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The rationale for the utilization of under desk bikes in office settings

Danielle Little

James Madison University

The Rationale for the Utilization of Under Desk Bikes in Office Settings

Danielle Little

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FACULTY COMMITTEE:

Committee Chair: A. Laura Dengo, PhD

Committee Members/ Readers:

Jeremey Akers, PhD, RDN

Sarah Carson Sackett, PhD

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Abstract

Inactivity and sedentary behavior are major health concerns, exacerbated by the amount of time individuals spend at work. **Purpose:** To examine if 30-60 minutes of daily under-the-desk bicycle (UDB) use while working for 8 weeks helped sedentary and physically inactive adults reach the U.S. physical activity guidelines (PAG) and improve perceptions of wellness and job satisfaction. **Methods:** Subjects (*n*=22, average age=45.3 yrs, average BMI=30.2 kg/m^2) cycled for 30-60 minutes on workdays for 8-weeks at a self-selected intensity level of 2 or 3 out of 8 total levels. Participants were advised not to engage in additional physical activity outside the study or modify their diet. Pre- and post-measures included self-reported height and weight, a 3-day food record, and the following questionnaires: Physical Activity Vital Signs, Workforce Sitting Questionnaire, Physical Activity Readiness Questionnaire+, Physical Activity Enjoyment Scale, Multidimensional Outcome Expectations for Exercise Scale, adapted-Health and Work Questionnaire, and behavioral beliefs construct. UDB use was reported weekly via the DeskCycle app. Participants were grouped based on HIGH (*n*=11) and LOW (*n*=11) cycling minutes and compliance, determined by the number of weeks cycling $\geq$150min. **Results:** UDB use increased physical activity levels to meet PAG in the HIGH group**.** Perceptions of overall health improved from baseline to post-intervention in both groups. The HIGH group had significant reductions weight (81.7$\pm$5.6 vs 77.9$\pm$5.5 kg) and BMI (29.3$\pm$1.5 vs 27.9$\pm$1.5 kg/m^2) compared to the LOW group [(87.5$\pm$5.8 vs 88.2$\pm$6.2 kg) (31.1$\pm$2.0 vs 31.3$\pm$2.1 kg/m^2)]. Change in aerobic activity was positively associated with compliance percent (p=0.041, r=0.44) and change in BMI with change in daily sedentary time (p=0.045, $r=0.56$). **Conclusion:** Our findings suggest that UDB use is an effective workplace intervention strategy to increase physical activity to meet PAG and aid weight loss in sedentary and inactive employees.

Literature Review

Physical activity is defined by the World Health Organization (WHO) as "any bodily movement produced by skeletal muscles that require energy expenditure" including all movement during leisure time and work (WHO, 2020). There are extensive benefits, both short- and long-term, associated with high levels of physical activity; however, inactivity, sedentary behavior, and their associated adverse health effects are a growing threat to the wellbeing of adults, worldwide. Given this growing prevalence of inactivity and sedentary behavior, there is a need for effective physical activity intervention strategies. This review elaborates on the current physical activity trends in the U.S. and the new role of corporate America in influencing individual health and wellness.

1. Physical activity and Health

Short-term or immediate benefits of physical activity include improved sleep quality, reduced feelings of anxiety, and reduced blood pressure (Center for Disease Control and Prevention [CDC], 2021). Long-term benefits include reduced risk of heart disease, stroke, and diabetes, as well as improved bone and brain health. In addition, regular physical activity may result in improved emotional and mental wellbeing, improved overall health status, and reduced risk for mortality and chronic disease development (Piercy et al., 2018). There is extensive evidence in support of the favorable health outcomes mentioned above and virtually everyone, regardless of age, race, gender, or size, can benefit from increased physical activity.

Perhaps the two biggest benefits associated with regular physical activity are the reduced risk for mortality due to any cause and the reduced risk for chronic disease development. There is ample research investigating the relationship between physical activity and all-cause mortality; specifically, comparing active individuals to sedentary and/or inactive individuals. Individuals with moderate to high levels of physical activity have a lower mortality rate when compared to individuals with sedentary habits and low physical activity levels, living an additional 1-2 years (Paffenbarger et al., 1986). Various activity types and levels contribute to and impact overall mortality risk. When physical activity is done for longer durations and at higher intensities mortality risk was even further reduced in both males and females of all ages (U.S Department of Health and Human Services [HHS], 1996). A systematic review of physical activity and all-cause mortality found a 30-50% risk reduction for cardiovascular-specific mortality in physically active individuals. Additionally, these individuals are at a substantially lower risk for suffering from a major coronary event when compared to their inactive counterparts (Nocon et al., 2008).

The prevalence of chronic disease in the U.S. continues to rise with nearly half of adults having at least one chronic condition and a quarter of U.S. adults having multiple chronic conditions (Boersma et al., 2020). Out of the ten most common chronic conditions, physical activity favorably influences seven of them, and in adults suffering from multiple chronic conditions, physical activity has been effective in symptom management and improving overall health-related quality of life (HRQOL) (Ward & Schiller, 2013). As physical activity and the risk of chronic disease development go hand-in-hand, there is a large burden put on the individual and health care infrastructure.

Individuals suffer from chronic conditions that hinder their HRQOL, while the health care system is tasked with managing chronic disease diagnosis and treatment at overbearing rates. This burden is especially seen in health care costs with adults ages 50 and older spending ~ $860 billion annually on health care (Watson et al., 2016). Similarly, on a national scale, physical inactivity is linked to $117 billion of the Nation's $3.8 trillion in annual health care costs (U.S Department of Health and Human Services, 2018b).

2. Physical Activity Promotion

As a key determinant of health and a modifiable risk factor for chronic disease, physical activity has become a focus of public health initiatives on a local, state, federal, and global scale. Current U.S. physical activity guidelines (PAG) recommend that adults participate in at least 150 minutes of moderate to vigorous physical activity (MVPA) per week in addition to muscle-strengthening activities that involve all major muscle groups on 2 or more days (U.S Department of Health and Human Services, 2018b). The guidelines take a public health approach to physical activity based on results of numerous epidemiological studies showing the health benefits of moderate-intensity activities of daily living. This approach is in contrast to previous guidelines and recommendations that were designed to focus primarily on endurance exercise to enhance performance. Guidelines and recommendations have been adjusted to focus on the functional benefits of participating in regular physical activity to improve health status and quality of life on both an individual and population level. Specific changes were made to include the recommended intensity and duration of physical activity in the total accumulation of physical activity. Previous guidelines stated only MVPA of at least 10-minute bouts could be included in the total; however, new guidelines state that MVPA of *any* duration may be included (Zenko et al., 2019), encouraging adults to move more and sit less throughout the day. In other words, some physical activity is better than none. Adults who sit less throughout the day and do *any* amount of MVPA, even if it does not amount to the recommended 150 minutes per week, gain some health benefits when compared to individuals who are sedentary and inactive (Watson et al., 2016).

Although the benefits of physical activity are well established and there are various public health initiatives and programs to promote physical activity, the prevalence of inactivity continues to rise and many Americans fail to meet the guidelines. Adherence data of the 2018 U.S. PAG in adults ages 18 and over found that only 53.3% met the guidelines for aerobic physical activity and only 23.2% met guidelines for both aerobic and muscle strengthening activity (Zenko et al., 2019).

Physical inactivity is defined as the non-achievement of aerobic PAG; engaging in less than 150 min per week of MVPA (Watson et al., 2016). 2019 data from the CDC reported nearly half (i.e., 48.5%) of U.S. adults were inactive, with 26% engaging in no leisure-time physical activity (Center for Disease Control and Prevention, 2019). The prevalence of inactivity increases significantly with age with 25.4% of adults ages 50-64 years old being inactive, rising to 26.9% among those ages 65-74 years, and 35.3% among those ≥ 75 years (Watson et al., 2016). Inactivity rates were also higher among women than men and Hispanic and non-Hispanic blacks than among non-Hispanic white adults (Watson et al., 2016). Among individuals with a diagnosed chronic disease, inactivity rates were 30% higher when compared to those without (Watson et al., 2016).

3. Barriers to Physical Activity

There are several contributing factors for inactivity in adults such as lack of time, energy, motivation, social support, skill, accessibility, fear of injury, etc. Understanding these specific barriers that negatively impact physical activity levels is helpful for the development of effective intervention and physical activity promotion programs. A systematic review of the barriers and motivators of physical activity participation found that issues of "being busy" and work constraints were the most reported barriers, while the main motivators were fear of becoming ill and the desire to stay independent (Spiteri et al., 2019). An individual's perceived lack of time for physical activity may be attributed to various responsibilities and commitments that take precedence such as childcare or work commitments. Other reasons an individual may not engage in physical activity include physical restrictions (injury or disability), lack of knowledge or low self-efficacy, lack of accessibility, financial issues, and not believing physical activity is necessary to remain healthy (Spiteri et al., 2019).

According to the Bureau of Labor Statistics, on average, an employed adult in the U.S. will spend 7.7 hours each day working, not including travel time (Bureau of Labor Statistics, 2021). The type of work that is being done during those hours spent should also be taken into consideration; specifically thinking about the amount of time spent active versus sedentary while working. Job requirements and the subsequent time spent sedentary vary among individuals; some jobs may require longer hours and the option to work from home, and in addition, individuals may have more than one job. The amount of time an individual spends at work, and the potential for most of it spent sedentary, is a major health threat to working adults.

4. Sedentary Behavior

Sedentary behavior is defined as any waking behavior characterized by an energy expenditure of less than 1.5 metabolic equivalents (METS) while in a sitting, reclining, or lying posture (Tremblay et al., 2017). The terms sedentary and inactive are often used interchangeably as if they are synonyms, but this is not the case. It is important to note that an individual can be classified as both physically active and sedentary – someone that meets the activity guidelines but spends a significant amount of time sedentary. In the last decade specifically, sedentary behavior has emerged as a new health risk factor for obesity, diabetes, all-cause mortality, cardiovascular disease, and cancer (Yang et al., 2019). A study by Yang and colleagues (2019), evaluated sedentary behavior trends of the U.S. population from 2001 to 2016 using data from the National Health and Nutrition Examination Survey. The results of this study revealed that total sitting time in adults increased from 5.5 hours/day to 6.5 hours/day in that 15-year timeframe (Yang et al., 2019). Sedentary behavior was assessed by total time spent sitting and by screen-based sedentary behaviors including watching television or videos and computer use outside of school or work. Sixty-two percent of adults aged 20-64 spent 2 or more hours a day sedentary while watching television or videos (Yang et al., 2019). When looking at sedentary behavior while watching television or videos in all ages, 28%-38% spent 3 or more hours, and 13% - 23% spent at least 4 hours in these activities (Yang et al., 2019). Similarly, 50% of adults spent at least one hour a day using the computer outside of school or work, a 21% increase from 2001 (Yang et al., 2019). When comparing the results by various socioeconomic and lifestyle characteristics, adults with higher socioeconomic status, education level, and/or body mass index (BMI) were most likely to report prolonged sedentary bouts (Yang et al., 2019). The results of this study show the increased prevalence of sedentary behavior among U.S. adults. However, studies that use self-report measures to collect data on sedentary time often result in underestimations; for example, when objective measures were used adults spent an average of 8.2 hours sedentary per day (Bauman et al., 2018). It is important to note that data collection took place prior to COVID-19 and it can be assumed that the restrictive measures of the pandemic only exacerbated sedentary behavior among the U.S. population. Given the lack of consistent, valid, and up-to-date data regarding specific sedentary behaviors, there are no established guidelines or recommendations that consider the potential dose-response relationship between sedentary time and adverse health risks. Although the current PA guidelines say "sit less and move more" there is no specification of how much sedentary behavior is too much. Variations in what sedentary behavior consists of also contribute to this discrepancy – i.e., questions may not ask about the specific sedentary modality such as time spent on a cell phone vs reading a book. In addition, when recording either total sedentary time or time spent engaging in specific sedentary behaviors, individuals may not consider or record their workplace habits, increasing the variation in data. Although a specific dose-response relationship has not yet been identified, research has shown that sedentary behaviors have adverse health effects such as an increased risk of obesity, type-2 diabetes, and cardiovascular disease (Bouchard et al., 2015).

