THE INFLUENCE OF BEHAVIOR-BASED COMPUTER INTERVENTIONS ON UTILIZATION OF SIT-TO-STAND DESKS AND THE SUBSEQUENT IMPACT ON PRODUCTIVITY: A LONGITUDINAL STUDY

A Dissertation

by

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ABSTRACT

Sedentary behavior has been recognized as a causal link to major health diseases such as heart disease, obesity, diabetes, and stroke. On average, working adults spend more than 90% of their time sedentary in their workplace which increases their susceptibility to these major disease processes. Interventions designed to illicit increased activity within the workplace, such as sit-to-stand desks, have been attempted in many instances but detriments to an individual's performance as well as sustained usage have been barriers to full adoption within the workplace. Two field studies were conducted to first, determine the impact of sit-to-stand usage on an individual's productivity and secondly, to understand the influence of computer-based prompting in modifying an individual's motivation to use sit-to-stand desks.

The first study (call center) compared a productivity metric of 167 call center workers who were divided into an experimental (stand-capable workstation) group or a control (seated workstation) group. The productivity metric was collected continuously over a 6-month period and then compared by group and job category. Findings indicated that there was a 46% increase in productivity over the 6-month period for the experimental group versus the control group, suggesting that stand-capable desks are a likely contributor to increased productivity.

The second study (Chevron) compared sit-to-stand desk usage of 200 office workers across 2 different geographic locations who had been assigned to one of two groups, experimental (received computer prompts) and control (no computer prompts). With computer software, all participant's daily standing transitions were objectively collected over a 6-week baseline period. Following the baseline period, the experimental group began receiving computer prompts for a 3-month continuously monitored period. Analysis of the resultant

findings indicated a 229% increase in standing transitions over the 3-month prompting period for the experimental group, suggesting that computer prompting could be used to motivate employees to change their sit-to-stand usage behavior.

When combining the results of the two studies, it is apparent that sit-to-stand desk usage has positive benefits within the areas of productivity and sedentary behavior reduction. Both areas are particularly relevant and important areas of concern and interest for industry leaders looking to increase productivity and reduce medical cost utilization within their workforce. These findings contribute to the ever-expanding knowledge base aimed at decreasing sedentary behavior by providing possible behavior change mechanisms to increase and sustain sit-to-stand desk usage.

DEDICATION

This body of work is dedicated to my wife, Kristi Garrett, who has been my staunchest supporter throughout this entire program. She has been a part of this process since before the beginning and has always been my most loyal and vocal advocate. If it were not for her continued support and encouragement I would have not been able to complete this goal.

Kristi, nor I, were prepared for the amount of sacrifice it would take to untimely see me walk across that stage and accept my diploma. The long hours of coursework, research, literature reviews, and journal analysis and re-writes took their toll and impacted me medically and professionally. Throughout all the health issues and relocations (due to career), Kristi has remained my true north star and has always been by my side.

She is my wife and my love, but above all these she is my best friend and companion. The one person I can always count on to be there with words of encouragement, to tell me “you’ll do great!” or simply “you can do it”. For all of these things and so much more, Thank you!

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CHAPTER I

INTRODUCTION

Sedentary behavior

It is estimated that most American adults spend 90% of their non-sleep time sedentary, with 8–9 hours of this sedentary daily time due primarily to time spent in their office environment (Straker et al., 2012; Straker et al., 2013). Sedentary behavior has been linked to mortality and several negative health outcomes including obesity, cardiovascular disease, and cancer (Katmarzyk, et al., 2009; Tremblay et al., 2010). Research has indicated that this may be true even for those who are meeting recommended physical activity guidelines (Hamilton et al., 2008; Katmarzyk et al., 2009). Call center operators have been observed spending ~ 90-95% of their work shift in their seats and work long hours without breaks as opposed to one-third or one-half for other office employees (Rocha, et al., 2005; Straker et al., 2013; Pickens et al., 2016). Additional consequences of prolonged sitting include lower back pain and body discomfort which has been shown to impact productivity with increased discomfort at daily work tasks resulting in perceived productivity losses of 10% to 20% (Hagberg, et al., 2002; Wahlström, et al., 2004; Rocha, et al., 2005; Marshall, et al., 2010).

Obesity has been linked to excess sedentary time, which in turn has been implicated in higher risks for cardiovascular disease, diabetes, and cancer (Katzmarzyk et al., 2009; Tremblay et al., 2010; Dunstan et al., 2012). Decreased caloric expenditure resulting from increased sedentary behavior has been linked to other comorbid disease processes such as cancer, diabetes, stroke, and cardiovascular disease (Hamilton et al., 2008; Owen et al., 2009; van Uffelen et al., 2010). The primary mechanism contributing to the elevated risks of these disease processes in office environs is the reduction of non-exercise activity thermogenesis (NEAT) which is the daily energy expenditure expended through all physical activity other than that of intentional exercise or sport activity (Levine et al., 2006). However, because of reduced seated time as a result of increased standing in office environments, an increase in NEAT levels can thereby off-set the possibility of elevated risks from these disease processes (Levine et al., 2007).

Prolonged sitting in office environments has been associated with increases in body discomfort (Marshall and Gyl, 2010). In adults, the impact of standing desks on modern office tasks in an experimental study has shown to reduce discomfort over time (~15 weeks), which has been argued to positively affect task performance (Robertson et al., 2013). Thus, it is likely that increased standing in office environments facilitate work efficiency and productivity in adults. In a simulated office environment/work study however, Husemann et al. (2009) reported that increased standing in offices while working did not significantly impact productivity. Unfortunately, this study examined the impact of acute standing (~1 week) on efficiency of simulated work rather than observing continued exposure to standing. Therefore, how continued exposure impacts work productivity in in-situ occupational environments is not known. It is important to examine this relationship between standing behavior and productivity in a naturalistic work environment so that the development of sustainable office ergonomics solutions will address task interruption challenges while having a positive impact on productivity and performance.

Despite the detrimental evidence associated with too much sitting, there are no established guidelines on the recommended amounts of sedentary time (Owen et al., 2009). Even though the American College of Sports Medicine (ACSM) and the American Cancer

Society generally recommend breaking up long periods of sedentary behavior with bouts of activity there are no specific guidelines related to amount of time spent in pursuit of increased activity (Garber et al., 2011; Kushi et al., 2012). With sedentary behavior recognized as an independent factor of mortality by the American Journal of Preventative Medicine (2011) behavioral interventions that target specific populations, behaviors, and settings are needed to reduce this health risk. Therefore, the establishment of physical activity guidelines and identification of tools to meet those guidelines are key to decreasing sedentary behavior in office environments.

Sit-to-stand desks

Sit-to-stand desks, as an office ergonomics solution to this problem, have the potential to improve caloric expenditure and reduce sedentariness in the workplace (Alkhajah et al., 2012, Pronk et al., 2012, Grunseit et al., 2013). However, the sustainability of sit-to-stand desk usage in maintaining physical activity and reduction in sedentary time within occupational settings has been a challenge (Wilks et al., 2006; Straker et al., 2013). In addition, modern office interventions that promote physical activity with automated reminders such as computer programs that prompt individuals to take breaks, have shown to decrease productivity as the individuals are prompted to either leave their workstations or discontinue their work for a short period (Evans et al., 2012). Still, replacing sedentary time with activity in office environments has the potential to reduce obesity, comorbid disease processes, increase physiological processes & cognitive performance, and decrease body discomfort.

Most sit-to-stand type devices consist of stand-biased, full sit-to-stand, and table top units with a small percentage of treadmill type workstations primarily used to increase physical activity without changes in positional height. Stand-biased workstations are adjusted to the standing height (96 cm+) of the worker rather than the fixed factory setting (76 cm) of a traditional seated workstation (Pickens, et al., 2016). Full sit-to-stand workstations allow the worker to raise and lower their workstation to accommodate ranges between the 5^{th} percentile female seated elbow height (55.88 cm) to 95^{th} percentile male standing elbow height (121.92 cm), thus allowing accommodation for ~95% of the working population (Cook & Burgess-Limerick, 2003). Table top units do provide the similar flexibility to alternate between sitting and standing as full-sit-to-stand devices and do so without major changes in the work environment, however the majority do not have the necessary range to fully accommodate 90% of the population (Cook & Burgess-Limerick, 2003).

The use of sit-to-stand workstations provides a minimally distracting alternative to increase activity (energy expenditure) as opposed to traditional worksite fitness programs or wellness initiatives that rely on structured participation and higher intensive activities that typically take place outside of non-working hours (Tudor-Locke, Schuna Jr., Frensham, & Proenca, 2014). However, comparisons between static standing for extended periods versus seating result in a minimal increase in overall energy expenditure for those individuals who chose to stand (Júdice, et al., 2016). Therefore, increases in energy expenditure are directly related to conditions that illicit physical activity, or movement, such as increased transitions (positional changes) or “leaning”.

Positional changes between sitting and standing can facilitate increased energy expenditure without major adjustments to the work environment through the introduction of sit-to-stand desks, stand-biased desks, table top units, or other types of office equipment (chairs or stools). Recent studies have explored the differences in caloric expenditure, heart rate, and VO_2 Max between sitting, standing and sit-to-stand transitions and have found modest differences in energy expenditure between static sitting and static standing with larger differences between sitting and sit-to-stand transitions (Healy, et.al., 2011; Peddie, et al., 2013; Júdice, et al., 2016). However, questions remain as to the appropriate balance between sitting and standing as well as the number of transitions an individual should perform during a set period with most recommending movement after 30 minutes of prolonged sitting (Dunstan, et al., 2012; Gallagher, Campbell, & Callaghan, 2014). While there is no consensus in the literature on the duration and frequency of sit-to-stand transitions, an increase in transitions would most likely have a positive impact in the reduction of sedentary behavior.

Productivity

There has been an abundance of research that has explored the decrements associated with task interruptions (i.e. phone calls, emails, etc.) in office environments (Bailey & Konstan, 2006). Therefore, it has been surmised that the introduction of methods to increase physical activity within office environments would have a negative impact on an office worker's task performance as they would constitute an additional interruption (Bassett, 2009; Alderman, et al., 2014). Research studies have been conducted on active workstations (treadmill desks and cycle desks) and activity permissive workstations (sit-to-stand or stand-biased) to determine what impact, if any, these methods have on productivity or task performance (Commissaris, et al., 2014).

Active workstations provide the ability to increase caloric expenditure and decrease sedentary behavior but there have been mixed claims on the efficacy of these workstations related to productivity and task performance (Thompson & Levine, 2011; Larson, et al., 2015). Research into treadmill desks have indicated that once an individual exceeds speeds over 2 mph (normal walking speed), task performance (error rates, accuracy, etc.) begins to decline (John, et al., 2009; Commissaris, et al., 2014). In addition, it has been suggested that individuals working while using a treadmill desk should limit activities to tasks that are less cognitively engaging such as talking on the phone or reading emails (Gustafson, 2015). However, additional research claims that there are no differences in task performance with no impact on productivity or cognitive performance for these active workstations (Alderman, Olson, & Mattina, 2014; Torbeyns, et al., 2014). While there is disagreement between negative or no impact to task performance decrements for active workstations, it is agreed that active workstations do decrease sedentary behavior (Larson, et al., 2015).

Activity permissive workstations (sit-to-stand, stand-biased, table-top units, etc.) provide the means to increase activity within the workplace but questions remain as to the impact of these workstations on productivity and task performance. Similar to active workstations, activity permissive workstations provide a means to increase physical activity. However, results of multiple studies have been mixed on the resultant impact on productivity with some studies indicating little or no impact on productivity (Karakolis, et al., 2016) while others show a positive impact (Garrett, et.al., 2016). There have been studies indicating that high intensity activity has a positive impact on working memory and cognitive functioning (Brisswalter, Collardeau, & René, 2002; Cassilhas, et al., 2007; McMorris, et. al., 2011). While positional changes are not high intensity physical activities, there are studies indicating that even low types of physical activities such as walking can maintain and even increase cognitive functioning as well as cortical plasticity (Weuve, et. al., 2004; Kramer & Erickson, 2007). Therefore, it could be surmised that increases in physical activity, no matter intensity, would have some impact on cognitive functioning and performance.

Motivational behavior change

According to the CDC, only 23% of adult Americans meet the weekly recommendation for physical activity (Blackwell & Clarke, 2018). Disease processes related to inadequate physical activity such as heart disease, stroke, high blood pressure, diabetes, are in part related to this lack of physical activity. Therefore, it is crucial to develop processes to decrease sedentary behavior during work and leisure time.

There are several health behavior change models; most notably Social Cognitive Theory, the Transtheoretical Model, Social Ecological Theory, and the Health Belief Model, all of which contain an element of interpersonal influencers, such as seeing others perform a healthy act or effecting change through the use of individual internal motivators (Schwarzer, 2008). Application of these theories could provide a grasp on the social processes that influence sit-to-stand desk usage and physical activity within the workplace while providing a crucial understanding of appropriate mechanisms to influence behavior change (Hall, et al., 2015). In much the same way that smoking cessation programs focus on the health benefits, individual motivators, and support; workplace wellness programs should focus on these same key elements in promotion of movement and reduction of sedentary behavior in work environs.

A key element of behavior change is an individual's motivation which can be classified into three broad categories; Intrinsic, Extrinsic, and Amotivation (Ryan & Deci, 2000a). Intrinsic motivation refers to a drive motivated by what is enjoyable or interesting, Extrinsic motivation refers to behavior driven by external rewards (fame, money, praise, etc.), and Amotivation motivation is the state of lacking any intention to act (Ryan & Deci, 2000a, Garrett, et. al., 2013). As there has been evidence to suggest that rewards (Extrinsic motivation) often inhibit or prevent long-term behavior change, processes that facilitate or promote an individual's Intrinsic motivational development are needed to ensure adherence and sustainment of long-term behavior change.

