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DIFFERENTIATING BETWEEN LOW LEVEL ACTIVITIES IN SEDENTARY OCCUPATIONS UTILIZING FITBITS

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by

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Abstract

Objective: Fitbits are popular devices used to track personal activity throughout the day. The potential usage of these devices in tracking sedentary activities in research studies rely on the validity and accuracy of the devices. The objectives of this study are to investigate if changes in daily activity is associated with changes in duration of standing time using a sit-to-stand workstation. Also to establish if an accelerometer may be used to detect differences between sitting and standing sedentary positions.

Methods*:* Sixteen participants wore Fitbit accelerometers throughout the workday and were emailed surveys on a weekly basis to report their sitting and standing percentages. Spearman correlation was used to compare mean daily step counts and mean standing percentages. A subsample of seven participants wore Fitbit and completed log sheets detailing precise periods of sitting and standing while at work. The number of steps registered during sitting and standing periods was compared for each individual using a paired t-test.

Results*:* No statistically significant correlation was found between a participant's mean standing percentage and mean daily step count (p-value = 0.563). Paired t-test analysis of participants found no statistically significant difference between the total number of steps registered while sitting and the total number of steps registered while standing (p-value = 0.034).

Conclusions: No observable association between daily activity and duration of standing time was found. The number of steps measured using a Fitbit accelerometer may not be a useful method to assess sit-to-stand workstation usage. Limitations with the study included possible selection bias, incomplete self-reporting surveys, low sample sizes and short study durations. Future studies accounting for these limitations may prove to yield more statistically significant results regarding the use of Fitbits in assessing sedentary activity.

Keywords: Fitbit; Sit-to-Stand Workstation; Occupational Sitting; Sedentary

Dedication

I wish to thank my parents Kirk and Debbie; siblings Ali and Cody; and my close friends for all of the love and support they have provided me with while pursuing my academic endeavors. Without them, none of what I have been able to do with my life thus far would have been possible. They have always supported my interests and passions and I know they will be there to continue to do so in the future. Thank you all for everything that you have done for me. I hope one day I may be able to return the favor.

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1. Introduction

1.1. Sedentary Lifestyle Health Hazards

Physical activity is known to play a key role in maintaining a healthy lifestyle (Pulsford et al., 2015). Aside from the day-to-day benefits that can be observed, such as an improved mental state, regular physical activity can also help prevent long-term illnesses (Owen et al., 2010). On the contrary, excessive amounts of inactivity, such as sitting for extended periods of time, can be quite detrimental to personal health (Chau et al., 2011; Pronk et al., 2012; Owen et al., 2010). Levels of physical activity can be classified into one of 4 categories, sedentary, light, moderate or vigorous. While studies have examined increased activity levels and their associated impacts on health, recent research interest has shifted to focus to the fourth level of activity, otherwise known as sedentary activity (Owen et al., 2010; Pate et al., 2008; Pulsford et al., 2015). Sedentary activity refers to physical activity that results in an energy expenditure ranging from 1.0 to 1.5 metabolic equivalents (METs) (Owen et al., 2010). Sedentary activities that result in low METs include tasks such as sitting, standing still, watching television, working on the computer, or laying down (Dutta et al., 2014; Owen et al., 2010; Pulsford et al., 2015). Increased time spent in sedentary activities has been correlated with an increased likelihood of certain health issues, such as cardiovascular disease, musculoskeletal disorders, diabetes, obesity, various types of cancer, and even premature mortality (Chau et al., 2011; Chau et al., 2012; Dunstan et al., 2013; Dutta et al., 2014; Garrett et al., 2016; Mummery et al., 2005; Owen et al., 2010; Pronk et al., 2012; Pulsford et al., 2015; Simons et al., 2013; Straker et al., 2014; Takacs et al., 2014; Van Uffelen et al., 2010; West et al., 2008).