5. Role of the Workplace in Physical Activity Promotion and Reducing Sedentary Behavior

As mentioned earlier, the two primary drivers and subsequent enablers of physical inactivity as reported by U.S. adults are perceived lack of time and work constraints (Spiteri et al., 2019). Given the amount of time adults spend at work, their workplace and work environment become contributing factors to individual perceptions of health and wellness. There are various ways in which a workplace influences an individual such as company values/viewpoints, emphasis on health and wellness, insurance and leave policies, as well as programs and initiatives centered around employee health (Goetzel et al., 1998). Additionally, a company may have an indirect influence on employee health and wellness as seen in the activity level present in the workplace and variations within individual occupations due to differences in job requirements and responsibilities. For example, the job requirements of a kindergarten teacher may result in more time spent active when compared to the job requirements of an administrative assistant who may spend more time sedentary. The 2017 Workplace Health in America survey asked individuals about the extent to which they believed their workplace fostered a “culture of health”, defined as an environment in which “leadership creates a work environment that values and supports employee health and provides healthy work conditions as the normal way of doing business” (National Center for Chronic Disease Prevention, 2018). Survey results showed that overall employees believed their work environments and conditions were generally healthy, but had room for improvement (Linnan et al., 2019). Given that almost half of U.S. adults suffer from at least one chronic condition, fail to meet the PAG, and report lack of time and work constraints as barriers to being active, interventions and health promotion programs should aim to integrate physical activity with convenience and effectiveness in mind (National Center for Chronic Disease Prevention, 2018). For this reason, worksite wellness programs have become an appealing option for aiding sedentary and inactive adults in becoming more active.

Workplace as an Intervention Setting

Workplace wellness interventions attempt to incorporate physical activity and additional components of health and wellness into the everyday lives of employees to create and maintain a healthy workforce. By implementing effective workplace wellness programs and policies, companies help to minimize health risks, improve HRQOL, and reduce the double burden of chronic illness on the individual and healthcare infrastructure.

There are financial, physical, and mental benefits of workplace health interventions that affect individual employees, companies, and the community. Companies and organizations benefit directly from having a healthy workforce through reduced health care expenses such as insurance costs, paid medical leave, and/or absenteeism, as well as through the potential increase in productivity, morale, and job satisfaction as reported by employees (Centers for Disease Control and Prevention, 2021). A comprehensive review of 73 published worksite wellness studies showed an average of $3.50 to $1 savings-to-cost ratio in reduced absenteeism and health care costs for companies that offered worksite wellness programs (Aldana, 2001). The efforts of employers to foster a healthy work environment extend into the surrounding communities as well through bridging the gap between the public and private sectors via partnerships. Companies and their involvement in surrounding communities may foster a stronger culture of health by utilizing public transportation, collaborating on policies regarding health and wellness, and influencing other community members to be more active.

In recent years, there has been an increased focus and research regarding workplace wellness programs. The CDC established the Workplace Health Research Network (WHRN), a program developed to further research the effectiveness of workplace wellness programs and the various factors that influence employee health (Center for Disease Control and Prevention, 2021c). The WHRN surveyed employers in 2017 to collect data describing the state of workplace health promotion programs and practices in the U.S. According to the data, 46% of worksites in the U.S. offered some type of health promotion to employees, ranging from offering brochures on various health topics to providing an onsite gym (Center for Disease Control and Prevention, 2018). Such health promotion programs were most commonly offered in the hospital industry (62.2%) and were least common in the arts, recreation, and food service industries (17.1%) (Center for Disease Control and Prevention, 2018).

Healthy People 2010 included occupational safety in health as a key focus area and included the following five components to a comprehensive workplace health promotion program: health education, supportive social and physical environments, integration of the worksite program into the organization's culture, links between health promotion and related programs like employee assistance, and screenings with follow-up (Davis, 2000). Of the 46% of worksites offering health promotion programs only 11.8% incorporated all five elements of a comprehensive program (Center for Disease Control and Prevention, 2018). Additionally, the comprehensive program existed mostly in organizations that had health promotion programs in place for at least 5 years, an annual budget for health promotion, and an assigned individual responsible for the program (Center for Disease Control and Prevention, 2018).

The National Institute of Occupational Safety and Health (NIOSH, 2017) published Workplace Solutions: Using Total Worker Health Concepts to Reduce the Health Risks from Sedentary Work. NIOSH provided the following recommendations if full health promotion programs were unable to be adopted by employers: allow for several short "movement breaks" throughout the day, hold walking meetings, park farther away from the worksite to increase walking time, and take the stairs instead of the elevator. While effective in temporarily reducing sedentary time, these recommendations are not a long-term solution to the issue of sedentary behavior in the workplace.

Just as adults face barriers to becoming more physically active, companies and organizations face barriers to offering health promotion programs. Reported barriers included cost, lack of employee interest, lack of physical space, and lack of experienced staff and did not vary based on worksite size (Center for Disease Control and Prevention, 2018). Intervention strategies have been designed to minimize the barriers faced by both employers and employees while improving health via reducing sedentary time and increasing physical activity.

6. Active Workstation Intervention Studies

Active workstations minimize the barriers faced by both employers and employees by providing a convenient option to be physically active without adversely impacting work responsibilities. Variations in cost, size, and type of workstation allow employers to best fit the needs of their employees and office space. The various options of workstations and the current literature regarding their effectiveness are detailed below.

Treadmill Desks

The active workstation concept was first introduced in 1989 by Edelso and Danoffz who proposed the use of a treadmill workstation to correct postural fixity in office workers. Edelso and Danoffz concluded that treadmill walking and word processing (typing) could be done at the same time and may yield physiological and psychological benefits without decreasing work performance (Edelson & Danoffz, 1989). The concept of a treadmill workstation has since been adopted and researched as a solution to the adverse health outcomes of sedentary work. Interventions such as the treadmill desk provide employees with an accessible way of reducing sedentary time without impacting work productivity.

In an acute study, Levine and Miller (2007) used a vertical workstation (i.e., treadmill desk) to investigate its effect on energy expenditure and potential weight loss implications in sedentary individuals with obesity. Fifteen sedentary individuals (14 females and 1 male) with BMIs between 30-35 kg/m^2, who did not participate in regular exercise, and were free of chronic disease were recruited to participate in the study. The study was done in one day in which individuals used the treadmill desk at a self-selected speed and were given a prompt to type about while using the treadmill for 1hr. Energy expenditure was measured during 15-35 min of the intervention hour. Energy expenditure was the highest when participants used the treadmill desk in comparison to working while standing or sitting alone, with a mean increase in energy expenditure of 119 kcal/hr when walking at an average pace of 1.1mph (Levine & Miller, 2007). The results of this study introduced active workstations and desk interventions as a potentially effective way to minimize the health issues related to sedentary behavior while providing promising weight loss implications.

Various studies have been done to evaluate the effects of treadmill active workstations on cognitive performance and productivity. In a systematic review, Ojo et al. (2018) examined the effect of active workstations on workplace productivity and performance. Office-based interventions using workstations such as sit-to-stand desks, treadmill desks, or cycling desks that focused on productivity or work performance were included in the review. All studies included were either randomized controlled trials or quasi-experimental studies; however, information on the length of studies reviewed was not given. Ojo and colleagues found limited evidence to suggest that treadmill active workstations decreased work-related productivity evaluated via typing and proofreading performance (Ojo et al., 2018). It is important to note that the limited evidence may be due to the lack of studies focused on treadmill workstations and productivity specifically. Additionally, there was significant evidence to suggest that sit-to-stand workstations did not significantly decrease work performance (Ojo et al., 2018)

In a 12-month randomized control trial, Arguello et al (2021) evaluated the effects of both sit-to-stand and treadmill desks on sedentary behavior in office workers who were overweight. The study cohort consisted of 66 office workers, 59 females and 7 males, between the ages of 18 and 65. Participants had BMIs greater than 25 kg/m^2 and did not participate in any structured physical activity for more than 2 days/wk. Prior to randomization, participants met with a trained researcher for a 30-minute one-on-one session about the benefits of reducing sitting time and increasing daily standing and time spent active. Supervisors received similar training and were provided additional information on the importance of providing verbal encouragement to employees. Both participant counseling and supervisor trainings were repeated in 3-month intervals throughout the 12-month study. Participants were then randomized to either the treadmill, sit-to-stand, or control group and received training on how to use their respective workstation. Once acclimated, study participants in the treadmill desk group were recommended to accumulate at least 2 hrs. of walking and 1 hr. of standing per day, while participants in the sit-to-stand group were given a 3-hr. recommendation. Control participants were encouraged to reach PAG but were given no specific recommendation for activity mode. In addition to workstation use, physical activity was assessed via activPal at baseline and each 3-month interval. The outcome variables of interest were the average total daily hours of wake-time spent sedentary measured via wake-wear data and self-report logs and collected throughout the 12-month study. The results showed that individuals in the treadmill desk group had both shorter and fewer total daily sedentary bouts than the sit-to-stand desk group, with both groups having fewer and shorter than the control (Arguello et al., 2021). Mean total daily sedentary behavior was not significantly different between groups at 3, 6, or 12 months and there were no significant changes when evaluating within-group comparisons (Arguello et al., 2021). Interestingly, increases in mean total daily standing time were observed in both the treadmill and sit-to-stand groups from baseline to 3 months; however, this trend only remained constant in the sit-to-stand group through month 12 (Arguello et al., 2021).

Weight loss implications of using a treadmill desk were investigated in a 1-year prospective study by Koepp et al (2013). Thirty-six office workers (25 women, 11 men) with jobs that required sitting for the majority of the workday participated in the study. These employees had their normal desk replaced with a treadmill desk but were not given any instructions for use. Participants could use the desk however and as often as they wanted. Additionally, the design of the desk allowed it to be easily adjusted for standing treadmill use or seated use. Measurements of daily physical activity, daily sedentary time, body composition, venous blood flow, and workplace performance outcomes were collected at baseline, 6 months, and following the completion of the study (Koepp et al., 2013). Daily activity time was measured via a belt-worn accelerometer 7 days a week throughout the study duration while energy expenditure lying, sitting, and walking was measured using indirect calorimetry (Koepp et al., 2013). Researchers hypothesized that access to a treadmill desk would be associated with increased daily physical activity and decreased daily sedentary time leading to weight loss. In comparison to baseline, subjects showed an increase in daily activity time at both 6 and 12 months while average daily sedentary time also decreased from baseline (i.e., a decrease of 91 min/day at 6 months, and an additional 43 min/day at 12 months; (Koepp et al., 2013). Out of the 36 participants, 22 showed weight loss of 3.4 ± 5.4 kg of fat mass however the weight loss ranged from -9kg to +4kg making it difficult for researchers to draw specific conclusions regarding weight loss associated with the treadmill desk intervention. The results of this study provide further support that active workstations, specifically treadmill desks, can be an effective tool in aiding weight loss.

