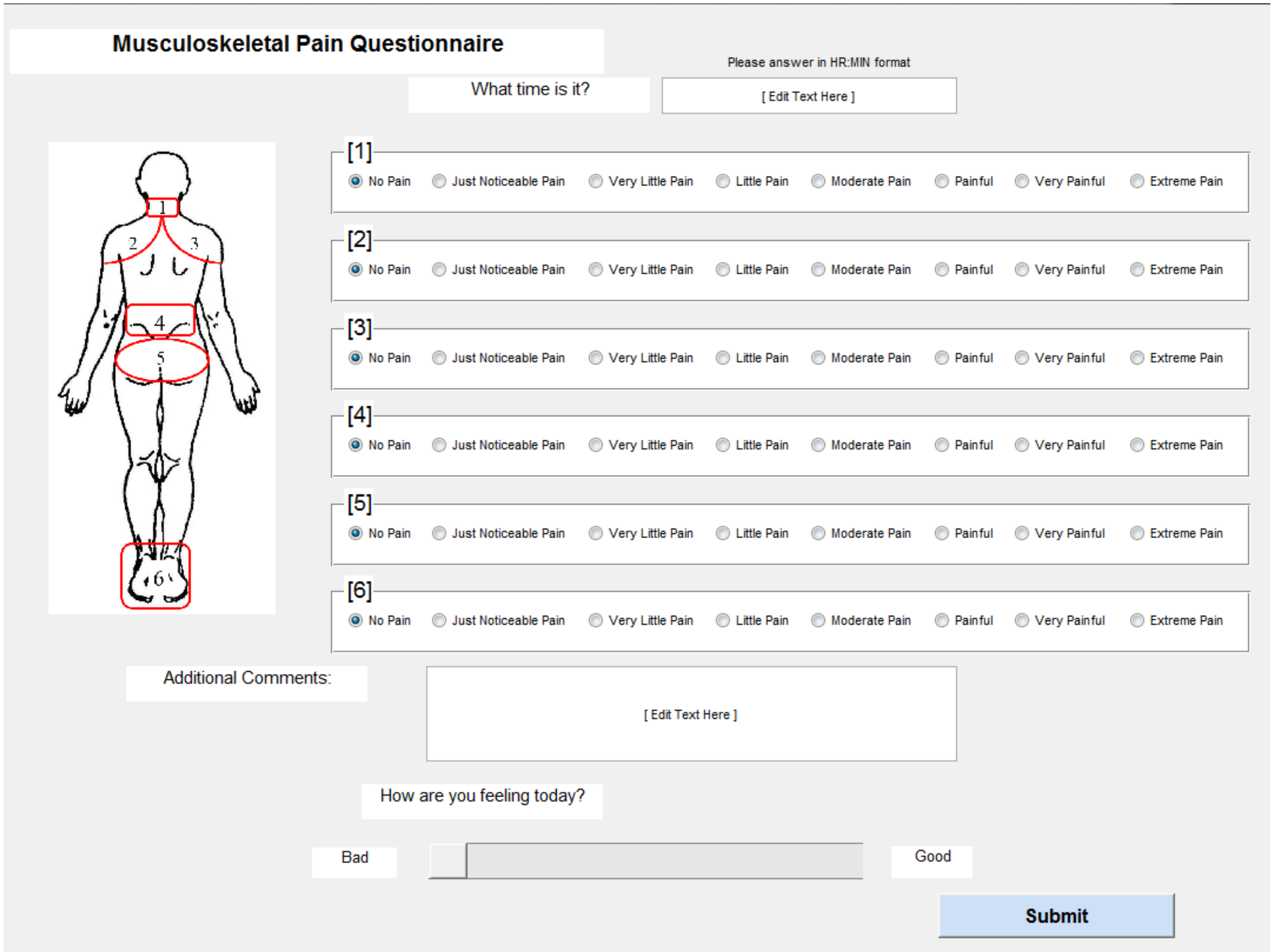
Appendices

Appendix A: Musculoskeletal Pain Survey (MPS) to assess musculoskeletal pain throughout the day.