1.2. Occupational Sedentary Behavior

According to Owen et al. (2010), human engagement in sedentary activities, especially sitting, have increased significantly as a result of changes in various components of everyday life, such as occupational settings, work commutes, leisure activities, and technological advances. Electronic resources, such as e-mail and the internet, have been attributed to increased sedentary activity (Owen et al., 2010). Requirements to physically leave the workspace to communicate with coworkers or to look up pertinent work information no longer exist in the same capacity it once did, given the ability to perform these activities from the comfort of an office chair (Dutta et al., 2014; Owen et al., 2010; Pulsford et al., 2015). A recent study found that adults in the United States sit an average of 8 to 9 hours per day (Bureau of Labor Statistics, 2009; Straker et al., 2013). An estimated 4.7 hours per day are spent engaging in a leisure activity, such as watching television or laying down (Bureau of Labor Statistics, 2016). These findings suggest that nearly 50.0% of an individual’s sedentary behavior is experienced at work. Increased occupational sitting time is concerning as recent research suggests that spending too much time in a sedentary activity can have negative influence on personal health (Pronk et al., 2012). Prolonged sitting time at work can lead to muscle degradation, back stiffness, mental fatigue, organ damage, and obesity (Berkowitz and Clark, 2014;

Approximately 35.7% of U.S. adults were classified as being obese in 2012 by researchers at the National Institute of Health (Ogden et al., 2012). If increased occupational sedentary time increases the risk of health hazards such as obesity, the amount of time spent sitting at work over a lifetime could prove quite hazardous to one’s health (Takacs et al., 2014). Even individuals actively engaging in regular physical activity are susceptible to increased risk of certain health issues, such as high body mass index (BMI) and/or premature mortality if the amount of time spent sitting at work exceeded 5 hours per day (Matthews et al., 2012; Mummery et al., 2005). Thus, the potential benefits of exercise are negated by the increased sedentary activity. These findings emphasize the need for additional research into occupational sedentary time in order to find suitable ways to reduce occupational sitting time and develop tools to gauge their influence (Pulsford et al., 2015).

1.3. Reducing Occupational Sitting Time

Physical and psychological factors may contribute to negative health effects in combination with increased occupational sedentary time. One of particular interest is the work environment (Pulsford et al., 2015). For example, Mummery et al. (2005) found blue-collared workers (e.g. construction workers) to have the most active occupational workstyle, with the least amount of reported sitting time. White-collared workers (e.g. administrative staff) followed with the second lowest amount of sitting time, whereas professional workers (e.g. academics) had the highest level of reported sitting time (Mummery et al., 2005). The differences in sedentary time observed between these occupational levels results from the amount or lack thereof physical labor involved with the occupation in question. An option to reduce the amount of occupational sitting time in a workplace is a sit-to-stand workstation. Sit-to-stand workstations allow the workplace to accommodate alternating sitting and standing positions, which in turn should reduce total occupational sitting time (Alkhajah et al., 2012; Dunstan et al., 2013; Dutta et al., 2014; Pronk et al., 2012). Proper ergonomic training when combined with sit-to-stand workstations has been found to double the effectiveness of the stations' utility in reducing occupational sitting time (Garrett et al., 2016; Robertson et al., 2008; Straker et al., 2013). Proper use of sit-to-stand workstations have been reported to decrease the amount of musculoskeletal complaints, improved mental state, and in some instances, increase performance of routine occupational tasks (Husemann et al., 2009; Robertson et al., 2008; Robertson et al., 2013).

1.4. Measuring Sedentary Activity

Although sit-to-stand workstations may present multiple qualitative benefits to employees, they can be costly expenditures for an employer. It is therefore important to measure quantitatively if workers utilize their workstations and validate a commercial device is capable of detecting changes in sedentary activity levels. A popular method of analysis into the use of sit-to-stand workstations are questionnaires (Chau et al., 2011; Chau et al., 2012; Jancey et al., 2014). Studies conducted by Chau et al. (2012) and Jancey et al. (2014) found that The Occupational Sitting and Physical Activity Questionnaire (OSPAQ) was an example of an acceptable measure of workplace activity, highly consistent in test-retest capability. The ability of questionnaires to effectively measure workplace activity when compared with accelerometers has validated their usage in assessing sit-to-stand workstations in occupational settings. The questionnaires allow for pertinent information to be reported by the employees utilizing the sit-to-stand workstations, such as the amount of time they spent sitting and/or standing while at work (Dutta et al., 2014).

