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Physical activity in a university community before and after a COVID-19 shutdown

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Physical Activity in a University Community Before and After a COVID-19 Shutdown

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Abstract

Reaching recommended levels of physical activity (PA) is important for achieving and maintaining health, however there are many potential barriers which may impact an individual's ability to engage in PA. The COVID-19 pandemic resulted in the transition to remote teaching and learning, shut-downs of places to engage in PA, and changes to the daily work routine of university staff. Therefore, overall PA levels were likely impacted. The purpose of this study was to assess whether a significant change in PA occurred before and after one university transitioned to remote learning and working due to COVID-19 shutdowns. Subjects were recruited from a university community who owned and wore a commercial PA monitoring device for the month before and after spring break in March of 2020. During the spring break, the campus went from in-person instruction to 100% online instruction. Subjects completed an anonymous online survey and uploaded step data from their online account. Repeated measures analysis of variance were applied to analyze differences between students and faculty/staff of the university. Paired sample and independent t-tests were utilized to examine differences before and after spring break. Pearson correlations were calculated to determine relationships between age, body mass index (BMI), and PA change data. Eighty subjects (63 female, 17 male) completed the survey. The sample included 42 students (age = 22.2 ± 6.3, BMI = 24.0 ± 5.7) and 38 staff and faculty (age = 43.1 ± 10.7, BMI = 29.0 ± 7.0). The 30-day step average for the month after spring break (7085.8 ± 3559.6) was lower than the 30-day step average for the month before spring break (8522.6 ± 3230.8, $P < 0.001$). The 7-day mean step average for the week after spring break (7128.2 ± 3365.3) vs. the week after was also lower (8688.7 ± 3365.3, $P < 0.001$). Weekday step averages were lower after spring break (6903.3 ± 3487.9)

vs. before (8678.7 ± 3199.4), $P < 0.001$), as were weekend step averages (7571.7 ± 4222.9 vs. 8116.6 ± 3830.4, for after and before break, respectively, $P = 0.03$). Results found that physical activity levels were altered after the transition to online learning. Overall, PA declined immediately after the week of spring break, as well as for the month after spring break. This change is likely a reflection of the significant amount of everyday transport PA that is needed to navigate daily life on a university campus (walking to class, to work, walking associated with job duties, etc.) that was removed due to stay-at-home orders, and could impact the health of these individuals as the COVID-19 pandemic continues.

Chapter I

Introduction

Physical Activity Changes in a Pandemic

During the early months of 2020, news began to spread of a highly contagious virus that would eventually amount to a global pandemic. Due to world-wide lockdowns and stay-at-home orders, almost all educational settings and non-essential jobs transitioned to remote learning and working. On March 7th, 2020, the first case of coronavirus (COVID-19) was reported in Virginia. In a state-wide order issued on March 23rd, 2020, gatherings of 10 or more were prohibited, all public and private schools were forced to close for the remainder of the school year, and public access to non-essential establishments, such as gyms and some outdoor recreational facilities, was prohibited. Subsequently, a stay-at-home order for the state was announced on March 30th, 2020. Specific to our community, James Madison University declared classes would remain online for the entirety of the semester on March 18th, 2020 and encouraged students to stay at their primary residences.

Generally, it is seen that physical activity (PA) may decline in the presence of stressful and even non-stressful life events (Engberg *et al.*, 2012). Changes to daily routines can create disturbances that lower the importance of being active. When time is an issue, other facets of life, such as rest, may be prioritized to combat stress and anxiety. Engberg et al. provided a review of how PA may be influenced by life changing events, such as beginning university, change in employment status, changes in romantic and non-romantic relationships, having a child, and violence or disaster. For the events listed above, significant declines in PA levels were found for participants (Engberg *et al*., 2012). Specifically, PA changes due to COVID-19 and stay-at-home orders will be evaluated.

Without the PA that individuals accrue while traveling to and from work or school, sedentary behavior likely increased, creating a potential negative impact on health for an entire population. Meyer et al. reported in a sample of 3,052 individuals that those who were previously active decreased PA by 32.3% at the onset of stay-at-home orders. In the same sample, sitting time and screen time increased by 26% and 37.8%, respectively, in the beginning of April 2020 (Meyer *et al*., 2020). At the same time point, however, it was reported that PA dropped by as much as 48% across the US (Evidation Health, 2020). Dunton et al. collected self-reported PA data from over 250 US adults and found average step count decreased by 36% (2000 steps) from March and April 2020 compared to May 2019 – February 2020 (Dunton *et al.,* 2020). Moreover, a university in the Midwest conducted a study to compare sedentary time and PA from pre- to post-transition to online courses. Out of almost 400 participants, it was found that sitting time increased by 13.9% after the transition, while undergraduate students reported a 33.7% decline in moderate PA primarily because they were no longer walking to and from class (Barkley *et al.*, 2020).