Appendix B: Health Screening Form

Health Screening Form:

This questionnaire asks some questions about your health status. This information is used to guide us with your entry into the study.

PARTICIPANT ID CODE: _____________ **DATE:** _______________

SELF REPORT CHECKLIST:

Past Health Problems:

[ ] Rheumatic Fever
[ ] Heart Murmur
[ ] High Blood Pressure
[ ] High Cholesterol
[ ] Congenital Heart Disease
[ ] Heart Attack
[ ] Heart Operation
[ ] Diabetes (diet or insulin)
[ ] Ulcers
[ ] Bleeding from Intestinal Tract
[ ] Epilepsy
[ ] Varicose Veins
[ ] Disease of the Arteries
[ ] Emphysema, Pneumonia, Asthma, Bronchitis
[ ] Back Injuries
[ ] Kidney and liver disease
[ ] Heartburn
[ ] Enteritis/Colitis/Diverticulitis
[ ] Bleeding Disorders

Present Health:

List current problems:
1.
2.

List medications taken now or in last 3 months:
1.
2.

For Females: Pregnant ________ Nursing ________

List Symptoms:

[ ] Irregular Heart Beat
[ ] Chest Pain
[ ] Shortness of Breath
[ ] Persistent Cough
[ ] Wheezing (Asthma)
[ ] Dizziness when standing
[ ] Fatigue
[ ] Cough up blood
[ ] Back Pain/Injury
[ ] Leg Pain/Injury
[ ] Shoulder Pain/Injury
[ ] Dizziness

Describe in more detail: ____.
____.
____.

Current Physical Training Status:

I consider my physical training status to be: High [ ], Average [ ], Low [ ]
List the types of physical activities that you do on a regular basis:

Habits:

Smoking: Never [ ] Ex-smoker [ ] Regular [ ] Average # cigarettes/day [ ]

Appendix C: Profile of Mood States Questionnaire (POMS)

The following list describes feelings people have. Please read each one carefully and select the answer that best describes your feelings in the past week.	❍ Not at all ❍ A little ❍ Moderately ❍ Quite a bit ❍ Extremely
1. Worn out	*[Use scale above for all feelings]*
2. Peeved	
3. Cheerful	
4. Restless	
5. Embarrassed	
6. Bewildered	
7. Hopeless	
8. Weary	
9. Bitter	
10. Vigorous	
11. Nervous	
12. Ashamed	
13. Forgetful	
14. Helpless	
15. Unable to Concentrate	
16. Resentful	
17. Full of pep	
18. Miserable	
19. Furious	
20. Lively	
21. On-edge	
22. Proud	
23. Confused	

24.	Sad
25.	Fatigued
26.	Grouchy
27.	Active
28.	Tense
29.	Competent
30.	Bushed
31.	Worthless
32.	Exhausted
33.	Angry
34.	Energetic
35.	Uneasy
36.	Satisfied
37.	Uncertain about things
38.	Anxious
39.	Discouraged
40.	Annoyed

Appendix D: Intake/ Job Questionnaire

Date: _______________ Participant Code: _________

	Question	Answer/ Additional comments
Personal	Name	
	Birth date	
	Age	
	Gender	
	Handedness	
	Height	
	Weight	
	Highest level of education completed?	
	How much knowledge do you have of the current literature surrounding using a sit-stand workstation?	None Minimal Moderate Lots
	Do you smoke? If so how much per day?	Yes No How much per day: _________________
Work	How many years have you worked for Propel Centre for Population Health Impact??	Years: ________________ Months: ________________
	How many years have you been doing this particular job?	
	How many years have you used a computer for?	
	List some tasks that you complete everyday…	
	How many hours a day do you spend sitting at your desk completing work?	Hours: ____________ Minutes: ___________
	How many hours do you spend a day working on your computer?	Hours: ____________ Minutes: ___________
	On average, how many hours do you spend typing or mousing each day?	Hours: ____________ Minutes: ___________
	I believe that using a sit-stand desk will improve my health, decrease MSD and increase overall feelings of well being scaled on a 1 2 3 4 5 scale	1 2 3 4 5 No YES