While questionnaires can be an effective means for analyzing worker activity levels, they are subject to reporting and recall bias, as they rely on the honesty of the individual completing the survey, and whether or not they accurately, under or over report their activity (Chau et al., 2011; Chau et al., 2012; Mummery et al., 2005). An alternative qualitative method for measuring changes in physical activity are accelerometers. Accelerometers are electronic machines capable of detecting and measuring activity in three planes, based off how intense an activity is and the duration for which it is performed (Owen; 2010; Takacs et al., 2014). There are many advantages of using accelerometers to collect data. Accelerometers serve as a strong validation method for objectively measuring physical activity (Chau et al., 2011; Chau et al., 2012; Jancey et al., 2014). Several studies have utilized various types of accelerometers, despite not being the official standard for assessing sedentary postural behavior, along with activity questionnaires for comparison and correlation of sit-to-stand workstation data. (Chau et al., 2011; Chau et al., 2012; Jancey et al., 2014; Owen, 2010).

Chau et al. (2012) found that accelerometers were very successful in being able to accurately assess the validity of the criteria measured with questionnaire responses. Jancey et al. (2014) also found strong associations with accelerometer usage and questionnaire reports. A commonly used accelerometer is the Fitbit®. Fitbit accelerometers are an effective means for data collection in activity level studies (Case et al., 2015; Diaz et al., 2015; Noah et al., 2013; Takacs et al., 2014). Fitbit accelerometers have been proven to perform effectively and are reliably accurate in measuring various activity levels, ranging from light-based activity to vigorous activity. Takacs et al. (2014) demonstrated the use of the devices in defined activities such as treadmill walking and found that Fitbits were both a valid and reliable way to step counts. Another by Case et al. (2015) found the Fitbit Flex, Fitbit One, and the Fitbit Zip to all be accurate in tracking personal step counts. Although these devices effectively measure light to vigorous intensity activities, such walking and running (Diaz et al., 2015), there is limited data on Fitbit accelerometer capabilities of measuring sedentary activities, such as sitting and standing still. As these activities both are considered sedentary, alternating between the two positions may not be capable of being measured. Thus, the potential applications of accelerometers and their capabilities in detecting changes in sedentary activity warrant further investigation.

1.5. Research Focus – Potential Application of Accelerometers

Given the success of Fitbit accelerometers in assessing light, moderate and vigorous activity levels, it is of interest to determine the capabilities of the devices in measuring small, yet important, changes in sedentary activity. This study examinde if Fitbit accelerometers are capable of detecting differences in sedentary activities by monitoring participants using sit-to-stand workstations. The main goal of the study will be to determine if the amount of time spent standing still at sit-to-stand workstation at work will be measured as an increased level of activity. The secondary goal of the study will be to establish if a Fitbit can be utilized to differentiate between two specific types of occupational sedentary activity, sitting and standing still. The following specific objectives will be investigated in this study.

1. Determine if the duration of standing time using a sit-to-stand workstation while at work is associated with daily activity level. Ho: no relationship will exist between mean standing percentages and mean daily step counts.
2. Determine if an accelerometer is capable of detecting differences between sitting and standing sedentary positions. Ho: more activity will not occur while in a standing position vs. while in a sitting position.

2. Methods

2.1. Research Design

An observational study was conducted on a convenience sample of Montana Tech faculty and staff. A group of 41 potential candidates were identified on campus as having a sit-to-stand workstation. Out of the 41 individuals, 16 responded and agreed to partake in the study, a resulting 39.0% (16/41) response rate. Participants were recruited using a University of Montana Institutional Review Board approved email. Recruitment was based on having largely sedentary occupations and similar occupational environments. Any interested candidates were able to partake in the study if they met the following inclusion criteria:

1. Full time employees (32 hours per week, minimal).
2. 50.0% of their workday consisted of sedentary work (sitting or standing).
3. Had a sit-to-stand workstation.
4. Agreed to complete a weekly sit-to-stand workstation survey.
5. Agreed to wear a Fitbit accelerometer every day at work during the study period.

The study was broken down into two different data collection intervals, which will be designated study A and study B. Study A was conducted over a 6-week period from April 2016 to mid-May 2016. The study examined activity during a 5-day work week, Monday through Friday, from 8:00 AM to 5:00 PM. Participants were requested to sign a consent form and were assigned randomly generated identification numbers in order to protect their identity and keep personal information confidential. Participants were asked not to alter their normal work behavior and to report the amount of time spent sitting and standing each day on a weekly basis. Self-reporting data were collected via surveys created and tracked by Qualtrics, an online research software. The data collected during this study included self-reported standing percentages and total daily step counts in order to examine objective 1. Study B was conducted over four weeks from mid-October to mid-November. Study B focused on collecting strictly monitored sitting vs standing data. Participants were asked to complete a log detailing time spent sitting and time spent standing still at work while wearing a Fitbit. The participants were asked not to alter their behavior, wear a Fitbit during their recorded 30-min intervals, and to only record times while in a sitting or standing position at their office workstation. A total of 4 hours of standing and 4 hours of sitting data were collected for each participant in order to examine research objective 2