As a result of the COVID-19 outbreak, screen time likely increased dramatically through both work and leisure time activities, which primarily occurred at home. Screen time is commonly seen as a way to relax and decrease stress; however, excessive consumption may create an epidemiological problem. Dependence on media and devices may also create addictive tendencies that affect everyday activities. Generally, it is seen that as time at home increases, screen time proportionally increases (Sultana *et al.*, 2021, Kiraly *et al.*, 2020). In a study evaluating lifestyle changes because of the pandemic, it was found that screen time increased by 61%, 74%, 87% for men, women, and adolescents, respectively (Carroll *et al.*, 2020). Such a large increase for adolescents was most likely due to the transition to remote learning and decreased transport PA. During the strictest time of lockdown in April and May, Pisot et al. found in over 4,100 participants that overall screen time increased by 65% (Pisot et al., 2020). While the psychological impact of the deadly virus cannot be ignored, new stressors presented coupled with increases in screen time due to the lockdown may further have contributed to declines in PA.

Increased screen time and decreased PA has been associated with greater levels of anxiety and depression creating a mental health concern propagated by unique stressors caused by COVID-19 (Meyer *et al.*, 2020). The fear and uncertainty that can result from major lifestyle changes, as well as normal routines being halted, can negatively impact mental health. In a population of university students, Husky et al. noted that moderate to severe levels of stress increased by 60.2% in students (Husky *et al*., 2020). This increase may likely be due to isolation and social environments no longer being safe. Meyer et al. observed that participants who went from active to inactive, due to facilities being taken away and remaining at home, had higher rates of depression, loneliness, and stress. Interestingly, results were comparable for those who increased their screen time (>8 hours per day) (Meyer *et al.*, 2020). These outcomes suggest that when major lifestyle changes take place out of an individual's control, the importance of being physically active may suffer. Stanton et al. observed symptoms of psychological distress compared to changes in health behaviors due to the pandemic among roughly 1,500 males and females. In subjects who described a negative change in PA (48%), all were at a significantly increased risk for depression, anxiety, and symptoms of stress (Stanton *et al*., 2020). Without proper adherence to PA recommendations, psychological distress may become more prevalent.

Because of efforts to stop the spread, individuals were required to get creative about how to achieve PA guidelines. Many low-cost options, such as parks and trails, as well as indoor facilities, were eliminated, which may have added to PA declines. It was reported by Lesser et al., that only 39% of previously active people were able to keep their desired PA choice due to restrictions (Lesser et al., 2020). Martinez et al. surveyed participants about what kind of activities they participated in before stay-at-home orders and how they have been affected by shutdowns. Out of the 980 individuals who participated in strength-training pre-shutdown, 62% completely stopped, most likely due to gym closures. When asked about aerobic training, 43% of individuals stopped participating because of additional barriers to equipment and closures of outdoor facilities (Martinez *et al.,* 2020). During the early period of COVID-19, Dunton et al. reported that 75% of individuals were participating in PA in their home or garage, 69% on sidewalks or roads, and 27% at a park or trail (Dunton et al., 2020). Because of the majority of PA being performed at home, the same quality and quantity may not be achieved because of lack of accountability that gyms and social settings provide.

Reviewing PA habits and sedentary time before the pandemic in university community members, particularly students, is important to understand how it has evolved since the shutdown. Hargens et al. conducted a study to identify associations between total sleep time (TST), sedentary time, and PA. For the population of students, it was found that average weekday step count was 9485.8 ± 3126.4, while the weekend was lower at 7217.6 ± 3453.7 steps. Similarly, weekend sedentary time was greater compared to weekdays (637.4 ± 130.9, 682.6 ± 90.3 min) (Hargens *et al*., 2020). Pre-pandemic, a similar study looking at step count in university students found step count to be higher on the weekends (8715.6 ± 5280.1) than the weekdays (8148.7 ± 4555.1) although they were not significantly different (Marquet *et al.*, 2018). Lastly, pedometers were utilized to track step count in a sample of 641 university students. Weekday step count averaged 11,823.4 ± 3074.8, while the two-day weekend was negligibly higher at 12,018 ± 2793 steps (Sigmundova *et al*., 2013).

<u>Complications of Sedentary Behavior</u>

Participating in regular PA is widely understood to be beneficial for proper physiological function. Specifically, regular PA can protect against a range of chronic diseases and conditions, including cardiovascular disease, type 2 diabetes, and several types of cancer (Healthy People 2020). It is recommended that adults achieve between 150 to 300 minutes of moderate-intensity aerobic PA or 75 to 150 minutes of vigorous-intensity aerobic PA each week to reduce the risk of developing chronic diseases and see considerable health benefits, such as improving cardiorespiratory fitness and decreasing levels of body fat (HHS 2018). While the health benefits of meeting and exceeding PA guidelines are well-documented, over 80% of adults are not meeting recommendations for aerobic and muscle-strengthening activities (Healthy People 2020).