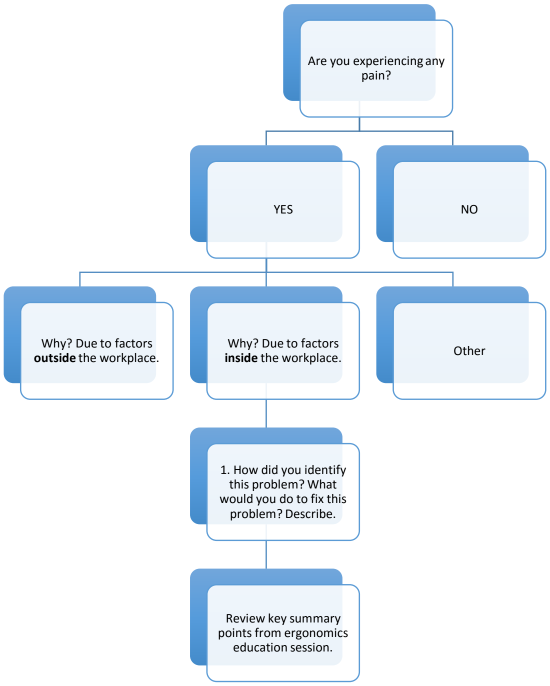
What specific benefits did you gain by alternating between a seated and standing position:	*(check all that apply)* ❍ Uncertain ❍ Less stressed ❍ More comfortable ❍ More productive ❍ More focused ❍ Happier ❍ Energized ❍ Healthier ❍ None of the above ❍ Other (please specify): ________________________________

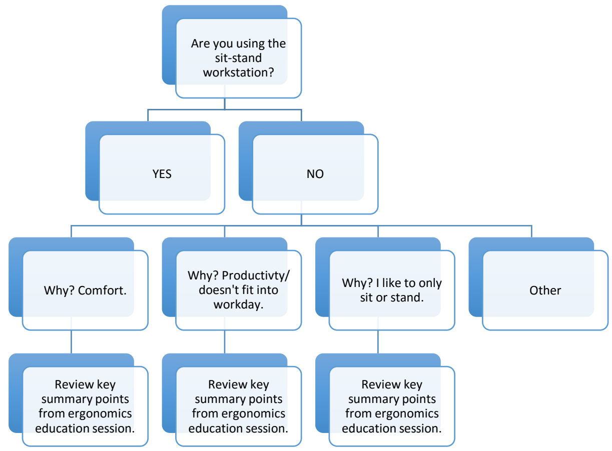
Appendix E: Ergonomic Knowledge Assessment

Knowledge Area Question	Agree	Not sure/ Don't know	Disagree
MONITOR POSITION			
My monitor should be located at least 1 arm's length away from me.			
The top of my monitor should be at eye level regardless of what type of glasses I wear.			
It does not matter how my monitors are oriented on my desk.			
KEYBOARD and MOUSE			
My wrists should always be higher than my elbows			
My wrist should be bent towards the ceiling while I am using my mouse			
When using my keyboard my elbows should be tucked in beside my body and not stretched out in front			
When typing my wrists should be slightly bent to either side			
I should rest my arms on the desk is possible while typing			
My mouse should be off to the side of my dominant hand			
CHAIR			
It does not matter if my feet touch the floor or not as long as the rest of my body is in a neutral/ "good" position.			
I should sit for as long as I can as long as I feel comfortable and my workstation is properly adjusted			
My armrests should always be adjusted so that they support my elbows as I am typing			
DESK			
My keyboard should always be at elbow height when I sit or stand at my desk			
The items I use most often should be anywhere on my adjustable desk			
SIT-STAND			
I should try and stand at my desk 5 times per week			
It is important to use my sit-stand desk			
I should take breaks from sitting 3 times a day to give my body a break			
I should vary between sitting and standing in a 3:1 ratio			

Appendix F: Flow chart to be used during weekly meetings with participants

New furniture and Research education group (NFR):





Description of what employee said they would do to fix their musculoskeletal pain problem:

New furniture group industry education group (NFI):

How is the sit-stand workstation?