Current research gaps

Since the advent and proliferation of computing devices in office and home environments, considerable research has been directed at the casual development of musculoskeletal disorders (MSDs) primarily associated with poor postures. More recently, the research focus of these computing devices has been on the impact on sedentary behavior for work and leisure time activities (Hamilton, et al., 2008). Sit-to-stand desks have been offered as a simple and easy means to decrease the sedentary nature of office environments, however the successful usage and sustainment of these interventions, along with their perceived negative impact on productivity, have been met with resistance by both office-based users and companies; inhibiting their widespread adoption.

There have been several studies that have investigated the impact of sit-to-stand desks on productivity with most finding no impact while others found task interruption as a main casual factor for negative productivity performance (Speier, et al., 1999). Call center employees are a prime population for the study of sedentary behavior and productivity as this population is, in effect, bound to their workstation and productivity metrics are objectively collected on a continuous basis. An understanding of body discomfort and its impact on productivity for workers, who have the option to change postures, will add in the determination of duration and frequency for sit-to-stand desk usage.

Development of sit-to-stand office software such as SitStand coach, Wellnomics Workspace, RSI Guard, and others are designed to increase sit to stand desk usage by prompting users to change positions. Typically, these software programs are based on a pre-set standing period for each bout of sitting with the primary goal to break up sitting behavior with prompts. Unfortunately, the majority of these software programs are simple “egg-timers” in nature and do not consider the potential negative impact of these interruptions (prompting) while the user is highly engaged in task completion which can be a challenge to the effectiveness of these software programs as a means to impact behavior change (Alderman, et al., 2014).

The software program, BakkerElkhuizen SitStand Coach, used for postural change prompts in our Chevron study used a specifically designed algorithm that determined when the user was present based on keystrokes and mouse movements (Alkhajah et al., 2012). The continuous interaction with the computer determined the appropriate timing for changing positions (seated vs standing) and made prompt recommendations based on the pre-set parameters based on previous literature suggesting 6 minutes of standing for every 30 minutes of seated time (Alkhajah et al., 2012). Users had the option to ignore the prompts or conversely change the desk height to a seated or standing height whenever they wished, and the software program would reset based on positional height. In this case, users had some control over the recommended positional change frequency and duration thus allowing some individual tailoring of the prompt frequency. Impact on body discomfort, therefore, could be used as a measurement tool in determining the appropriate balance between sitting and standing duration as well as frequency of positional changes.

The objectives of these two research studies was the determination of body discomfort and whole body postures on productivity and the effectiveness of computer prompts to illicit increased sit-to-stand desk utilization through frequent positional changes. Public health implications from these two studies are an understanding of the appropriate balance between sitting and standing times, appropriate behaviour change mechanisms to increase postural changes, what overall attributes of sit-to-stand desks will sustain long-term usage, and the impact on health benefits such as obesity and certain types of cancer as well as strokes. An understanding of these factors will aid companies to integrate sit-to-stand desks effectively into their workplace wellness programs thereby impacting the overall health and well-being of their working population.

CHAPTER II

CALL CENTER PRODUCTIVY OVER 6-MONTHS FOLLOWING A STANDING DESK INTERVENTION*

Occupational Abstract

Stand-capable desks have been shown to successfully reduce sedentary behavior in the modern office, but whether their utilization improves cognitive productivity is not known. We compared productivity between stand-capable desk users and traditional seated desk users in a call center environment. Data were collected daily over a continuous six-month period. We found that increased stand-capable desk use is a likely contributor to increased productivity over traditional seated desk use. These findings indicate that use of stand-capable desks as ergonomic interventions to improve physical health among employees may also positively impact their work productivity.

Technical Abstract

Background: Many office employees are spending up to 90% of their workday seated, and employers are considering stand-capable desks as a way to increase physical activity throughout the day. When deciding on adoption of stand-capable workstations, a major concern for employers is that the benefits, over time, may not offset the initial cost of implementation. ***Methods:*** This study compared objective measures of productivity over time between a group of stand-capable desk users and a seated control group in a call center.

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Comparison analysis was completed for continuous six-month secondary data for 167 employees, across two job categories.

Results: Users of stand-capable desks were ~45% more productive daily compared to their seated counterparts. Further, productivity of the stand-capable desk users significantly increased over time, from ~23% in the first month to ~53% over the next six months. Finally, this productivity increase was similar for employees across both job categories.
Conclusions: These findings suggest important benefits of employing stand-capable desks in the work force to increase productivity. Prospective studies that include employee health status, perceptions of (dis)comfort and preference over time, along with productivity metrics, are needed to test the effectiveness of stand-capable desks on employee health and performance.

Introduction

It is estimated that most American adults spend 8–9 hours of their daily waking time sedentary, with most of this sedentary time due primarily from their office environment (Straker et al., 2013). Sedentary behavior has been linked to mortality and several negative health outcomes including obesity, cardiovascular disease, and cancer (Katmarzyk, et al., 2009; Tremblay et al., 2010). Research has indicated that this may be true even for those who are meeting recommended physical activity guidelines (Hamilton et al., 2008; Katmarzyk et al., 2009). In particular, call center operators have been observed spending ~ 90-95% of their work shift in their seats and work long hours without breaks (Rocha, et al., 2005; Pickens, 2016). Working adults in call centers spend nearly 90% of their work time sedentary as opposed to one-third or one-half for other office employees (Straker et al., 2013). Consequences of prolonged sitting include lower back pain and body discomfort (Rocha, et al., 2005; Marshall, et al., 2010). These outcomes can impact productivity; increased discomfort at daily work tasks has shown to result in perceived productivity losses of 10% to 20% (Hagberg, et al., 2002; Wahlström, et al., 2004).

Excess sedentary time has been linked to obesity, which in turn has been implicated in higher risks for cardiovascular disease, diabetes, and cancer (Katzmarzyk et al., 2009, Tremblay et al., 2010, Dunstan et al., 2012). Sit-to-stand desks, as an office ergonomics solution to this problem, have the potential to improve caloric expenditure and reduce sedentariness in the workplace (Alkhajah et al., 2012, Pronk et al., 2012, Grunseit et al., 2013; Commissaris et al., 2015). However, the sustainability of sit-to-stand desk usage in maintaining physical activity and reduction in sedentary time within occupational settings has been a challenge (Wilks et al., 2006; Toomingas et al., 2012; Straker et al., 2013). Nonetheless, the perceived benefits of stand-capable office environments, which include declines in musculoskeletal complaints, augment the health benefits reported in previous studies (Alkhajah et al., 2012, Pronk et al., 2012, Grunseit et al., 2013).

Among adults, the use of standing desks on modern office tasks in an experimental study has been shown to reduce discomfort over time (~15 weeks), which has been argued to positively affect task performance (Robertson et al., 2013). Thus, it is likely that stand-capable office environments facilitate work efficiency and productivity in adults, like that observed in adolescents. However, in a simulated office environment/work study, Husemann et al. (2009) reported that stand-capable offices do not significantly impact productivity. Because that study examined the impact of acute standing (~1 week) on efficiency of simulated work, it remains unknown whether continued exposure to standing affects work productivity in-situ occupational environments. It is important to examine this relationship in a naturalistic work environment, however, as the sustainability of office ergonomics solutions relies on whether these interventions present productivity and task interruption challenges.

The present study investigated the impact of stand-capable workstations (sit-to-stand and stand-biased) in a call-center on employee productivity over a six-month period. Productivity data, based on the number of successful encounters per hour, was collected by the company's proprietary software. It was hypothesized that employees assigned to stand-capable desks would demonstrate higher productivity than those in the traditional seated desks, and that these differences would be sustained over the six-month period.

Methods

Subjects

As part of normal business operations, data on employee's performance were collected daily and as a condition of employment, the company reserves the right to use that information for research purposes. Therefore, de-identified secondary data were provided to Texas A&M researchers for analysis without the need of informed consent from the employees. Study participants included 167 employees in a call center (118 females and 49 males) who provided telephonic health and clinical advising. The study participants' workstations consisted of traditional seated workstations, sit-to-stand workstations, and stand-biased workstations. A prior study on this population indicated small differences in standing behavior between participants using stand-biased and sit-to-stand workstations (Pickens, 2016). Therefore, for the purposes of this study, the stand-biased and sit-to-stand workstations were combined into one category and are referred to as stand-capable workstations going forward. In addition, the prior study (Pickens, 2016) administered online surveys that collected information as self-reported seated time, biometrics, body discomfort, and musculoskeletal symptoms (Pickens, 2016).

The intervention group consisted of 44 health advisors (Stand-HA: 23 females, 21 males) and 30 clinical advisors (Stand-CA: 28 females, 2 males), all of whom had stand-capable desks. The control group consisted of 58 health advisors (Sit-HA: 33 females, 25 males) and 35 clinical advisors (Sit-CA: 34 females, 1 male), all of whom had traditional seated desks. Because the call-center installed new desks for a new employee cohort, the Stand-CA and Stand-HA groups were new employees, having been with the company for 3 months or less, whereas the Sit-CA and Sit-HA employees had been employed for one year or more. To minimize confounds of employee experience, only those employees who had been employed for a minimum of 30 days and were working at the stand-capable or traditional seated workstations, were included in the study. Since this study occurred in an in-situ occupational environment, rather than in a controlled laboratory environment, attrition did occur. The retention rates were as follows: Stand-HA 93%, Sit-HA 93%, Stand-CA 83%, and Sit-CA 89%. In all attrition cases, employees left the company or transitioned to a different job within the 6-month period and thus had to be excluded from the study.

Equipment

Both the sit-to-stand and stand-biased workstations used a SteelCase™ (Grand Rapids, Michigan) Series 5 Desk that had an electric motor allowing it to adjust from

64.77cm to 129.54cm tall. This allowed the user to press an up or down button to adjust the desk surface to proper height for sitting (68.58-78.74 centimeters) and proper height for standing (93.95-116.84 centimeters) (ANSI/HFES 100, 2012). The sit-to-stand workstations had a standard height task chair, The SteelCase™ Think Chair Model 6205, which has a seat height that can be adjusted between 40.64 centimeters and 53.34 centimeters (Figure 1).

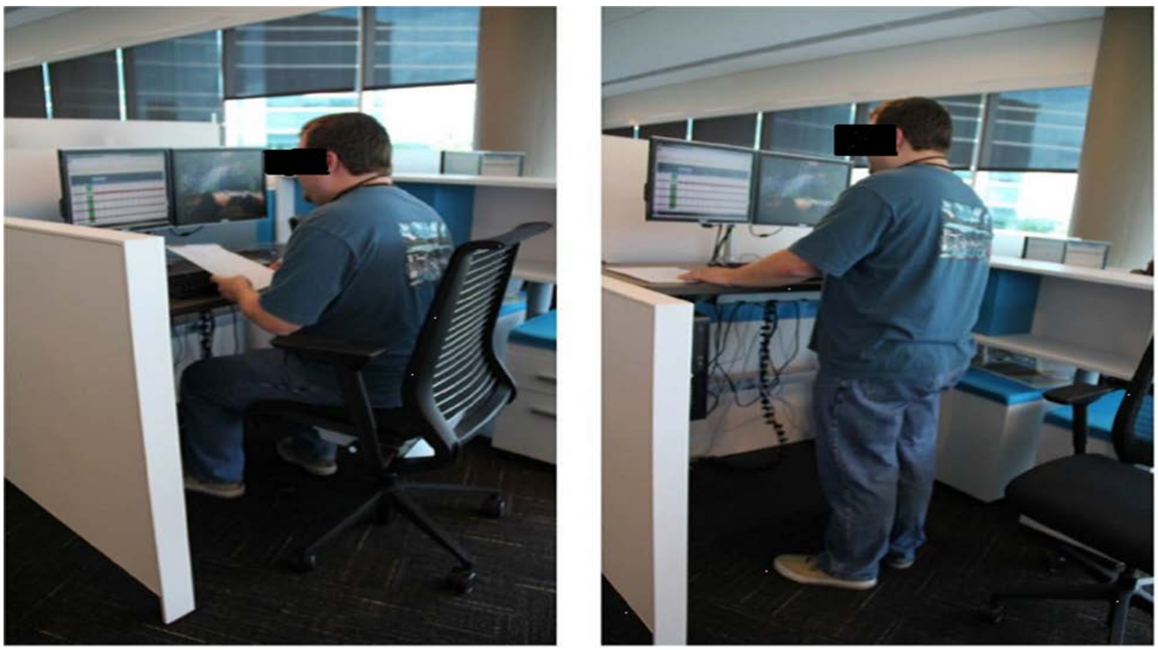

Figure 1. Sit-to-stand workstation

The stand-biased workstations had a raised height or bar height task chair. The Neutral Posture Inc. (Bryan, Texas) U4IA4692 Mesh Back Stool was used, with attached foot platform at 15.24 and 25.4 centimeters and a seat height that can be adjusted between 64.77 and 91.44 centimeters (Figure 2).

