EFFECTS OF THE FITDESK ON WORK PERFORMANCE IN COLLEGE STUDENTS

by

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ABSTRACT

Being sedentary is a behavior that is practiced far too often by individuals. This is worrisome because evidence suggests that uninterrupted periods of sitting can be harmful to one's health. The purpose of this study was to examine the effects of a cycling workstation, the FitDesk, on work performance, blood pressure, heart rate, and the energy expenditure of college students. It was hypothesized that pedaling with the FitDesk would not have an effect on college students' typing performance, reading comprehension, and attention/information processing when compared to those sitting at the FitDesk. In addition, an acute reduction in blood pressure, increase in heart rate, and increase in energy expenditure was anticipated in those pedaling with the FitDesk. Twenty sedentary college students randomly assigned to complete a 30-min. pedaling condition and a 30- min. sitting condition using the FitDesk while performing three randomized tasks: a reading comprehension task, typing task, and an attention/information processing task. Energy expenditure and heart rate were assessed during each trial. Blood pressure was measured prior to the start of each trial and at the end of each trial. The results indicated that there were no significant differences in reading comprehension, typing performance, and attention/information processing tasks between the pedaling and sitting conditions. Heart rate, blood pressure, and energy expenditure significantly increased in the pedaling condition when compared to sitting condition. It was concluded that students could pedal with FitDesk and not influence

work performance while increasing their energy expenditure, which may help with weight loss and reducing sedentary behavior.

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LIST OF ABBREVIATIONS

BSU	Boise State University
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
HR	Heart Rate
HPL	Human Performance Laboratory
KCALS	Kilocalories
PED	Pedaling Condition
SIT	Sitting Condition

CHAPTER ONE: INTRODUCTION

Sedentary Behaviors

Long periods of sedentary behavior are being practiced far too often by individuals.[5] Sedentary behaviors are described as either being 1) physically inactive or 2) as activities that involve sitting, lying down, and using very little energy (≤1.5 Metabolic Equivalent Total [METs]).[5,6]

Evidence suggests that uninterrupted periods of sitting could be harmful to one's health.[1] As much as 57% of a person's waking hours are spent in sedentary behaviors which could be due to one's occupation, type of transportation used to get to and from, and the decline of physically active occupations.[2,3] Healy, et al. examined sitting time in a workplace setting and results indicated that 75% of an 8-hour workday was spent in sedentary activities.[4]

Effect of Sedentary Behaviors on Health

Previous research indicates that the physiology behind sedentary activity effects health independently and differently when compared to the physiology of exercise. Spending large amounts of time sitting has been linked to metabolic syndrome, type 2 diabetes, obesity and cardiovascular disease independent of the amount of physical activity performed.[7] A suggested potential mechanism for this could be related to uninterrupted periods of sitting possibly leading to decreased lipoprotein lipase activity, which is needed for triglyceride uptake and HDL-cholesterol production, and a decrease in glucose uptake.[6]

This phenomenon has been termed the "Active Couch Potato" because even those who meet the daily recommendations for physical activity may still be at risk for lifestyle diseases due to too much time passively sitting.[6] Along these lines, Katzmarzyk and Lee demonstrated that limiting sitting to <3 hours/day and limiting television watching to <2 hours/day may increase life expectancy by 2 years.[8]

College Students' Sedentary Behavior

Decreasing sedentary behavior can be a challenge, especially if one's occupation requires sitting for long periods of time. College students practice large amounts of sedentary behavior during classes that have no physical activity breaks and spending lots of time studying – a generally passive activity. Maher,, et al. showed that college students spent 66.9% of their waking time in sedentary activities.[9] And according to the American College Health Association, only 46% of students' report meeting the recommended amount of daily physical activity of at least 30 minutes of moderate-intensity exercise ≥ 5 days/ week or 20 minutes of vigorous-intensity exercise ≥ 3 days/ week.[10] Lack of time, fatigue, and not having the appropriate facilities are the most common barriers preventing college students from decreasing their sitting time.[11]

Active Workstations

Active workstations, which are workstations that have integrated physical activity (walking or pedaling) have been used in previous studies to decrease sedentary behaviors.[12] Examples include treadmill workstations, pedaling workstations, and sit-to-stand desks. All have been shown to decrease sedentary behaviors in participants.[12]

Koepp, et al[13] examined the use of treadmill workstations verses traditional workstations in office workers and results showed that participants adapted to the treadmill quickly, physical activity increased, and daily sedentary time decreased. Larsen, et al[14] examined the effect of prolonged sitting, combined with taking walk breaks on a treadmill on blood pressure in overweight/obese adults. Results showed that both systolic and diastolic blood pressures were significantly lower by 2-3 mmHg and 2 mmHg respectively.[14] Treadmill workstations, however, may be cost and space prohibitive and pose a barrier for those who are overweight or obese and/or have lower extremity and/or back problems.[15]

An alternative option is using a non-weight bearing active workstation, such as a cycling workstation. Elmer and Martin[15] examined the effects of a cycling workstation and the metabolic cost associated with self-selected pedaling used by recreationally active men in their work settings. Results demonstrated that those using cycling workstations reduced their sedentary behaviors and their risk of metabolic disease while at work, and still accomplished their jobs with no effect on work performance.[15] In addition; the metabolic cost of pedaling was 2.5 times greater when compared to sitting.[15]

Need of the Study

Though previous literature has shown benefits of using active workstations, there is a need for determining how exercising with the FitDesk (Revo Innovations LLC; Antioch, TN), a cycling workstation, effects the metabolic cost while exercising and completing work-related tasks when compared to sitting. Conducting this provides information for universities and colleges as a potential tool to improve student health, in addition to employers looking for methods to reduce sedentary behaviors in workers. It will also provide caloric expenditure of exercise with the FitDesk, which can help those who are sedentary and looking for ways to increase energy expenditure during traditionally passive activities.

Purpose

The purpose of this study was to examine the effect of a cycling workstation, the FitDesk, on blood pressure, heart rate, work performance tasks, and the energy expenditure of college students. Specifically assessing the influence of pedaling on typing speed and error rates, reading comprehension, attention/information processing, systolic and diastolic blood pressures, heart rate, and energy expenditure.

Hypothesis

It was hypothesized that using the FitDesk would not have an effect on college students' reading comprehension, typing speed, and attention/information processing when compared to those sitting. In addition, an acute reduction in blood pressure, increase in heart rate, and increase in energy expenditure would be seen in those using the FitDesk. [16] The first hypothesis was that there would be no effect on reading comprehension when using a cycling workstation. Cho, et al[17] study showed that reading comprehension was not affected by the cycling workstation. The second hypothesis was that there would be no decrease in typing speed when using a cycling workstation when compared to a traditional workstation. It was found that typing speed did not decrease while using a bicycle ergometer.[16] The third hypothesis was that there would be no effect in attention/information processing. John, et al[18], found that there were no significant differences between walking and sitting conditions in the attention/information processing. The fourth hypothesis was that blood pressure would be reduced as this was observed using a cycling workstation. Larsen, et al.[14] found that systolic and diastolic blood pressures were reduced when breaking up prolonged sitting with either 2-minute bouts of light-intensity walking or 2-minute bouts of moderate-intensity walking when compared to uninterrupted sitting. The fifth hypothesis was there would be an increase in heart rate and energy expenditure in the pedaling condition when compared to the sitting due to the body's response to movement.

Significance of the Study

Because of the increasing amounts of sedentary behavior, it is of concern that interventions be used to reduce those behaviors while not effecting work performance. However, there is lack of research in college students using the FitDesk. Observing the metabolic cost associated with self-selected pedaling is of significance along with providing an avenue that reduces sedentary behavior and blood pressure in college students.