Are you enjoying your new workstation?

Appendix G: Daily reports of pain in each region. All participants' results are shown on the graphs

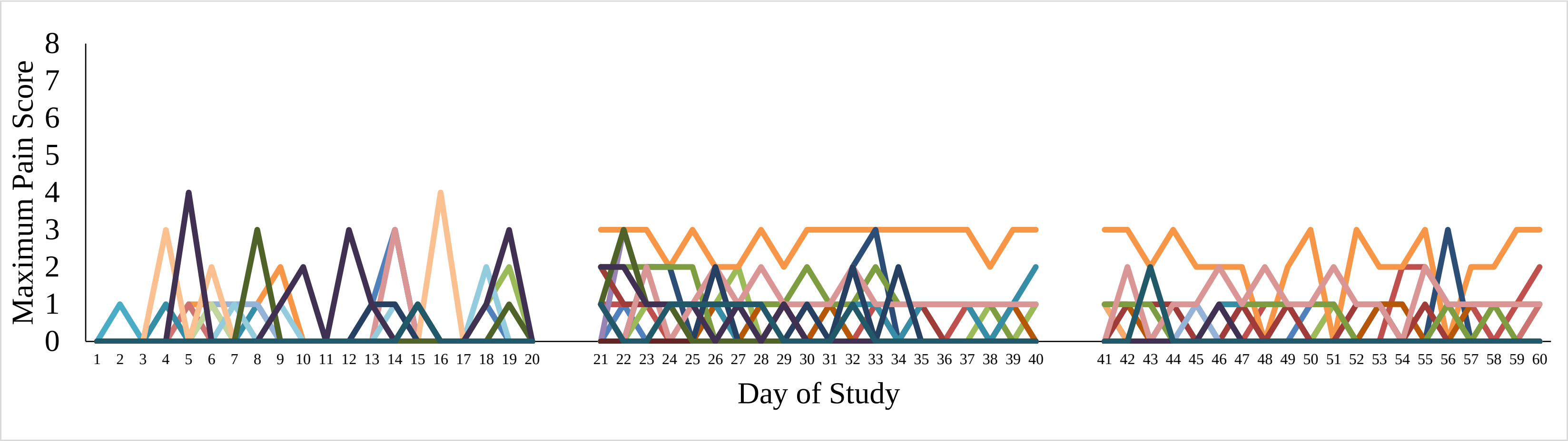


Figure 1: Maximum pain score reported each day for the feet.