Sit-to-stand Desks:

While treadmill desks have potential positive health implications for reducing sedentary time and weight loss, a major drawback to implementation is the cost of the equipment, averaging $2,000 per desk (*Best Treadmill Desks of 2022*, 2019) and the office space they require. Standing desk converters and sit-to-stand desks provide a more economically feasible and space-saving option to reduce sedentary time in the workplace.

Weatherson et al (2020) investigated the impact of a low-cost standing desk in reducing workplace sitting in a randomized controlled trial. Sitting time was compared among 48 office workers using either a cardboard standing desk converter or a standard sitting desk over 6 months. Participants were predominately female (n=44), had an average age of 39.8 years, and had an average BMI of 23.49 kg/m^2. Participants were randomized into the intervention or control group, with the intervention group receiving a low-cost cardboard fixed-height standing desk converter to use for the 6-month study duration and individuals in the control group not receiving any additional materials or information on the benefits of reducing sitting time. The primary outcome of interest was time spent sitting at work and prolonged sitting bouts, measured using an activPAL3 activity monitor. Secondary outcomes of work enjoyment and occupational fatigue were measured via surveys. Results showed a decrease in sitting time by an average of 52 min/day in workers using the standing desk when compared to a standard office desk. This decrease was seen at 3 months and maintained at 6 months, although this 3- and the 6-month difference was not statistically significant. Secondary outcome data results found no group-by-time interaction for work enjoyment or occupational fatigue. While low-cost and potentially effective in decreasing sitting time, some desk-converter models are not always feasible as they are not adjustable (making it challenging to accommodate for height differences) and may not be suitable for long-term use (Weatherson et al., 2020). Sit-stand or sit-to-stand workstations provide users the option of working while seated or standing – the workstation can be easily converted for use either way. While slightly more expensive than standing desk converters, sit-to-stand desks can be adjusted to accommodate for height differences, making them more feasible for long-term use.

Results of the Weatherson et al. (2020) study were consistent with the previous findings that sit-stand workstations are effective in reducing sitting time while at work;

however, additional research is needed to evaluate the long-term impact. In addition, while research has found that the use of standing desks is effective in reducing sedentary time while at work, it is unclear whether individuals compensate by increasing sedentary time outside of the workplace.

The Stand More At Work (SMArT) intervention was a multi-component intervention designed to reduce occupational and daily sitting time in the short, medium, and long term (Edwardson et al., 2018). The two-arm, 12-month, randomized control trial consisted of 146 employees at the National Health Service trust in England. Participants were 80% female, were an average age of 41.2 years old, and were desk-based staff who spent the majority of their work day seated (Edwardson et al., 2018). The intervention consisted of organizational, environmental, individual, and group strategies to elicit behavior change, but for the purpose of this review, I will highlight the environmental strategy: the use of a height-adjustable desk in an office setting. Control participants did not receive any additional lifestyle advice or guidance throughout the intervention; however, they were provided with the results of any/all health measures taken throughout the duration of the study. Those in the intervention group (n=77) received a height-adjustable workstation for use throughout the 12-month study up to their discretion. The primary outcome variable of interest was the change in occupational sitting time and was measured via an activPAL accelerometer in both the intervention and control groups at baseline, 3-, 6-, and 12 months (Edwardson et al., 2018). Participants who were assigned to the SMArT intervention had a reduction in occupational sitting time by 72 min/day and daily sitting time by 63 min/day when compared to control participants; these results were consistent at each 3-month interval (Edwardson et al., 2018). In addition, positive changes in observed work-related and psychological health were found among individuals assigned the SMArT intervention. Results of secondary outcome measures such as work engagement, occupational fatigue, job performance, and psychological health implicated improvements among the intervention group when compared to the control with the biggest difference in reported anxiety, consistent at each time point (Edwardson et al., 2018). While the results of this study provide promising data to support the use of standing workstations to reduce both occupational and daily sitting time, as well as improve wellness, the attributable magnitude of impact to standing alone is unclear as there were multiple components to the intervention that may have impacted and influenced behavior (Edwardson et al., 2018).

Cycling workstations:

Just as prolonged sedentary bouts have adverse health implications, prolonged standing may be associated with increased musculoskeletal stress; a concern for older and heavier-weight individuals already under increased musculoskeletal stress. To accommodate for the potential adverse musculoskeletal implications while reducing sedentary time, additional modalities of active workstations may need to be considered.

A newer type of active workstation is the cycling workstation. Cycling workstations allow for a sort of "mindless movement" that emphasizes the notion that any movement is better than none as stated in the current PAG. Specifically, a cycling workstation in the form of under desk bikes (UDB) has gained popularity. Like sit-to-stand and treadmill desks, UDB allows individuals to increase the amount of time spent physically active without impacting productivity. A UDB provides a non-weight bearing alternative to treadmill walking and by emulating the lower-body movement of riding a full-size bike, greater physical activity benefits can be achieved through adjustments to resistance and duration. In addition, UDBs are less expensive in comparison, do not require additional office space, and are more portable than sit-to-stand and treadmill desks. The amount of research and the number of studies using cycling workstations is limited; however, present data provides promising implications for their use in reducing sedentary time and increasing physical activity.

Sliter et al. (2014) designed a study to evaluate the various active workstation options and subsequent ways to evaluate effectiveness. Psychological and performance outcomes, specifically individual well-being, and performance, were evaluated and compared among sitting, standing, walking, and cycling desks in an acute experimental study. Well-being was defined by individual perceptions of arousal, boredom, stress, and task satisfaction and was assessed via questionnaires, checklists, and surveys (Sliter & Yuan, 2014). Performance was evaluated by the number of items correct on a given task. Participants (n=180) were randomly assigned to one of the active workstation conditions (sitting, standing, cycling, or walking) and were given instructions for tasks they were to complete during the 35-minute study session. Tasks differed slightly between workstation types; however, all required navigating a particular website. Results were then scaled and scored by subtracting the total number of items correct from the total number attempted. The main effects on well-being and performance were conducted for each outcome and compared across all conditions. Highlighting cycling workstation data specifically, results show higher arousal and less boredom while utilizing walking and cycling workstations in comparison to seated and standing workstations (Sliter & Yuan, 2014).

However, no significant data was found to support higher satisfaction or lower stress while using a cycling workstation in comparison to sitting, standing, or walking (Sliter & Yuan, 2014). The results of this study provide promising implications for the future of cycling workstations. As cycling workstation options are newer and not yet utilized as much as their alternatives, data to support higher arousal and less boredom while cycling may help publicize them as an effective intervention option.

Elmer & Martin (2014) acutely studied the metabolic costs that are associated with pedaling while performing a standardized typing task and assessed the influence of pedaling on typing performance, both of which were compared to sitting while typing. Study participants consisted of 10 healthy males who spent a "considerable amount of time sitting at a desk each day" and were recreationally active and familiar with cycling exercises (Elmer & Martin, 2014). Participants engaged in two 10-minute trials, seated while typing and pedaling at a comfortable speed. During each trial, physiological responses were recorded. Results showed that while the METS were roughly 2.5 times higher while pedaling, the number of typing errors and time required to complete the typing task did not differ when compared to their seated trial. Similarly, typing while using a cycling workstation elevated metabolic costs by an average of 155 kcal/hr. when compared to typing alone. The mean power output of cycling individuals was 38W and the intensity was described by study participants as "very very light" indicating that the physical demands were not of concern. The data from this study suggest that cycling workstations may be an effective modality for facilitating physical activity without compromising work performance in the short-term (Elmer & Martin, 2014). However, given the small study cohort, acute study duration, and all-male sample, future research is needed. Although this study focused on metabolic outcomes, it is important to note that the cycling workstation used is not portable or suitable for office use due to its size.

Torbeyns et al (2014) conducted a 5-month mixed-method study to investigate the potential for bike desks to reduce sedentary time in an office setting; the objective was to investigate the use of bike desks and subsequent employee experience in an office setting. Eligible participants had a sedentary occupation, defined by spending a minimum of 75% of the workday sedentary, and participated in 2.5 hrs. or less of physical activity per week (Torbeyns et al., 2014). Nineteen office workers (2 male and 17 female), with an average age of 39.9 years volunteered and completed the study. Participants were issued a height adjustable bike desk and were instructed to cycle at their desired intensity for 8 x 25 min per week throughout the 5-month study; these cycling bouts were also allowed to be accumulated 4 x 50 min. The amount of time cycled, intensity, and distance was registered by the bike and participants received an email containing such information every four weeks. Participants completed a questionnaire following the end of the intervention period that contained questions regarding their experience utilizing a bike desk. Questions included positive or negative effects of cycling, effects on motivation and productivity, energy levels, and overall health, as well as how many hours of cycling they believed to be ideal and if they would continue to use the desk given the opportunity. On average participants cycled for 98.1 min/week and covered an average distance of 27.3 km/week. Although an increase in activity via cycling desk use is noteworthy, the qualitative data from the survey results provide perhaps even more encouraging data. Survey results showed that 63% of participants were enthusiastic about the bike as an alternative way of working in the office, 90% would continue cycling given the opportunity, and 68% reported feeling extra motivated because of the cycling intervention. Additionally, 56% perceived increased energy levels throughout the day due to the intervention. No participants reported feeling more fatigued as a result of cycling and 26% of participants reported feeling less fatigue during cycling than during normal office work. Researchers also observed a link between cycling time and overall experience; those who cycled more than the average amount were in general more positive about the cycling experience and reported no negative effect on job performance. The results of this study provide many promising implications for the adoption of cycling workstations in an office setting. Not only did bike desk use help sedentary individuals increase their daily and weekly activity levels, but 68% of participants felt the intervention positively influenced their health and lifestyle, suggesting that these positive effects remain present outside of the office setting. These results also help minimize employer concerns regarding decreased energy levels and worker productivity as well, as the work environment as 63% of participants, reported feeling like the intervention had a positive effect on their relationship with colleagues. Although encouraging results, it is important to note that researchers did observe a significant drop in both cycling time and distance after the first 4-weeks of the intervention; however, both parameters remained stable for the rest of the study duration. This initial decrease followed by a plateau may have been a result of the initial excitement and novelty of the bike desk wearing off and participants no longer being as interested or perhaps an initial adjustment period in which individuals established a new work routine to include cycling. It is unknown whether another decrease in cycling time and distance would occur over time; however, the observed plateau may be indicative of consistent use once adapted. Additionally, while those who cycled more reported experiencing more positive effects, it is not possible to know if these positive effects were a result of longer exposure or if only participants with positive experiences felt motivated to cycle more. It is also unknown whether consistency would diminish given individual spontaneity. Participants were instructed to follow an 8 x 25 min or 4 x 50 min cycling schedule, which may not be realistic usage in a non-intervention setting. In addition, the bike desk utilized in the intervention is one of the larger and more expensive options; while the pedaling action remains consistent across devices, differences in budget, size, and office space availability may limit these findings from being generalized. Other limitations included a small, female-dominant cohort of volunteers and the brief study period of time (Torbeyns et al., 2014).