CHAPTER TWO: LITERATURE REVIEW

Sedentary Behaviors

It has been stated that people are becoming increasingly sedentary.[19] Two definitions are often used to describe sedentary behavior: physical inactivity or time spent sitting[19]. Researchers have suggested that a consistent definition is needed to describe sedentary behavior and inactivity. In general, sedentary behaviors are activities that involve sitting, gaming, watching television, and/or any other behaviors that produce little movement.[19]

Tremblay, et al[19] discussed sedentary behavior, measures of assessing sedentary behavior, and self-reports of sedentary behavior. It was concluded that the word sedentary should not be used in place of inactivity and vice versa because sedentary behavior has independent effects on health outcomes and physical function, and thus should be treated separate from physical activity.[19]

Sedentary Behaviors Effects on Health

It is important to limit the amount of time spent sitting because long durations of sitting have been linked to metabolic syndrome, type 2 diabetes, obesity and cardiovascular disease.[7] In the past, there has been a focus on the health outcomes of the lack of regular exercise.[20] The rise in sedentary behaviors and their effects on health independent of exercise activity, a new field, inactivity physiology, has been established, separating itself from exercise physiology, which is the molecular and physiological responses to exercise.[21] Ekblom-Bak, et al [21] discussed this theory and concluded the following: 1) too much sitting and too little exercise independently increase disease risk, 2) sedentary behavior is distinct, with effects on health risk separate from leisure-time exercise, 3) the molecular and physiological responses to large amounts of sitting are different than the responses following physical activity, and 4) those who are not physically active will increase their risk even more by practicing large amounts of sitting. The research supporting sedentary behavior's independent effects on health is very small, but consistent and that future research focus should not only be on increasing physical activity, but the risks associated with excessive sitting and decreasing sedentary behavior.[21]

Insulin action has also been examined during periods of limited muscle activity. Stephens, et al[22] examined the effect of sitting on insulin action in relatively fit and non-obese participants. Insulin action was assessed in the morning following three, 24-hr conditions: not sitting, having a balance between sitting and expending energy, and sitting. Results showed that whole body insulin action was 39% lower in the sitting condition and 18% lower in the balanced condition when compared to the no sitting condition. It was concluded that one day of sitting can significantly reduce whole body insulin action.[22]

Hu, et al[23] examined the relationship between sedentary behaviors (including long periods of television viewing) and risks of obesity and type 2 diabetes in women.[23] Participants were women from the Nurses' Health Study from 1992 to 1998. At baseline, participants had a BMI < 30 $kg \cdot m^{-2}$, and were free from disease and diabetes. Results showed that throughout the six years of follow-up, time spent watching television was positively associated with risk of developing obesity and type 2 diabetes mellitus.[23] Every

2-h/day increment of television watching was associated with a 23% increase in obesity and 14% increased risk of diabetes.[23] In contrast, standing or walking at home 2h/day was associated with a 9% decrease in obesity and 12% decrease in diabetes.[23]

Sedentary behavior can also increase the risk of developing cardiovascular disease. Chomistek, et al[24] examined the associations between sitting time and physical activity with the risks of developing cardiovascular disease in women. Participants were part of the Women's Health Initiative Observational Study and provided hours sitting per day and their physical activity at baseline (1993 to 1998) and during a follow up (September 2010). Results showed that those who sat for ≥10h/day had an increased risk for cardiovascular disease when compared to those who sat for ≤ 5h/day.[24] Those with low amounts of physical activity also had a 2% higher risk of developing cardiovascular disease.[24] In addition, the least active who reported sitting for ≥10h/day had the highest risk of developing cardiovascular disease.[24] Similar results were found when examining the risk of coronary heart disease and stroke in the same participants.[24] This study demonstrated that long durations of sitting are associated with a higher risk of developing cardiovascular disease independent of physical activity levels in women.

Clemes, et al[25] examined sedentary behavior during and after work and measured whether participants balanced their time spent sedentary at work with being less sedentary outside of work. Two-hundred-ten office employees participated in this 7-day study and their activity was measured with ActiGraph accelerometers. Results showed that participants spent more time sedentary (68% vs 60%) on workdays and less time in light activity (28% vs 36%) when compared to non-work days.[25] In addition, those who were the most sedentary at work were also the most sedentary outside of work.[25] There were no significant differences between gender and time spent in moderate to vigorous activity during non-working hours.[25] Therefore, those who are extremely sedentary at work, continue to be so outside of work.

Breaking Up Sedentary Behaviors

Healy, et al[2] examined the effects of sedentary behavior on the body and the association of interrupting sedentary behavior. Data included anthropometric measures, an oral glucose tolerance test, a behavioral assessment, and tracking of daily physical activity with an accelerometer. Results showed that during the hours that participants were awake, 57% of their time was spent being sedentary, with moderate-vigorous activity only 4% of the time.[2] Also, those who had more breaks in sedentary activities had a lower waist circumference by 5.95cm and a lower 2-hr plasma glucose by 0.88mmol/L.[2] This study suggests that more breaks in sedentary time benefited the participants by reducing their metabolic risk factors.

Looking further into actual sitting time and the benefits of taking a break from sitting, Bailey, et al[26] examined the effects that uninterrupted sitting, sitting with stand-up breaks, and sitting with walking breaks had on health. Ten participants completed the three 5-hour trials on three separate visits. Results showed that those who walked during their break had a 16.7% lower glucose response over a 5-hr time frame to a test drink when compared to the uninterrupted sitting and sit-to-stand groups. There were no significant differences in glucose response between the uninterrupted sitting group and sit-to-stand group. It was concluded that interrupting sitting with a brief walk can lower glycaemia in adults.

Larsen, et al[14] examined the effect 7 hours of uninterrupted sitting had on resting blood pressure in comparison to sitting with brief bouts of light and moderate intensity physical activity. Nineteen overweight or obese adults were recruited to participate in a randomized, three-condition crossover trial, with one week in between conditions: uninterrupted sitting, sitting with 2-minute bouts of light-intensity walking every 20 minutes, and sitting with 2-minute bouts of moderate-intensity walking every 20 minutes. After 2-hours of sitting, subjects consumed a test meal followed by continuing the conditions over another 5 hours. Resting blood pressure was measured every hour and 5 minutes before each activity bout and postprandial blood glucose and insulin responses were measured following test meal. Results showed that those who interrupted sitting with walking had lower systolic blood pressure by 2-3mmHg when compared to uninterrupted sitting.[27] There were no significant differences between both activity groups. Additionally, those in the uninterrupted group had a 24-29% higher post-meal glucose AUC and a 23% higher insulin AUC when compared to both activity groups.

These results suggest that breaking up periods of prolonged sitting may lower systolic and diastolic blood pressure in overweight/obese adults.

Are College Students Sedentary?

What about those in a college/university setting? Buckworth, et al[28] took a closer look at college students by examining the relationship between physical activity, exercise, and sedentary behaviors in college students enrolled in 10-week conditioning activity classes. They used questionnaires to measure exercise behavior, sedentary activities, and physical activity history. Results showed that students practiced sedentary behaviors almost 30 hours per week. A gender difference was seen in which males had longer duration of exercise than females (61.89 minutes vs 37.21 minutes), while at the same time, males spent more time than females practicing sedentary activities (31.62 minutes vs 28.43 minutes). Though there are limitations with this self-report study, it can be concluded that college students spend a lot of time being sedentary.

Gomez-Lopez, et al[11] examined the potential barriers to being physically active that college students face. Three hundred and twenty-three University of Almeria students participated. Potential barriers were measured with a questionnaire analyzing sports habits and lifestyles. Results showed that external barriers were greater than internal barriers with lack of time, being tired, and lack of access to appropriate facilities, being the most common external barriers. Gender played a role in internal, motivational, differences. In conclusion, universities could use this information to create healthier campuses and promote active lifestyles by encouraging students to break up prolonged sitting.

Common limitations observed when reviewing the literature discussing college students having high amounts of sedentary time were the use of self-reporting. Measuring daily activity levels with use of an accelerometer would provide more reliable results and verify self-reported information. However, using accelerometers may not be the most cost-effective choice, especially when using a large sample size.

Active Workstations

It is important to decrease the amount of time spent sitting, especially for college students. If interventions are not available to help college students, then they will likely develop the habit of large amounts of sitting time which will put them at increased risk for cardiometabolic disease as they age. Active workstations, which are workstations that have integrated physical activity (walking or pedaling), include treadmill workstations, cycling workstations, sit-stand desk, and under the desk cycling, can be used to provide an avenue to combat sedentary behaviors.[12]

Alkhajah, et al[29] studied the sit-stand workstation and its effect on reducing office worker sitting time. Thirty-two office workers (n=18 intervention; n=14 control) were recruited and those in the intervention group had the sit-stand workstation installed. The intervention group was given instructions on how to use the desk, instructions on correct posture, and the importance of postural change throughout the day. Participants wore an activPAL3 activity tracker to measure time spent sitting and standing, and step count while at work and outside of work and were assessed at baseline, with 1-week and 3-month follow-ups. In addition, fasting total cholesterol, HDL cholesterol, triglycerides, and glucose levels were measured at baseline and at the 3-month follow-up. Results showed that those in the intervention group decreased their sitting time at the 1-week assessment by 143 minutes/day at the workplace and maintained those results at 3 months (-137 minutes/day). The intervention group that used the sit-stand workstation improved their HDL cholesterol levels (+0.26, 95% CI 0.10, 0.42 mmol/L; p=0.003) when compared to the control group that used normal workstations. There were no significant differences between groups in fasting total cholesterol, triglycerides, and glucose. It was concluded that the sit-stand workstation can reduce sitting time in office workers and improve health.