Numerous associations between sedentary behavior and negative health outcomes exist. While a universal definition is lacking in the literature, sedentary behavior refers to low amounts of movement and energy expenditure while sitting or lying down (< 1.5 METs) (HHS 2018, Tremblay *et al*., 2010, Dempsey *et al.,* 2014). Sedentary behaviors, such as sitting, watching TV, driving, and computer work, are shown to have an impact on metabolism, bone mineral content, and cardiovascular health (Tremblay *et al*., 2010, WHO). The SITT formula, which stands for sedentary behavior frequency, interruptions, time, and type, can be applied to characterize behaviors that lack changes in intensity. Interruptions are considered activities that break up sedentary behavior, such as standing up from a computer chair while working at a desk. Time includes duration of sedentary behavior, and type refers to the mode of activity (Tremblay *et al.,* 2010). Insufficiently active is slightly different than being sedentary in that it is defined as receiving less than 10 MET hours of activity per week. Being insufficiently active puts individuals at a 20% to 30% increased risk of death compared to those who are sufficiently active (receiving 500 MET minutes of PA per week) (HHS, WHO).

Metabolic abnormalities have been reported in individuals who spend most of their waking hours in sedentary behavior characterized by decreased HDL and reductions in insulin sensitivity (Tremblay *et al.,* 2010, Lemes *et al.,* 2019). Specifically, Lemes et al. studied the correlation between TV viewing time and metabolic syndrome (MetS). Compared to the 'low' TV watching cohort, subjects who engaged in high and moderate durations and frequencies of viewing had an increased risk of MetS by 77% and 49%, respectively (Lemes *et al.,* 2019). Similarly, participants who did not take part in any amount or intensity of PA doubled their risk of MetS compared to individuals who achieved 150 minutes of activity per week (Ford *et al.*, 2005). Sedentary behavior significantly increases the risk of metabolic dysfunction (Lemes *et al.*, 2019, Ford *et al.*, 2005).

A further consequence of engaging in sedentary behavior is reduced bone mineral density (BMD). The necessity for bone health is seen in a variety of populations, such as postmenopausal women and aging individuals. Reductions in BMD are often observed when bone deposition is decreased and resorption is increased, which can be mitigated with reductions in sedentary time (Tremblay *et al.*, 2010, Braun *et al.*, 2017). In postmenopausal women, estrogen decreases, which may increase bone resorption and lead to decreases in BMD. In addition, it is observed that as women get older, they participate in less physical activity and engage in sedentary behaviors (Siris *et al*., 2001). This combination often leads to increased osteoporosis and osteopenia rates, which put women at a higher risk of fracture (Siris *et al*., 2001). It is recommended that engaging in muscle-strengthening activities at least two days a week incorporating major muscle groups provides advantages that mitigate the effects of bone mineral loss (HHS). As seen from a meta-analysis by Berard et al., improved bone health was observed in women who take part in moderate-intensity activities, such as walking and other leisure time activities. Studies reached the consensus that participating in non-sedentary behavior can significantly decrease the risk of BMD loss in postmenopausal women (Berard *et al.*, 1997). In general, bone health is critical to maintain functionality and quality of life.

Finally, cardiovascular health can be impacted by sedentary behavior and improved by both aerobic exercise and resistance training. It is well-established in the literature that individuals who are primarily sedentary are at an increased risk for a cardiac event and early mortality (Same *et al*., 2016, Chomistek *et al*., 2013, Matthews *et al*., 2012). When examining roughly 71,000 individuals from the Women's Health Initiative Observational Study who were not affected by cardiovascular disease (CVD) at baseline, Chomistek et al. found an increased CVD risk between women who sat at least 10 hours a day compared to those who only sat five hours per day (hazard ratio (HR): 1.18) (Chomistek et al., 2013). Comparably, Matthews et al., analyzed the effect of sedentary time on CVD mortality in participants who had no prior health concerns. Over the eight-year period, it was reported that individuals who watched at least seven hours of daily TV were at an increased CVD mortality risk compared to their counterparts who only viewed one hour per day (HR 1.85). Surprisingly, subjects who spent seven hours in moderate-to-vigorous PA (MVPA) per week but also had the same amount of TV viewing time still had a greater chance of experiencing CVD mortality (HR 2.00) contrasted to their counterparts (Matthews *et al*., 2012).

At present, increases in sedentary behavior, specifically screen time, are positively associated with declining PA levels. A dose-response relationship has also been observed between sedentary behaviors and obesity and diabetes (Tremblay *et al*., 2010, Dempsey *et al.*, 2014). According to the Nurses' Health Study, a two-hour a day increase in TV time increased the risk of obesity by 23% for women ages 30 to 55 who were not obese at baseline. Moreover, sitting for two additional hours at work increased the risk of obesity by 5% (Hu *et al*., 2003). A similar study further validated that increases in screen time simultaneously increases the risk of obesity for both men and women (Shields *et al*., 2008b). The risk for development of diabetes is similar to obesity risk, where greater levels of screen time increases deleterious outcomes (Hu, 2001; Hu 2003). Spending large quantities of time in sedentary behavior greatly increases the risk of negative health outcomes, such as obesity, cardiovascular disease, and metabolic syndrome across all populations.