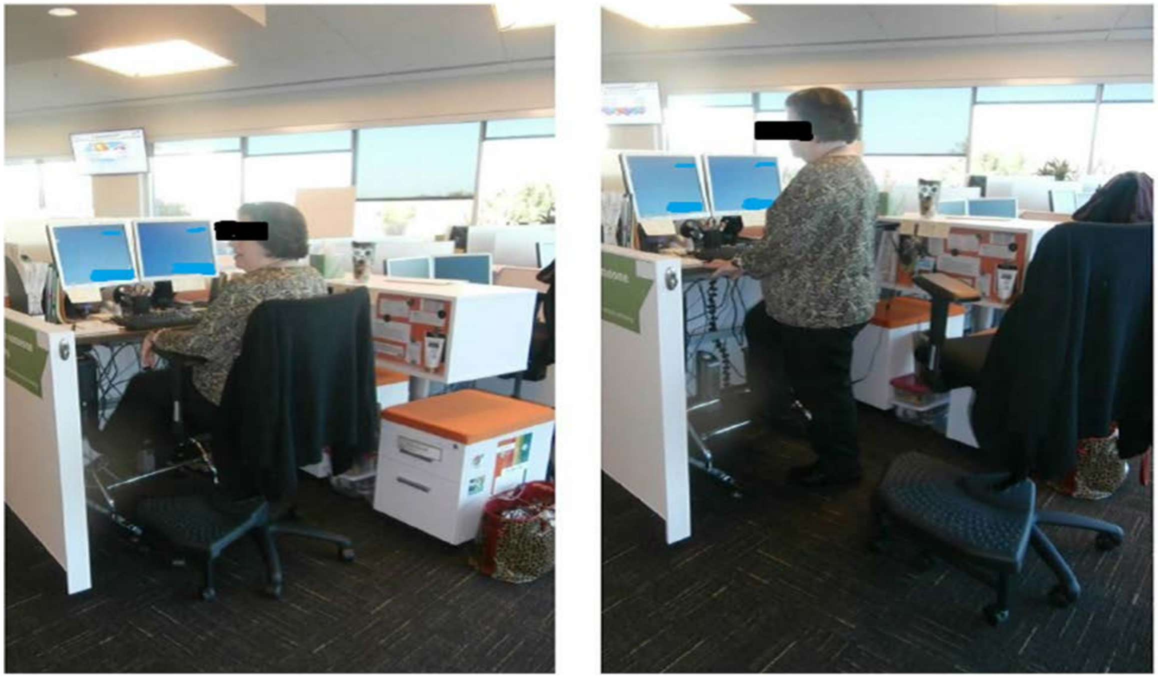

Figure 2. Stand-Biased workstation

Footrests that allow a user to prop one foot up at 20.32 or 30.48 centimeters were purchased for stand-biased desk users. Anti-fatigue mats were purchased for sit-to-stand users. Monitor arms for a dual monitor set-up were purchased and installed at each workstation. The seated comparison group was seated in groups of six at a traditional desk with monitor arms for a dual monitor set-up (Figure 3).

Figure 3. Traditional seated workstation

Data Collection

The stand-capable desks were installed in the call center late January 2013 as part of a major addition of newly hired health and clinical advisors, and the new employees were relocated to the new facility the beginning of February 2013. Since the new employees were assigned to the stand-capable workstations by the company, the sample is one of convenience rather than random assignment. Following approval by the Texas A&M Institutional Review Board, data collected by the host company's proprietary software was de-identified and provided for analysis. Quantitative productivity data was collected daily over a continuous six-month period (March 2013 through August 2013). Productivity data, based on the number of successful encounters per hour by advisor, were collected by the company's proprietary software. As defined by the company, successful encounters were the completion of a call with a member in which the advisor reviews previous goals and sets a new goal. During a call, the advisor speaks with the member, takes notes, asks questions, and performs tasks within the computer system which includes updating the member's profile and goals. Specifically, for health advisors, the company generates revenue on the number of reported successful calls. The company links calls and outcomes to the calls digitally and records related parameters such as time on the call. Revenue for the company is directly tied to successful calls and those calls average a value of $100 each which is comparable to national trends. A successful encounter per hour rate was calculated for each participant and means were obtained across each month for the six-month period.

Since the control groups had been employed with the company longer than the comparison groups and had the potential for higher accrued time off (vacation/sick leave) total time on dialer (TOD), which is a measure of an advisor’s availability to make or take calls, was calculated over the 6-month period and analyzed for group and job type differences.

Statistical Analysis

The dependent variable, mean successful encounters per hour, was visibly checked for parametric assumptions and a follow up Shapiro-Wilk test determined that the data were normally distributed. Two clinical advisors (one each from Sit and Stand groups) were excluded from the study because their productivity data for four months were not available. A three-way mixed-factor analysis of variance (ANOVA) was performed to examine the effects of intervention group (control vs. stand-capable desks), job category (health vs. clinical advisor), and time period (6 months) on mean successful encounters per hour. An independent t-test was conducted to determine group and job type differences for TOD. Statistical significance was determined when $p < 0.05$. Significant interaction effects were examined using pairwise comparisons with Bonferroni corrections as required. All statistical analyses were conducted using SPSS 22 (IBM SPSS Statistics). Summary data are presented as means (SD).

Results

Based on the online survey data collected in the prior study (Pickens, 2016), self-reported seated time showed that those on the stand-capable side of the call center were seated for an average of 72-73% of their day compared to those on the seated control side that spent 91% of their day seated (Pickens, 2016). Additionally, at 6 months, nearly 75% of those with stand-capable workstations self-reported decreased body discomfort as a factor for continued stand-capable desk use (Pickens, 2016). Moreover, there was not a statistical significant difference in TOD between stand-capable and seated groups, with stand-capable groups having a higher TOD than seated groups, 6.93 ± 25.56, $t(101.18) = .271$, $p = .787$.

A significant group x time interaction ($F_{(5, 111)} = 5.97$, $p < 0.0001$, partial $\eta^2 = 0.051$; Fig. 4) was found.

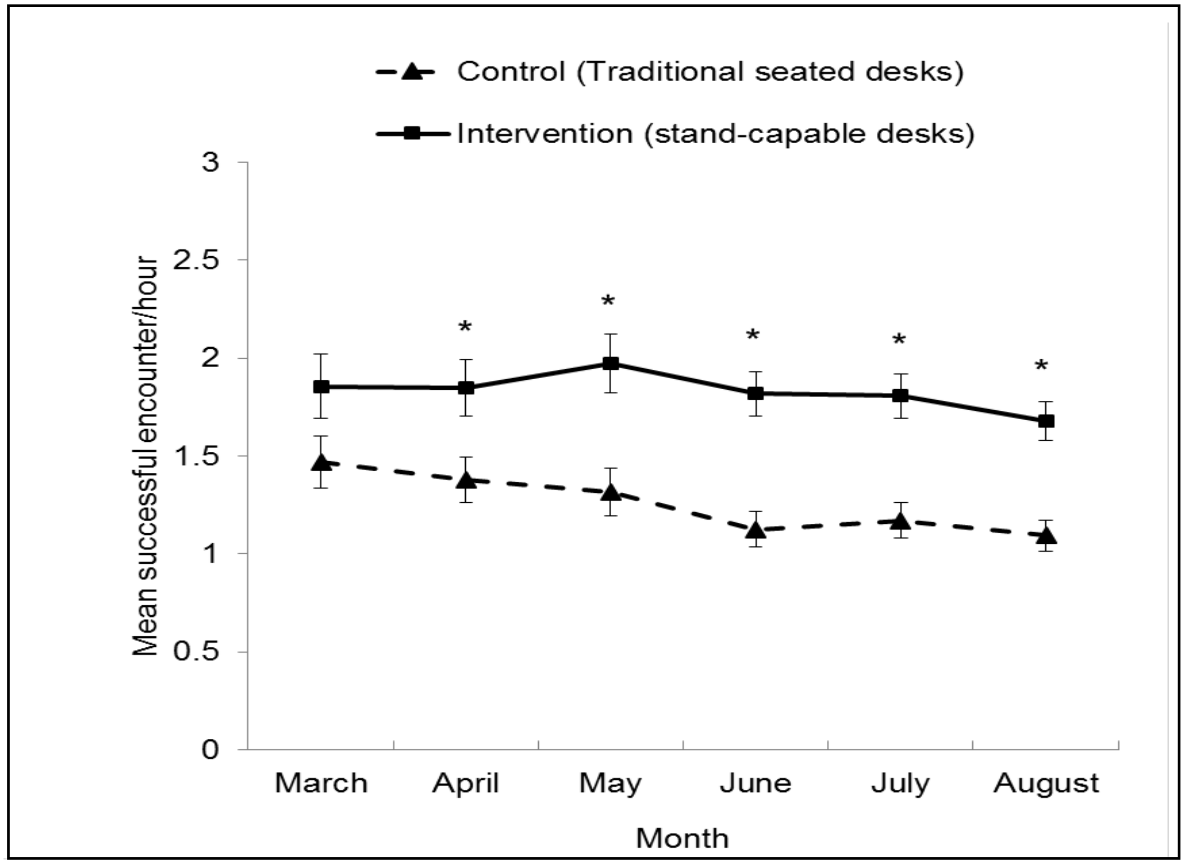

Figure 4: Effects of intervention group and time period on mean successful encounters/hour. * Represents significant differences between groups at each time period. Error bars represent 95% confidence intervals.

Pairwise comparisons between groups for each month revealed that the effect of the intervention was significant from the 2nd to the 6th time period (all $p < 0.005$). Main effects of group ($F_{(1, 111)} = 60.13$, $p < 0.0001$, partial $\eta^2 = 0.351$), job category ($F_{(1, 111)} = 65.52$, $p < 0.0001$, partial $\eta^2 = 0.375$), and time ($F_{(5, 555)} = 21.1$, $p < 0.0001$, partial $\eta^2 = 0.16$) were found on successful encounters. Productivity among employees with stand-capable desks was ~46% higher than that among those with traditional seated desks (1.26 (0.57) successful encounters/hr.). Additionally, health advisors demonstrated ~49% increase in successful encounters/hour when compared to clinical advisors (1.24 (0.61) successful encounters/hr; Fig. 5). In general, productivity during the first three months was greater than during the last three months of the six-month period.

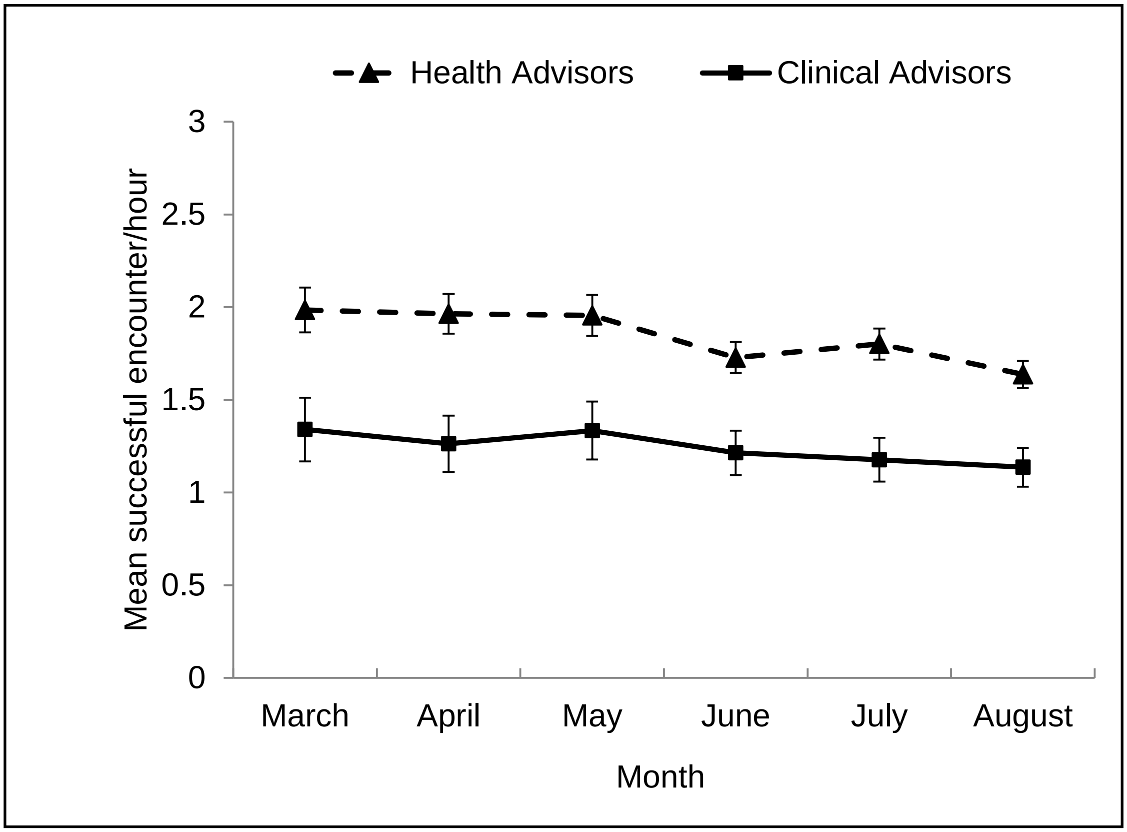

Figure 5: Main effects of job category and time period on mean successful encounters/hour. Error bars represent 95% confidence intervals.

Discussion

We compared the effects of stand-capable offices (sit-to-stand and stand-biased workstations) in a call-center on employee productivity over a six-month period. Productivity across two job categories, health advisors and clinical advisors, were obtained using the company's performance metric software. The main findings were that employees assigned to the stand-capable desks demonstrated higher productivity than those in the traditional seated desks, particularly from the 2nd to the 6th month, and that this trend was consistent across both the health and clinical advisors.

On average, stand-capable health advisors had 0.5 more successful calls per hour during the 6-month period than their seated counterparts. As the company generated revenue based on the completion of successful calls, significant additional revenue was realized. Similarly, stand-capable clinical advisors had 0.4 more successful calls per hour per clinical advisor during the 6-month period, compared to the traditional seated clinical advisors group. Clinical advisors do not generate revenue on a fee per successful call rate as health advisors; rather the reduction in health care utilization over the year determines the amount of fees paid to the company. As the stand-capable clinical advisors had a higher successful daily call rate than the traditional seated clinical advisors, the opportunity exists to decrease health care utilization costs at a significantly higher rate. While health advisors had significantly higher successful calls per hour than the clinical advisors (owing to the nature of their job), the positive impact of the intervention was similar across both job categories.