Elmer, et al[15] examined the effect of a cycling workstation on energy expenditure while doing a typing task and the accuracy and reliability of the power measurement from the workstation in desk bound office workers. Ten recreationally active college students performed two 10-minute typing trials that involved sitting or pedaling. Energy expenditure was assessed using open circuit spirometry and the station-estimated power output was compared to measure output. Results showed that the energy expenditure when typing while pedaling was 255±14 kcal in comparison to the energy expenditure when typing while sitting, 100±11 kcal throughout the 10-minute trial. There were no differences in typing time (pedaling: 7.7±1.5; sitting: 7.6±1.6 min) and number of errors (pedaling: 3.3±4.6; sitting: 3.8±2.7 errors) between conditions. The power measurement of the workstation overestimated actual work output by 14-138% when compared to actual power ($r=0.998$, $p< 0.01$).[15] It was concluded that cycling workstations can be used without hindering typing performance, but that the inaccuracy of the workstation may mislead users as to how much physical work they are actually doing.

Koepp, et al[13] examined the use of treadmill workstations to help decrease sedentary behavior and increase physical activity. Thirty-six employees used treadmill desks in their office for 1 year. Participants wore an accelerometer to track their daily physical activity and completed surveys to assess work performance. Participants were assessed on their daily physical activity, work performance, body composition, and blood work at baseline and six and 12 months. Results showed that those using the treadmill desk increased physical activity from baseline, 3,353±1,802 activity units/day, to 4,460±2,376 activity units/day at six months, to 4,205±2,238 activity units/day at 12 months. Time spent sedentary also decreased across time (1,020±75 min/day, 929±84 min/day, 978±95 min/day; at baseline, six months, and 12 months respectively).[13] There was a small weight loss from baseline, 86.3 ± 26.5 kg, to 12 months, 85.1 ± 25.6 kg. HDL increased from baseline, 55 ± 20 mg/dl, to 60 ± 23 mg/dl at 12 months. No other significant changes were observed in triglycerides, glucose, and total cholesterol. It was concluded that using a treadmill workstation, decreases sitting time and increases step count.

Schuna, et al[30] also examined the use of a treadmill workstation. Physical activity and sedentary behavior of overweight and obese office workers were assessed via accelerometer before and after a 3-month intervention for 41 participants (n=21 intervention; n=20 control). Results showed that the treadmill group increased daily steps (1622 steps/day) and light physical activity (2.5 km/hour to 2.9 km/hour) when compared to the control group. The treadmill group also reduced sedentary time (-3.6 minutes/hour) when compared to the control group.[30] It was concluded that treadmill workstations can effectively promote a change in physical activity and sedentary behavior amongst overweight and obese office workers.

There are some limitations to be aware of with using active workstations. One limitation is the cost. Active workstations can range anywhere from $29 to well over $1,199. Some employers may not have it in their budget to provide active workstations. Space may be another restriction. Also, there may be those who have physical limitations that prevent them from using an active workstation. Additionally, previous studies mainly focused on treadmill workstations, with little research done on the cycling workstations. Overall, more studies should be done to explore the options that active workstations must offer to decrease the amount of time spent sitting.

Effects of Active Workstations on Performance

Improving health with the use of active workstations is great, but what are the effects on work performance? Employers are unlikely to support their use if productivity falls. John, et al[18] examined the effects of a treadmill workstation on work performance. Attention and processing speed, cognitive function, and fine motor movement were assessed during two visits separated by 2 days for 20 college students with no previous treadmill workstation experience. Results showed that those in the sitting group had better results with typing speed (40.2±9.1 vs. 36.9±10.2), mouse clicking (26.6±3.0 vs. 28.2±2.5s), drag and drop tests (40.3±4.2 vs. 43.9±2.5s), and math reasoning tests (71.4±15.2 vs. 64.3±13.4%). However, there were no significant differences between groups for reading or attention and processing speed. Perhaps the results would have been different if the study had been done if the participants were allowed to become familiar with movement while working.

Contrary to John, et al[18], Bantoft, et al[31] found no effect of working while sitting, standing, and walking on memory, attention, and information processing speed. Participants completed a cognitive assessment battery (estimated intellectual capacity screening, anxiety and depression scale, memory/attention/information processing measures) while using the workstations in sitting, standing, or walking conditions separated by 7 days using both a treadmill workstation and sit-stand workstation.[32] Results showed no change in performance on cognitive tests in relation to work position. It was concluded that altering work position (sit, stand, or walking) produced no change in cognitive function and as a result, students can use active sit-stand and treadmill workstations without having a change in cognitive function while gaining the additional physical health benefits associated with active workstations.

Labonté-LeMoyne, et al[32] also examined the effects of a treadmill workstation on work performance. This study investigated the presence of a positive, short-term delayed effect of memory and attention after using the treadmill workstation. Eighteen college students either sat or walked while reading a text and receiving emails, followed by performing a recall task and completing a self-perceived on-task attention questionnaire. Results showed that those who walked had a short-term increase in memory and attention (memory: 0.75±0.10; attention: 6.33±0.72) when compared to those who sat (memory: 0.70±0.09; attention: 5.50±1.08). It was concluded that there is a delayed effect, which is when the individual has stopped walking, when using a treadmill workstation and that that could be beneficial for workers' work performance.

What about the effect of a cycling workstation on work performance? Cho, et al[17] examined the effect that a desk-compatible recumbent bike workstation would have on reading and typing. Twelve college students with experience in using a mouse and keyboard completed a reading comprehension and typing task while sitting and while cycling across 3 different cycling conditions: low-level (10 watts), high-level (25 watts), and self-selected level, with 2-minute rest periods between conditions. Results showed no effect on reading comprehension while pedaling and that typing was affected at higher watts (no cycling: >52 average words/minute high-level cycling: <46 average words/minute). It can be concluded that using a desk-compatible recumbent bike in a workstation will not influence reading comprehension, but typing may be effected if pedaling at higher workloads.

Straker, et al[3] also observed the effects of walking and cycling workstations on keyboard and mouse performance. Thirty office workers performed 3 different standardized computer tasks (typing test, mouse pointing test, and combined keyboard and mouse task) in 6 workstation conditions (sitting, standing, walking at 1.6km/hour and

3.2 km/hour, and cycling at 5 and 30 watts). Participant performance, perceived performance, and heart rate were measured. Results showed a 6% decrease in actual typing speed and 3% increase in error rate in both walking groups when compared to those in the sitting group. In addition, the cycling group that pedaled at 5 watts had a 3% decrease in actual typing speed and 0.7% increase in error rate when compared to the sitting group. There was no significant effect on typing performance in the cycling group that pedaled at 30 watts. There was a 14% decrease in mouse pointing speed in both walking conditions, a 5% decrease in mouse pointing speed in cycling conditions, and no difference in mouse pointing speed during standing and sitting conditions. Both walking conditions had a 15% decrease in speed in the combined keyboard and mouse task, a 3% decrease in speed in cycling conditions, and no difference in speed in standing and sitting conditions. The slower walking condition and standing workstation yield the same heart rate while the faster walking condition and faster cycling condition yield the same heart rate as well. The values for this variable was not reported. To conclude, there were decrements in performance. However, it could have been due to the speed selected for both walking and cycling conditions. One walking condition in this current study was at 3.2 km/hour and one cycle condition was at a power output of 30 watts. Future research should examine if decrements in performance occur at a relative workload and at the effects of acclimation.

Commissaris, et al[16] started to answer this question via the use of three different active workstations (a treadmill, an elliptical trainer, and a bicycle ergometer at two workload intensities, 25% heart rate reserve and 40% heart rate reserve) compared to a conventional standing workstation. Fifteen adults completed four office tasks (typing, reading, telephone, and mouse clicking) and four attention tests across the five conditions at in one day. Results showed a significant difference in mouse performance (speed) in the different active workstations (walk: p=0.000, elliptical: p=0.04, cycling 25%: 0.027, cycling 40%: 0.025) when compared to those in the sitting condition. A significant difference was also seen in mouse task accuracy in the active workstations (walk: p= 0.001, elliptical: p= 0.029, cycling 25%: 0.038, cycling 40%: p= 0.003). Typing performance was only affected in the walking condition (p= 0.000), while reading was affected in none of the conditions. There was also no effect on cognitive performance in any of the conditions. It was concluded that office tasks were hardly affected when using standing and active workstations. However, the results may have been different if testing was split into two days as opposed to testing one day for several hours or if the participants could become more familiar with each condition.