Creating healthy PA habits and meeting guidelines as an adolescent and young adult is crucial as research shows patterns carry over into adulthood. With aging adults, it also becomes more difficult to reverse the negative outcomes of being sedentary. Kelder et al., observed over a seven-year period that individuals in the 'low' PA category at baseline remained low, while those in the 'high' category remained highly active (Kelder *et al.*, 1994). In a study tracking PA from childhood into adulthood over 27 years, Telama et al., found that early childhood PA was significantly correlated with levels of PA in young adulthood. Furthermore, both indirect and direct effects of PA over the longitudinal time-period were significant (Telama *et al.*, 2007). Because a great number of individuals were without their normal mode of PA due to shut-downs, sedentary habits may have been established that will become increasingly difficult to overturn as time moves on.

Wearable Technology

Over the last decade, the use of consumer wearable technology (CWT) to track physical activity and improve physiological performance has increased exponentially with the developing technology of Apple Watches, Fitbits, and Garmin devices (El-Amrawy *et al.*, 2015). With now over 10% of adults using a physical activity tracker, the general population is increasingly aware of exercise habits and day-to-day activity levels (DiFrancisco-Donoghue *et al*., 2018). Prominent features on these devices include step counting, heart rate, sleep tracking, and energy expenditure.

A number of studies have provided evidence that owning a device may increase physical activity, while decreasing sedentary time and total body weight (Barwais *et al*., 2013, Cadmus-Bertram *et al*., 2015, Pellegrini *et al*., 2012). Over a four-week period, Barwais et al. reported a 21% decrease (2.4 hours) in sedentary time, a 67% increase in moderate activity, and a 60% increase in vigorous activity in participants who wore a device. A significant difference in light intensity activity was observed as well in the intervention group, which increased from 4.3 ± 2.0 hours/day to 6.8 ± 1.7 hours/day. Opposingly, the control group increased their sedentary time and spent less time being physically active (Barwais *et al.*, 2013). Cadmus-Bertram et al. performed a study on women who were receiving an average of 33 minutes of MVPA per week with an average of 5,866 steps per day at baseline. When wearing a Fitbit, the study reported a significant increase in activity levels (62 minutes per week) compared to women who wore a standard pedometer. The Fitbit group also increased their daily step count by 789. (Cadmus-Bertram *et al*., 2015).

Of growing concern in recent years is the validity and reliability of data reported from CWT. In a study that had participants wear 10 different trackers (including the Fitbit Zip and Fitbit Flex), step count was compared between an exercise bout lasting 30 minutes walking on a treadmill. An Optogait system *(OPTOGait, Microgate S.r.I, Italy 2010)* was the gold standard for laboratory conditions, which comprises two beams connected to the sides of the treadmill that utilizes an LED lighting system to accurately measure the number of steps taken. The Fitbit Zip and Fitbit Flex differed by 46 and 188 steps compared to the Optogait system, respectively (Kooiman *et al*., 2015). Takacs et al. observed discrepancies between manual step counting and the Fitbit One and found no significant differences between measurements with correlation coefficients ranging from 0.97 – 1.00. The average observer count was 515 ± 29 steps, while the Fitbit One recorded 515 ± 30 steps during a treadmill walking session (Takacs *et al.,* 2014). Similarly, when studying differences in step count over seven days between two different Fitbits (Fitbit One and Fitbit Charge) and an ActiGraph (AG), Hargens et al., found average step count for the commercial devices to be significantly higher compared to the AG (Hargens *et al.*, 2017). The Fitbit Charge (FC) had a mean average difference of 2,013.3 steps while the Fitbit One (FO) differed by 1,064.1 steps compared to the AG. In regard to MAPE between the devices and the AG, the FC measured at 20.7%, and the FO was 11.4% (Hargens *et al.*, 2017).

Over the last several years, the Apple Watch has grown in increasing popularity. Wallen et al. conducted a study on individuals to measure the validity of four different devices, including an Apple Watch. Compared to the reference method, which was a treadmill video recording, the Apple Watch had a correlation score of 0.70 showing strong validity. The mean differences between observed and expected step count was -47 steps. Roughly, the Apple Watch underestimated total step count by only 4% (Wallen *et al*., 2016). Likewise, Bunn et al. compared eight devices against the Consumer Technology Association (CTA) standards. The Apple iWatch Series 1 met the CTA standard of MAPE less than 10% for both walking and running and showed significant correlation to the manual counting of steps (Bunn *et al.,* 2018). Veerabhadrappa et al., utilized a treadmill protocol comparing an Apple Watch to the manual counting of steps for different walking speeds. The watch recorded 2,965 ± 144 steps while 2,964 ± 145 steps were counted resulting in an error of only 1.07 steps (0.034%) (Veerabhadrappa *et al.*, 2018).

Using a 30-minute treadmill walking protocol, Modave et al., recruited subjects to wear several devices compared to an ActiGraph to measure step count. For ages 18-64, an Apple Watch recorded 967 ± 48 steps, which was not significantly different from the ActiGraph at 995 ± 25 steps (Modave *et al.,* 2017).