There are several studies that suggest an inverse relationship between productivity and body discomfort (Davis & Kotowski, 2014; Robertson, et al., 2013; Karakolis & Callaghan, 2014). Aligned with findings from these studies, Pickens et al. (2016), who collected data in tandem on the same study participant pool and followed the study design as the current study, found that employees assigned to the stand-capable workstations reported significantly lower body discomfort compared to the seated controls over the six-month period. Previous research on standing desks utilization and associated comfort requires a habituation period of few weeks (Pickens et al. 2016). It is likely that this habituation was associated with similar productivity levels between the two groups in the first month, with benefits beginning to show from the second month onwards. However, it can be counter argued that decreased body discomfort alone may not be indicative of increased productivity observed in this study. It is possible that the same productivity could have been achieved if body discomfort had been reduced even for those in the seated workstations through effective ergonomic improvements in the seated workstations. Moreover, it is possible that the change in discomfort observed in Pickens et al. (2016) may be attributed to time on job, or other factors that are related to the duration of employment, rather than the experience with the stand-biased workstations. The authors believe that the 90 days of pre-baseline for the newer workers in the treatment group (60 days of training and 30 days of break-in doing their new jobs in the stand capable workstations) was more than adequate to minimize experience variation between groups. The fact that at 9 months total or 6 months into the measurement period the newer workers were still having less discomfort and more productivity points to the value of the workstation differences in the measured outcomes. As with any field research, more work is warranted to determine the relationship between discomfort and improved performance in real work scenarios with longer longitudinal investigations.

Previous studies have indicated that physical activity has substantial preventable and restorative properties for cognition and brain function (Kramer & Erickson, 2007). Specific to standing desk applications, cognitive benefits of standing desks have been previously established in school-based intervention studies. For example, reducing sedentariness in school children has been linked to improved student attention and focus (Koepp et al, 2012; Dornhecker et al., 2015), and a more recent study showed that it improves basic cognitive functioning via enhancements in the frontal regions of the brain (Mehta et al., 2015). While the current study focused on secondary data analyses on productivity outcomes, cognitive metrics to examine standing behavior benefits were not available. As such, future research should focus on obtaining potential cognitive effects of increased physical activity using stand-capable workstations in both controlled laboratory and naturalistic field studies.

It is important to note both the strengths and limitations of this study. The study was conducted in a company whose business is in the health promotion domain; it is possible that the employees with stand-capable desks have a higher usage than other companies that are not focused on health (e.g., information technology). In addition, owing to constraints out of scope of the study, employees were not randomly assigned to the conditions and as such this may have introduced selection bias. However, because employees were assigned to their workstations, this is a strength of the study as it reduces or eliminates volunteerism bias therefore increasing the generalizability of the study results to other populations. One other limitation should be noted. Since the stand-capable advisors were dealing with new clients, it is possible that the client's population may have been highly motivated to engage with the advisors. It is possible that some of the variance between the stand-capable and traditional seated advisors could be attributed to differences in the populations they were attempting to engage. Moreover, employees assigned to the stand-capable desks had been with the company significantly less than the traditional seated advisors. However, to address this potential confound, study participation was limited to employees who had been working independently for a minimum of 30 days (following a 60-day training period) thus allowing new employees to habituate to sit-to-stand workstations as well as increase their familiarity with company procedures and work practices. To further address differences between groups, this study would have been strengthened considerably if pre-existing performance data on the control (seasoned coaches) were available. Having this information may have better addressed associated experience differences between the groups. Ongoing future studies that include prior performance data on the control groups will be able to address this limitation. Interestingly, even though advisors assigned to stand-capable desks had been with the company significantly less than the traditional seated advisors, they still were able to outperform the more experienced and seasoned advisors (who had been assigned to the seated desks).

Finally, productivity was measured using the company's proprietary software and thus productivity metric algorithms were not made available to the researchers. Even though the metric used to evaluate cognitive performance is specific to this company and potentially not generalizable to non-call center environments, previous studies have used task complexity and critical decision making as representations of cognitive demands and have reported increases in cognitive performance while using sit-to-stand desks (Robertson et al., 2013). A strength of this approach was that all the workers were monitored continuously and objectively thru digital software recording of the desired outcomes as opposed to more common subjective and sampling approaches used in other studies in this field. Our findings indicate that productivity improved with the stand-capable desks, and as such the company was provided with a very relevant, objective metric through which they can base strategic decisions on, whilst encouraging the physical health of their employees.

In summary, we found that individuals that could stand throughout the day can operate at higher productivity levels than those that do not have the capability to stand while working. Questions remain as to the underlying mechanism(s) that impacted the productivity results of these groups. It is possible that reduction in body discomfort, enhanced cognitive function due to physiological changes, or a combination of these factors played a role in the increased productivity for those in the stand-capable condition. Further work is warranted to examine the effects of stand-capable desks, preferably through randomized controlled trials, to establish their non-physical benefits, both at the basic (cognition) and at macro-organizational (productivity, employee morale, etc.) levels.

CHAPTER III

COMPUTER-BASED PROMPT'S IMPACT ON POSTURAL VARIABLITY AND SIT-STAND DESK USAGE; A CLUSTER RANDOMIZED TRIAL*

Abstract

Sit-to-stand workstations have been deployed in office environments to reduce sedentary behavior and improve worker's health. However, efforts to initiate and sustain long-term usage of sit-stand workstations has been a challenge, with primarily anecdotal evidence suggesting many employees cease using their sit-stand workstations once the newness diminishes. To objectively determine sit-stand workstation usage and what impact computer-based prompts would have on sit-stand desk use and sustainability, 200 office workers (118 control and 82 treatment) in two different geographic locations were continuously monitored over a 4 ½ month period, which consisted of a 6-week baseline and a 3-month experimental period. During the 3-month experimental period, computer-based prompts elicited a 229% increase in daily standing transitions which was sustained over the entire 3 months with 40% of the participants adhering to a pre-determined sit to stand schedule. These findings indicate that the use of computer-based prompts can be used to motivate employees to change their behavior regarding the use of sit-to-stand workstations.

*Reprinted with permission from Applied Ergonomics, 79, Garrett, G., Zhao, H., Pickens, A., Mehta, R., Preston, L., Powell, A., & Benden, M., Computer-based Prompt's impact on postural variability and sit-stand desk usage behavior; a cluster randomized control trial, 17-24, 2019.

Introduction

Within the last 15-20 years, sedentary behavior has become a catch phrase for the media, medical professionals, researchers, industry leaders, and even office furniture manufacturers with research supporting the growing concern that sitting for extended periods of time can cause a multitude of health problems; body discomfort, heart attack, stroke, diabetes, and is a likely contributor to obesity (Thorp, et.al., 2014; Ding, et.al., 2016; Karakolis, et.al., 2016). Recent research pointing to sedentary behavior as the primary culprit have suggested many ways to reduce this behavior, particularly in the office environment (Thorp, et. al., 2014; Davis & Kotowski, 2014; Gao, et. al., 2016). In an effort to offset the negative cost impact and health effects of sedentary behavior in the office environment, many companies have implemented office furniture interventions of varying types.

Interventions may be categorized as active workstations, such as treadmill desks, bicycle desks, and even a "hamster wheel" designed desk (Commissaris, et. al., 2014; Torbeyns, et. al., 2014; Tudor-Locke, et. al., 2014; MacEwen, et.al., 2015), or activity permissive workstations, such as sit-to-stand, stand-biased, table-top, and lean workstations (Torbeyns, et. al., 2014; Karol & Robertson, 2015; MacEwen, et.al., 2015). Active workstations require the user to engage with and activate the workstation, providing the benefit of increased caloric expenditure while decreasing sedentary time. However, there have been some stated negative impacts on cognitive function, productivity, and other task related measures associated with their use (Thompson & Levine, 2011; Larson, et. al., 2015). Activity permissive workstations, on the other hand, allow the user to choose when and if they will engage the device, determining their own caloric expenditure and decreased sedentary behavior. Evidence on the impact of standing workstation posture indicate a positive impact on cognition, body comfort, and productivity (Hedge & Ray; 2014; Dornhecker, et. al., 2015; Garrett, et. al., 2016, Mehta, et. al., 2016; Pickens, et. al., 2016). While the absence of randomized control investigations may limit the translational effectiveness of active or activity permissive interventions on reducing sedentary behavior (Larson, et. al., 2015), the general consensus is that frequent movement is a necessary element for a healthy and pain-free life (Pronk, et. al., 2012; Buckley, et. al., 2013; Straker, et. al., 2013; Buckley, et. al., 2015; Healy, et. al., 2015). Therefore, the key lies not only in determination of an effective intervention to initiate movement, but largely how to promote sustainment of that movement.

Activity permissive workstations have a decided advantage over traditional workstations within office environments, as they are overall, less costly, have a smaller "footprint" (require less floor space), present improved ergonomics via ease of adjustment to custom positions for seated and standing work, and are easier to install than interconnected cubicle systems. However, the majority of companies that implement activity permissive workstations view the workstations, themselves, as the intervention, rather than a tool that must be used daily to reduce sedentary behavior over the worker's career. Numerous studies have illustrated that activity permissive workstations are more effective when end-users receive detailed instructions on how to use the device coupled with ongoing messaging that reinforces the positive benefits of continued use (Grunseit, et. al., 2013; Chau, et. al., 2014). However, positively influencing an individual's behavior to encourage and sustain sit-to-stand desk usage has been a challenge (Wilks, et. al., 2006; Tommingas, et. al., 2012; Straker, et. al., 2013).

Even though physical activity has been shown to have positive health effects, more than 50% of individuals who engage in an exercise program have either dropped out or significantly reduced their initial activity within 3-6 months (Dishman, 1986; Garrett, 2013). These same statistics can be applied to most office environments that have employed sit-to-stand workstations, demonstrating that once the “newness” of the sit-to-stand workstation wears off, motivation to continue usage of these workstations also declines (Wilks, et.al., 2006; Gilson, et.al., 2012). Motivation, that which moves us to act, is a key component in behavior change models and can be classified into three general categories; intrinsic, extrinsic, and amotivation (Ryan & Deci, 2000b). In short, intrinsic motivation refers to that which is internal and doing something that is enjoyable; extrinsic motivation is doing something considered uninteresting but leads to a separable outcome; and finally, amotivation is the state of lacking any intention to act (Legault, et. al., 2006). As individuals move from an externally regulated self to an internally regulated self, it can be surmised that those individuals who have an integrated regulation may, over time, transition to an intrinsically motivated self as the process or task becomes enjoyable (Calder & Staw, 1975; Brinthaupt et.al., 2013). Computer-based prompts, acting as an external catalyst, may serve as a “bridge” from an extrinsic to an internal or intrinsic motivation thereby increasing and sustaining the use of sit-to-stand desks.

The present study investigated the motivational impact of computer prompts on employee activity permissive workstation (sit-to-stand desk) usage in two separate office environments. Frequency of sit-to-stand desk usage, based on the number of daily transitions (changes between sitting and standing), was collected continuously over a four-and-a-half-month period. After an initial six-week monitored baseline period, participants were randomly assigned to one of two conditions (absence and presence of computer prompts) and monitored continuously for three-months. It was hypothesized that employees who received computer prompts would be motivated to increase their daily transitions from sitting to standing over those who were not, and that these differences would be sustained over the three-month experimental period.

Methods

Subjects

The intervention for the present study was conducted at two Chevron U.S.A. Inc. locations; Houston, TX and San Ramon, CA. Two-hundred sixty-two office workers (147 females, 113 males, and 2 who declined to self-identify and were between 20 – 65 years of age) consented to participate in the study. The office worker's roles were diverse, for example, sales, general affairs, accounting, etc. All participants were informed about the purpose of the study and provided informed consent as approved by the Texas A&M Institutional Review Board. While 262 participants had consented to participate, only 207 were ultimately able to participate in the study due to incompatibly of desk actuators with the required BakkerElkhuizen cables. Since this study occurred in an in-situ occupational environment, rather than in a controlled laboratory environment, attrition did occur; a total of seven participants left the company before the initiation of the experimental period, thus a total of 200 participants completed the study in its entirety.

Equipment

All study participants used a sit-to-stand desk (Series 7.2, SteelCase Inc., Grand Rapids, Michigan) with an electric motor allowing adjustment from 68.6 cm to 119.4 cm in height. Height adjustment was accomplished by the user pushing a button on the desk control panel to adjust the desk surface to proper height for sitting (68.6 cm - 78.7 cm) or standing (93.9 cm - 116.8 cm) (ANSI/HFES 100, 2007). Employees were provided one of four standard desk chairs, with a user-adjustable seat range of 41.9 cm and 54.5 cm; the SteelCase Inc. Leap Chair being the most prevalent.

As part of the ergonomics program at Chevron, some employees were provided workstation accessories; either through request or upon recommendation by a member of the ergonomics team during a workstation evaluation prior to the implementation of this study. Workstation accessories consisted of seated footrests (Safco® 12.7 cm or Safco® 20.3 cm) or standing footrests (Workrite Height and Angle FootResterTM) adjustable at 2.5 cm intervals and allowed the user to prop one foot up at 10.2 cm – 38.1 cm. There were some employees with an anti-fatigue mat (Smart Step® Companion Mat) which had a non-slip top and non-skid bottom having dimensions 45.7 cm (L) x 55.9 cm (W) x 1.9 cm.