Being able to maintain work performance is of concern when using an active workstation. There is contradictory research showing no effect or an effect on work performance due to the active workstation. This may be related to differences in mode and intensity.

Another limitation that was observed was the use of participants who did not accurately fit the criteria. If one is testing work performance in office workers, then office workers should be used as participants. Participants who are not office workers and/or are not familiar with the tasks could affect the results of the study. Additionally, the duration of previous studies may have affected outcomes. Testing participants for several hours at a time could have also caused physical and/or mental fatigue and influenced the outcome.

The current study will take into consideration these limitations to prevent any effect on results.

Conclusion

Practicing excessive sedentary behavior can affect the well-being of individuals by putting them at higher risk for metabolic disorders and that decreasing the amount of time sitting, even if it means walking for 2 minutes, can improve one's well-being. College students are at particular risk as they attend class throughout the day and may have jobs that require them to sit for long periods of time. It is in their best interest to combat their sedentary behavior to reduce risk of hypokinetic diseases. Reducing sitting time could be done using active workstations which have been used in office settings to help decrease the amount of time sitting without effecting work performance. This information will be used to help examine the effects of the little-researched FitDesk (a cycle workstation) on task performance (reading, typing, and mouse clicking), blood pressure, heart rate, and energy expenditure for college students.

CHAPTER THREE: METHODS

Participants

Boise State University's Institutional Review Board approved this study and participation was completely voluntary. Participants read and signed an informed consent and completed a brief healthy history questionnaire prior to starting the experimental trials (Appendix C & D). After performing a power analysis that estimated the amount of participants needed, 20 college male and female (age 18 – 64 years) sedentary students were recruited from the Boise State University campus. Participants were limited to those with a height between 147cm-198cm due to the FitDesk manufacturer's guidelines. There were no restrictions on bodyweight. To prevent any false low scores in typing, participants self-reported sufficient experience with a computer keyboard to be a part of this study.

Measures

Non-invasive Physiological Measures

Heart rate was assessed using a Polar Heart Rate Monitor (Polar Electronic Inc., Kempele, Finland) that was worn around the chest. Blood pressure was assessed using an automatic blood pressure monitor (Omron Healthcare Inc., Lake Forest, Illinois). Energy expenditure was measured using open circuit spirometry (True Max 2400, Parvo Medics, Sandy, Utah). Participants wore headgear that contained a non-rebreathing valve that was held in their mouth. Participants were instructed to place the mouthpiece in their mouth with their teeth over small knobs and lips completely over the mouthpiece, creating an airtight seal between the mouthpiece and the lips. A breathing tube was attached to the outlet of the valve and nose clips were placed on the participants' nostrils so that the only air that could go in or out was through the mouthpiece. The headgear was tightened so that it was secured around the participants' head so that it would not move throughout the trials. Calibration was performed via the manufacturer's specifications prior to each session.

Student Performance Measures

Reading Comprehension Task: To measure reading comprehension, participants read a short article and answered five multiple-choice questions (four different choices each). Articles were randomly selected and were taken from a reading comprehension workbook: *Reading for Comprehension Level H*, (Continental Press, Elizabethtown, Pennsylvania) which is written at an 8^{th} grade level. This was chosen because the average U.S. adult reading level is eighth grade.[17] Reading time and number of correct answers were recorded for each passage.

Typing Task: Typingtest.com (TypingMaster Inc., Helsinki, Finland) was used to assess typing speed and accuracy. It has a split screen display, so that the participant can see the text required to be typed at the top and then a blank text box for the text to be typed in at the bottom. Participants were given 3 minutes to type the required passage and once the participant was done typing, accuracy and words per minute (WPM) were displayed.

Attention/Information processing: The Stroop Color and Word Test (Stoelting Co., Wood Dale, IL.) was used to measure attention and information processing speed. This test has three sections composed of 100 items each and participants have 45 seconds to complete as many items as possible per section.[18] The first section requires participants to read the names of colors printed in black ink. The second section has four items represented by four consecutive X symbols printed in red, blue, or green and participants have to identify the color of the print. The last section are names of colors (red, blue, green) printed in a color not represented by the word (i.e. the word red printed in green ink). The number of correct items for each section were recorded.[18]

FitDesk

The FitDesk (Revo Innovations LLC; Antioch, TN) is a cycling workstation providing light physical activity (<3 METs). It is quiet, easy to maneuver, and equipped with a performance meter that displays time on bike, mileage pedaled, speed in meters, and estimated calories. Resistance was sat at 3 out of 8, which was very light for participants.

Procedures

This study involved one visit to the Human Performance Laboratory (HPL), located on Boise State University campus inside of the Norco Building.

Orientation/Informed Consent/Assessments (1.5hrs.)

This study involved one visit to the Human Performance Laboratory (HPL), located on Boise State University campus inside of the Norco Building. Upon arrival at the HPL, participants were provided an orientation to the purpose of the study, protocols, and instruments that would be used throughout the study. During this time and at any time during the study, participants were able to ask any questions that they may have had in regard to the research. Participants were told that they had the option to withdraw from the study at any time without penalty.

Prior to testing, participants were given the opportunity to familiarize themselves with the FitDesk and given directions on how to complete the different work performance tasks. The order of the tests and the interventions were randomized. Participants were then connected to the metabolic cart and heart rate monitor chest strap. A blood pressure cuff was placed on their upper left arm and remained in place throughout the experimental trials. Blood pressure was measured prior to the start of each task and at the end of each task.

In the sitting condition, participants were required to place their feet on the floor while sitting on the FitDesk and complete the randomly ordered reading comprehension, typing, and attention/information processing tasks. When participants finished each task, a 5-minute rest period was provided before starting a new task to ensure that heart rate and energy expenditure were back at resting levels. During this 5-minute rest period, participants were instructed to leave on the facemask that was hooked up to the metabolic cart. In addition, there was a 10-minute rest period between switching conditions. During this 10-minute break, participants were allowed to take off the facemask and get off the FitDesk. The metabolic cart was paused so that no further readings were recorded. Prior to the end of the 10-minute break, participants placed the metabolic facemask back on and were ready to complete the next condition once the 10 minutes were up.

In the pedaling condition, participants pedaled at a self-selected speed and at a resistance set at 3 with the FitDesk. Participants were instructed to begin pedaling at the start of the pedaling condition. Once comfortable, participants completed the same tasks in a newly established random order. Participants were also instructed to continue pedaling during blood pressure measurements and 5-minute rest periods.

Data Analysis

Statistical analysis was performed using IBM SPSS Statistics 24 software (Chicago, Illinois). Descriptive statistics were calculated for all variables: typing speed and number of errors, reading comprehension time to complete and accuracy, attention/information processing score, blood pressure, heart rate, and energy expenditure. Paired-sample t-tests were performed to assess any differences in typing performance (WPM and errors), reading comprehension (time to complete and accuracy), and attention/information processing score between pedaling and sitting conditions. Additional paired-sample t-tests were completed to determine any differences in the change in blood pressure before and after performing a task, heart rate, and energy expenditure between the pedaling and sitting conditions. Because of the many variables and high correlation, a Bonferroni correction was used. A p value less than or equal to 0.017 was considered statistically significant. This was determined by dividing the standard p value 0.05 by 3, in which 3 represents the three performance tasks and also the three physiological measures. A test of order effect was also performed by doing a paired-sample t-test to determine if performance improved due to the order of the task. To perform this test, the order of the tests was used as the factor as opposed to using the treatment conditions. A p value less than or equal to 0.05 was considered statistically significant.

CHAPTER FOUR: RESULTS

Twenty participants (Age: 22.45±5.94yrs; 3M/17F, Height: 166.25±8.453cm, Weight: 71.52±21.51kg) were recruited from Boise State University to determine if using the FitDesk would have an effect on work performance and physiological measures. One participant's energy expenditure (kcals) was excluded from the final data set because of an error with the metabolic cart, preventing an accurate measurement of expended energy. Additionally, a different participant's attention/information processing score was excluded from the final data set due to incorrectly completing the task.

Figures 1 and 2 show that there were no significant differences ($p \leq 0.017$) in the reading comprehension task between sitting and pedaling conditions. Results from the reading time (minutes) were 02:51±02:00 and 02:51±02:17;$t=-0.007$,$p=0.994$ respectively. The number of correct questions in the reading comprehension task between sitting and pedaling conditions were 3.9±1.37 and 4.45±0.83;$t=2.34$,$p=0.03$.