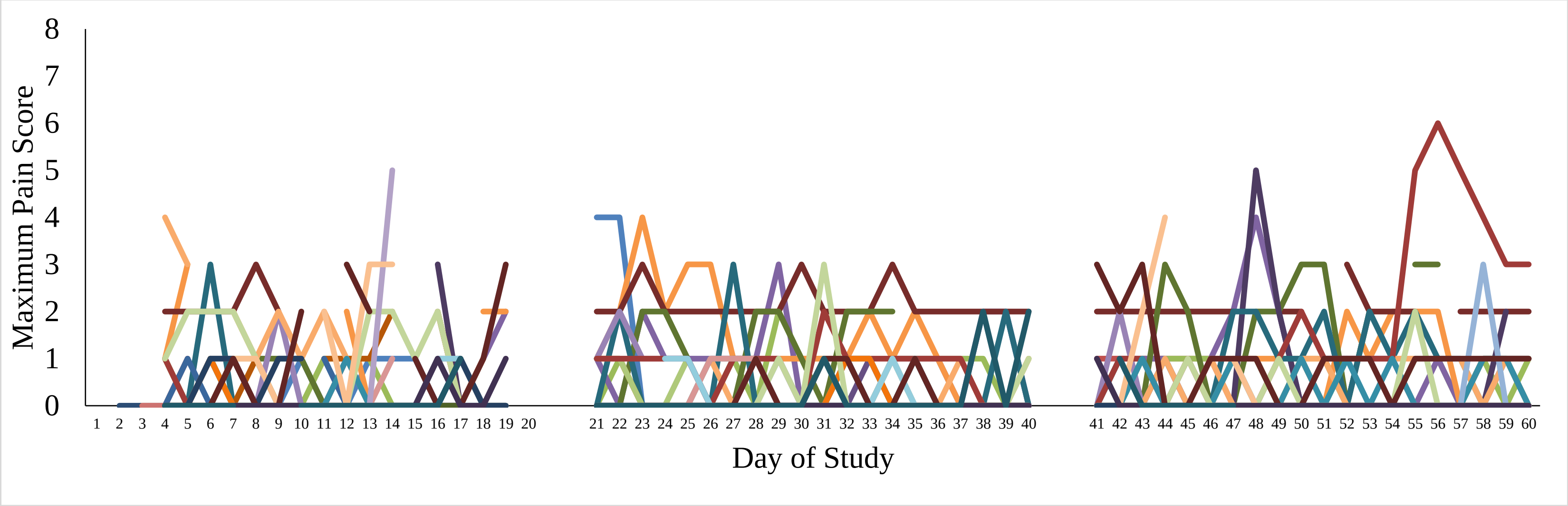


Figure 2: Maximum pain score reported each day for the low back region.

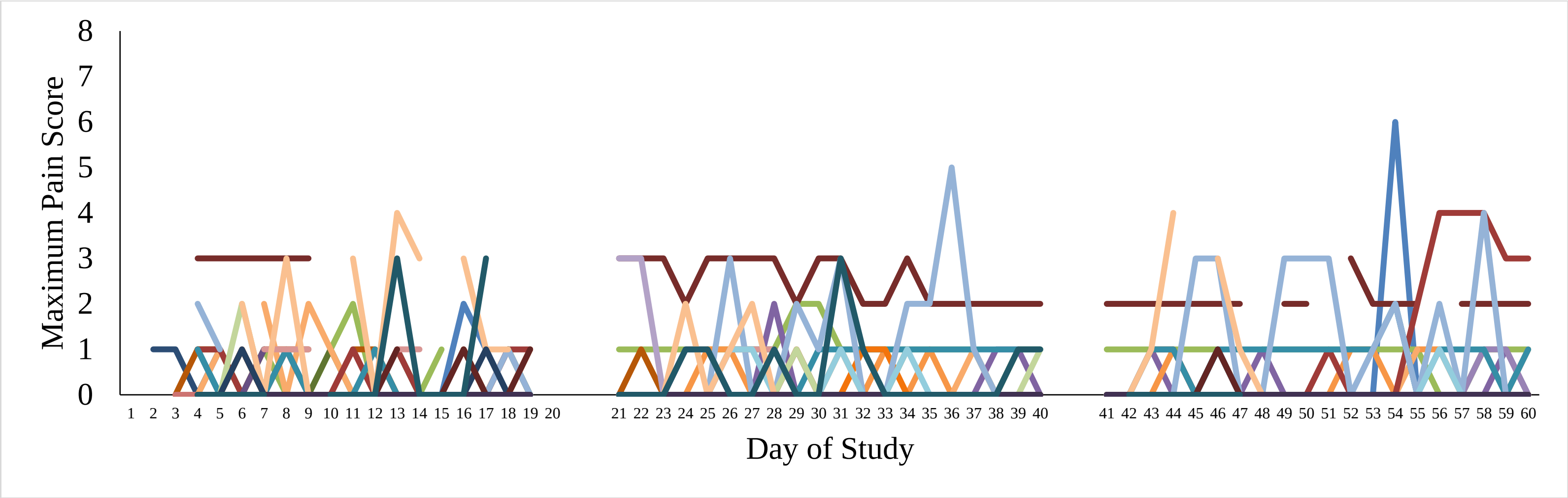


Figure 3: Maximum pain score reported for the buttocks region.