Lastly, Garmin offers an array of wearable technology from simple to complex. Montes et al., assessed step count differences between a criterion measure and a Garmin Vivosmart. When addressing free living versus a treadmill walking and running protocol, MAPE were both less than 10% and 5% respectively. Average step count for free living walking using the Garmin device was 557 ± 43, while the manual step count was recorded at 561 ± 43. For the laboratory condition, free motion walking step count was 557 ± 44 with the Garmin device and 560 ± 44 steps for the manual counter. (Montes *et al*., 2020). As seen above, Modave et al. utilized numerous wearable devices to evaluate step count accuracy to an AG. While analyzing two different Garmin devices, it was found that neither significantly over- nor underestimated step count (990 ± 33, 993 ± 17) compared to the AG (995 ± 25) for participants 18 – 64. (Modave *et al.,* 2017).

<u>Purpose</u>

To date, there is little information regarding the changes in PA in university community members over the period of stay-at-home orders that occurred as a result of the pandemic. Therefore, the purpose of this study was to examine how PA levels changed from before a university going to remote learning, to after the transition. Due to increased time spent at home and screen time, it is hypothesized that step count with be significantly decreased from pre- to post transition.

Assumptions

It is assumed that each participant involved with the study filled out the survey as correctly as possible with the known data from their device. It is also assumed that the devices used record data accurately, and that individuals wore their devices for a consistent amount of time each day.

Limitations

A potential limitation with the study includes the fact that the subject sample may not be completely random as requests for participants were sent via bulk-email messages to JMU students and faculty/staff. Additionally, this study was retrospective in nature.

Delimitations

A delimitation of the study includes being limited to only people who wear an activity tracker, such as a Garmin, Fitbit, or Apple Watch. Individuals who wear activity trackers may be prone to be more active than those who do not.

Chapter II

Methodology

Subjects

Subjects will be recruited from the James Madison University (JMU) community who owned and wore a commercial physical activity (PA) monitoring device for the month prior to the JMU spring break in March 2020, as well as the month after. Community members will include any faculty, staff, student, and other individuals with affiliation to JMU. Acceptable PA devices include Fitbits, Garmin wearables, and Apple Watches. The below procedure was approved by the Institutional Review board at JMU before data collection began. All subjects will provide informed consent prior to completing the survey.

Procedures

Subjects will complete an anonymous online survey (Qualtrics, Provo, UT) and input step data from their CWT online account. The survey consists of questions regarding total steps per day for the month before and after spring break. If a participant did not wear their device on a given day, we ask that they leave that day blank. Basic demographic questions, such as sex, age, and body weight, will be included on the survey.

Statistical Analyses

Paired sample t-tests will be utilized to examine differences in PA levels before and after JMU spring break for all subjects. Changes in step count will be evaluated for the month and week before and after spring break. Weekday and weekend step count differences will also be analyzed. Repeated measures analysis of variance will be applied to analyze differences between students and faculty/staff of JMU. Pearson correlations will be calculated to determine relationships between age, body mass index (BMI), and PA change data.

Chapter 3

Manuscript

Physical Activity in a University Community Before and After a COVID-19 Shut-down

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Abstract

Introduction: Reaching recommended levels of physical activity (PA) is important for achieving and maintaining health, however there are many potential barriers which may impact an individual's ability to engage in PA. The COVID-19 pandemic resulted in the transition to remote teaching and learning, shut-downs of places to engage in PA, and changes to the daily work routine of university staff. Therefore, overall PA levels were likely impacted. The purpose of this study was to assess whether a significant change in PA occurred before and after one university transitioned to remote learning and working due to COVID-19 shutdowns.

Methods: Subjects were recruited from a university community who owned and wore a commercial PA monitoring device for the month before and after spring break in March of 2020. During the spring break, the campus went from in-person instruction to 100% online instruction. Subjects completed an anonymous online survey and uploaded step data from their online account. Repeated measures analysis of variance were applied to analyze differences between students and faculty/staff of the university. Paired sample and independent t-tests were utilized to examine differences before and after spring break. Pearson correlations were calculated to determine relationships between age, body mass index (BMI), and PA change data.

Results: Eighty subjects (63 female, 17 male) completed the survey. The sample included 42 students (age = 22.2 ± 6.3, BMI = 24.0 ± 5.7) and 38 staff and faculty (age = 43.1 ± 10.7, BMI = 29.0 ± 7.0). The 30-day step average for the month after spring break (7085.8 ± 3559.6) was lower than the 30-day step average for the month before spring break (8522.6 ± 3230.8, $P < 0.001$). The 7-day mean step average for the week after spring break

(7128.2 ± 3365.3) vs. the week after was also lower (8688.7 ± 3365.3, P < 0.001). Weekday step averages were lower after spring break (6903.3 ± 3487.9) vs. before (8678.7 ± 3199.4), P < 0.001), as were weekend step averages (7571.7 ± 4222.9 vs. 8116.6 ± 3830.4, for after and before break, respectively, P = 0.03).