Carr et al. (2012) examined the feasibility of a portable pedal exercise machine in reducing sedentary time in the workplace in a 4-week experimental study. Eighteen healthy (88% female), full-time employees working in sedentary occupations with an average age of 40.2 years participated in the study. articipants were provided access to a portable pedal exercise machine for 4-weeks while at work. To focus solely on feasibility and acceptability, participants were only provided with access to the machine; no instructions for use, additional resources, or other materials such as information on reducing sedentary time or the benefits of physical activity were provided throughout the study. Pedaling minutes and number of days were recorded from the pedal machine while a feasibility questionnaire was used to evaluate opinions and experiences with the machine. Overall, participants pedaled an average of 23.4 min/day, used the machine more than half of all working days (i.e., 12 of 20), and reported overall positive experiences with the pedal machine (i.e., if offered one by their employer they would utilize it) (Carr et al., 2012). Compliance, defined as the use of the machine, decreased over the 4-week study duration, possibly due to lack of motivation and/or interest given there was no defined behavioral intervention protocol for participants to follow. Limitations include a predominantly female cohort, lack of specific behavioral intervention, and short study duration.

The most recent cycling workstation intervention study was conducted by Guirado et al, (2022), which evaluated the effect of a portable pedaling machine on cardiometabolic risk factors in healthy employees. Eligible participants were full-time employees who reported spending ≥ 75% of their working day seated and engaged in less than 2.5 hrs. (150min) per week of PA. The study participants included 32 females with an average age of 44 years who averaged 37 working hours per week during the 12-week study. Participants were randomized to either the intervention group that received a cycling program or a control group that continued normal working behaviors throughout the intervention period. Participants in the intervention group were instructed to cycle for 60 min/day, either continuously or incrementally, throughout the 12-week study. Cycling was done at a controlled intensity of 2 (out of 8 levels), and time and distance covered were reported daily and weekly via diary entry. Anthropometric and biological measures were collected at baseline and post-intervention as well as daily PA and sedentary time, measured via 7-day ActiGraph. The primary outcome of interest was a change in sedentary time cardiometabolic risk factors, evaluated by the change in total and LDL cholesterol. Study results support the researchers' hypothesis that 60 minutes of cycling per day would decrease sedentary time on weekdays while improving cardiometabolic health outcomes. Those in the intervention group showed significant reductions in sedentary time, paired with significant increases in light and moderate physical activity. Additionally, these changes were associated with improvements in the cardiometabolic risk factors of interest, total cholesterol and LDL cholesterol. The results of this study provide further support for the use of cycling workstations to reduce sedentary time while suggesting positive implications for use in improving cardiometabolic risk factors.

Purpose

The use of active workstations has proven to be an effective modality to counter sedentary behavior and physical inactivity while mitigating the barriers to being physically active faced by U.S. adults. Currently, there is no standard protocol for evaluating the effectiveness of a cycling workstation in an office setting. As discussed in the above studies, various components may be used to evaluate effectiveness such as cycling time and resistance, frequency of use, impact on total physical activity (such as compensatory behavior adoption), perceptions of work-related health, psychological impact, etc.; however, there is no defining factor or standard. Without such parameters, the current literature regarding cycling workstations is lacking not only in amount but in clarity and consistency. Current research focuses primarily on the cognitive work-related implications of cycling workstations, such as productivity and performance measures, and fails to include implications of use on overall health and wellness. Additionally, interventions framed around using cycling workstations to reduce sedentary time as opposed to increased physical activity may indirectly discourage participation. Reframing the study approach as an opportunity to increase physical activity while at work may yield more positive results and remove the perceived "time barrier" to physical activity adoption.

Of specific interest to the present study, there is a limited number of studies aimed at evaluating the effectiveness of cycling workstations, specifically UDB, in changing PA levels and perceptions of health and wellness in sedentary and inactive individuals. Thus, the primary aim of our study is to investigate the impact of using a portable UDB for 8-weeks on physical activity levels in relation to national guidelines and changes in individual perceptions of health and wellness. Additional research is needed to investigate the effectiveness of a cycling workstation, specifically a portable UDB, in an office setting to increase PA, and subsequently influence perceptions of overall health and wellness in sedentary and inactive employees.

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Research Question, Hypothesis and Objectives

Research question: Does incorporating 30-60 minutes of daily under-the-desk cycling while working for 8 weeks help sedentary and physically inactive adults reach the U.S. physical activity guidelines and improve perceptions of wellness and job satisfaction?

Hypothesis: University employees who participate in 30-60 minutes of daily under-the-desk cycling over 8 weeks will have improved perceptions of wellness and job satisfaction and reach the weekly U.S. Physical Activity Guidelines.

Study Objectives:

1. To examine if sedentary and physically inactive university employees reach U.S. Physical Activity Guidelines by incorporating the use of an under-the-desk bike at their workstation for 8 weeks.
2. To examine if increasing physical activity by using under-the-desk bikes while working improves perceptions of health, wellness, productivity, and energy levels at work during the 8-week intervention period.

Materials and Methods

Subjects. Subjects are full-time university employees, recruited via bulk institutional email to all faculty and staff, with at least half of daily work duties taking place while sitting in an office ($\geq$ 4 hrs./day), not meeting the aerobic U.S. PAG of 150 min/week (U.S Department of Health and Human Services, 2018a), and free of overt disease that would interfere with physical activity. Screening tools, described below, included the Physical Activity Vital Signs (PAVS) (American College of Sports Medicine, 2021), Workforce Sitting Questionnaire (WSQ)(Chau et al., 2011), and the Physical Activity Readiness Questionnaire (PARQ+)(Warburton, 2011). The James Madison University Institutional Review Board approved the protocol (IRB 20-1711) and informed consent was obtained before starting participation.

Intervention. This is an 8-week quasi-experimental study to explore the impact of UDB use while working. Participants will be issued a DeskCycle2 UDB and instructed to cycle between 30-60 min/workday, at a resistance level of 2 or 3 out of the 8 levels which would allow them to complete work activities while cycling. UDB use will be reported weekly via email and monitored using the DeskCycle app and Bluetooth sensor which records time, steps, miles walked, and miles biked. An additional hard-copy log will be made available for participants to record daily UDB use. An adapted version of the Health and Work Questionnaire (Adapted-HWQ) (Shikiar et al., 2001) will be completed weekly to monitor workplace productivity and satisfaction concerning worker health. Participants will be asked not to engage in any additional exercise outside the study nor alter their diet during the intervention period. Figure 1 illustrates the study design and provides details on the recruitment and retention of participants.

Measurements.

Screeners: The screening surveys below will be used to determine eligibility to participate in the study.

PAVS (American College of Sports Medicine, 2021). The PAVS questionnaire measures the total minutes of physical activity engaged in per week as well as the number of days spent performing muscle-strengthening exercises. Individuals that reported totals < 150 min per week of physical activity are eligible to participate.

WSQ (Chau et al., 2011). The WSQ estimated both total, and domain-specific, time spent sitting based on workdays and one non-workday during the prior 7 days. Individuals that report significant time spent sitting (4+ hrs.) on a working day are eligible to participate.

PARQ+(Warburton, 2011). The PARQ+ will be used to screen for adverse medical conditions and assess the safety of engaging in physical activity for potential participants. Individuals with medical conditions that may put them at risk will be instructed to contact their primary care doctor before continuing.

Baseline & Post-Testing: All tools used to collect pre- and post-testing data will be entered into QuestionPro software (Survey Analytics, LLC, Austin, TX) so that participants can complete the measures online.

Demographics. Participants will self-report gender, age (years), weight (kg), and height (ft).

Adapted-HWQ (Shikiar et al., 2004). The HWQ uses 24 items to assess workplace productivity in relation to the worker's health as assessed by several domains related to the work environment and personal life. We will use item numbers 1, 3, 6, 12a, 13a, 14a, 20, 21, 22, and 24 to measure participants' perceptions of productivity, satisfaction, and overall health. In addition to its completion during pre- and post-intervention, participants will complete the adapted-HWQ weekly throughout the duration of the intervention.

Multidimensional Outcome Expectations for Exercise Scale (MOEES)(Wójcicki et al., 2009)**.** The MOEES scale assesses how valuable an individual views the outcomes resulting from participating in exercise. MOEES scores will be collected pre- and post-intervention to measure the perceived value and effectiveness of using a UDB to achieve desired health outcomes.

Physical Activity. The Physical Activity Enjoyment Scale (PACES)(Motl et al., 2001). PACES will be used to evaluate the impact of UDB use on the enjoyment of being physically active. ***The Behavioral Beliefs Construct*** questions from Proenca et al. 2018 will be used to assess an individual's beliefs about physical activity, sitting, and UDB use. ***Weekly UDB use*** will be reported via email by sharing the output from the DeskCycle app in conjunction with the Bluetooth sensor. ***PAVS*** was initially used for recruitment purposes but will also utilized for post-testing.

Sedentary behavior. The WSQ, described above, will be used to screen potential participants, and will also be collected post-intervention.

Dietary Intake: Dietary intake will be collected and analyzed using the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool, version 2020 developed by the National Cancer Institute, Bethesda, MD. Participants will be asked to complete 3-day food records, two weekdays and one weekend day, within the first two weeks of the intervention and during week eight.

Post-Cycling Questionnaire: A post-intervention questionnaire will be used to assess participants' overall experience, positive and/or negative impacts, as well as barriers to participation. This questionnaire included Likert scale items and open-ended items.

Statistical Analysis

Statistical analysis was performed using SPSS Software version 27 IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The Shapiro-Wilk test will be used to assess normality. Pooled analysis will include all study participants with complete baseline and post-data. For analysis purposes, participants will be divided into two equal size groups according to a high/low split based on minutes cycled per week and intervention compliance. Descriptive data will be expressed as means with standard errors and frequencies. Independent samples T-Test will be used to test for differences between means at the same time point. Repeated measures ANOVA with 1-within and 1-between subjects factors will be done to explore differences in variables of interest as a result of the UDB intervention. Bivariate correlations will be run to assess the relationship between study parameters. Values of $P < 0.05$ will be considered statistically significant.

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Abstract

Inactivity and sedentary behavior are major health concerns, exacerbated by the amount of time individuals spend at work. **Purpose:** To examine if 30-60 minutes of daily under-the-desk bicycle (UDB) use cycling while working for 8 weeks helped sedentary and physically inactive adults reach the US physical activity guidelines (PAG) and improve perceptions of wellness and job satisfaction. **Methods:** Subjects (n=22, average age= 45.3 yrs, average BMI: 30.2 kg/m^2) cycled for 30-60 minutes on workdays for 8-weeks at a self-selected intensity level of 2 or 3 out of 8 total levels. Participants were advised not to engage in additional physical activity outside the study or modify their diet. Pre- and post- measures included self-reported height and weight, a 3-day food record, and the questionnaires: Physical Activity Vital Signs, Workforce Sitting Questionnaire, Physical Activity Readiness Questionnaire+, Physical Activity Enjoyment Scale, Multidimensional Outcome Expectations for Exercise Scale, adapted Health and Work Questionnaire, and behavioral beliefs construct. UDB use was reported weekly via the DeskCycle app. Participants were grouped based on HIGH (n=11) and LOW (n=11) cycling minutes and compliance, determined by the number of weeks cycling $\geq$150min. **Results:** UDB use increased physical activity levels to meet PAG in the HIGH group. Perceptions of overall health improved from baseline to post-intervention in both groups. The HIGH group had significant reductions in weight (81.7 $\pm$ 5.6 vs 77.9 $\pm$ 5.5 kg) and BMI (29.3 $\pm$ 1.5 vs 27.9 $\pm$ 1.5 kg/m^2) compared to the LOW group [(87.5 $\pm$ 5.8 vs 88.2 $\pm$ 6.2 kg) (31.1 $\pm$ 2.0 vs 31.3 $\pm$ 2.1 kg/m^2)]. Change in aerobic activity was positively associated with compliance percent (p=0.041, r=0.44) and change in BMI with change in daily sedentary time (*p*=0.045, *r=0.56*)). **Conclusion:** Our findings suggest that UDB use is an effective workplace intervention strategy to increase physical activity to meet PAG and aid weight loss in sedentary and inactive employees.