Figure 1. The difference in reading times in sitting condition versus pedaling condition.

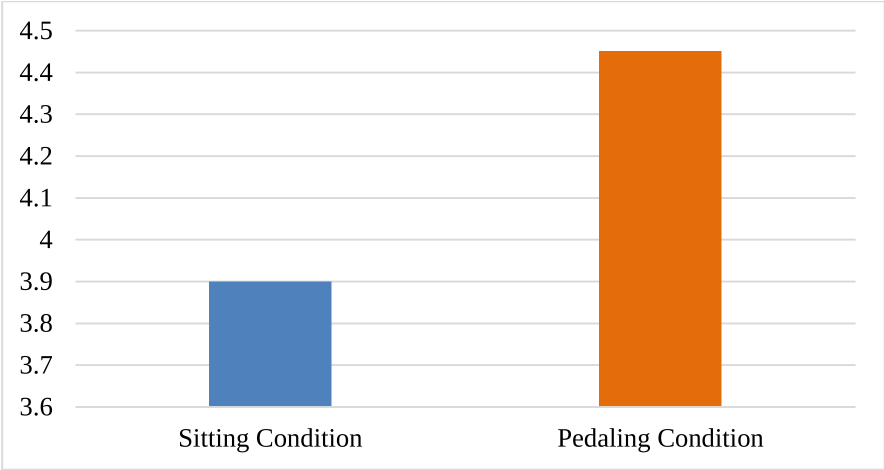

Figure 2. The number of correct questions in the reading task in sitting condition versus pedaling condition.

Typing performance was not significantly different between sitting and pedaling conditions. Figure 3 shows how similar the typing speed was in sitting and pedaling conditions (47.45±17.09 WPM and 46.55±14.54 WPM;t=-1.50,p=0.676, respectively). The number of typing errors was less in the sitting condition, however it was statistically significant (18.55±25.84 and 21.85±29.36;t=1.01,p=0.324).

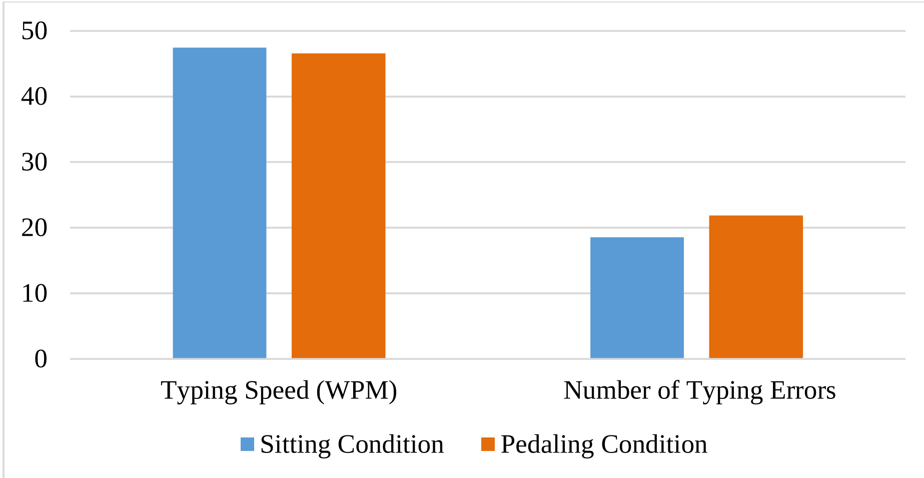

Figure 3. Typing speed in words per minute and the number of typing errors in sitting condition versus pedaling condition.

There also was no significant difference in attention/information processing tasks between sitting and pedaling conditions (Figure 4). Results from attention task 1, attention task 2, and attention task 3 are as follows for sitting and pedaling conditions: 66.45±18.49 and 66.5±12.68;t=0.014,p=0.989, 65.1±17.94 and 66.85±10.50;t=0.594,p=0.56, and 52.25±16.29 and 51.6±12.75;t=-0.219,p=0.829.

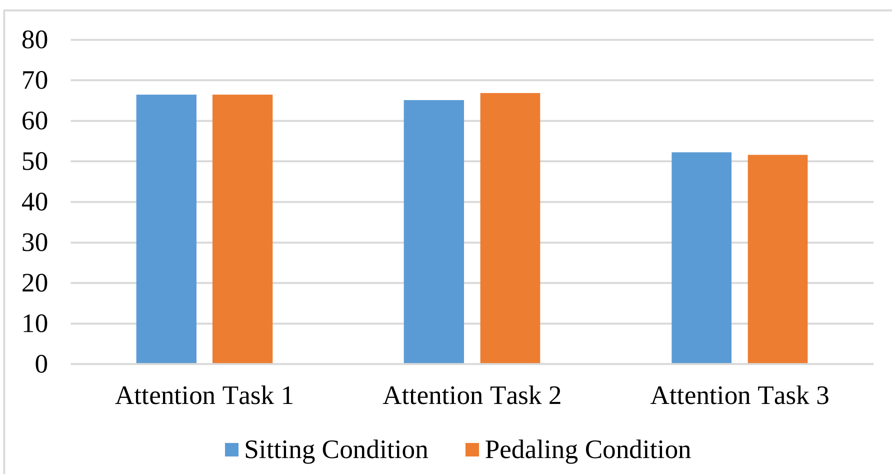

Figure 4. The number of items completed within 45-seconds of each attention task in sitting condition versus pedaling condition.

Energy expenditure for the complete trial in the pedaling condition was significantly greater (p≤0.017), 63.24±17.70 kcals ($\bar{x}$ ±SD), than in the sitting condition, 33.86±12.19 kcals; $t(19)= -12.228$, $p< 0.001$ when resistance was set at 3 and participants were instructed to pedal continuously (Table 1). There were no significant differences in resting heart rates prior to the start of completing the reading comprehension, typing performance, and attention/ information processing tasks between conditions (Table 3). Significant increases were seen when comparing heart rates in the last minute of both reading comprehension (95.06±14.79 bpm and 85.87±10.67 bpm; $t(19)=3.45$, $p=0.003$, pedaling and sitting, respectively) and attention/ information processing (98.01±15.76 bpm and 87.64±12.50 bpm; $t(19)=3.00$, $p=0.007$, pedaling and sitting, respectively) tasks (Table 1).

Table 1. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in energy expenditure and heart rate for the pedaling and sitting conditions on the FitDesk. Significance level was p≤ 0.017

	Mean	**SD**	**Sig. (2-tailed)**
Kilocalories in SIT	33.86	12.189860	p<0.001
Kilocalories in PED	63.24	17.701480	
Reading-HR in SIT	85.87	10.6714	0.003
Reading-HR in PED	95.06	14.7898	
Typing- HR in SIT	84.94	13.4986	0.039
Typing- HR in PED	93.39	17.4893	
Attention-HR in SIT	87.64	12.5036	0.007
Attention-HR in PED	98.01	15.7592	

Diastolic blood pressure significantly decreased before and after completing the reading comprehension task in the sitting condition (82.1±11.192mmHg and 77.1±8.491mmHg, $t(19)=3.517$, $p= 0.002$) (Figure 5). There were no significant differences in systolic blood pressures before and after completing the work performance tasks in the sitting condition (Table 4). Additionally, there were no significant differences in diastolic blood pressures before and after completing the typing performance and attention/ information processing tasks in the sitting condition (Table 4). There were no significant differences in both systolic and diastolic blood pressures before and after completing the work performance tasks in the pedaling condition (Table 5).