Conclusion: Results found that physical activity levels were altered after the transition to online learning. Overall, PA declined immediately after the week of spring break, as well as for the month after spring break. This change is likely a reflection of the significant amount of everyday transport PA that is needed to navigate daily life on a university campus (walking to class, to work, walking associated with job duties, etc.) that was removed due to stay-at-home orders, and could impact the health of these individuals as the COVID-19 pandemic continues.

Introduction

In March of 2020, the outbreak of Coronavirus (COVID-19) in the US forced the closure of all non-essential businesses, workplace, and educational settings to stop the spread of the virus and protect health-care providers and hospitals from being overwhelmed. James Madison University, specifically, transitioned to fully online learning for students, faculty and staff on March 18th, 2020 through the spring semester. Additionally, the state of Virginia underwent a stay-at-home order beginning on March 30th, 2020 that remained in effect for several months.

As a likely result of stay-at-home orders, physical activity (PA) decreased significantly for some individuals, including students, while sedentary time increased in the earliest months of the pandemic (Meyer, 2020, Evidation Health, 2020, Dunton, 2020, Barkley, 2020). Students may receive most of their PA by walking to classes and other campus buildings, which was mostly eliminated with the transition. This is concerning because while engaging regularly in PA protects against lifestyle-related chronic diseases, sedentary behavior is associated with negative health outcomes (Healthy People, 2020). Sedentary behavior can be defined as participating in activities that expend low amounts of energy (< 1.5 METS), such as computer work or watching television (Tremblay, 2010). Metabolic abnormalities, cardiovascular disease, and diminished bone health are a sample of conditions that may arise due to a lifestyle characterized by sedentary behavior (Lemes, 2019, Chomisteck, 2013, Braun, 2017).

When major life changes occur creating psychological stressors, it has been shown that PA levels decrease consequently (Meyer, 2020, Husky, 2020). Anxiety, depression, and symptoms of stress rates have been shown to rise as PA decreases (Stanton, 2020). A change in everyday routine coupled with normal modes of PA being taken away by the closure of gyms and some outdoor facilities may have contributed to added psychological distress. Due to isolation and concerns about safety, mental health is at an all-time low in university students (Husky, 2020). In individuals who were previously active before the pandemic, many became inactive because of barriers and hardships that came with trying to find ways to achieve PA guidelines (Lesser, 2020, Martinez, 2020). Furthermore, spending more time at home is correlated with increased screen time, which rose amongst most age groups during quarantine due to remote learning and working (Sultana, 2021, Kiraly, 2020). As fear and uncertainty grew particularly in March and April of 2020, destressing with devices and media outlets grew in popularity as a way to stay connected to the constantly changing world.

There is little information to date regarding PA and how it has evolved due to the shutdown in university community members. This population, especially students, is unique because even temporary changes to PA habits may increase the risk of long-term health complications. Therefore, the purpose of this study is to analyze step count differences before and after the transition to remote working and learning. It is hypothesized that step count will be significantly lower for both students and faculty/staff after the transition. Additionally, differences between groups will be assessed to examine how the transition impacted students and faculty/staff step counts.

Methodology

Subjects

Subjects were recruited from the James Madison University (JMU) community who owned and wore a commercial physical activity (PA) monitoring device for the month prior to the JMU spring break in March 2020, as well as the month after. Community members included any faculty, staff, student, and other individual affiliated with JMU. Acceptable PA devices included Fitbits, Garmin wearables, and Apple Watches. The below procedure was approved by the Institutional Review board at JMU before data collection began. All subjects provided informed consent prior to completing the survey.

Procedures

Subjects completed an anonymous online survey (Qualtrics, Provo, UT) and input step data from their consumer wearable technology (CWT) online account. The survey consisted of questions regarding total steps per day for the month before and after spring break. If a participant did not wear their device on a given day, it was asked that they leave that day blank. Basic demographic questions, such as sex, age, and body weight, were included on the survey.

Consumer Wearable Technology

CWT has become increasingly popular among adults. Owning a device, such as a Fitbit, Apple Watch, or Garmin device has been shown to make individuals aware of their habits, which can lead to elevated PA levels and reduced sedentary behavior. (DeFrancisco-Donoghue, 2018, Barwais, 2013). Numerous studies have been conducted to analyze differences and evaluate the validity and reliability between gold standard measurements compared to the devices listed above. In the majority of cases, CWT has been shown to correlate significantly with any criterion measure and can be used to accurately measure step count and PA changes (Hargens, 2017, Veerabhadrappa, 2018, Montes, 2020).

Statistical Analyses

Repeated measures analysis of variance was utilized to analyze main effects for time and group for step counts before and after spring break. A period of the month prior to spring break and the month after spring break were analyzed, as well as a week prior to- and after spring break. Additionally, weekday and weekend days were analyzed. For any interaction noted, post-hoc analyses included independent sample t-tests to evaluate differences between groups before and after the transition, and paired sample t-tests to evaluate changes before and after spring break for each group separately. Pearson correlations were calculated to determine relationships between age, body mass index (BMI), and PA change data.