Introduction

Physical activity is a key determinant of health with benefits ranging from short term improvements in mood, to reduced risk for chronic disease development and all-cause mortality (Piercy et al., 2018). Individual physical activity participation is highly predicted by motives and barriers; with lack of time and work constraints being the two most reported barriers faced by U.S. adults (Spiteri et al., 2019). Prevalence of inactivity and sedentary behavior is increasing, with over half of adults failing to meet recommended levels of physical activity and suffering from at least one chronic condition (Boersma et al., 2020). In the last decade specifically, sedentary behavior has emerged as a new health risk factor for obesity, diabetes, all-cause mortality, cardiovascular disease, and cancer (Yang et al., 2019). Given the high prevalence of inactivity and the adverse health effects of sedentary behavior, there is a need for physical activity promotion interventions that address the main barriers for behavior modification related to active lifestyles.

Currently, US adults spend an average of 7.7 hours per day at work, and it can be assumed that a large amount of this time may potentially be spent sedentary (Bureau of Labor Statistics, 2021). By eliminating perceived time and work barriers, workplace health interventions aim to minimize the adverse effects of sedentary work while subsequently increasing physical activity levels. Active workstations provide a feasible option to include physical activity in office settings and accommodate for individual needs as there are variations in size, cost, and type.

Cycling workstations, specifically under desk bikes (UDB) are a newer type of active workstation. Current research shows the effectiveness of UDB use at work in reducing sedentary behavior and increasing physical activity while having no adverse impact on work performance (Torbeyns et al., 2014) (Guirado et al., 2022). However, given the novelty of UDB, the data regarding their effectiveness varies in consistency and validity. Additional studies are needed to explore the effectiveness of workplace UDB interventions in a non-acute manner to increase physical activity, reduce sedentary time, and influence individual perceptions of health and wellness. Hence, the aim of the present study was to evaluate the effectiveness of an 8-week quasi-experimental UDB intervention on reaching recommended levels of physical activity and improving perceptions of wellness in sedentary and inactive university employees. We hypothesized that 30-60 min of UDB cycling per working day over 8-weeks will result in meeting the 2018 U.S. PAG and improve perceptions of wellness and job satisfaction.

Materials and Methods

Subjects. Subjects were full-time university employees, recruited via a bulk institutional email to all faculty and staff, with at least half of daily work duties taking place while sitting in an office ($\geq$ 4 hrs./day), not meeting the U.S. PAG of 150 min/week aerobic activity (U.S Department of Health and Human Services, 2018), and free from overt disease or physical conditions that would interfere with physical activity. Screening tools, described below, included the Physical Activity Vital Signs (PAVS; (American College of Sports Medicine, 2021), Workforce Sitting Questionnaire (WSQ; (Chau et al., 2011), and the Physical Activity Readiness Questionnaire (PARQ+; (Warburton, 2011). The James Madison University Institutional Review Board approved the study protocol (IRB 20-1711) and informed consent was obtained before starting participation.

Intervention. Subjects participated in an 8-week quasi-experimental study promoting the use of a UDB while working. Participants were issued a DeskCycle2 UDB (Tysons, VA) and instructed to cycle between 30-60 min/workday at a resistance level of 2 or 3 out of the 8 levels, which would allow them to complete work activities while cycling. Per the manufacturer website, DeskCycle use at a resistance level of 3 "doubles energy expenditure (in comparison to sitting still) without working up a sweat" (3D Innovations LLC, 2018). Additionally, cycling could be completed in a single continuous bout, or accumulated incrementally throughout the day. UDB use was reported weekly via email and monitored using the DeskCycle app and Bluetooth sensor which record time, steps, miles walked, and miles biked. To ensure technological issues would not impact data collection an additional hard-copy log was made available for participants to record daily UDB use. An adapted version of the Health and Work Questionnaire (Adapted-HWQ; (Shikiar et al., 2001) was completed weekly to monitor workplace productivity and satisfaction concerning worker health. Participants were advised not to engage in any additional exercise outside the study nor alter their diet during the intervention period. Figure 1 illustrates the study design and provides details on the recruitment and retention of participants.

Measurements.

Screeners: The screening surveys below were used to determine eligibility to participate in the study.

PAVS (American College of Sports Medicine, 2021). The PAVS questionnaire measures the total minutes of physical activity engaged in per week as well as the number of days spent performing muscle-strengthening exercises. Individuals who reported totals of < 150 min per week of physical activity were eligible to participate.

WSQ (Chau et al., 2011). The WSQ estimated both total and domain-specific time spent sitting based on workdays and one non-workday during the prior 7 days. Individuals who reported significant time spent sitting (4+ hrs.) on a singular working day were eligible to participate.

PARQ+(Warburton, 2011). The PARQ+ was used to screen for adverse medical conditions and assess the safety of engaging in physical activity for potential participants. Individuals with medical conditions that may put them at risk were instructed to contact their primary care doctor before continuing. The PARQ+ was completed at baseline only.

Baseline & Post-Testing: All tools used to collect pre- and post-testing data were entered into QuestionPro software (Survey Analytics, LLC, Austin, TX) so that participants could complete the measures online.

Demographics. Participants self-reported gender, age (years), weight (kg), and height (ft).

Adapted-HWQ (Shikiar et al., 2004). The HWQ uses 24 items to assess workplace productivity in relation to one's health as assessed by several domains of the work environment and personal life. We used item numbers 1, 3, 6, 12a, 13a, 14a, 20, 21, 22, and 24 to measure participants' perceptions of productivity, satisfaction, and overall health. In addition to its completion during pre- and post-intervention, participants completed the adapted-HWQ weekly throughout the duration of the intervention.

Multidimensional Outcome Expectations for Exercise Scale (MOEES)(Wójcicki et al., 2009)**.** The MOEES scale assesses how valuable an individual views the outcomes resulting from participating in exercise. MOEES scores were collected pre- and post-intervention to measure the perceived value and effectiveness of using a UDB to achieve desired health outcomes.

Physical Activity. The Physical Activity Enjoyment Scale (PACES)(Motl et al., 2001). PACES was used to evaluate the impact of UDB use on the enjoyment of being physically active. **The *Behavioral Beliefs Construct*** questions from Proenca et al. 2018 were used to assess an individual's beliefs about physical activity, sitting, and UDB use. ***Weekly UDB use*** was reported via email by sharing the output from the DeskCycle app in conjunction with the Bluetooth sensor. **PAVS** was initially used for recruitment purposes but was also utilized for post-testing.

Sedentary behavior. The WSQ, described above, was used to screen potential participants and was collected post-intervention.

Dietary Intake: Dietary intake was collected and analyzed using the Automated Self-Administered 24-hour (ASA24) Dietary Assessment Tool (v.2020) developed by the National Cancer Institute. Participants were instructed to complete a 3-day food record, two weekdays and one weekend day, within the first two weeks of the intervention and during week eight.

Post-Cycling Questionnaire: A post-intervention questionnaire was used to assess participants' overall experience, positive and/or negative impacts, as well as barriers to participation. This questionnaire included Likert scale items and open-ended items.

Statistical Analysis

Statistical analyses were performed using SPSS Software version 27 IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The Shapiro-Wilk test was used to assess normality. The pooled analysis includes the 22 participants with complete baseline and post-data. For analysis purposes, participants were divided into two equal size groups (n=11) according to a high/low split based on minutes cycled per week and intervention compliance. Descriptive data are expressed as means with standard errors and frequencies. Independent samples t-tests were used to test for differences between means at the same time point. Repeated measures ANOVAs with 1-within and 1-between subject factors explored differences in variables of interest as a result of the UDB intervention. Bivariate correlations were run to assess the relationship between study parameters. Values of $P < 0.05$ were considered statistically significant.

Results

A total of 34 participants started the UDB intervention, of which 26 submitted cycling logs for the 8-week intervention (n=8 dropouts) but only 22 completed all baseline and post measures. Reasons for dropout included sickness/Covid-19 (n=2), injury not related to the cycling intervention (n=1), office/desk set-up (n=3), and lack of/insufficient UDB use (n=2). Results are presented for the 22 individuals with complete data and were grouped according to a high/low split for cycled minutes per week and intervention compliance. All participants were instructed to cycle between 30 and 60 minutes each workday for 8 weeks, hence intervention compliance refers to the number of weeks that participants cycled for at least 150 min. The average compliance difference for both groups was about 50%, and there was a significant difference (independent samples t-tests) in the total minutes cycled throughout the 8 weeks as well as in the average cycling steps/week between groups (all $p<0.01$, Table 1). The high minutes/high compliance (HIGH) group reported enjoying cycling more and had higher average cycling minutes each week compared to the low minutes/low compliance (LOW) group (Figure 3). Sedentary hours while working and total sedentary hours/day, taking into account workdays and non-workdays, decreased for both groups but was not statistically significant.

After 8-weeks of UDB use, the HIGH group had significant reductions in weight (81.7 $\pm$ 5.6 vs 77.9 $\pm$ 5.5 kg) and BMI (29.3 $\pm$ 1.5 vs 27.9 $\pm$ 1.5 kg/m^2), however this was not the case for the LOW group's weight (87.5 $\pm$ 5.8 vs 88.2 $\pm$ 6.2 kg) or BMI (31.1 $\pm$ 2.0 vs 31.3 $\pm$ 2.1 kg/m^2) (repeated measures ANOVA). Pearson bivariate correlations also found change in weight was inversely associated with compliance percent ($p<0.01$; Figure 3A) and with weekly average cycling minutes ($p=0.03$; Figure 3B), while change in BMI was positively associated with change in daily sedentary time ($p=0.045$; Figure 3D). At the conclusion of the intervention there was a significant time effect for increased weekly aerobic activity ($p<0.05$) as found by repeated measures ANOVA analysis. The change in aerobic activity/week was positively associated with compliance percent ($p=0.041$; Figure 3C). Table 2 presents the dietary intake data at baseline and post for both groups. There was a time effect for energy, as well as grams of protein and fat, but no time by group interaction.

General perceptions of health and wellness while using the UDB are included in Table 3. Perceptions of overall health improved from baseline to post-intervention in both groups, with the majority in each group describing their health post-intervention as "good" or "very good". While all subjects "agreed" or "strongly agreed" that sitting all day at work is not healthy, the HIGH group had a higher percent of individuals believe that sitting all day contributes to unhealthy weight gain (54.5%) than the LOW group (9.1%). At baseline and post-intervention, both groups agreed that light activity during the workday is better than sitting and that benefits from being physically active are not contingent upon exercising to a sweat. Individuals in the LOW group believed completion of usual work tasks was impacted by UDB use and were less likely to continue cycling given the option. In contrast, the HIGH group agreed that usual work tasks could be completed while using the UDB, with more individuals reporting being "very likely" to continue cycling (63.6%) than in the LOW group (18.2%).