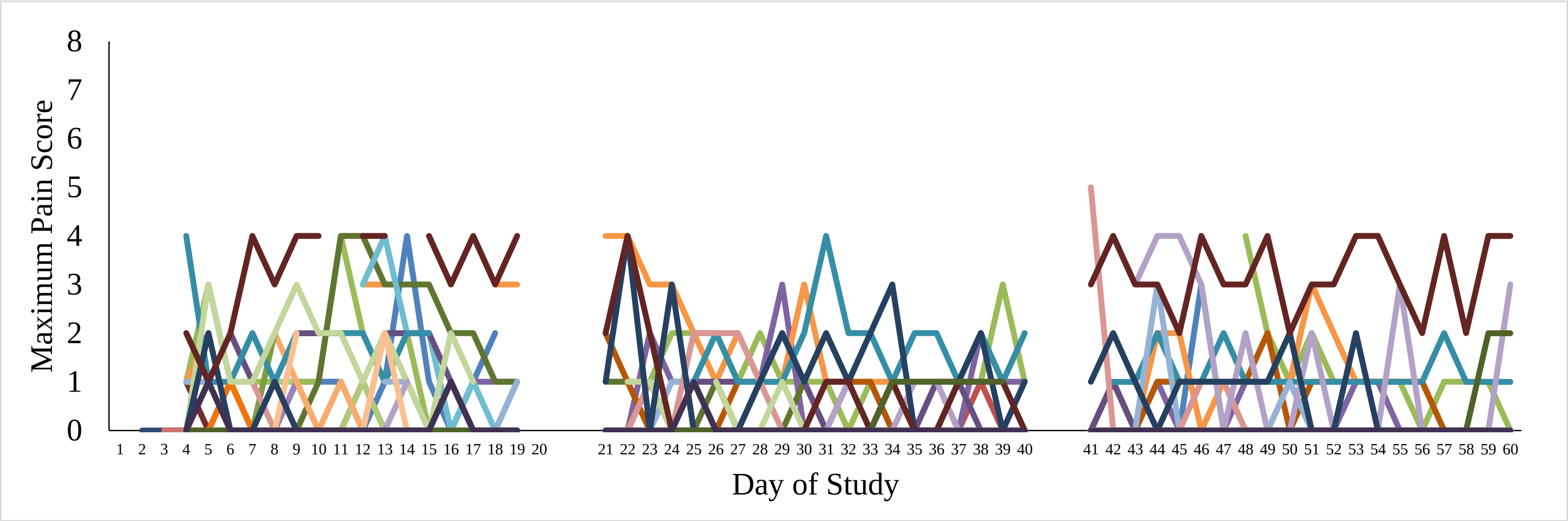


Figure 4: Maximum pain score reported for the neck region.