A computer-based software program, SitStand Coach Version 2.4.0 (BakkerElkhuizen Software, Flevoland, The Netherlands) was installed on company provided laptops for all employees who consented to participate in the study. All laptops were Lenovo PCs running a 64-bit WindowsTM 7 Enterprise operating system connected to a docking station at the participant's primary workstation. The SitStand Coach software can track sit-to-stand desk usage (movement of the desk top between seated and standing height) as well as the participant's active interaction with the computer (typing and/or mousing) in two different modes: "monitor" and "active". In monitor mode, the software simply monitors the participant's desk usage and active interaction with the computer; the user must initiate their own change in desktop height without system prompts. In active mode, the software will prompt the user with onscreen notifications, to change desk height between sitting and standing positions. Selecting either “Raise Desk” or “Lower Desk” within the onscreen notification box will automatically move the desktop to the user’s preset height for sitting or standing or the user may opt to move the desk height manually by pressing keys Ctrl + ⊞ + S on the keyboard. The user also has the option to postpone positional changes by clicking “postpone” within the onscreen notification box. If “postpone” is selected, the user is re-prompted in 10 minutes to change position and will be continually re-prompted until the desktop position is changed, or the user disconnects their laptop from the docking station. For the purposes of this study and to reduce confounds between users, positional change notifications were locked (i.e. user could not edit settings) so that for every 30 minutes of elapsed sitting time the users were prompted to stand for 6 minutes (Alkhajah et al., 2012). To capture this data, cables provided by BakkerElkhuizen were installed, connecting the docking station to an open port on the Linak actuator motor on the sit-to-stand desk. Data recorded by the SitStand Coach software were uploaded daily to the BakkerElkhuizen Software off-site servers where it was later de-identified and provided to Texas A&M University researchers for analysis.

Data Collection

Participants were asked to complete an online survey after completion of the experimental portion of the study. Only 168 of the total 200 participants completed the survey and self-identified their location and group (Houston Control group = 42; San Ramon Control group = 29, Houston Experimental group = 56; San Ramon Experimental group = 41) therefore survey data tables only represent those respondents. The survey included biometrics (gender, height, weight, and age), work location, the participant’s workstation (accessories, frequency of usage), standing habits (frequency, factors that contributed to standing behaviors, and detriments to standing), changes in weight, body part discomfort rating, overall sitting time, commute time, and computing usage outside of work. Additionally, experimental participants who interacted with the SitStand Coach software completed a survey summarizing their individual experiences with the software.

Baseline Period

After employees consented to participate in the study, SitStand Coach software and cables were installed on the employee's computers. During the six-week baseline period, all users were objectively monitored in monitor mode by SitStand Coach from December 1^{st}, 2016 to January 15^{th}, 2017. In addition to user ID and date, several other metrics were objectively collected:

- Total active computer time
- Active sitting time
- Active standing time
- Number of times desktop transitioned to a sitting or standing height

Active computer, sitting, and standing time were calculated using a proprietary BakkerElkhuizen Software algorithm based on previous research (Homan & Armstrong, 2003). A daily number of standing transitions along with daily total active computer time, daily active sitting time, and daily active standing time was calculated for each participant and compared for each time period (pre and post) and across groups (control and experimental). End-of-year vacations and holidays were not a barrier, as only active days at work with the user logged into their computer at their desk were recorded.

Experimental Period

Beginning January 16th, 2017 participants were randomly assigned to one of two conditions, Group 1 (experimental: receiving computer prompts) and Group 2 (control: no computer prompts). To reduce the possibility of cross-contamination between the two groups, Group 1 participants were sent computer coding overnight by the Chevron IT department that deactivated the SitStand Coach monitor mode and installed the active mode. Group 1 began to receive onscreen notification prompts to change from seated to standing position while Group 2 continued in monitor mode. Both groups were monitored continuously over the next 3-months. Cluster randomized assignment to groups was based on geographic location as well as the location of the participant's workstation to further reduce the potential for contamination between the groups. For example, those participants in Houston, TX whose primary workstation was on the 2nd floor were assigned to the experimental group whereas those on the 3rd floor were assigned to the control group. The process was applied randomly at both locations until an approximate 50% division of participants into each group was achieved. As there were concerns by the company that participants could be identified, exact numbers of control and experimental participants for each location were not provided to the researchers, rather an overall breakdown of experimental and control participants for sitting and standing time were provided. However, out of the 173 participants who completed the survey, and self-identified for location and experimental or control group, there were 42 and 29 control participants for Houston and San Ramon respectively, 56 and 41 experimental participants for Houston and San Ramon, and finally there were a total of 5 participants who did not self-designate their work location nor participant status. A daily number of standing transitions along with daily total active computer time, daily active sitting time, and daily active standing time was recorded for each participant within each group.

Statistical Analysis

The survey data that were collected using questionnaires are analyzed first. There were no statistical differences in responses between groups or locations and are therefore reported as number of responses by group (experimental or control) for each question answered.

Data on computer use times and transition times from the baseline period and the intervention period were combined to compare changes over time in the experimental and control groups. Before performing any analyses, data were examined using tables and graphs to check for their distribution forms and data accuracy. Erroneous data such as negative computer use times were deleted. The primary outcome of interest was daily standing transitions. The data were analyzed using a marginal approach, the generalized estimating equation (GEE), to draw conclusions about trend in the behavior of the sample population. Since the daily standing transition is a count, a Poisson model with a log link function was used, and the covariates include period (0 for baseline and 1 for trial period), treatment (0 for control group and 1 for experimental group), and the interaction between treatment and period (other covariates, for example, location, were not provided to us). An exchangeable correlation structure is used, and robust standard errors were designated because they are correct even when the correlation structure of the data was misspecified. Statistical significance was determined when $p < 0.05$. The period and treatment interaction terms compare the different change behaviors of daily standing transitions between the experimental group and the control group, when subjects were continuously observed from baseline (month 0) to trial period (months 1, 2, 3, 4), therefore, it tests whether the treatment of interest, computer prompt, has any effect on the incidence of daily standing transitions. All statistical analyses were conducted using Stata 14.2.

To conceptualize a better understanding of the behavior modification effect of the computer prompting software, a transition per hour (TPH) variable was calculated, based on the ratio of the standing transitions and total computer time in hours for each participant. Since many participants' total computer times were close to zero on some days, we combined the standing transitions and computer times over each month first for each participant and calculated an average TPH per participant per month. The marginal GEE approach was again used for the analysis for TPH, with a log link function and gamma distribution and an exchangeable correlation structure. A robust standard error was used which would provide valid inference even when the variance model was not correctly specified. The same covariates, period (baseline vs experimental period), treatment (control vs experimental), and the interaction between treatment and period, were used. Again, the interaction term will test whether the treatment intervention, computer prompt, had any effect on TPH.

Results

Survey Results Key Findings

As there were no statistical differences between survey responses by location, demographic survey data for the Houston, TX and San Ramon, CA populations, as well as all other subsequent survey data, were combined into Control and Experimental groups and are, reported as a response by group (Table 1).

Table 1. Summary of Demographics Subjective Survey Questionnaire

Item	Control n=71	Experimental n=98
Age Range (years)		
20-25	1	1
26-30	1	7
31-35	8	10
36-40	8	8
41-45	9	17
46-50	6	13
51-55	20	27
56-60	14	12
61-65	3	2
Skip	1	1
Height Range (meters)		
< 1.52	1	2
1.52-1.60	13	15
1.60-1.67	20	31
1.67-1.75	23	16
1.75-1.83	8	22
1.83-1.91	5	10
1.91-1.98	1	2
> 1.98	0	0
Commute Time (minutes)		
0-30	19	27
31-60	18	25
61-90	19	21
91-120	9	14
121-150	4	9
151-180	1	1
> 180	1	1

Notes: Data is presented as total number of responses per participant by group.

Standing behavior survey questions indicated that much of the Experimental group continued to stand because of increased comfort while it took less than a week to habituate to standing at their desk occasionally (Table 2). While the Experimental group indicated fatigue and discomfort as they experienced symptoms when first making the transition to standing at their desks, decreased body discomfort and increased focus were cited as main factors in continuing to use the desk for standing (Table 2).

Table 2. Summary of Standing Behavior Subjective Survey Questionnaire

Item	Control n=71	Experimental n=98
Reasons to Stand		
Don't Stand	0	3
Encouraged	10	6

Table 2. Continued

Item	Control n=71	Experimental n=98
Curiosity	6	22
Increased Comfort	39	62
Increased Productivity	24	32
Recommended	24	35
Other	9	11
Seeing Others Stand	18	16
Weight Loss	32	42
Increased Alertness	40	52
Reasons Not to Stand		
Decreased Alertness	1	3
Increased Discomfort	16	22
Extra Energy Required to Stand	12	11
Other	14	17
Lack of Privacy	10	11
Decreased Productivity	10	13
No Reasons Not to Stand	29	40
Additional Time Required to Stand	2	8
Habituation Time for Standing		
Don't Stand	2	2
Stand but Not Comfortable	9	7
< 1 Week	46	69
1-2 Weeks	5	13
2-4 Weeks	9	7
1-2 Months	0	0
> 2 Months	0	0
Symptoms Experienced When 1st Transitioning to Standing		
Don't Stand	1	2
Discomfort	10	12
Fatigue	14	10
Other	7	6
Pain	1	1
Soreness	3	8
Skip	39	64
Experiences After Starting to Stand		
Decreased Focus	1	1
Decreased Pain and Discomfort	9	21
Decreased Productivity	1	2
Increased Energy	26	38
Increased Focus	28	38
Increased Pain and Discomfort	3	2

Table 2. Continued

Item	Control n=71	Experimental n=98
Increased Productivity	17	23
Reduced Energy Level	1	0
Don't Stand	2	2
Skip	27	32

Notes: Data is presented as total number of responses per participant by group.

There was a higher reported incident of body discomfort by the Experimental group for the 7 days prior to the survey completion which primarily consisted of back, feet and hips (Table 3). It is interesting to note however, that self-reported body discomfort over the previous 12 months is not statistically different between the two groups which could be an indication that habituation (decreased body discomfort) to increased standing may take longer than 3 months for some individuals.

Table 3. Summary of Physiologic and Body Discomfort Subjective Survey Questionnaire

Item	Control n=71	Experimental n=98
Changes in Weight After Starting Standing		
Gained Weight	5	2
Lost Weight	12	15
No Change	45	63
Not Sure	9	17
No Response	0	0
Lower Body Discomfort Previous 7 Days		
Yes	6	17
No	65	81
Skip	0	0
Location of Lower Body Discomfort		
Back	4	7
Ankles	0	1
Feet	1	6
Hips	4	7
Knees	0	2
Thighs	0	1
Other	0	1
N/A	62	73
Lower Body Discomfort Previous 12 Months		
Yes	9	11
No	62	87

Table 3. Continued

Item	Control n=71	Experimental n=98
Skip	0	1
Location of Lower Body Discomfort Past 12 Months		
Back	6	5
Ankles	0	2
Feet	2	1
Hips	2	4
Knees	2	0
Thighs	0	1
Other	1	2
N/A	58	83

Notes: Data is presented as total number of responses per participant by group.

Studies have indicated that the use of a standing footrest reduces pressure on the lower lumbar region (Lee, et al., 2018) and while only 22% of the Experimental group used their footrest frequently or all the time, there was not a statistical difference in incidence of reported low back pain (Table 4). With an increase in standing time low back discomfort would be expected with infrequent footrest use. However, the lack of self-reported discomfort could be an indication that the prompting schedule frequency was enough to mitigate the prevalence of low back discomfort.

Table 4. Summary Workstation Accessory Survey Questionnaires

Item	Control n=71	Experimental n=98
Workstation Accessories		
Sitting Footrest	0	0
Fatigue Mat	19	27
Standing Footrest	27	46
Nothing	31	41
Other	3	2
Footrest Use Frequency		
Never	4	12
Sometimes	18	24
Frequently	4	7
All the Time	1	3

Notes: Data is presented as total number of responses per participant by group.

Finally, in addition to the post-survey questionnaire, the Experimental group completed a separate post software evaluation on the SitStand Coach program that was designed to illicit feedback on their interaction with the software prompts. Survey data obtained from the Experimental group revealed that ~71% felt the software prompts were helpful in using the sit-to-stand workstation and increased their transitions from sitting to standing, ~83% believed the software increased their standing time, with ~42% stating the software usage increased their mental awareness by standing more often. In addition, nearly 75% of the Experimental group indicated that their likelihood to continue using the computer prompts to stand was probable or definite (Table 5).

Table 5. Summary of Software Evaluation by Experimental Group (received prompts)

	Experimental
Item	n=98
Software Helpfulness In Using Sit-Stand Workstation	
Very Unhelpful	5
Somewhat Unhelpful	6
Neutral	17
Somewhat Helpful	30
Very Helpful	40
Software Increased Transitions to Standing	
Significantly Less Often	1
Slightly Less Often	2
No Change	14
Slightly More Often	34
Significantly More Often	47
Software Increased Standing Time	
Significantly Less Time Standing	3
Somewhat Less Time Standing	3
No Change	2
Slightly More Time Standing	39
Significantly More Time Standing	32
Software Impacted Body Discomfort	
Significantly Increased	0
Slightly Increased	5

Table 5. Continued

Item	Experimental n=98
No Change	69
Slightly Reduced	16
Significantly Reduced	8
Software Impacted Fatigue Levels	
Significantly Increased	0
Slightly Increased	5
No Change	58
Slightly Reduced	26
Significantly Reduced	9
Software Impacted Mental Awareness	
Significantly Increased	4
Slightly Increased	40
No Change	44
Slightly Reduced	7
Significantly Reduced	3
Software Impacted Productivity Levels	
Significantly Increased	4
Slightly Increased	31
No Change	59
Slightly Reduced	3
Significantly Reduced	1
Software Impacted Overall Well-Being	
Significantly Increased	5
Slightly Increased	40
No Change	49
Slightly Reduced	3
Significantly Reduced	1
Likelihood of Continuing Computer Prompts	
Definitely Not Continue Use	9
Probably Not Continue Use	16
Probably Continue Use	24
Definitely Continue Use	49

Notes: Data is presented as total number of responses per participant.

Daily Standing Transitions Analysis

Average daily transitions to standing for baseline and intervention periods for the control and experimental groups are shown in Figure 6. For the Experimental group, their average daily transitions at the baseline period were not statistically different than the Control group, but there was a ~64% increase in daily transitions for the Experimental group when comparing baseline to intervention periods.