2.2. Equipment

This study focused on step count data collected via Fitbits. Sit-to-stand workstation designs varied amongst participants. Some participants utilized sit-to-stand workstations previously provided by the university, that allowed for the workstation monitor and keyboard to be raised or lowered via an articulating arm. Other participants utilized makeshift stations that allowed them the capability of working unhindered in either position. An example of a makeshift station was the utilization of a metal desk organizer to elevate the workstation to allow a standing work position. Weekly self-reporting surveys were sent out via Qualtrics. Participants without an accelerometer were provided with a Fitbit Flex for their participation in the study. Participants that successfully completed the study were allowed to keep the accelerometer for personal use upon the conclusion of the study. If participants already possessed a Fitbit accelerometer, they were allowed to enroll their device in the study and received a gift card of equivalent value for their participation

2.3. Data Collection

Data collection for this project was conducted utilizing three different collection methods:

1. Step count data was collected via Fitbit accelerometers. Participants were emailed a link requiring them to sync their accelerometer with an online database known as Fitabase®. The accelerometer would automatically upload the participant's data to the online database whenever the device synchronized with the participant's mobile app.
2. Participants in Study A were emailed surveys weekly via Qualtrics, an online research software. Participants completed weekly surveys, approximating their time spent sitting or standing every day per week. Data were recorded as percentages for time spent sitting and standing each day.
3. Participants in Study B filled out sitting and standing time logs. The date, time, duration, and position (sitting or standing) was recorded by participants as they completed each recording session. The accelerometers automatically uploaded the participant's data to the online database whenever the device synchronized with the participant's mobile app.

2.4. Data Management

2.4.1. Study A

Step data recorded via accelerometers were batch downloaded from Fitbit's online data storage program Fitabase®. These data files were managed in Microsoft Excel to remove dates and times not within the respective study parameters. Study A data included a 5-day workweek, Monday through Friday, from 8:00 AM to 5:00 PM. Accelerometers took readings every second, which resulted in approximately 972,000 step data points. The data were condensed by calculating the mean daily step count per individual. This was accomplished by gathering all hourly data points and summing them into daily totals. Daily totals were then summed and averaged by the number of days in the study (e.g. 154,467 steps/30 days = 5149 avg. daily steps).

Personal self-reporting questionnaire data were downloaded from Qualtrics and examined in Microsoft Excel. The data set included both sitting and standing percentages, equating to 100.0%, recorded for 5 days per week of a 6-week study period. As the first objective was to examine the standing percentages against average daily steps, only standing percentages were examined and averaged per participant. Survey results presented each participants entries regarding sitting time and standing time in percentages per day for each week. The surveys were used to calculate the overall average percent standing time per week. Standing percentages were averaged per week before being averaged over the total six-week study period, resulting in an overall average percent standing time. During standing percentage analysis, it was determined that not all participants completed a questionnaire for each week of the study. Therefore, instead of the self-reported percentages being averaged over the 30-day study period, the data were divided by the number of days for which questionnaires were completed. For example, participants 8, 10, and 11 completed only five questionnaires, their respective data were divided by 25 (5 weeks x 5 days) to calculate the standing percent average. Corresponding adjustments were made to the average daily steps per participant following this change.

2.4.2. Study B

Study B step data recorded via Fitbits were batch downloaded from Fitabase®. Study B data were more varied, as participants were required to record the specific dates, time, and duration they spent either sitting or standing. This interval did not outline specific times that needed to observed, merely that the participants take careful notes of when they did conduct their 30-min sitting or standing sessions. Participants were required to gather eight 30-min sitting sessions and eight 30-min standing sessions. The 16 individual 30-min sessions equate to an 8-hr period, with 4-hrs spent sitting and 4-hrs spent standing.