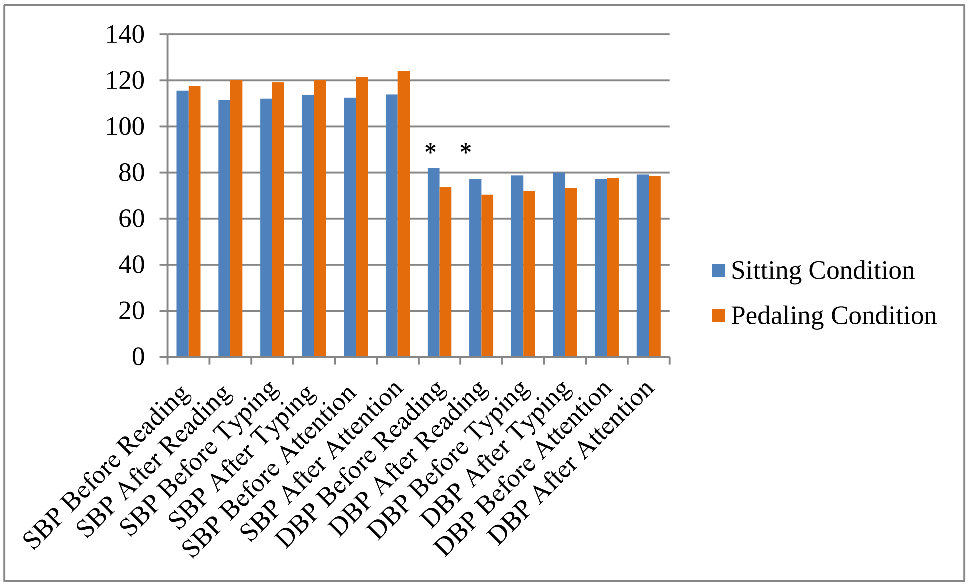

Figure 5. The change in systolic and diastolic blood pressure before and after reading comprehension, typing performance, and attention/ information processing speed tasks in sitting and pedaling condition. The asterisk represents significance in that condition.

Pedaling speed was recorded before the start of each task and at the end of each task as an observational measure. Participants were not required to pedal for a certain amount of time prior to recording their pedaling speed. Participants significantly increased their pedaling speed while completing both typing and attention/information tasks (Figure 6). Pedaling speed before starting typing task was 11.14±2.47 mph and 12.70±3.03 mph upon finishing. Before starting attention task 1, attention task 2, and attention task 3, pedaling speed was 11.83±2.14 mph, 12.37±2.31 mph, and 12.55±2.28

mph collectively. Upon completing attention task 1, 2, and 3, pedaling speed was 13.76±3.39 mph, 13.86±3.38 mph, and 13.75±3.12 mph collectively.

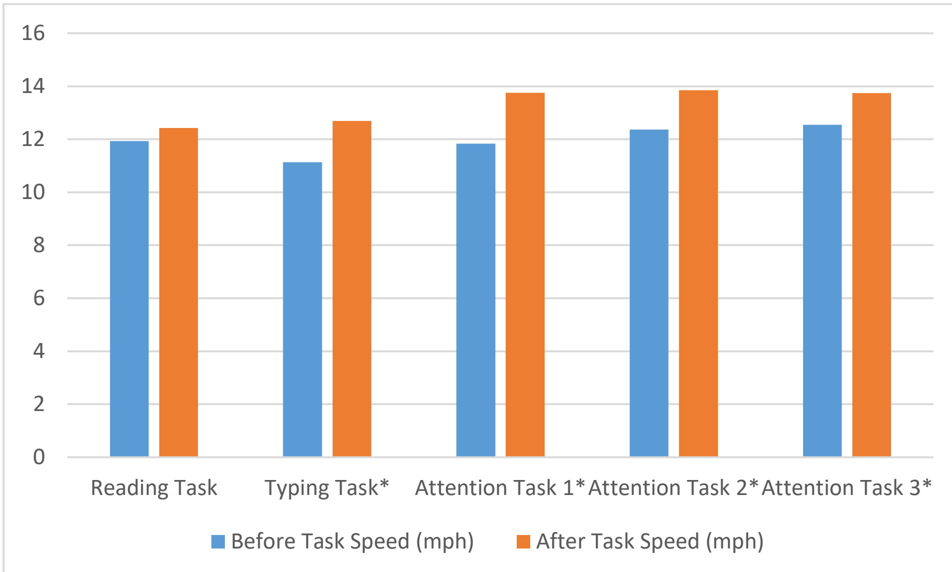

Figure 6. Pedaling speed at the beginning and conclusion of the various tasks completed on the FitDesk. The asterisk represents significance. Significance level was p≤ 0.017

The test of order effect showed there was an order effect in attention task one (60.75±19.63 and 71.2±10.42, t(19)=-3.39, p= 0.003), attention task two (62.6±17.45 and 69.4±10.28, t(19)=-2.67, p= 0.015), and attention task three (47.8±16.35 and 56.05±11.18, t(19)=-3.60, p= 0.002) between trial one and trial two. This test showed that participants performed better in the second trial when compared to the first trial due to the order of the tests.

Table 2 shows results from the survey about the FitDesk with 1= strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, and 5= strongly agree. The post survey showed that participants were indifferent towards the comfort of the FitDesk and that they did not have a preference when asked if they preferred performing the tasks while pedaling or while feet were placed on the ground. Participants agreed that they enjoyed performing the work tasks while pedaling using the FitDesk and that they would use the FitDesk if it were available on campus.

Table 2. Participants' perceptions about pedaling and sitting on the FitDesk.

	Mean	**Std. Deviation**
Comfort of FitDesk	3.45	0.945
Enjoyed pedaling w/ FitDesk	4.25	0.786
Preferred doing tasks while pedaling	3.7	0.979
I would use FitDesk if on campus	4.1	0.641
Where on campus should FitDesk be located?	Student Union Building, Interactive Learning Center, Resident Halls, and Library	

CHAPTER FIVE: DISCUSSION

The purpose of this study was to examine the effects of using the FitDesk on reading comprehension, typing, attention/information processing tasks and physiological measures (energy expenditure, heart rate and blood pressure) in college students during a one-session, randomized crossover study. It was hypothesized that pedaling at a self-selected pace on a resistance set at 3 on the FitDesk would not influence college students' reading comprehension, typing speed, and attention/information processing when compared to sitting uninterrupted at the FitDesk. Additionally, it was hypothesized that an increase in energy expenditure, increase in heart rate, and acute reduction in blood pressure would be seen in those pedaling the FitDesk.

The hypotheses that self-selected pedaling with the FitDesk would not influence college students' reading comprehension, typing speed, and attention/information processing when compared to sitting condition were accepted. Additionally, the hypotheses that an increase in energy expenditure and heart rate in the pedaling condition when compared to the sitting condition were accepted. However, the hypothesis that there would be an acute reduction in blood pressure was rejected.

Major Findings

One major finding was that there was no effect of a self-selected pedaling pace on the FitDesk with resistance set at 3 on reading comprehension in college students. This was similar to the results of a previous study that did not find significant effects on reading comprehension during cycling.[33] Commissaris, et al[16] also examined reading performance during exercise on three dynamic workstations (treadmill, elliptical, and cycling) and a standing condition. The authors also found no statistical different in reading performance.[16] Commissaris, et al[16] asked the participants in the cycling condition to pedal at two different intensities (25% and 40% of participants' heart rate reserve) whereas the current study allowed participants to pedal at their own self-selected speed and not at a percentage of their heart rate reserve.

The results of this study indicated that there were no significant differences of pedaling on typing speed and the number of typing errors. Commissaris, et al[16] examined the effect of cycling on typing performance and showed that typing speed and typing errors were not affected when cycling at 25% and 40% of their heart rate reserve when compared to treadmill walking – which showed a deterioration in typing performance. It was suggested that this was due to the upper body being more stable during seated workstations.[16] Elmer, et al[15] also found no significant differences in typing performance in the pedaling condition when compared to the sitting condition. Thus, typing ability is not affected by using a cycling workstation.

There were no significant differences on attention/information processing during pedaling when compared to the sitting condition. John, et al[18] also did not find any significant differences in Stroop Test results, however, they used a treadmill workstation and not a cycling workstation to compare to their sitting condition. This suggests that one's attention will not be affected by relatively light-intensity physical activity during work/studying. Thus, attention and processing are not affected by using a cycling workstation.