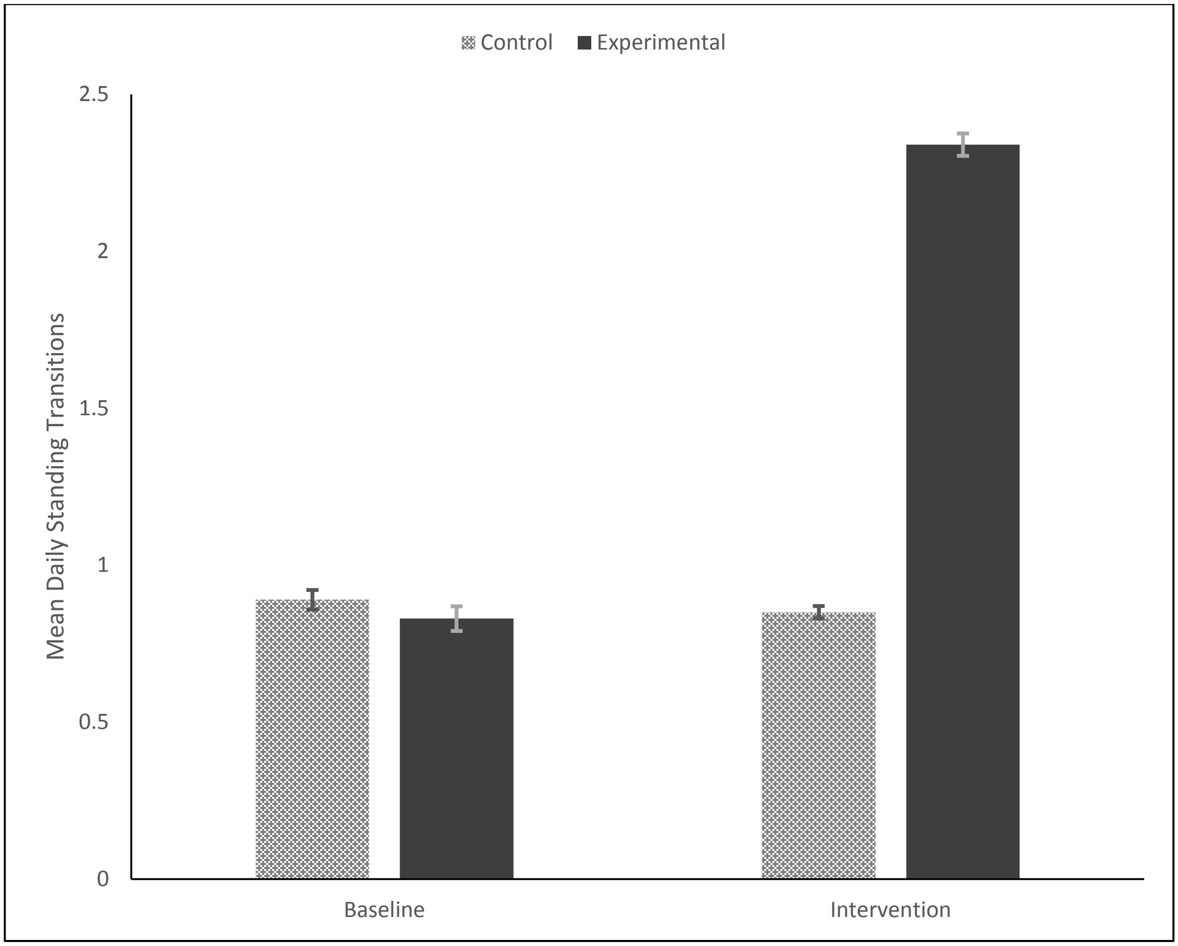

Figure 6: Group differences for pre- and post-intervention on daily standing transitions. Error bars represent standard error.

Using a GEE approach, controlling for both the Experimental group and the time of computer use, the Experimental group showed a ratio of 0.80 (*p* =0.137, 95% CI: 0.60, 1.07) at the baseline period. The Control group had a non-significant decrease in the standing transition with an estimated ratio of 0.92 (*p* =.231, 95% CI: 0.81, 1.05) in standing transitions during the intervention period when compared to the baseline period. Therefore, the randomization worked reasonably well, and the two groups were quite similar in terms of average standing transitions before employing software computer prompts. At the initiation of the intervention period, the Experimental group showed a significant increase in the number of standing transitions as compared to the Control group, with an estimated ratio between the Experimental group and the Control group being 2.29 ($p < 0.0001$, 95% CI: 1.79, 2.94), a 229% increase in overall standing transitions when comparing the ratio of the change of the standing transitions from baseline to trial period (Fig. 6).

In addition, the ratio of time spent standing to time spent sitting was examined to determine how closely each group adhered to the prompting schedule, 6 minutes of standing time for every 30 minutes of sitting time. To investigate this, the standing time of each participant was divided by the sitting time. A new, binary variable was created, where 0 indicated a ratio less than 0.2, and 1 indicated a ratio greater than or equal to 0.2. Ratios between 0.195 and 0.199 were also assigned a value of 1. Overall, 40% of the experimental participants met or exceeded the prompting schedule of standing to sitting time over the 3-month observational period.

The average Transitions per Hour (TPH) for each Experimental group were plotted over time and are shown in Figure 7. It showed that there was a significant increase in TPH for the Experimental group during the first month after the software was applied, with the TPH decreasing gradually over time, but it continued to remain higher than the Control group through the end of the trial period (month 4). The GEE analysis showed that the two groups were similar in terms of average TPH at the beginning of the study (ratio = 0.88, $p = 0.393$, 95% CI: 0.67, 1.17). There was a statistically significant reduction of TPH for the Control group moving from baseline (month 0) to the trial period (month 1, 2, 3, 4) (ratio = 0.88, $p = 0.033$, 95% CI: 0.78, 0.99). The interaction term between the intervention and period was also statistically significant, with an estimated ratio of 2.09 (*p*

< 0.0001, 95% C.I: 1.66, 2.62) between the intervention groups, when considering the change of TPH from baseline to the trial period.

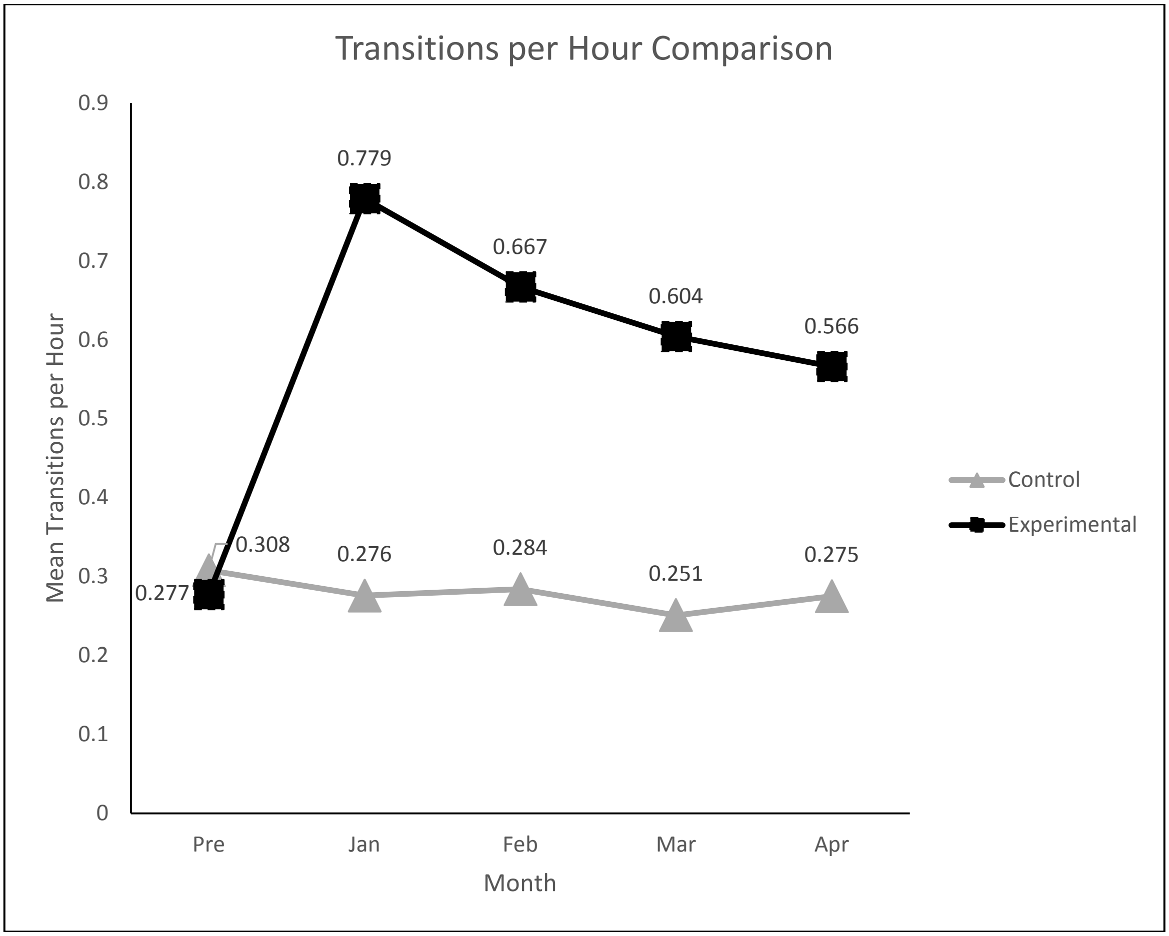

Figure 7: Group differences for pre- and post-intervention on transitions/hour rate (TPH).

Based on this evidence, the introduction of this experimental software increased the incidence of transitions from sitting to standing, as well as improved compliance to the prompting schedule and overall group mean standing time per day.

Discussion

The motivational effect of computer prompts on two geographically separate office environments in the USA was compared over a three-month period. Standing transitions were encouraged using an off-the shelf behavioral prompting software. The main findings were that employees that received computer-based prompts demonstrated higher standing transitions than those who received no prompts, and that this trend was consistent over the three-month time period. The use of objective measurement techniques combined with subjective surveys, and the ability to randomly assign participants to conditions is a significant addition to the current methodology for this type of research. We believe this to be the first notable contribution to the field using these new and advanced methods of continuous daily, objective digital monitoring of events and times.

On average, employees receiving computer prompts, transitioned to a standing position 229 times more than those who did not receive prompts with 40% of those in the Experimental group following the standing prompt schedule. While 40% is considered quite high for most behavior change models, a previous study reported compliance as high as 61% for sit-to-stand prompting software (Sharma, et al., 2018). Differences in compliance may be a result of the human interaction characteristics of the software interface as well as the duration of the prompting schedule. It is possible that a prompting schedule of 20 minutes standing for every 30 minutes sitting may illicit a higher compliance rate (Sharma, et al., 2018). This is an important implication for the public health domain as research has indicated that there are health benefits for office workers who are less sedentary. In addition, even though the increase in standing time was significant, the increase in standing was not for extended periods of time throughout the day. This is a key finding, as new research has suggested that standing for long periods can also be detrimental to an individual's health compared to sitting for long periods (Halim & Omar, 2011; Waters & Dick, 2015). The fact that the experimental group indicated a significant overall reduction in body discomfort, increased focus, and decreased fatigue with only a modest increase in overall standing time is further testimony to the effectiveness of the sit-to-stand workstation as a tool to decrease sedentary behavior whilst providing additional ergonomic benefits such as ease of adjustment to fit any size worker while sitting or standing.

Previous studies have examined “rewards” as a means for compliance such as getting people to lose weight or stop smoking (Ryan & Deci, 2000a, b). While those who receive “rewards” initially show better compliance at the beginning, long term compliance is less than those who receive “no-rewards” (Amabile, 1993). This is a possible indication that there is a limited impact of rewards on engagement (compliance) and a negative impact on long-term engagement or persistence. Indeed, evidence suggests, performance incentive devices can additionally undermine an individual’s intrinsic motivation (Benabou & Tirole, 2003). Since the participants in this study were not rewarded externally for compliance in using their sit-to-stand workstation, it can be reasonably determined that the benefits (decreased body discomfort, increased focus, etc.) experienced by the users served as an internal motivator while the computer prompt served as the external catalyst to initiate workstation usage; aiding the user to move from an externally motivated state to one that is internal in motivation.

There are several limitations in this study, chiefly, a planned follow-up 6-week monitor mode data collection would have confirmed that the experimental group indeed transitioned from extrinsic to intrinsic motivation which would have further strengthened this study. Future studies should incorporate a reversal (A-B-A) phase design to have greater confidence in the efficacy of the computer-based prompts. In addition, active computer time was calculated based on the user’s interaction with the computer and did not account for time that the user may have been on the phone, reading for long periods of time, or otherwise engaged with other tasks while at their desk or away. Finally, due to privacy concerns imposed by the company, we were unable to further delineate certain key variables by age or gender. Since employers are unlikely to offer gender or age specific solutions this is not a large limitation but instead points to the need for custom machine learning that can pattern an individuals' habits and tailor interventions that they respond to best. A final limitation is the potential for volunteer bias for those that opted to participate in the study as all the workers at the site had been using an electric sit-stand desk for more than a year. However, this can also be considered a strength as most studies involve very short or recent intervention timelines with the sit-stand desk with even heavier recruiting or volunteer bias from those that participate.

Conclusion

In summary, it was found that individuals who received computer prompts were more active and transitioned between sitting and standing more frequently throughout the day than their counterparts who did not receive prompts. Based on the participants' subjective questionnaire, many participants cited a decrease in body discomfort, increased mental focus, and increased productivity as reasons to continue making frequent posture changes, using their sit-to-stand desk frequently. Questions remain as to whether the change in behavior would be sustained over time and what mechanisms would illicit that behavior. Further work is needed to examine the motivational attributes of computer-based prompts, to determine if there are other more appropriate methods to stimulate and sustain sit-to-stand desk usage and define the optimal transitions per hour that will illicit measurable health benefits.