The participants monitored and recorded 16 individual 30-min sessions apiece. During these sessions, each participant was asked not to alter their normal workstation behavior, other than to refrain from recording excess walking events (e.g. walking to the bathroom). Participants were instructed to record data only while in their workstation setting. If excursions out of the work area area occurred, participants would cease logging data for the time gone and resume upon arrival back to their workstation. Fitbit data were synced to Fitabase and then batch downloaded. Participant log sheets were used to identify the correct step time intervals, allowing the data to be condensed and examined. Once each 30-min session was collected for each participant, session total registered steps were calculated by summing each minute’s recorded steps for the 30-min session. From these session totals, a final sitting step total and standing step total were calculated by summing the six session totals for each category per participant. Thus, resulting in one sitting step total and one standing step total per participant.

2.5. Statistical Analyses

2.5.1. Study A

Statistical analyses of the data were preformed utilizing Minitab 17 statistical software. Self-reported standing percentages and mean daily step counts were first calculated in Microsoft Excel. Standing percentages and mean daily step counts for each participant were analyzed using Spearman correlation. The Spearman correlation method was chosen given that the data did not meet the assumption of being linearly distributed. The Spearman correlation was performed under the null hypothesis that no relationship would exist between standing percentages and mean daily step counts (Ho: $r = 0$). The Ho hypothesis would be rejected if a relationship was found to exist between the two variables (Ha: $r \neq 0$). The p-value will determine the statistical significance of the relationship between variables if found to be less than α (0.05).

2.5.2. Study B

Statistical analyses of the data were processed utilizing Minitab 17 statistical software. A final sitting step total and standing step total for each participant was calculated and paired in Microsoft Excel. The mean number of steps registered while sitting was compared with the mean number of steps registered while standing utilizing a paired t-test. A paired t-test was chosen to test that more activity would occur with a standing position as opposed to a sitting position (Ha: $\mu_d > 0$). The difference between the number of registered steps while sitting vs. while standing was calculated and included in the analysis. The assumptions of the t-test were met by having a continuous dependent variable and the independent variable were matched pairs. The difference between the two variables contained no significant outliers and was normally distributed.

3. Results

3.1. Correlation of Mean Standing Percentage vs. Mean Daily Step Count (Study A)

Of the 16 individuals that agreed to participate, 12 successfully completed all required components of the study, 75.0% (12/16). Four participants failed to either register their accelerometer or synchronize their daily sit-to-stand workstation usage with Fitabase, thus resulting in exclusion from data analysis. The 12 remaining participants were monitored for the 30-day (5 days' x 6 weeks) study period. The mean standing percentage, mean daily step count, and number of days with questionnaire entries were paired by participant for the 12 participants that successfully completed the study parameters. Mean standing percentages varied noticeably between participants, ranging from 27-86%. Mean daily step counts ranged from as low as 3,033 steps to as high as 7,094 steps. The number of recorded self-reporting surveys also varied, with 58.3% (7/12) participants having 30 recorded questionnaire entries, 25.0% (3/12) having 25 recorded entries, and 16.7% (2/12) having only 20 recorded entries; see Table I. The comparison between mean standing percentage and mean daily step count per participant can be seen in Figure 1.

Table I: Self-reported standing percentage, daily step average, and number of recorded questionnaire days observed per participant.

Participant	Mean Standing Percentage (%)	Mean Daily Step Count	Number of Days with Questionnaire Entries
1	47	5149	30
2	86	4399	30
3	31	5183	30
4	54	3515	20
5	83	5354	30
6	69	6452	30
7	29	7094	30
8	28	3730	25
9	53	5291	20
10	35	3448	25
11	52	7979	25
12	27	3033	30

Analysis of the self-reported mean standing percentages revealed a mean of 49, a standard error mean of 6, standard deviation of 20, and a variance of 436. Mean daily step count data for the participants revealed a mean of 5,052, a standard error mean of 444, a standard deviation of 1539, and a variance of 2,368,801. The Spearman correlation analysis revealed a weak relationship ($\rho = 0.301$) between participants' self-reported standing time percentages and their respective average daily step value. Furthermore, the correlation was not statistically significant between a participant's mean standing percentage and mean daily step count (p-value = 0.342). 3.5% (R^2) of the variability in steps was accounted for due to percent standing. As shown in the scatterplot in Figure 1, no clear relationship between the participant's mean standing percentage and mean daily step count is evident.