Adapted-HWQ data was collected weekly as a secondary outcome measure. The selected HWQ questions assessed the following variables while at work: work efficiency, quality, and amount; job satisfaction, concentration, and personal reward from work. In addition, frequency of boredom, restlessness, and exhaustion were assessed. There were no repeated measures time x group interactions for any of these characteristics.

Qualitative and quantitative data were collected using a post-cycling questionnaire that included questions regarding UDB use: positive/negative influences of cycling, ideal amount of cycling (min/days), level of enjoyment, perceived barriers to cycling, and whether or not one would continue to use the UDB given the opportunity. Answers were not stratified by group. Discomfort was a commonly reported barrier among participants; participants reported feeling socially uncomfortable cycling during meetings, in front of others (i.e., coworkers), and physically uncomfortable due to desk set-up. There was a consensus that usual office tasks could be completed without impact while using the UDB; however, when completing more intensive computer-based tasks, participants found UDB distracting. Ideal cycling amount as reported from participants ranged from 30-120 min/day, 3-5 days/week. Perceived ideal amount of daily cycling was positively correlated with compliance ($r=0.59$, $p= 0.004$), weekly average steps ($r=0.76$, $p< 0.001$), and average weekly cycling minutes ($r=0.798$, $p<0.001$).

Positive impacts of cycling while working included feeling a sense of accomplishment, enhanced mental clarity and focus, and increased motivation. Negative impacts were mainly centered around a sense of failure/lack of accomplishment if daily cycling goals were not met. Although individuals felt better about being physically active, many felt discouraged by the lack of noticeable physical changes, in terms of weight loss, from UDB use.

Discussion

One of the main findings of our study was that most participants, who were originally inactive and sedentary, were able to meet the PAG by using the UDB for 8-weeks. There were 8 participants (36% of pooled sample) who averaged below 150 min/week of UDB use; however, 5 of them cycled, on average, 141-147 min/week. The extent to which UDB use influenced lifestyle habits, specifically physical activity levels, outside of the workplace remains unknown. We advised participants not to engage in any additional physical activity outside of the study. In good theory, any observed changes in study parameters, specifically aerobic activity, could be attributed to UDB use alone.

Interestingly, even though all participants increased their weekly activity levels by using the UDB this was not reflected in the answers provided in the PAVS questionnaire at the end of the intervention. While there were no differences in self-reported aerobic activity (PAVS) between the HIGH and LOW groups, potentially due to a small sample size, there was a significant correlation between intervention compliance and change in aerobic activity.

In a post-intervention questionnaire, individuals in the LOW group considered ≈30 min/day of cycling on most of the workdays to be ideal, compared to ≈59 min/day by the HIGH group. This perceived "ideal" cycling time/workday by both groups leads us to believe that the cycling intervention was reasonable and that using the UDB while at work can help individuals meet the PAG. Issues of "being busy" and work constraints are some of the most reported barriers to physical activity faced by U.S. adults who, on average, spend 7.7 hrs./day at work (Spiteri et al., 2019)(Bureau of Labor Statistics, 2021). Utilizing the workplace as an intervention setting is a convenient and effective solution to increasing physical activity without impacting work or personal responsibilities. Active workstations are a feasible workplace intervention to implement, as variations in type, size, and cost allow employers to select one best fit for their needs. Low-cost portable UDB, like the one used in our study, help expand the type of workplace setting that can be used as an intervention setting. Previous cycling intervention studies have used larger and more expensive desk bike models and may not be practical in some office settings (Sliter & Yuan, 2014; Torbeyns et al., 2014). Additionally, our 8-week 30-60 min/day study protocol is practical for use among inactive and sedentary individuals that may find longer duration studies intimidating;

given the light intensity of UDB use, it is also a feasible modality for individuals with injuries or physical limitations that prevent participation in weight-bearing activities. For example, Torbeyns et al (2014) study protocol included a 8 x 25 min/day or 4 x 50 min/day cycling schedule for 5-months, which may feel overwhelming and discouraging to participants that already struggle with inactivity.

Our results showed that 30-60 min/workday of UDB cycling for 8-weeks had significant reductions in weight and BMI in sedentary and inactive university employees in individuals who cycled more and had a higher intervention compliance. The results of our study provide promising weight-loss implications for low-intensity physical activity in sedentary and inactive individuals. Participants in our study cycled at a self-selected intensity of 2 or 3 out of the 8 total resistance levels; the goal being to promote activity without hindering work performance or causing adverse musculoskeletal effects. Per the manufacturer website, DeskCycle use at a resistance level of 3 "doubles energy expenditure (in comparison to sitting still) without working up a sweat" (3D Innovations LLC, 2018). The changes in weight and BMI observed in our study are possibly a result of an increase in energy expenditure while working. A study by Elmer and Martin (2014) explored differences in energy expenditure while typing when sitting versus using a cycling workstation (Elmer & Martin, 2014). Energy expenditure was 2.5 METS higher while using the cycling workstation, in which cycling intensity was described as "very very light", and work performance was not negatively impacted. Given the light intensity of activity, there is potential for individuals to feel as if no benefits are being achieved. However, at baseline and post-intervention, both the LOW and HIGH groups believed that "you do not have to exercise to a sweat to benefit from physical activity". These findings confirm the available evidence that an individual does not have to work at an uncomfortably high intensity to benefit from being physically active and further emphasize the notion that "any movement is better than none" (U.S Department of Health and Human Services, 2018a).

Regarding potential confounding variables to the observed weight loss, participants were asked to refrain from altering their diet for the duration of the study to control for its potential impact on weight changes. While our dietary data has a time effect for energy, grams of protein, and fat there is no time-by-group interaction present, indicating that changes in weight and BMI cannot be attributed to modification in dietary intake. The observed changes in BMI were significantly associated with changes in sedentary time, supporting the evidence that decreasing sedentary time is effective in weight loss and management (Roake et al., 2021).

The novelty of UDB may help explain trends in use in terms of minutes cycled and degree of intervention compliance. High levels of excitement may foster unrealistic outcome expectations from cycling, resulting in dissatisfaction and reduced engagement with the intervention. Additionally, excitement may positively influence compliance as individuals may be more open-minded regarding outcomes and UDB use due to high(er) motivation. The potential impact of novelty was present in the study of Torbeyns et al (2014), in which they observed a significant drop in both cycling time and distance following the first 4-weeks of the 5-month intervention, but engagement then remained stable for the rest of the study. This initial drop followed by a plateau in data was attributed to the potential influence of novelty as well as the impact of adjusting to UDB use (Torbeyns et al., 2014). On the opposite side of the "novelty effect", individuals may struggle to find time for cycling in their everyday work routine. With variations in schedule and work responsibilities, UDB use may be low and sporadic until an individual feels less overwhelmed by the addition of cycling. The presence of the bike under an individual's desk may subconsciously remind and encourage cycling, even if done in small amounts, and eventually make the addition less overwhelming.

When considering cycling motivation and physical activity trends across the intervention it is important to consider the intervention time period. Our study consisted of two cohorts, the first completing the intervention in the Fall 2020 semester, and the second completing the intervention in the Spring 2021 semester. The first cohort completed the intervention while COVID-19 restrictions and remote work were still highly prevalent; some individuals used the UDB while working remotely and not in their normal on-campus office. Given this change in office setting we are unable to confirm if UDB use was affected (higher/lower). Additionally, the intervention timeline of the second cohort extended into the summer break period; participants were given the option to take the UDB home for use; however, motivation may have been impacted by a change in work schedule and demands, and it is unknown if the observed results would have been different if UDB use was completed entirely in their normal office setting.

In terms of cycling experience for our study participants, individuals in the LOW group had lower levels of cycling enjoyment when compared to the HIGH group. Similarly, Torbeyns et al (2014) observed a link between cycling time and enjoyment and found that those who cycled more than the average amount were in general more positive about the cycling experience. Participants in the Torbeyns et al (2014) study who cycled more reported a higher degree of enjoyment; however, it is not possible to know if this was a result of longer exposure (use), or if only participants with positive usage experiences felt motivated to cycle more. Similar to our LOW group, it is unknown whether individuals had lower levels of cycling enjoyment due to less use, or if lack of enjoyment discouraged use. Additionally, the HIGH group was more likely to continue cycling after the intervention concluded than the LOW group, possibly due to cycling enjoyment. We believed that UDB enjoyment would translate to observed PACES differences between groups however no significant differences were observed. Although the PACES survey asks questions regarding an individual's feelings while physically active, cycling enjoyment differences did not translate in scores. In our study, individuals rated cycling enjoyment based on a 10-point sliding scale with higher scores indicating a higher degree of enjoyment. PACES scores are measured using a 5-point ordinal scale. Thus, the failure of increased cycling enjoyment to result in a change/difference in PACES score may be attributed to scoring discrepancies.

The MOEES scale was selected with the intention to evaluate *effectiveness* of UDB use to achieve desired health outcomes. We believed differences in levels of cycling enjoyment between groups would also result in differences in MOEES scores specifically due to the perceived relationship between outcome expectations and enjoyment. For example, if an individual's outcome expectations of UDB use are being met, they would have a more enjoyable time while cycling. However, the MOEES scale does not include questions regarding the specific experience, just the subsequent outcome from participation. Cycling enjoyment may not have translated to MOEES scores as it is not an outcome that happens because of exercise, it (enjoyment) is a feeling present during exercise

When our participants were asked about the barriers to UDB use, lack of comfort was often reported. Some individuals felt uncomfortable using the UDB while in meetings, in front of others, and found cycling distracting while working on intensive computer-based tasks. In addition, variations in office setting may have further impacted feelings of discomfort and subsequently impacted use. For example, individuals in a shared office space may have felt more uncomfortable cycling than an individual with a private office. Physical discomfort (e.g., knees hitting the desk while cycling) resulting from desk set-up and UDB design was also reported. In some cases, the UDB did not fit comfortably enough for use under an individual's desk and had to be relocated for use elsewhere in the office. Three of our participants dropped out due to issues with office/desk set-up. Given the lack of research done using UDB models similar to ours, we are unable to confirm if these feelings of discomfort were reported by other researchers.

Many previous studies involving active workstations have focused primarily on the cognitive work-related outcomes of use and failed to evaluate changes overall perceptions of health and wellness (Alderman et al., 2013; Arguello et al., 2021; Edelson & Danoffz, 1989; Ojo et al., 2018). We observed improvements in perceptions of overall health in both the HIGH and LOW groups after the 8 weeks. Improvements in health perceptions are not limited to the workplace and may encourage/influence healthier lifestyle choices outside of work. Regarding perceived ability to complete work tasks while cycling, participants generally agreed that usual work tasks were not impacted; however, some participants found cycling distracting when completing intensive computer-based tasks. Ability to complete tasks and perceived level of distraction due to cycling may vary between occupation type.

We hoped to see significant differences between adapted-HWQ scores between groups to show the impact of UDB use on job satisfaction, however there were no significant differences observed. The lack of differences in scores between groups could be due to the small sample size as well as variations in occupation and the individualization of questions. Given that individuals rated their own productivity and work performance, an individual's perceived self-efficacy may have impacted the degree they rated their accomplishments. Additionally, fluctuating work demands throughout the study duration may have impacted the lack of observed differences in scores as well.