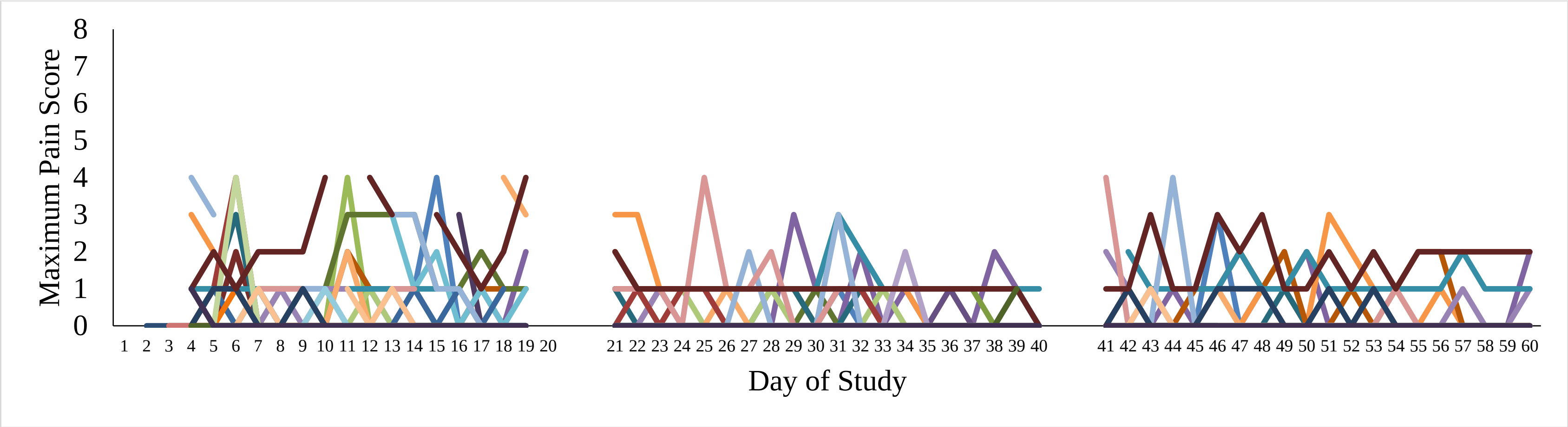


Figure 5: Maximum pain score reported each day for the left shoulder region.

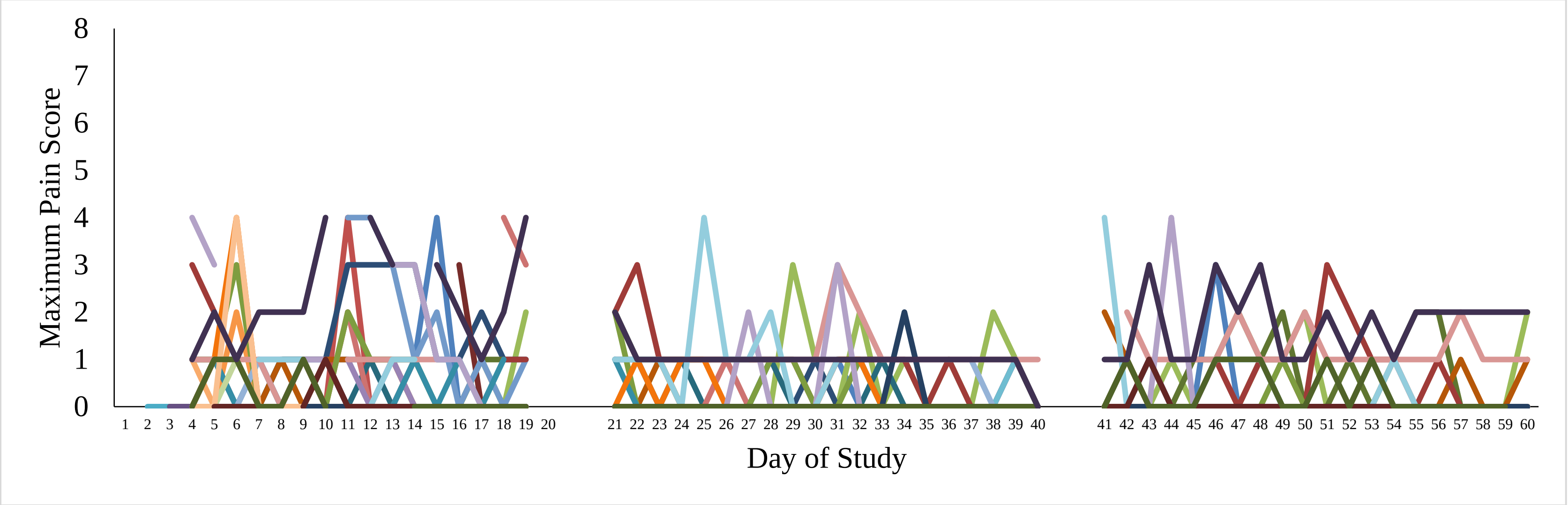


Figure 6: Maximum pain score reported each day for the right shoulder region.