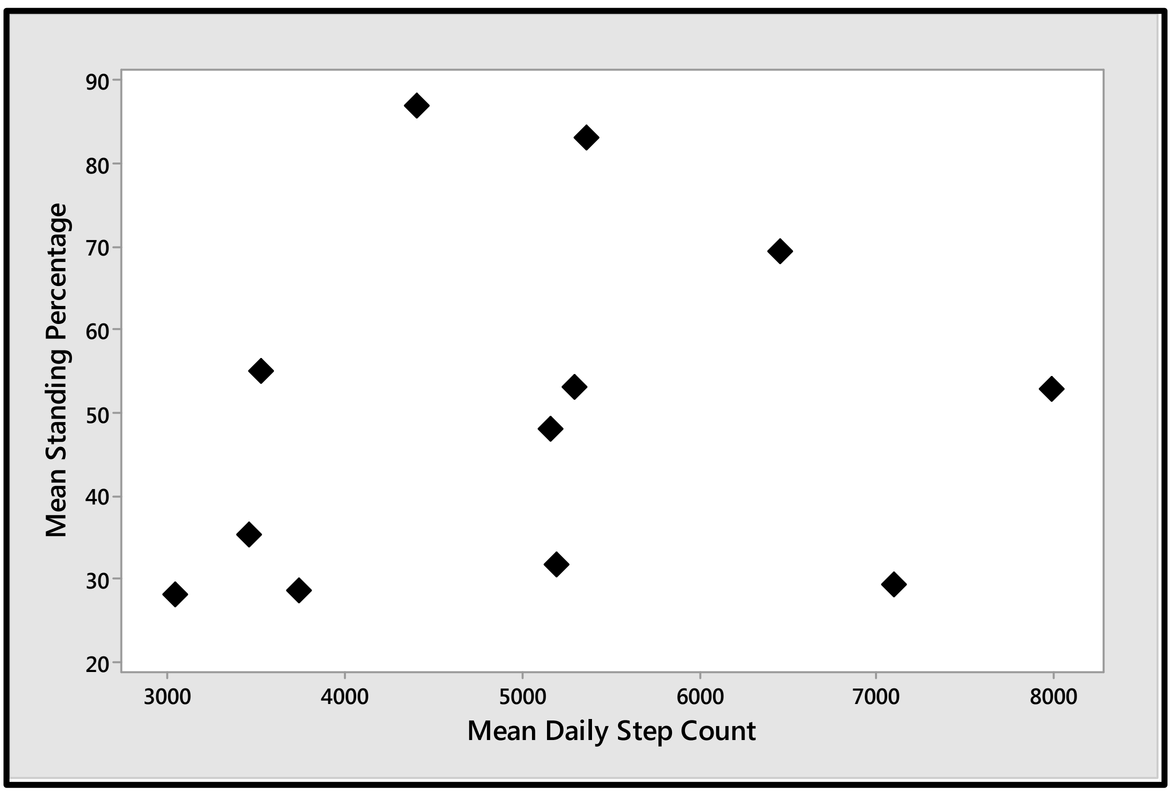

Figure 1: Scatterplot graph of mean daily step count compared to participant mean standing percentages.

3.2. Capability of Fitbit differentiating between sitting vs. standing positions (Study B)

Seven individuals from the Study A group were recruited to participate in Study B. Of the seven, six successfully completed all required components of the study, 85.7% (6/7). One participant failed to comply with the study parameters, thus resulting in exclusion from data analysis. The total number of registered steps while sitting and the total number of registered steps while standing were calculated and paired per participant. The total number of steps registered while standing varied substantially between participants, ranging from 0 steps to 814 steps. The total number of steps registered while sitting varied less, ranging from 0 steps to maximum of 314 steps. The difference in the total number of registered steps was calculated for each participant, ranging from -23 steps to 500 steps. The negative value here resulted from a participant having more while sitting than while standing (*0 (standing) – 23 (sitting) = -23 steps*).

Analysis of the total number of steps registered while standing found a mean of 309, standard error mean of 139, standard deviation of 340, and a variance of 115,439. The total number of steps registered while sitting for participants revealed a mean of 67, a standard error mean of 49, a standard deviation of 122, and a variance of 14,956. Based off of the paired t-test analysis, no statistically significant difference was detected between the total number of steps registered while sitting and the total number of steps registered while standing (p-value = 0.113). The distribution and variance for the number of steps registered while standing and number of steps registered while sitting can be seen in Figures 2.