Strengths of our study include intervention duration, relevancy to national guidelines, focus on overall health, and feasibility. There are a limited number of studies done that use cycling workstations/UDB beyond an acute study duration (Torbeyns et al., 2014) (Guirado et al., 2021). Our 8-week study duration allowed participants enough time to adjust to adding cycling to their workday routine while providing ample time for effects to be evaluated. To our knowledge, there have been no studies done specifically aimed at using UDB use to increase physical activity to achieve U.S. PAG; previous studies aim at using UDB to reduce sedentary time with emphasis on increasing physical activity. Previous research studies focused on the impacts of UDB use have had acute study durations and focus mainly on cognitive performance-based outcomes and fail to consider the impact on the individual (Elmer & Martin, 2014) (Sliter & Yuan, 2014). Our study however focused on individual perceptions of health and wellness both while at work and outside of work – encapsulating the various potential benefits of use, not just those that are work-specific. Lastly, the DeskCycle model used is feasible for most individuals/companies interested in purchasing an UDB as it is reasonably priced, portable (in comparison to other bike desk models), and easy to use.

Limitations to our study include a small sample size, use of self-report measurements for weight, and no inclusion of an objective measure of physical activity outside of the intervention. Some of the limitations may be attributed to the time in which the intervention took place. Recruitment was completed on two occasions during Fall of 2020 and April 2021. No objective physiological measures were completed because of research limitations with human subjects during the initial phases of the Covid-19 pandemic. In addition, the fact that some university employees were working mostly from home or with a mixed home-office schedule was challenging for recruitment and intervention completion/compliance. HIGH/LOW groupings were used in analysis to accommodate for lack of control group. Issues recording weekly cycling activity because of technical difficulties with the DeskCycle app and Bluetooth sensor were present for a few participants (n=2) and was more commonly reported among non-iPhone users. Individuals received a hard copy cycling log prior to beginning the intervention to accommodate for any potential technological issued faced and although participants made us aware of the issue and adjustments were made for them to manually record and self-report cycling data, this increased participant burden.

Future research should include validated and uniform weight change measurements, a true control group, and additional measurements, such as an accelerometer, to evaluate if UDB use influences lifestyle behaviors outside of the workplace. Future UDB study protocol should include physiological and lab-based anthropometric measurements of weight and BMI changes, longer intervention periods with follow-up, and larger sample sizes. Additionally, focus should remain on further investigating the effects of UDB use on individual perceptions of health and wellness.

Conclusions

The results of our study provide promising implications for the effectiveness of UDB in office settings to promote the achievement of the PAG and reduce the prevalence of inactivity and sedentary behavior among U.S. adults. By utilizing the workplace as an intervention setting the lack of time and work constraint barriers are minimized and physical activity is able to be conveniently integrated into the daily schedule of a working adult. Additionally, UDB use increases energy expenditure, is non-weight bearing, and is done at a low intensity, making it a feasible modality for increasing physical activity in most individuals, reducing the risk of the adverse health effects associated with sedentary behavior and inactivity. Our findings support the use of UDB as an intervention strategy to increase physical activity and subsequently mitigate the effects of inactivity and sedentary behavior as faced by U.S. adults.

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Table 1: *Primary and secondary outcome measurements of 8-week intervention*

Variable	Low Minutes / Low Compliance		High Minutes / High Compliance	
	Low Pre n=11	Low Post n=11	High Pre n=11	High Post n=11
Age, years	43.4 (2.9)	---	47.1 (3.1)	---
Weight, kg	87.5 (5.8)	88.2 (6.2)	81.7 (5.6)	77.9 (5.5)*[a]
BMI, kg/m^2	31.1 (2.0)	31.3 (2.1)	29.3 (1.5)	27.9 (1.5)*[a]
Aerobic activity, weekly min	51.4 (9.7)	60.9 (14.0)	64.5 (15.2)	115.0 (19.1)*[b]
Strength activity, times / week	0.2 (0.2)	0.6 (0.4)	0.1 (0.1)	0.4 (0.3)
PACES	56.6 (3.8)	52.8 (2.7)	64.5 (3.6)	66.1 (2.2)*[c]
MOEES	57.1 (1.6)	58.9 (1.8)	60.3 (1.4)	61.2 (1.8)
Sedentary hours while working	7.6 (0.4)	7.3 (0.5)	7.0 (0.6)	6.3 (0.8)
Sedentary hours - working day	12.3 (0.8)	11.5 (0.6)	11.7 (0.9)	11.1 (1.2)
Sedentary hours – non work day	8.5 (1.2)	8.0 (0.7)	10.5 (0.6)	9.2 (1.5)
Total sedentary hours /day average	11.2 (0.9)	10.4 (0.6)	11.3 (0.7)	10.3 (1.3)
Total min cycled	---	1102 (60.7)	---	1833.3 (110.6)**
Average min cycled / week	---	137.8 (7.6)	---	229.2 (13.8)**
Compliance, %	---	42.0 (6.8)	---	92.0 (3.0)**
Average cycling steps / week	---	9355.5 (1099.9)	---	22020.5 (1635.3)**
How many minutes of cycling/day while working would be ideal?	---	30.5 (1.7)	---	58.9 (7.3)*
How many days of cycling/week would be ideal?	---	4.3 (0.3)	---	4.8 (0.2)
To what degree do you enjoy cycling while working	---	6.0 (0.6)	---	8.8 (0.6)*

Mean (SEM)
Note: sample sizes for sedentary data at both time points are n=9 for low minutes/low compliance and n=5 for high minutes/high compliance. Sample size for "average cycling steps / week" for both groups is n=9.
PACES: Physical Activity Enjoyment Scale
MOEES: Multi-dimensional Outcomes Expectations for Exercise Scale
*Significant difference at $p<0.05$, [a]time x group interaction, [b]time effect, [c]group effect.
**Significant difference at $p<0.01$

Table 2: *3-day food record dietary intake averages by group*

Variable	Low Minutes / Low Compliance		High Minutes / High Compliance	
	Low Pre n=7	Low Post n=7	High Pre n=10	High Post n=10
Energy, kcal	1818.3 (154.5)	1497.8 (192.0)	1445.3 (87.2)	1266.2 (159.4)*[b]
Carbohydrate, g	183.0 (23.3)	158.0 (30.6)	162.4 (11.8)	157.1 (11.1)
Protein, g	90.5 (9.1)	69.3 (4.9)	71.2 (6.6)	63.6 (5.2)*[b]
Fat, g	79.7 (5.8)	64.5 (7.2)	62.7 (5.4)	56.1 (6.1)*[b]
Saturated Fat, g	28.0 (2.7)	21.2 (3.5)	19.7 (2.0)	16.9 (1.9)*[b]
Monounsaturated Fat, g	27.2 (2.1)	23.3 (2.3)	23.8 (2.4)	19.7 (1.7)*[b]
Polyunsaturated Fat, g	17.6 (1.4)	14.2 (2.0)	13.5 (1.1)	14.9 (2.8)
Cholesterol, mg	295.4 (39.1)	311.7 (38.7)	166.9 (17.9)	210.9 (29.8)*[c]
Fiber, g	17.3 (1.3)	12.8 (1.1)	13.9 (1.3)	12.2 (1.5)*[b]

Mean (SEM)

*Significant difference at $p<0.05$, [a]time x group interaction, [b]time effect, [c]group effect.

Table 3: *General health, behavioral beliefs and "acceptance" of 8-week cycling intervention.*

		Low Minutes / Low Compliance		High Minutes / High Compliance	
		Low Pre	Low Post	High Pre	High Post
In general, would you say your health is	Poor	---	---	---	---
	Fair	2 (18.2%)	1 (9.1%)	---	---
	Good	4 (36.4%)	6 (54.5%)	7 (63.6%)	5 (45.5%)
	Very Good	5 (45.5%)	3 (27.3%)	4 (36.4%)	4 (36.4%)
	Excellent	---	1 (9.1%)	---	2 (18.2%)
Sitting all day at work and not moving is not healthy for me.	Strongly disagree	---	---	---	---
	Disagree	---	---	---	---
	Neutral	---	---	---	---
	Agree	2 (18.2%)	3 (27.3%)	2 (18.2%)	2 (18.2%)
	Strongly Agree	9 (81.8%)	8 (72.7%)	9 (81.8%)	9 (81.8%)
Light activity during the work day is better than sitting all day	Strongly disagree	1 (9.1%)	---	---	---
	Disagree	---	---	---	---
	Neutral	---	---	---	---
	Agree	2 (18.2%)	6 (54.5%)	3 (27.3%)	2 (18.2%)
	Strongly Agree	8 (72.7%)	5 (45.5%)	8 (72.7%)	9 (81.8%)
You have to exercise to a sweat to get any benefit from being physically active.	Strongly disagree	1 (9.1%)	1 (9.1%)	2 (18.2%)	2 (18.2%)
	Disagree	6 (54.5%)	8 (72.7%)	5 (45.5%)	6 (54.5%)
	Neutral	3 (27.3%)	1 (9.1%)	3 (27.3%)	2 (18.2%)
	Agree	1 (9.1%)	1 (9.1%)	1 (9.1%)	1 (9.1%)
	Strongly Agree	---	---	---	---
If I use this pedal desk regularly I will lose weight.	Strongly disagree	---	---	---	1 (9.1%)
	Disagree	3 (27.3%)	3 (27.3%)	---	---
	Neutral	4 (36.4%)	6 (54.5%)	8 (72.7%)	8 (72.7%)
	Agree	3 (27.3%)	2 (18.2%)	3 (27.3%)	1 (9.1%)
	Strongly Agree	1 (9.1%)	---	---	1 (9.1%)
Sitting all day at work and not moving contributes to unhealthy weight gain.	Strongly disagree	---	---	---	---
	Disagree	---	---	---	1 (9.1%)
	Neutral	1 (9.1%)	---	---	---
	Agree	4 (36.4%)	10 (90.9%)	3 (27.3%)	4 (36.4%)
	Strongly Agree	6 (54.5%)	1 (9.1%)	8 (72.7%)	6 (54.5%)
To what degree do you agree with the following statement: I can complete my usual work tasks while using this under the desk bike	Strongly disagree	---	1 (9.1%)	---	---
	Somewhat disagree	---	7 (63.6%)	---	1 (9.1%)
	Somewhat agree	---	2 (18.2%)	---	3 (27.3%)
	Strongly agree	---	1 (9.1%)	---	7 (63.6%)
How likely are you to continue cycling at the office (or while working from home) if the equipment was accessible	Not very likely	---	1 (9.1%)	---	---
	Fairly likely	---	8 (72.7%)	---	4 (36.4%)
	Very likely	---	2 (18.2%)	---	7 (63.6%)