There was significantly higher energy expenditure in the pedaling condition when compared to the sitting condition. Each condition's duration was an average of 24 minutes and the average total kilocalories expended while pedaling was 63.24 kcals across that time when compared to the sitting condition, which expended an average of 33.86 total kcals ($p \leq 0.017$). Because of the amount of kilocalories expended, this activity would be considered a low intensity activity. The kilocalories expended in the sitting condition and pedaling condition were converted into metabolic equivalents (METs) to make it easier to classify this type of activity (equation used can be found in Appendix F). It was found that the average METs used during the sitting condition was 1 and the average METs used in the pedaling condition was 2. Both conditions' METs would be considered as very light activity.[10] This is significant because the additional energy expenditure results in less accumulated sedentary time, which could have long term benefits for one's health. Because it is recommended that individuals perform a minimum of 150 minutes of exercise per week, this additional energy expenditure and lifestyle change could help reduce the risk of developing cardiovascular disease and reduce mortality from these conditions while improving cardiovascular and functional capacities and quality of life.[10,34] A sedentary lifestyle reduces functional capacity that are equivalent to the effects of aging.[34] Also, breaking up sedentary behavior may help improve overall health long-term.[29] However, more research is needed in examining the long-term health outcomes of limiting sedentary behavior.[35]

As expected, heart rate was significantly higher in the pedaling condition in the last minute of completing reading comprehension and attention/ information processing tasks when compared to the sitting condition. When workload is increased, systolic blood pressure is expected to rise and diastolic blood pressure is expected to stay the same or decrease insignificantly in response to dynamic exercise in healthy people.[36] Heart rate increases during physical activity due to the increased cardiac output that is required for the working muscles.[34]

Though a significant reduction was seen in the change in diastolic blood pressure before and after completion of the reading comprehension task in the sitting condition (82.1±11.192mmHg and 77.1±8.491mmHg, $t(19)=3.517$, $p= 0.002$), results showed that there were no significant changes in diastolic blood pressure before and after completion of the reading comprehension task in the pedaling condition. Systolic blood pressure before and after completion of the work performance tasks in both sitting and pedaling conditions were not significantly different. Additionally, there were no significant changes in diastolic blood pressure before and after completion of typing performance and attention/ information processing tasks in both sitting and pedaling conditions. The decrease in diastolic blood pressure is primarily due to the vasodilation of the arteries from the exercise bout.[37]

The current study allowed participants to pedal at a self-selected speed on a resistance setting of three because maintaining a target speed can be difficult and have a negative effect on task performance.[17] In this study, participants' speed significantly increased at the end of performing both typing performance and attention/information processing tasks when compared to their starting speed which was recorded at the beginning of the task. This increase in speed was not seen in the reading comprehension task. This could be because both typing and attention/information processing tasks required the participant to focus more on the task and required the participants to focus on speed and accuracy, thus causing them to similarly increase their pedaling speed as their attentional intensity increased. Eysenck suggested that humans are single-minded and have a unity of purpose or single goal in mind, which provides a contrast with human behavior. [38] It is theorized that because of this single-minded behavior, participants increased their pedaling speed throughout the task due to being focused on completing the task with high accuracy and fast as possible.

Lastly, results from the post survey indicated that participants enjoyed pedaling with the FitDesk and that they would use it if it were available on campus. Participants were neutral about the comfort of the FitDesk and their preference for completing tasks while pedaling. Additionally, when asked where students would like to see this active workstation on Boise State University campus, results showed two common locations that students preferred: Student Union Building and Interactive Learning Center. Both areas have food franchises within them that students frequent, as well as, study areas. These results can provide useful information for the university to help students reduce sedentary behavior.

Limitations

One limitation in the study design was being limited to one exercise intensity. This limited the results to just that intensity as opposed to being able to use multiple exercise intensities. Another limitation was the order effect testing. Though all three tasks were randomized, there was an order effect seen in the attention/information processing task. This could be due to performing both sitting and pedaling conditions on the same day as opposed to completing the conditions on separate days like John et al.[18] had done in their study. Performing both conditions on the same day allowed participants the advantage of becoming better with the requirements of the tasks. Additionally, having a small sample size was a limitation in the study design. Being able to have more participants would have given more data and improved the results of the study.

There were issues with measuring the blood pressure with an automated machine, which may have skewed the blood pressure data that were reported. There were times were the automatic blood pressure monitor may have given an inaccurate reading and/or take several minutes to display a reading. Doing so manually with a stethoscope and sphygmomanometer could have helped improve the accuracy of the measurements. However, because this limitation was not observed until after the start of data collection and on select participants, the automatic blood pressure monitor was continued to be used to prevent skewing the results.

Some participants had a problem with the size of the mouthpiece that was worn to collect expired gasses and determine energy expenditure. The mouthpiece should have had a tight seal when in the participant’s mouth; however, some participants were able to breathe out of the corner of their mouth, therefore skewing the results. This could have caused the results to be lower or higher than it should have been.

Practical Implications

Studying with the FitDesk could help reduce sedentary behavior in college students without influencing work performance. Additionally, being able to expend almost double the number of kilocalories while studying can result in additional daily energy expenditure, independent of being physically active. Additionally, this will help students reduce their risk of metabolic syndrome, type 2 diabetes, obesity and cardiovascular disease because they would be decreasing the amount of time spent sedentary.[7]

Future Directions

Future research could determine the effects of the FitDesk on academic performance (test anxiety/test performance) and retention in college students. Knowing how active workstations affect students' learning ability and performance would be beneficial for universities and institutions to learn as a recruitment tool. It would be interesting to examine how much use an active workstation would be used when it is completely voluntary. In addition, observing the effect the FitDesk would have on test anxiety and if it could be used as a tool to help decrease it. If using the FitDesk during solitary studying would limit the number of distractions and promote greater concentration on homework would be interesting to learn more of when compared to studying at a normal desk. Furthermore, learning the effect of the FitDesk on glucose levels, total cholesterol, and triglycerides would be important to know as a preventative measure for those that may be at risk for developing metabolic disease and dyslipidemia. The university could also use this information by incorporating these active workstations on campus. In addition, the university could observe the use of the FitDesk in classroom settings and determine the effect it has on academic performance and test anxiety. Doing this could help with recruitment, retention, and the student experience.

Conclusions

Practicing sedentary behaviors can be harmful to one's health, regardless of meeting the daily recommended guidelines for physical activity.[1] In addition, most adults do not meet the recommended amount of physical activity.[6] However, using an active workstation may help to prevent sitting for long durations. In agreement with most previous research, the current study found that pedaling with the FitDesk did not influence work performance in college students when compared to sitting uninterrupted. Furthermore, results from the post-survey showed that students are willing to use the FitDesk if available on campus and that they enjoyed pedaling with the FitDesk. Institutions can use this information to help reduce sedentary behaviors by incorporating these active workstations around campus in departmental buildings and in the library.

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APPENDIX A

IRB Approval Protocol

This research was conducted with the approval of the Boise State Institutional Review Board protocol number: 103-MED16-009.

APPENDIX B

Tables

Table 3. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in resting heart rate before completing the tasks between conditions. Significance level was p≤ 0.017. PED=pedaling condition/SIT=sitting condition

	Mean	**SD**	**Sig. (2-tailed)**
Resting HR in Reading Task in SIT	83.05	14.354	
Resting HR in Reading Task in PED	91.7	14.053	0.072
Resting HR in Typing Task in SIT	86.25	11.206	
Resting HR in Typing Task in PED	88.2	16.421	0.656
Resting HR in Attention Task in SIT	82.2	15.793	
Resting HR in Attention Task in PED	90.95	17.473	0.047

Table 4. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in the change in systolic blood pressure and diastolic blood pressure before and after completing work performance tasks in sitting condition. Significance level was p≤ 0.017. SIT=sitting condition

	Mean	SD	Sig. (2-tailed)
SBP Before Reading in SIT	115.6	12.258	
SBP After Reading in SIT	111.55	11.487	0.049
SBP Before Typing in SIT	112.1	12.859	
SBP After Typing in SIT	113.75	11.002	0.329
SBP Before Attention in SIT	112.45	11.464	
SBP After Attention in SIT	113.9	11.457	0.414
DBP Before Reading in SIT	82.1	11.192	
DBP After Reading in SIT	77.1	8.491	0.002
DBP Before Typing in SIT	78.7	7.533	
DBP After Typing in SIT	79.95	10.38	0.307
DBP Before Attention in SIT	77.15	10.184	
DBP After Attention in SIT	79.15	8.041	0.216

Table 5. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in the change in systolic blood pressure and diastolic blood pressure before and after completing work performance tasks in pedaling condition. Significance level was p≤ 0.017. PED=pedaling condition

	Mean	**SD**	**Sig. (2-tailed)**
SBP Before Reading in PED	117.6	10.287	
SBP After Reading in PED	120.3	14.694	0.254
SBP Before Typing in PED	119.2	14.667	
SBP After Typing in PED	120.15	17.279	0.819
SBP Before Attention in PED	121.4	13.2	
SBP After Attention in PED	124.05	18.251	0.508
DBP Before Reading in PED	73.65	13.461	
DBP After Reading in PED	70.35	12.779	0.216
DBP Before Typing in PED	71.95	17.497	
DBP After Typing in PED	73.15	8.61	0.765
DBP Before Attention in PED	77.6	15.892	
DBP After Attention in PED	78.5	15.511	0.788

Table 6. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in work performance between conditions. Significance level was p≤ 0.017. PED=pedaling condition/SIT=sitting condition