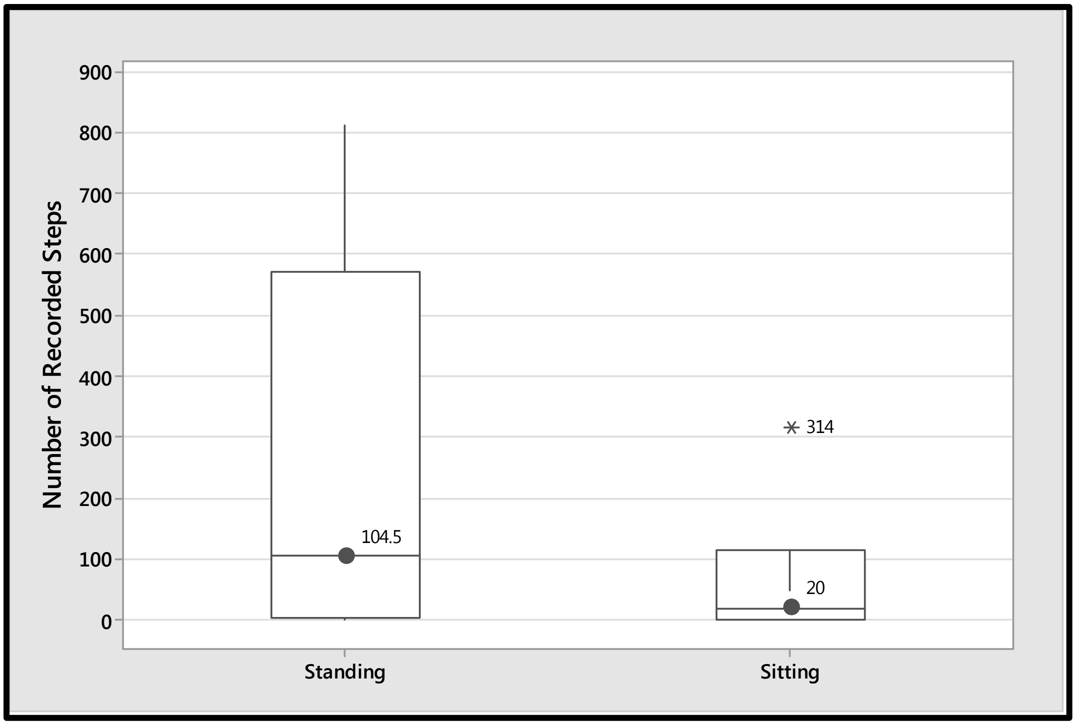

Figure 2: Box and whisker plot of total number of steps registered while standing compared to total number of steps registered while sitting.

4. Discussion

The first objective of this study was to determine if the duration of time spent standing still while using a sit-to-stand workstation is associated with daily step activity level. Self-reporting surveys and accelerometers were used in tandem to examine if the two variables were correlated. Based off the results obtained from the study, there was no statistically significant correlation between the mean standing percentages and the mean daily step counts. The second objective of this study was to determine if Fitbit accelerometers were capable of distinguishing between sitting and standing sedentary positions. There was no statistically significant difference between the total number of steps while sitting and the total number of steps while standing. This result suggests that the Fitbit may not be capable of differentiating between the sedentary positions of sitting and standing still.

As previously mentioned, Fitbits have been determined capable of distinguishing between varying levels of activity. However, differences in activity level classification may vary based on the cut points used for step counts (Chau et al., 2011; Chau et al., 2012). Some studies classified both sitting and standing postures as sedentary activities; whereas others classified only sitting as sedentary and standing as a light activity level (Chau et al., 2011; Chau et al., 2012; Jancey et al., 2014). For example, Jancey et al.'s (2014) study defined sitting as a sedentary activity but standing as a light intensity activity for their accelerometer data classifications. When compared to self-reported activity level data, accelerometers were found to have strong associations in successfully measuring sitting, standing, and walking activities (Jancey et al., 2014).

There are a number of limitations that could have possibly contributed to the insignificant findings of Study A and Study B. Study A had a very low response rate (39.0%), potentially negatively impacting the results of the study. This could represent selection bias as the study only tried to recruit individuals with existing sit-to-stand workstations. The impact on the results would be that the convenience sample may not serve as a fair representation of the campus population utilizing sit-to-stand workstations. Expanding upon the study to include individuals who may be interested in obtaining sit-to-stand workstations and providing them on the condition that they participate in future studies may correct for this error. During Study A, the participants were only told to wear their Fitbits during the allotted study time frame and record their estimated sitting and standing percentages. They were also instructed not to alter their behavior. Therefore, participants wore the accelerometers throughout the workday, never removing them and thus data from accelerometers could include time spent sitting, standing, going to the campus gym, grabbing lunch, traveling in a vehicle, etc.