CHAPTER IV
CONCLUSION

Study comparisons

The studies contained herein were long term field studies, 6 and 4 ½ months respectively, and included adult office workers assigned to either a control or treatment group. Each study used different computer software applications to collect data but in both cases the intervention data were collected continuously and objectively. While each study's outcome was significantly different in scope, the principal intention was the determined effectiveness of sit-to-stand desks employed in office environments. As such, the studies should be viewed in totality, rather than independent stand-alone studies when attempting to understand the impact of sit-to-stand desks on an office worker's overall health, mental well-being, and performance.

The design of the studies contained both strengths and limitations, which are outlined in Table 6. Chief strengths between the studies are: both contained a control and experimental group, the data was objectively collected through the use of computer aided software, and the studies were performed in naturalistic settings; a clear departure from previous studies conducted in laboratory settings with participants completing office replicated tasks. Additionally, the studies contained a large participant pool (> 150) and were conducted over a lengthy time period (> 4 months) lending themselves to further generalizability across populations; important factors which further strengthen the impact findings of sit-to-stand desks on office worker populations.

Primary limitations between the two studies are: assignment of participants to the control groups, study location, and health behavior construct. In study #1, the researchers

Table 6. Study Comparisons

Study	n	Type of study Population	Baseline Length	Intervention Length	Data Collection	Type (s) of sit-to-stand desks	Prior sit-to-stand usage	Study Location	Prior Intervention Exposure	Health behavior change construct
#1 (Productivity)	167	Non-Volunteer	None	6 months	Objective Productivity Subjective Body Discomfort Survey	Electric & Stand-biased	30-Days	1 Building	Stretch Break software with prompts	Self-Monitoring
#2 (Chevron)	200	Volunteer	6 weeks	3 months	Objective Desk Usage Subjective Body Discomfort Survey	Electric	≤ 1 Year	2 Cities Multiple Buildings and Floors	Stretch Break software with prompts	Computer Based Prompts

were unable to randomly assign participants and the control group was located on the same floor as the experimental group. Even though there was a significant distance separation between the two groups in study #1, there did exist the potential for cross-contamination (unintentional sit-to-stand usage bias) by the control group whereas the groups in study #2 (control and experimental) were separated by floors, buildings, and even cities. Limitations on behavior change is also noteworthy in that the participants in study #1 received minimal direction on the use of sit-to-stand desk usage and had a 30-day habituation period while the study #2 participants had their desks for more than a year and had access to the company ergonomics program as a support system. Therefore it is difficult to quantify/determine specific causal factors that impacted the standing behavior of study #1 participants, while it is clear that the prompting software acted as the catalyst to increase sit-to-stand desk usage in study #2. In each case however, increased sit-to-stand desk usage appears to be impacted primarily through the reduction in body discomfort regardless of the mechanism (or lack thereof) employed to effect behavior change on sit-to-stand desk usage.

Research process

Performing research studies within laboratory confines can be a challenge, from participant recruitment to actual data collection, but lab studies cannot compare to the effort required to perform field studies. While study #1 was analysis of data provided by the company, it was part of a much larger study that required coordinated effort between company management and the research team, deployment of wearable sensors/monitoring equipment and multiple survey collections as well as continued meetings (in-person/telephonic) with the company to ensure legal and ethical considerations were met. While study #1 was a challenge for the reasons listed and even though it was in a different state from the research team, it was not as complex a study as #2.

Data collection for the Chevron study (study #2) began in December, 2016 but the development and subsequent funding for this research protocol actually began much earlier. In the fourth quarter of 2014 a submission for research funds was submitted to the Office Ergonomics Research Committee (OERC) outlining a proposed study using participants in an office environment and tracking their sit-to-stand behavior with computer software. The proposal was accepted for funding by the OERC in December, 2014, with the stipulation that a portion of the research funding would be provided once a company agreed to participate (for fiscal year 2015) and the remainder provided once the results were submitted to a peer-review journal. Unfortunately, the individuals at Chevron working with the research team at Texas A&M had determined that they would not be able to support the research effort, so the search for a new participant pool began.

Throughout the first quarter of 2015, the search for a company willing to allow us to perform research on their worker population continued, with only one promising option. Wellnomics©, a sit-to-stand software company in New Zealand, was interested in supporting the OERC research by working with an Australian government entity named Comcare. Comcare is a government facility located in Canberra, Australia and had worked with Wellnomics© previously. As Wellnomics© negotiated with Comcare for the study implementation, representatives from Wellnomics© and I held meetings to refine the research protocol and develop subjective surveys throughout the second half of 2015.

Entering the fall of 2015, there was still no progress on signing a research contract between Comcare and Texas A&M and pressure was mounting from the OERC to initiate the research protocol. Interestingly, Chevron who had denied participation the following year, contacted the Texas A&M research team about the study. It was decided then, by the Texas A&M research team, that whichever entity was able to provide a letter of intent first, would be the one chosen for the study. In December 2015, nearly a year after the OERC acceptance, Chevron delivered their letter of intent to participate. Ironically, a couple of days later, Comcare also provided a letter of intent so it was decided that both studies would continue, with the Comcare study going to one of my classmates.

Working with the Chevron contacts we began the arduous task of survey development, refining the research protocol, software implementation, and integration of the desks with the company provided computer systems. In addition, there were several meetings with the Chevron and Texas A&M legal departments to ensure both parties' interests were met and the privacy of the Chevron employee's was not violated. It was also during this time that talks began with Chevron, Texas A&M, and the software developer BakkerElkhuizen to determine how the software would be deployed, what information would be collected, and how the user would interact with the software. There were several iterations of the software developed and tested with Chevron before a final version was determined. In all, it took nearly a year to finalize the research protocol and launch the study in December 2016, two years after the acceptance of the research submission by the OERC.

Public health relevance

Since the early 1900's there has been a steady increase in the prevalence of obesity which is a significant risk factor for major diseases such as heart disease, stroke, diabetes and certain cancers (Wolf & Colditz, 1998). Likely contributors to this rise in obesity are; decreased cost of food due to agricultural improvements, decrease in work-related activity, income, and technological advances (Lakdawalla & Philipson, 2009). Work related inactivity has increased linearly with technological advances which have been designed to increase work performance (positive) while at the same time "tying" workers to their work space (decrement).

Only 23% of adults meet the weekly recommendation of 150 minutes of aerobic or muscular activity (Blackwell & Clarke, 2018) and it has been suggested that this recommendation is insufficient to off-set the time that workers spend sedentary during most of their daily workday (Hamilton, et. al., 2008). Therefore, increased activity outside of scheduled or planned physical activity (exercise) is an important factor when considering methods to impact the rise in obesity levels and the co-morbid disease processes. Sit-to-stand desks can provide workers opportunities to increase their activity while at work and at the same time increase productivity and reduce overall body discomfort.

Previous studies have incorporated such devices as accelerometers to collect and measure the amount of activity of workers in office environs. However, these types of devices lack the ability for continuous monitoring longer than 2 weeks and must be adhered directly to the skin. The computer based software that was used in study #2 was able to collect data continuously over 4 months and required no additional engagement from the participant. Thus allowing a naturalistic observation of the participant while reducing the potential for confounds introduced when interacting with the researcher. Indeed, the ability to monitor and collect data in such a fashion further enhances the reliability and efficacy when deciding upon future programs and requirements designed to reduce sedentary behavior and illicit healthy behaviors.

Public health policies are focused on smoking cessation, exercise recommendations, medication adherence, and preventative health measures (vaccines, screenings, mammograms, etc.) but have yet to focus on the growing concern of sedentary behavior. As mentioned earlier, there are recommendations for planned exercise but no recommendations to date for unplanned activity or maximal sedentary time. Through the use of the computer based prompts in study #2 and analysis of standing prompt adherence, we are much closer to establishing recommendations for workday activity. However, continued research is needed to determine the appropriate balance of sitting and standing that will illicit health improvements while at the same time encouraging compliance to an active workspace. With increased activity in the workplace, many of the comorbid diseases associated with obesity could be reduced.

Lastly, in both studies, body discomfort was a key element in the use and sustainability of sit-to-stand and stand-biased workstations. Since these types of workstations can be adjusted to fit the worker, ergonomic related injuries (e.g. neck, shoulder, upper arm, wrist, and lower body regions) are greatly reduced with a minimal increase in desk, or standing behavior. On average across both studies, an increase of ~ 90 minutes daily was sufficient to illicit reported benefits in body comfort, which is approximately 21% of a typical workday. This is a major finding and is consistent across both studies. Incorporation of sit-to-stand desks into a company's wellness program could potentially illicit even higher gains in the reduction of ergonomic related body discomfort, leading to a decrease in overall health care cost utilization.

Future research

Based on the studies discussed in this paper, ~90 minutes of additional activity appears to be sufficient to illicit reduced body discomfort, improved productivity, improved mental focus, and an overall improved sense of well-being. However, questions still remain as to the appropriate balance between sitting and standing time and the number of daily workday transitions needed to maximize the benefits of sit-to-stand desks. In addition, effective methods to ensure behavior change to compliance to computer based prompting schedules has yet to be determined as our study had a 40% compliance rate whereas another study indicated a 60% compliance rate (Sharma, et. al., 2018). Further research is needed to define balance between sitting and standing times and achieve a higher compliance rate to computer prompting software. It is more likely that individualized prompting rather than a "one-size" fits all approach will achieve those higher compliance rates.

Data analytics along with the Internet of Things (IoT) or AI is a likely next step in the evolution of sit-to-stand desk usage. Computer systems that can "read" body temperature through thermal imaging, pupil dilation and eye saccades through eye-tracking software, and body posturing via body scanning will be able to predict and determine body posture changes and do so at a time that will ensure the highest rate of compliance. In addition, AI will monitor room temperature for variances and adjust accordingly based on the individual's body temperature, reduce monitor glare by opening/closing blinds or adjust internal lighting, adjust white noise generator to reduce ambient noise, and even filter emails, phone calls, and other types of messaging to reduce task interruption and increased productivity. Interestingly the same products that are currently increasing our sedentary behavior such as voice activation devices (thermostats, lighting, entertainment, etc.) will one day be used to illicit non-sedentary behavior, monitor our health, and improve our overall body comfort.

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APPENDIX A

CHEVRON PRE-SURVEY QUESTIONNAIRE

Thank you for participating in the Chevron and Texas A&M Sit-Stand Study. A post-survey will be sent at the conclusion of the study to gather additional information about your experience. If at any time during the study you have any questions or need additional assistance, please contact Dave Blackman at BLDV@chevron.com. All information gathered in the surveys will remain anonymous.

Please select your gender
- Female
- Male
- Skip Question

Please select your office location:
- Houston
- San Ramon

What is your height?
- <5'0"
- 5'0"
- 5'1"
- 5'2"
- 5'3"
- 5'4"
- 5'5"
- 5'6"
- 5'7"
- 5'8"
- 5'9"
- 6'0"
- 6'1"
- 6'2"
- 6'3"
- 6'4"
- 6'5"
- 6'6"
- >6'6"
- Skip Question

How much do you weigh (lbs)?
- Enter weight here
- Skip Question

Please select your age range
- 20-25 years
- 26-30 years
- 31-35 years
- 36-40 years
- 41-45 years
- 46-50 years
- 51-55 years
- 56-60 years
- 61-65 years
- 66-70 years
- 71+ years
- Skip Question

How long is your <u>TOTAL</u> commute per day (time spent in the car, bus, train, etc)?

- 0-30 minutes
- 31-60 minutes
- 61-90 minutes
- 91-120 minutes
- 121-150 minutes
- 151-180 minutes
- >180 minutes

Estimate the total number of hours you spend at your primary workstation in a typical 9-hour workday (excluding meetings, time away from your desk, etc).

- ~0 hours
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- >8 hours

Of the hours you spend at your primary workstation in a typical 9-hour workday, how many of those hours do you spend in a <u>STANDING</u> position?

- I don't stand
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- >8 hours

How much of your average workday do you spend in a seated position (meetings, at your primary workstation, etc)?

- ~0 hours
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- >8 hours

What factors influenced you toward trying out or continuing to work in a standing position (select all that apply)?

- ☐ Increasing body comfort
- ☐ Increasing productivity
- ☐ To burn more calories and/or lose weigh
- ☐ To stay alert
- ☐ Curiosity to try it out
- ☐ Seeing others standing while using their desk
- ☐ Recommendation by ergonomic evaluator/safety professional
- ☐ Recommendation by supervisor/manager
- ☐ Being encouraged by colleague
- ☐ Other (please specify)
- ☐ I don't work in a standing position

Please select any of the following items that you currently have at your workstation:

- ○ Footrest that is used while standing
- ○ Standing pad/ fatigue mat
- ○ Other (please specify)
- ○ I don't have anything additional at my desk

How often do you use your footrest while standing?

- ○ Never
- ○ Sometimes
- ○ Frequently
- ○ All of the time

What factors, if any, make you NOT want to work in a standing position (select all that apply)?

- ☐ Discomfort while standing
- ☐ Extra required energy
- ☐ Productivity impacts
- ☐ Alertness impacts
- ☐ Time required to adjust the workstation
- ☐ Privacy
- ☐ Other (please specify)
- ☐ There are no factors that make me not want to work in a standing position

---

Approximately how long did it take you to become comfortable with standing at your desk while working?