	Mean	**SD**	**Sig. (2-tailed)**
Reading Time in SIT (minutes)	02:51.3	02:00.5	0.994
Reading Time in PED (minutes)	02:51.3	02:17.4	
Number of Correct Questions in SIT	3.9	1.373	0.03
Number of Correct Questions in PED	4.45	0.826	
Typing Speed in SIT (WPM)	47.45	17.093	0.676
Typing Speed in PED (WPM)	46.55	14.54	
Number of Typing Errors in SIT	18.55	25.836	0.324
Number of Typing Errors in PED	21.85	29.364	
Attention Task 1 in SIT	66.45	18.486	0.989
Attention Task 1 in PED	66.5	12.676	
Attention Task 2 in SIT	65.1	17.935	0.56
Attention Task 2 in PED	66.85	10.499	
Attention Task 3 in SIT	52.25	16.29	0.829
Attention Task 3 in PED	51.6	12.75	

Table 7. Descriptive statistics and paired-sample t-tests to determine if there was a significant difference in blood pressure for the pedaling and sitting conditions on the FitDesk. Significance level was p≤ 0.017

	Mean	SD	Sig, (2-tailed))
Speed Before Reading Task (mph)	11.935	2.6925384	
Speed After Reading Task (mph)	12.425	2.887883	0.182
Speed Before Typing Task (mph)	11.14	2.4741612	
Speed After Typing Task (mph)	12.695	3.0301077	0.002
Speed Before Attention Task 1 (mph)	11.83	2.1442948	
Speed After Attention Task 1 (mph)	13.755	3.385336	0.001
Speed Before Attention Task 2 (mph)	12.365	2.3074878	
Speed After Attention Task 2(mph)	13.855	3.3808244	0.001
Speed Before Attention Task 3 (mph)	12.545	2.2795371	
Speed After Attention Task 3 (mph)	13.745	3.1223262	0.011

APPENDIX C

Image of FitDesk

FitDesk™

APPENDIX D

Informed Consent

Study Title: Effects of FitDesk on Work Performance in College Students

Principal Investigator: Brittany Price **Co-Investigator:** Dr. Shawn Simonson

Sponsor: N/A

This consent form will give you the information you will need to understand why this research study is being done and why you are being invited to participate. It will also describe what you will need to do to participate as well as any known risks, inconveniences, or discomforts that you may experience while participating. We encourage you to ask questions at any time. If you decide to participate, you will be asked to sign this form and it will be a record of your -

- **PURPOSE AND BACKGROUND**

Previous studies have shown that long periods of sitting have a negative effect on one's health, for example, spending large amounts of time sitting has been linked to metabolic syndrome, type 2 diabetes, obesity and cardiovascular disease regardless of the amount of exercise one gets. Active workstations, which are desks that have integrated treadmills for walking or bicycles for pedaling have been used to help decrease sedentary behaviors. The purpose of this study is to examine the effect of a cycling workstation, the FitDesk, on energy expenditure, blood pressure, heart rate, and work performance of sedentary college students. Specifically assessing the influence of pedaling on typing speed, reading comprehension, attention/information processing, systolic and diastolic blood pressure, heart rate, and metabolic rate.

- **PROCEDURES**

You will be asked to come to the Human Performance Laboratory in the Norco Building for one visit. Before this visit, you should not eat nor consume caffeine 3 hours prior .

Prior to beginning the study, you will be asked to review this informed consent document. In addition to the written details in this document, you will be given a verbal explanation of the study. You will be given ample time to review this informed consent form and to inquire about the study procedures. If you decide to participate you will be required to sign this form.

Before any exercise testing takes place, you will be asked to complete a modified Physical Activity Readiness Questionnaire (PAR-Q). You will then be provided time to become familiar with the tests and equipment used in the study.

During this study your metabolic rate, heart rate, and blood pressure will be monitored while you are completing three different "work tasks" while either sitting or pedaling on the FitBike workstation. The three tasks are reading comprehension, typing, and attention/information processing. Blood pressure will be taken before and after each task. You will wear a heart rate transmitter strap around your chest, below your breast bone and a face mask that is apart of the metabolic cart You will complete 2 randomized conditions, separated by at least 10 minutes. Additionally, each task is separated by 5 minutes. One condition will involve sitting at the FitDesk with feet placed flat on the ground while completing the three tasks. The second condition will involve you pedaling on the FitDesk while performing the three tasks.

The visit will take approximately 1.5 hours to complete.

- **RISKS/DISCOMFORTS**

There are two potential sources of mild discomfort that may occur with participating in this study which include: 1) mild discomfort from pedaling and 2) mild discomfort from the face mask. In addition, the possibility of serious events happening in people who have no previous history of heart, respiratory, or muscular disease is low. The Human Performance Laboratory has a planned emergency response and all testing personnel are CPR certified.

- **BENEFITS**

There will be no direct benefit to you from participating in this study. However, the information that you provide may help researchers gain insights into the benefits of the FitDesk and how it relates to the intensity levels recommended by the American College of Sports Medicine guidelines. This may help universities create spaces for participating in physical activity while studying.

- **EXTENT OF CONFIDENTIALITY**

Reasonable efforts will be made to keep the personal information in your research record private and confidential. Any identifiable information obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by law. The members of the research team and the Boise State University Office of Research Compliance (ORC) may access the data. The ORC monitors research studies to protect the rights and welfare of research participants.

Your name will not be used in any written reports or publications which result from this research. Data will be kept for three years (per federal regulations) after the study is complete and then destroyed.

For this research project, the researchers are requesting demographic information. Due to the make-up of Idaho's population, the combined answers to these questions may make an individual person identifiable. The researchers will make every effort to protect your confidentiality. However, if you are uncomfortable answering any of these questions, you may leave them blank.

- **PAYMENT**
  You will not be paid for your participation in this study.

- **PARTICIPATION IS VOLUNTARY**
  You are free to make a decision to participate in this study, and if you should choose to participate, you may withdraw from the study at any time without penalty. Your decision as to whether or not to participate in this study will have no influence on you present or future status as a student of Boise State University. If you withdraw from the study, your data will be given to you or destroyed.

- **QUESTIONS**
  If you have any questions or concerns at any time during the course of the study or after completion of the study, you may contact the Principal Investigator, Brittany Price: (219) 427-8040, fitdeskresearch@gmail.com or Co-Investigator, Dr. Shawn Simonson (208) 426-3973, shawnsimonson@boisestate.edu.

If you have questions about your rights as a research participant, you may contact the Boise State University Institutional Review Board (IRB), which is concerned with the protection of volunteers in research projects. You may reach the board office between 8:00 AM and 5:00 PM, Monday through Friday, by calling (208) 426-5401 or by writing: Institutional Review Board, Office of Research Compliance, Boise State University, 1910 University Dr., Boise, ID 83725-1138.

DOCUMENTATION OF CONSENT

I have read this form and decided that I will participate in the project described above. Its general purposes, the particulars of involvement and possible risks have been explained to my satisfaction. I understand I can withdraw at any time.

Signature of Study Participant Date

Signature of Person Obtaining Consent Date

APPENDIX E

Health History Questionnaire

NAME: ____ AGE: _______

First Last

DATE OF BIRTH: __________ GENDER: __________

TELEPHONE: ___________________________ E-mail address: ______________________________

Person to contact in case of an emergency: __________________________ Phone # _________________

(relationship) ______________________

Physical Activity Readiness Questionnaire (PAR-Q)

Please read the questions carefully and answer each honestly:

YES **NO**

_____ _____ 1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?

_____ _____ 2. Do you feel pain in your chest when you do physical activity?

_____ _____ 3. In the past month, have you had chest pain when you were not doing physical activity?

_____ _____ 4. Do you lose your balance because of dizziness or do you ever lose consciousness?

_____ _____ 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?

______ ______ 6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

______ ______ 7. Do you know of <u>any other reason</u> why you should not do physical activity?

<u>FOR STAFF USE:</u> ____
____
____
____
______

APPENDIX F

Post Survey

FitDesk Post Evaluation Survey

		S trongly Disagree	D isagree	N either Agree or Disagree	A gree	S trongly Agree
	Question	**1**	**2**	**3**	**4**	**5**
1.	The FitDesk was comfortable.					
2.	I enjoyed performing the work tasks while pedaling using the FitDesk.					
3.	I preferred performing the work performance tasks while pedaling the bike vs. when my feet were on the ground.					
4.	I would use this desk if it were available on campus.					
5.	Where, on campus, would you like to see these FitDesks located (Student Union Building, Library, Interactive Learning Center,, etc.)?					

APPENDIX G

Metabolic Equation