However, in the self-reporting survey, participants were only asked to report their proportion spent sitting and time spent standing at work while at their workstation. No specific information pertaining to when participants were sitting or standing was collected. Therefore, instead of comparing a participant's self-reported standing percentage with their registered number of steps previously thought to be spent sitting or standing, the self-reported standing data was actually being compared to data inclusive of walking and other activities. An additional problem existing with the usage of self-reporting surveys is recall bias. Participants were asked to report sitting and standing time percentages on weekly basis. The survey used to collect the data was sent out every week on Friday. Thus, participants were attempting to recall their sitting and standing percentages for every day of the week on Friday. This could affect the results as incorrect approximations of sitting and standing percentages could have been reported if detailed daily accounts for each activity were not kept by the participants. The use of a daily survey to collect self-reported data on percentages for standing and sitting time may prove to be more variable than a weekly log. Another limitation in Study A was the use of a correlation to examine a relationship between mean standing percentages and daily activity levels. The use of a correlation can prove useful when all potential variables are known. However, there may be confounding effects associated with the study variables that are unknown. This could potentially result in incorrect assumptions being made, as to whether or not a true correlation exists between the study variables.

Future studies should utilize a detailed log of sit-to-stand workstation usage prior to examining whether or not increased sit-to-stand workstation usage relates to an increased activity level. Additionally, the proportion of time-spent standing is not necessarily indicative of normal standing workstation use. Measuring the amount of postural adjustments between sitting and standing positions may prove to represent a more accurate representation of sit-to-stand workstation usage. Future studies could also collect personal demographics that could prove useful in studies interested in examining differences between respective categories, such as male vs. female.

Although Study B found that there was no difference detected between when a participant was standing vs. when they were sitting; the study was conducted after Study A. While this allowed for the error of including walking activity in the previous study to be corrected and controlled for using detailed sit-to-stand workstation logs, Study B was conducted utilizing a very small sample size (n = 6). Therefore, the hypothesis testing could have been underpowered. Thus, these results should not be considered representative and instead should be view as pilot study results that could provide an approximate sample-size for a larger study. Additional potential limitations to the study include that the sample population was a convenience sample and that only one type of workspace was examined. Expanding upon these limitations by including a larger, more widespread participant group and examining additional types of work environments could potentially influence these findings. The use of a daily log sheet may provide more accurate and reliable data given the percentages would be reported on the same day the activities were performed.

The main strength of the study was investigating whether an accelerometer could distinguish between sedentary sitting vs sedentary standing positions, which has not been previously attempted. Despite our results showing that no significant difference in the standing steps and sitting steps could be seen, the amount of steps registered while standing was generally higher than the number of steps while sitting. This finding is important as it suggests that accelerometers, in this case Fitbits, may be useful in ergonomic studies monitoring sit-to-stand workstation usage, but further research is needed to determine if a statistically significant difference can be detected with larger data sets. Additional research will also help establish how researchers and employers can utilize the data to measure the degree of sit-to-stand workstation usage and to determine if sit-to-stand workstations result in changes in activity of the users.

Suggestions for future research include repeating Study A, but accounting for time spent sitting, standing and walking in the self-reporting questionnaire, so that activities can be correctly correlated with the mean daily step counts; expanding Study B to include a larger sample size to verify the significance of the Fitbit’s ability to distinguish between sitting and standing positions would also be beneficial. Having a statistical analysis with stronger power would yield stronger confidence in any statistical test. This data could also serve to determine if the number of registered steps can be predicative of sit-to-stand workstation usage.

Overall, this study demonstrated that an increased amount of standing time was not associated with increased activity throughout the workday. Although non-significant, a weak positive relationship was detected. This study also demonstrated that the Fitbit accelerometer was not capable of distinguishing between sitting and standing sedentary positions. Improving upon the limitations within this study, such as an increased sample size, with further research could provide stronger insights into a Fitbit's capability to detect differences between sedentary activities. The findings of this pilot study could be useful in planning future studies aimed at utilizing Fitbit accelerometers in assessing occupational sedentary activities.

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