- ○ Less than a week
- ○ 1-2 weeks
- ○ 2-4 weeks
- ○ 1-2 months
- ○ More than 2 months
- ○ I am still not comfortable standing while working
- ○ I do not work in the standing position

When you first started standing while working did you experience any of the following symptoms that you attribute to the change (select all that apply)

- ☐ Fatigue
- ☐ Discomfort
- ☐ Soreness
- ☐ Pain
- ☐ Other (please specify)
- ☐ None of the above
- ☐ I do not work in standing position

Since starting to use your workstation in a standing position, has your weight changed?

- ○ I have lost weight
- ○ I have gained weight
- ○ No change in my weight
- ○ Not sure if there has been a change in my weight
- ○ Skip Question

Which of the following have you experienced at work since you started using your workstation in a standing position (select all that apply)?

- ☐ Increased pain and discomfort
- ☐ Decreased pain and discomfort
- ☐ Increased focus and alertness
- ☐ Decreased focus and alertness
- ☐ Increased productivity
- ☐ Decreased productivity
- ☐ Increased energy level
- ☐ Reduced energy level
- ☐ None of the above

Please describe any other benefits or disadvantages you have noticed since you started working in a standing position.

This question is specific to any time during the day that you are sitting or reclining. This would include time spent in a car, bus, train, sitting at work, sitting or reclining at home, watching TV, sitting with friends, reading, working on your computer at home, watching a tablet or phone, but do not include time spent sleeping.
How much time do you spend sitting or reclining on a typical day?

- ~0 hours
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- ~9 hours
- ~10 hours
- >10 hours

How much time do you spend on a computer at home on a typical day?

- None
- Less than one hour per day
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- More than 4 hours per day

How much time do you spend on your phone and/or tablet at home on a typical day?

- None
- Less than one hour per day
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- More than 4 hours per day

Have you experienced any lower body discomfort in the previous 7 days (low back, hips, thighs, knees, ankles, feet)?

- Yes
- No

Have you experienced any lower body discomfort in the previous 12 months that has prevented you from carrying out normal activities (eg. job, housework, hobbies)?

- Yes
- No

APPENDIX B

CHEVRON POST-SURVEY QUESTIONNAIRE

Thank you for participating in the Chevron and Texas A&M Sit-Stand Study. Your answers to this post-survey will help impact a positive change in Chevron's Repetitive Stress Injury Prevention Program.

What is your sit-stand study participant number? (Supplied to you in the welcome email)

Please select your office location:
- Houston
- San Ramon
- Other (please provide location)

What is your height?
- <5'0"
- 5'0"
- 5'1"
- 5'2"
- 5'3"
- 5'4"
- 5'5"
- 5'6"
- 5'7"
- 5'8"
- 5'9"
- 6'0"
- 6'1"
- 6'2"
- 6'3"
- 6'4"
- 6'5"
- 6'6"
- 6'7"
- 6'8"
- >6'8"
- Skip Question

Please select your age range
- 20-25 years
- 26-30 years
- 31-35 years
- 36-40 years
- 41-45 years
- 46-50 years
- 51-55 years
- 56-60 years
- 61-65 years
- 66-70 years
- 71+ years
- Skip Question

How long is your TOTAL commute per day (time spent in the car, bus, train, etc)?

- 0-30 minutes
- 31-60 minutes
- 61-90 minutes
- 91-120 minutes
- 121-150 minutes
- 151-180 minutes
- >180 minutes

Estimate the total number of hours you spend at your primary workstation in a typical 9-hour workday (excluding meetings, time away from your desk, etc).

- ~0 hours
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- >8 hours

Please select any of the following items that you currently have at your workstation:

- Footrest that is used while standing
- Standing pad/ fatigue mat
- Other (please specify)
- I don't have anything additional at my desk

What factors, if any, make you want to NOT work in a standing position (select all that apply)?

- Discomfort while standing
- Extra required energy
- Productivity impacts
- Alertness impacts
- Time required to adjust the workstation
- Privacy
- Other (please specify)
- There are no factors that make me want to not work in a standing position

Approximately how long did it take you to become comfortable with standing at your desk while working?

- Less than a week
- 1-2 weeks
- 2-4 weeks
- 1-2 months
- More than 2 months
- I am still not comfortable standing while working

When you first started standing while working did you experience any of the following symptoms that you attribute to the change (select all that apply)

- ☐ Fatigue
- ☐ Discomfort
- ☐ Soreness
- ☐ Pain
- ☐ Other (please specify)
- ☐ N/A

Since starting to use your workstation in a standing position, has your weight changed?

- ○ I have lost weight
- ○ I have gained weight
- ○ No change in my weight
- ○ Not sure if there has been a change in my weight

Which of the following have you experienced at work since you started using your workstation in a standing position (select all that apply)?

- ☐ Increased pain and discomfort
- ☐ Decreased pain and discomfort
- ☐ Increased focus and alertness
- ☐ Decreased focus and alertness
- ☐ Increased productivity
- ☐ Decreased productivity
- ☐ Increased energy level
- ☐ Reduced energy level
- ☐ None of the above

Please describe any other benefits or disadvantages you have noticed since you started working in a standing position.

This question is specific to any time during the day that you are sitting or reclining. This would include time spent in a car, bus, train, sitting at work, sitting or reclining at home, watching TV, sitting with friends, reading, working on your computer at home, watching a tablet or phone, but do not include time spent sleeping.

How much time do you spend sitting or reclining on a typical day?

- ~0 hours
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- ~5 hours
- ~6 hours
- ~7 hours
- ~8 hours
- ~9 hours
- ~10 hours
- >10 hours

How much time do you spend on a computer at home on a typical day?

- None
- Less than one hour per day
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- More than 4 hours per day

How much time do you spend on your phone and/or tablet at home on a typical day?

- None
- Less than one hour per day
- ~1 hour
- ~2 hours
- ~3 hours
- ~4 hours
- More than 4 hours per day

Have you experienced any lower body discomfort in the previous 7 days (low back, hips, thighs, knees, ankles, feet)?

- Yes
- No

Have you experienced any lower body discomfort in the previous 12 months that has prevented you from carrying out normal activities (eg. job, housework, hobbies)?

- Yes
- No

APPENDIX C

CHEVRON EXPERIMENTAL GROUP SOFTWARE SURVEY

Sit Stand Software Evaluation

We're interested in your feedback on the Efficiency Sit Stand software you've been using for the last 3 months. This questionnaire will take ~5 mins

*** 1. How helpful did you find the Efficiency SitStand Coach software in using your sit stand desk?**

- ○ Very helpful
- ○ Somewhat helpful
- ○ Neutral
- ○ Unhelpful
- ○ Very unhelpful

*** 2. After using the sit stand software did you change between sitting and standing more often each day?**

- ○ Significantly more often
- ○ A little more often
- ○ No change
- ○ A little less often
- ○ Significantly less often

*** 3. Did you spend more time in standing at your workstation each day once the software started reminding you?**

- ○ Significantly more time standing
- ○ Slightly more time standing
- ○ No change
- ○ Slightly less time standing
- ○ Significantly less time standing

*** 4. Since using the sit stand software have you noticed any changes in the following while at work (check all that apply)?**

	Significantly Reduced	Slightly Reduced	No change	Slightly Increased	Significantly Increased
Discomfort	○	○	○	○	◉
Fatigue	○	○	○	○	◉
Mental alertness	○	○	○	○	○

	Significantly Reduced	Slightly Reduced	No change	Slightly Increased	Significantly Increased
Productivity	○	○	○	○	○
Overall Well-being	○	○	○	○	○

5. What were the benefits of using the SitStand Coach software (if any)?

6. What were the drawbacks of using the SitStand Coach software (if any)?

7. If available, would you continue to use a standing prompt software?

- ○ **I would definitely continue to use**
- ○ **I would probably continue to use**
- ○ **I probably would not continue to use**
- ○ **I definitely would not continue to us**

APPENDIX D

CHEVRON RECRUITMENT EMAIL TEXT

sit-to-stand study participants needed

Dear OpCo Team Member,

The Office HES RSIP Team is seeking voluntary participants in the San Ramon and Downtown Houston locations for a joint Chevron-Texas A&M study to determine the effectiveness of sit-to-stand workstations.

ACTION REQUESTED: Please register per the Sit Stand Sign Up Sheet, by no later than October 3rd. Sign-ups are limited to the first 600 people.

Your participation will help advance the science behind RSI Prevention. The study will address whether comfort varies with different ratios of sitting and standing, whether software design elements prohibit or increase the frequency of sitting and standing, and whether behavioral interventions can increase frequency of standing.

Timing of the study, and your estimated time commitment:

- Sept. 15th – October1st: Sign-ups (5 mins).
- Week of October 3rd: Participant pre-survey (5-10 mins).
- Week of October 3rd: Installation of software and sit/stand workstation cable for the study (5-10 mins)
  – a project member will perform this directly at your workstation.
- October 3rd – November 13th: Active data gathering period, no additional time commitment. You will continue to work as normal during the entire period, and sit/stand utilization data will be gathered in the background.
- Nov 14th - Feb 12th, 2017: Computer prompts will be activated to influence use of sit-to-stand desk. No time commitment will be needed. You will continue to work as normal during the entire period and sit-to-stand desk utilization will be collected.
- Week of Feb13th, 2017: Participant post-survey (5-10 mins).

Data to be Collected

As described above, hardware and software will be installed at your workstation to collect information on your frequency of sit/stand. This will be removed after the study. You will also be asked to complete a brief pre- and post- study survey on subjects such as current sitting/standing habits, commute time, and home sedentary behaviors, as well as to provide your age, height, weight, gender, discomfort level, and perceived time using sit/stand desk in standing position. The survey information **will be collected anonymously**, made available by aggregate summary only and no individual-specific detail will be separated out and/or shared. **This information will not be accessible by supervisors/managers, and will not be used for any employment purposes**. (In the avoidance of doubt, employees with discomfort should continue to contact Rapid Response, as discomfort information submitted for the study will not be accessible to Rapid Response.)

Please contact Dave Blackman, HES Specialist, Office HES Team, with questions about your participation in this study.

Additional information about the study and it's purpose may be obtained by contacting Gregory Garrett at Texas A&M University (979) 446-4101, ggarrett@sph.tamhsc.edu or the Texas A&M University Institutional Review Board (IRB) 979- 845-4969 and reference study #IRB2016-0132.

Thank you very much for your participation in supporting a World Class safety organization.

APPENDIX E

CHEVRON CONSENT FORM

Use of Sit-to-stand Workstations:
Does the Implementation of Behavioral Interventions Impact the Usage of Sit-to-stand Desks?

Introduction
The purpose of this form is to provide you information that may affect your decision as to whether or not to participate in this research study. Also, if you decide to be involved in this study, this form will be used to record your consent.

If you agree, you will be asked to participate in a research study examining computer prompted behavioral interventions associated with the use of electric sit-to-stand workstations and sitting time. The purpose of this study is to examine the use and benefits of electric sit-to-stand desks that can be easily changed between sitting and standing height. You have been selected to be a possible participant because you work at Chevron and are currently using an electric sit-to-stand desk. This study is being sponsored/funded by Texas A&M University.

Definitions:
Sit to stand workstation: regular height chair with desk that can be adjusted between seated or standing height

Behavioral Intervention: a computer program that will prompt the worker to sit or stand periodically throughout the workday

What will I be asked to do?
If you decide to participate in this study, you will allow the installation of computer software on your work computer that will record the number of times you raise and lower the desk and will record the length of time during the workday that you are in a seated or standing position. No personal or identifiable information will be collected. You will be asked to complete an online questionnaire at the beginning of the study that will ask questions related to your workstation setup, training you received about the sit-to-stand desk, time spent at your workstation, previous sitting and standing habits at your workstation, current physical activity outside of your workplace, computer use outside of your workplace, gender, height, and weight. Additionally you will be asked to complete an online questionnaire at the beginning and end of the study (2 times total) over the length of the study (~132 days) related to your body discomfort level and perceived productivity. You will have the choice to abstain from answering any questions in the questionnaire without penalty.

No identifiable information about you related to this study will be shared with Texas A&M University and nothing from this study will be used in making any decisions related to your employment with Chevron.

What are the risks involved in this study?
The risks associated with this study are minimal and are not greater than risks you ordinarily encounter in daily life. However, keep in mind that participation in this research study is not a substitute for consultation with a physician for any medical or health-related condition you may have.

What are the possible benefits of this study?

You will receive no direct benefit from participating in this study; however, information from this study will help with standing office changes to help reduce sedentary time and improve health.

Do I have to participate?

No, you do not have to be in this research study. Participation is voluntary and is not a condition of your employment with Chevron. There is no penalty for choosing not to participate, and you can withdraw from the research study without any penalty if you change your mind later.

Who will know about my participation in this research study?

This study is confidential and the records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Consent forms will be stored in a secure location at Chevron and only Dave Blackman will have access to any personal identifying information. Texas A&M Researchers, Gregory Garrett and Dr. Mark Benden, will only have access to de-identified information provided to them by Chevron.

Whom do I contact with questions about the research?

If you have questions regarding this study, you may contact Dave Blackman (Chevron) at (925) 570-4248 or dblackman@chevron.com or Gregory Garrett (Texas A&M University) at (979) 446-4101 or ggarrett@sph.tamhsc.edu.

Whom do I contact about my rights as a research participant?

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you can contact these offices at (979) 458-4067 or irb@tamu.edu.

Signature

Please be sure you have read the above information, asked questions and received answers to your satisfaction. You will be given a copy of the consent form for your records. By selecting "yes" or "no", you consent to participate in this study by completing questionnaires. As your participation is voluntary, you are releasing Chevron and Texas A&M University, their employees, agents, and representatives from any and all claims, losses, and liability of any kind or damages, including, but not limited to illness or personal injury in any way arising from your participation in this research study.

I agree to participate or abstain from this research study by selecting the appropriate choice below. I understand the purpose and nature of this study and I am participating voluntarily. I understand that I can withdraw from the study at any time, without any penalty or consequences.

- Yes
- No