Results

Subject characteristics for students and faculty/staff are presented in Table 1. BMI was higher for faculty/staff vs. students (P = 0.001). However, BMI for all subjects was not correlated to change in step count for the week (r = 0.104, P = 0.371), the month (r = -0.004, P = 0.972), weekend days (r = 0.01, P = 0.93), or weekday days (r = -0.008, P = 0.94) suggesting minimal impact on results.

Repeated measures ANOVA showed that the shutdown impacted students and faculty/staff differently. It was revealed that step count significantly decreased from pre- to post-transition for the week (P < 0.001), the month (P < 0.001), weekend days (P = 0.033), and weekday days (P < 0.001) for all subjects. (Table 2) There was a group by time interaction effect for the month prior to spring break compared to the month after (P = 0.002). (Figure 1) Similarly, weekend days (P = 0.01) and weekday days (P = 0.003) also showed a group by time interaction. (Figures 3, 4) For the week prior to spring break compared to the week after, only a main effect for time was seen. (Figure 2)

Independent sample t-tests before the transition revealed no differences in step count between groups for the month (P = 0.87), 7 days (P = 0.25), weekend days (P = 0.07), or weekday days (P = 0.62). However, the month (P = 0.045), and weekend days (P = 0.03) were significantly different after the transition between students and faculty/staff. A trend is seen in that there was not a significant difference in step count between groups for the week (P = 0.26) or weekday days (P = 0.06) post-transition. Changes in step count from pre- to post-transition were significantly lower in students for the month (P = 0.02), weekend days (P = 0.04), and weekday days (P < 0.05). (Table 2) There were no significant differences between groups and step count for the week (P = 0.4). (Table 2)

Post-hoc paired sample t-tests were completed for each group. For students, the month ($P < 0.001$), the week ($P < 0.001$), weekend days ($P = 0.004$), and weekday days ($P < 0.001$) had significantly lower step counts after the transition. (Table 3) As revealed by Pearson correlations, there was no association between age and student change in step count for the month ($r = -0.22$, $P < 0.01$), the week ($r = -0.12$, $P < 0.01$), weekend days ($r = -0.15$, $P < 0.01$), or weekday days ($r = -0.22$, $P < 0.01$). BMI was also not associated with change in step count for students at any time point (month: $r = -0.004$, week: $r = -0.02$, weekend days: $r = 0.21$, weekday days: $r = -0.08$, $P < 0.01$).

Weekday days ($P = 0.006$), the month ($P = 0.02$), and the week ($P = 0.006$) post-transition were significantly lower for faculty/staff. (Table 4) Weekend days were not significantly lower from before to after the transition for faculty/staff ($P = 0.66$). (Table 4) Pearson correlations revealed no association between age and change in step count for faculty/staff for the month, the week, weekend days, or weekday days, respectively ($r = -0.05$, $r = -0.18$, $r = -0.18$, $r = -.004$, $P < 0.05$). Yet, BMI was associated with step count changes in faculty/staff for the month ($r = 0.39$, $P < 0.05$), the week ($r = 0.35$, $P < 0.05$), and weekday days ($r = 0.47$, $P < 0.01$). No association was seen between BMI and step count change in faculty/staff for weekend days ($r = 0.05$, $P < 0.05$).

Discussion

Results from this study suggest that PA, as measured by step count, declined after a university community's spring break due to the COVID-19 shutdown. Students experienced a significant reduction in step count across all time points. Average step count for faculty/staff significantly declined at all time points except weekend days post-transition. Although both groups had significant declines in step count, students experienced these declines in a greater magnitude. It has been previously noted that when major life changes occur, PA rates may decline putting individuals at a greater risk for negative psychological outcomes (Meyer, 2020). When normal routines are interrupted, individuals may be more likely to eliminate activities that seem unnecessary (Meyer, 2020, Stanton, 2020). This may conclude why 80% of US adults do not meet PA guidelines (Healthy People 2020).

When observing changes in PA in college age individuals after shifting class to online in a Midwest university, it was found that 13.9% (7.8 hours) additional weekly sitting occurred, while moderate PA declined at an alarming rate of 33.7% (Barkley, 2020). Although the current study did not measure sedentary behavior directly, when PA decreases, sedentary time likely increases. Since the current study reported the greatest decrease in weekday step count for students (2445.2), increased sedentary time was a likely outcome. The greatest contributing factor to declines in weekday steps for students was most likely due to the drop in transport PA. With classes being online, students no longer had to walk from building to building and spent the majority of time sitting due to lock down restrictions. Pisot et al. found that physical inactivity doubled, and screen time increased by 65% for adults during quarantine as measured by an online survey combining the Simple Physical Activity Questionnaire (SIMPAQ) and the European Health Interview

Survey (Pisot, 2020). The current study may be able to draw a similar conclusion considering the majority of work was being done online using various screens.