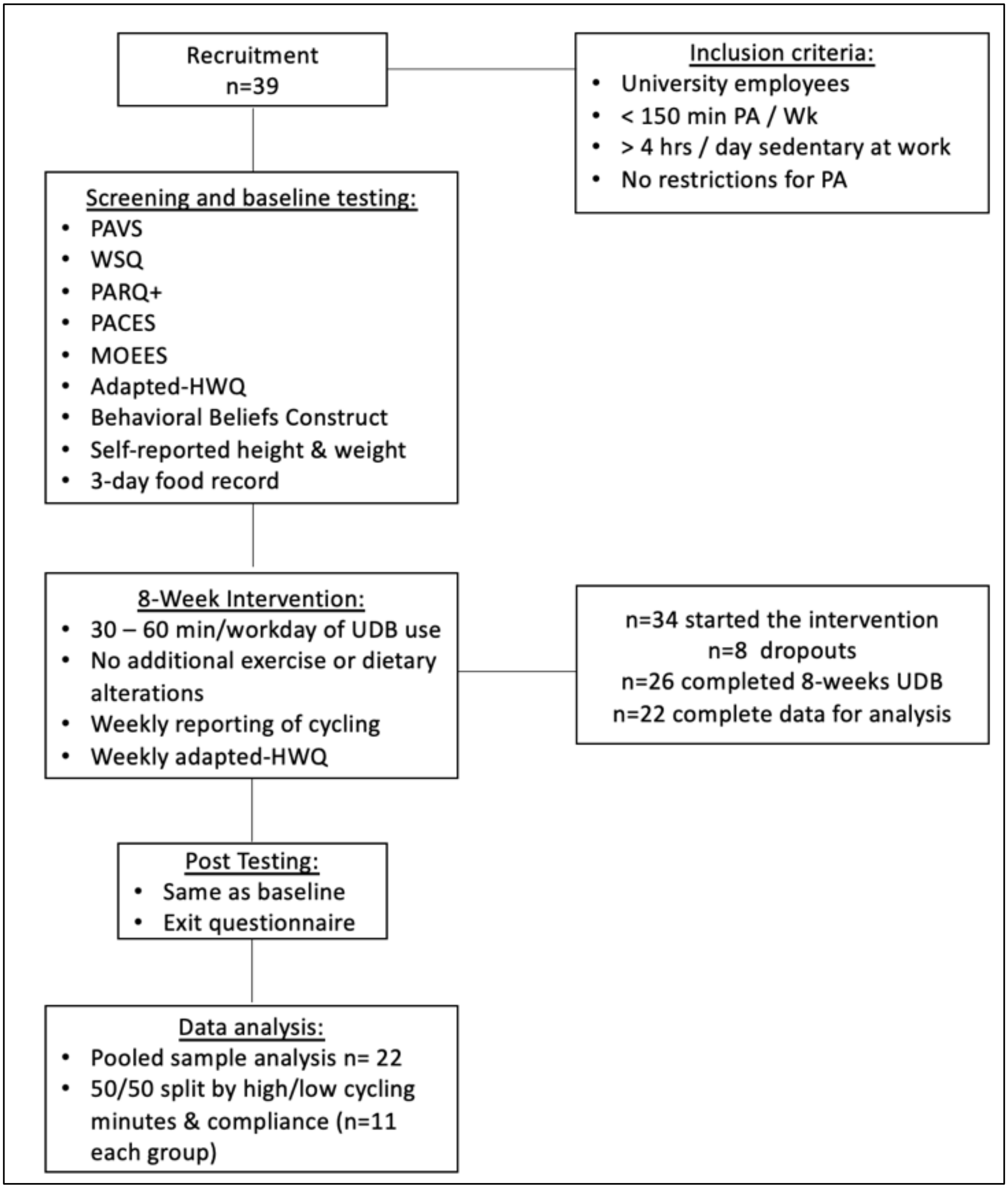

Figure 1: *Study Design Flow chart*

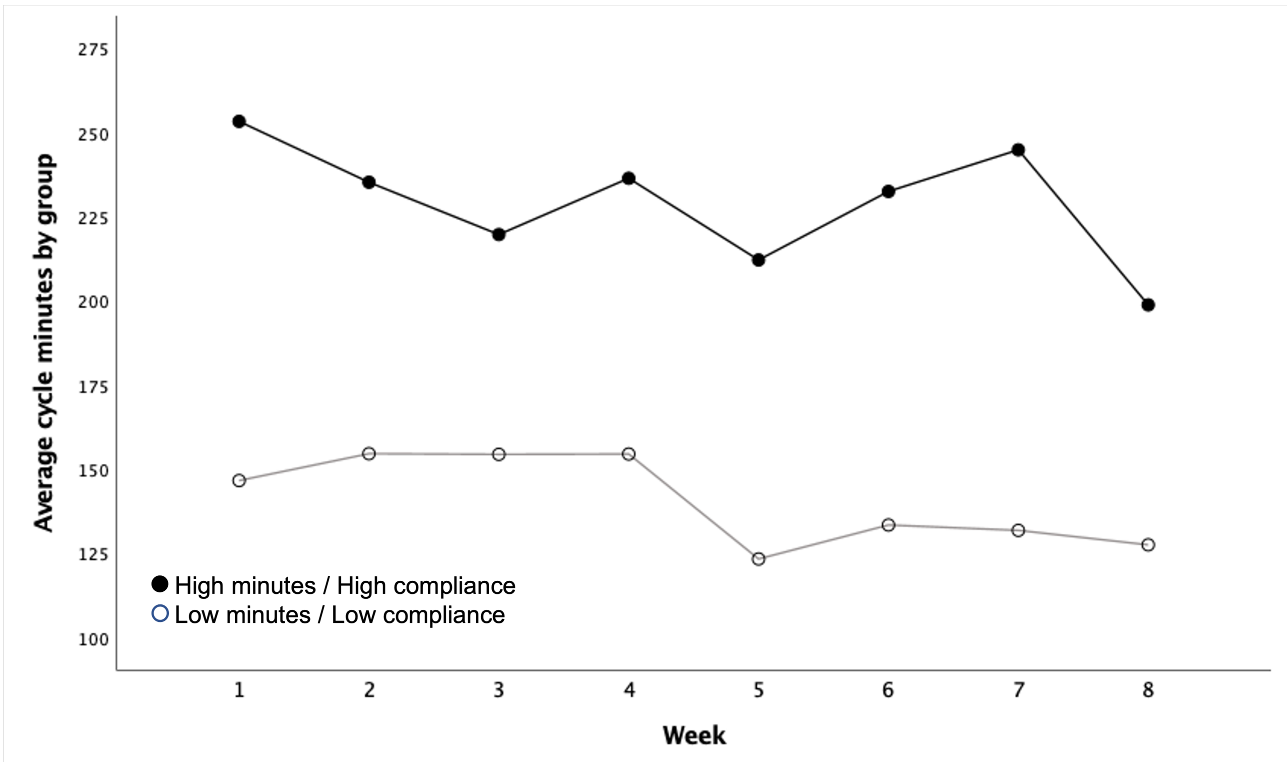

Figure 2: *Average 8-week cycle minutes by group*

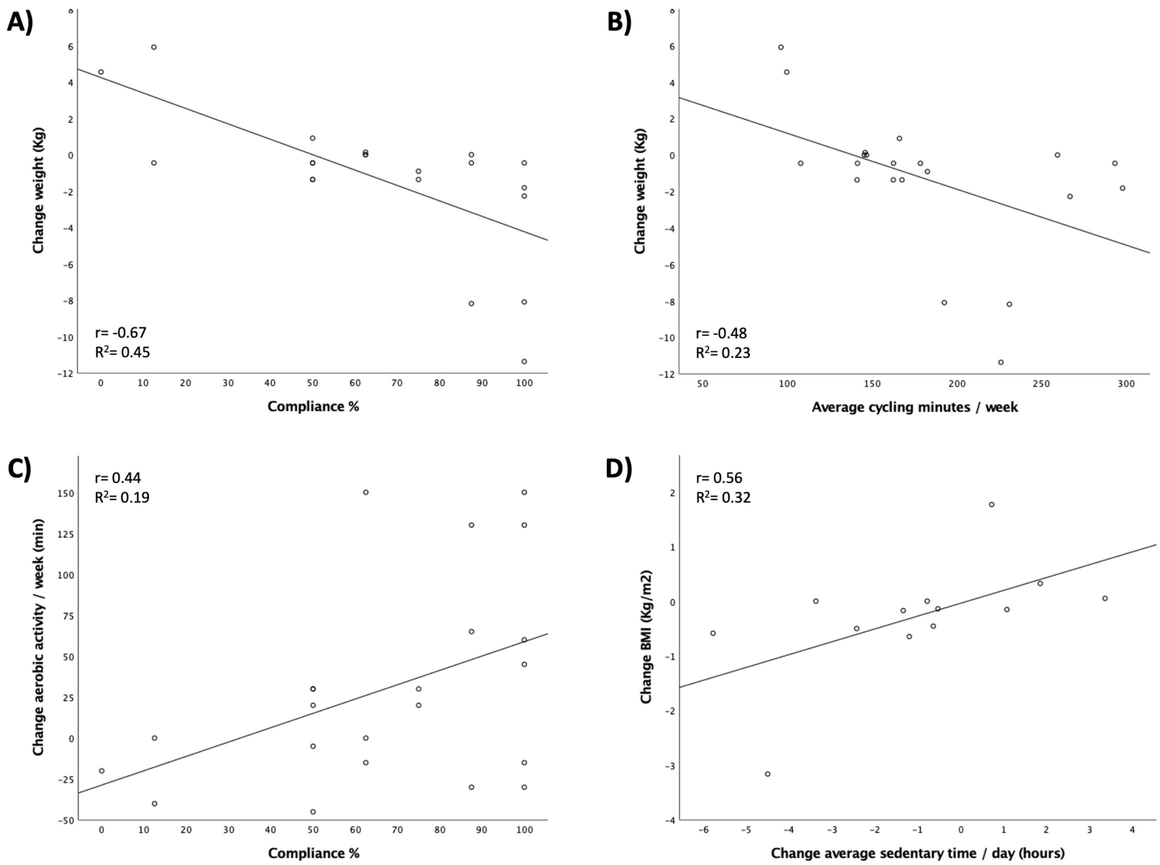

***Figure 3**: Bivariate correlations for primary outcome measurements*

A) changes in weight and compliance with the weekly 150 minutes of cycling per week for 8 weeks (n=21); B) changes in weight and average cycling minutes/week (n=21); C) changes in minutes of aerobic activity at post-intervention and compliance (n=22); and D) changes in BMI and changes in sedentary time//day (n=13).

Appendix

JAMES MADISON UNIVERSITY

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE:	December 01, 2020
TO:	Ana Dengo Flores, PhD, Dept. of Health Professions
FROM:	Taimi Castle, Professor, IRB Panel
PROTOCOL TITLE:	Cycling workstations: Feasibility of reducing sedentary time, promoting physical activity guidelines, and increasing wellbeing
FUNDING SOURCE:	College of Health and Behavioral Studies
PROTOCOL NUMBER:	20-1711
APPROVAL PERIOD:	Approval Date: September 01, 2020 Expiration Date: August 31, 2021

The Institutional Review Board (IRB) for the protection of human subjects has reviewed the amendment to protocol entitled: Cycling workstations: Feasibility of reducing sedentary time, promoting physical activity guidelines, and increasing wellbeing. The proposed modifications have been approved for the procedures and subjects described in the amendment request. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed. Although the IRB office sends reminders, it is ultimately your responsibility to submit the continuing review report in a timely fashion to ensure there is no lapse in IRB approval.

This approval is issued under 's Federal Wide Assurance 00007339 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under the Committee's Assurance, please do not hesitate to contact us.

Please direct any questions about the IRB's actions on this project to the IRB Chair:

Dr. Taimi Castle
castletl@jmu.edu
(540) 568-5929

Taimi Castle