A study conducted before COVID-19 examined PA habits, including step count, in a population of 81 university students. Hargens et al. and the current study observed similar daily step counts pre-pandemic (8866.6 ± 2884.3 vs. 8307.4 ± 3128.3). Weekday and weekend step counts for Hargens et al. (9485.8 ± 3126.4 vs. 7217.6 ± 3453.7) were also comparable to the current study (8621.6 ± 3225.9 vs. 7543.6 ± 3291.6) before the shut-down (Hargens, 2020). This suggests that the data obtained through survey response, based on commercial device data, was in line with previously published data using research grade accelerometers.

While there was a greater decrease in step count for students compared to faculty/staff for the month, weekend days, and weekday days, it was surprising that there were no significant differences between groups for the week. It is possible this was influenced by the novelty of COVID-19. Many were still unsure of the severity of the virus and potentially less likely to understand the importance of stopping the spread. Students may have come back to campus believing life would return to normal and were still gathering with friends. Although weekend step count was significantly lower after spring break for all subjects, this effect was primarily due to students decline in steps as weekend step count did not decline for faculty/staff. The weekends are a time for students to take a break from their studies and enjoy the opportunities college life has to offer, but once lock downs began, essentially all events were canceled, and students no longer found it safe to be around friends and large gatherings. Given closures of varying modes of exercise coupled with social time becoming non-existent, students may have been more prone to engage in sedentary behaviors.

In faculty/staff, BMI was positively associated with step count change for the month, the week, and weekday days. As BMI increased, a greater reduction in step count was observed from before to after spring break. Perhaps those who were previously active became inactive due to decreased ways to engage in PA, while those were already inactive remained inactive. The change in weekday step average was not as drastic for faculty/staff (924.6) compared to students (2545.2) because their normal routines may have not been as drastically impacted compared to students. With commute time eliminated, faculty/staff may have been able to pivot modes of PA more efficiently and had addition time to be active (Barkley, 2020). Moreover, weekend step count was not altered at all for faculty/staff (+126.1). Schedules are more prone to be stable and can more efficiently adjust when routines are disrupted at a certain age. Opposingly, BMI had no effect on step count change for students at any time point. The BMI range for students was much narrower compared to faculty/staff reinforcing the differences in lifestyles between groups.

The impact of regular PA and reducing time spent in sedentary behavior is seen consistently to reduce the risk of chronic physical and mental health conditions (Lemes, 2019, Same, 2015, Meyer, 2020, HHS, 2018). Specifically, being physically inactive may increase the risk of developing cardiovascular disease. It has been observed that long-term exercise may generate functional and structural adaptations to the vascular wall (Padilla, 2011). Boyle et al. noted that when reducing previously active men’s step count to below 5,000, they had decreased vascular function underlining the importance of avoiding chronic sedentary behaviors (Boyle 2013). Creating healthy PA habits when young can set a precedence moving forward as adults are more likely to remain active if active as a child or young adult (Telama, 2007). Further, increases in screen time, which have occurred due to spending more time at home, have been shown to decrease positive mental health outcomes (Meyer 2020, Husky, 2020). As the vicious cycle of increased sedentary behavior and screen time negatively impacts PA, breaking the patterns of low PA and step count may become more and more difficult as restrictions ease in the future.

Due to the constantly evolving information related to the novelty of COVID-19 that focuses primarily on larger populations, this study provides a unique look into changes that occurred in a primarily residential university community. With many university community members engaging in less PA after the shutdown potentially due to changes in schedules and space to be active, it is crucial to understand how sedentary behavior is contributing to both physical and mental health conditions. Providing knowledge and data may encourage individuals to find creative ways to achieve guidelines and sit less, while making the censoring of screen time a priority.

A limitation of the present study is that the subject sample was obtained using convenience sampling as requests for subjects were sent via bulk-email messages to JMU students and faculty/staff. This study is retrospective in nature and assumes participants wore the device for a similar number of hours each day. Further, this study was limited to only people who wear an activity tracker, such as a Garmin, Fitbit, or Apple Watch. Individuals who wear activity trackers may be prone to be more active than those who do not (Pellegrini, 2012).

Based on the health implications of not receiving adequate levels of PA, it is important to evaluate if step counts increase in this population when normality resumes. As restrictions are lifted and classes move to face-to-face, step count should increase if declines were primarily due to the elimination of transport PA. Though hopefully there will not be another global pandemic, understanding why PA declines during major life changes is crucial for early intervention and prevention. If the pandemic promoted lifestyle changes that do not shift once life returns to 'normal', a different kind of global health pandemic may occur as a result of increasing sedentary behaviors. Moving forward, future research would benefit greatly from examining long-term impacts on PA from COVID-19.

In conclusion, step count significantly declined for community members of a university. This effect was potentially created by the transitions to learning and working from home due to COVID-19. A secondary effect of declining step counts may be due to gym closures forcing individuals to find other modes of exercise that are more difficult to incorporate. Removing consistency can result in subjects no longer taking time for PA because as psychological stressors increase, individuals may engage in less PA. Students were more likely affected by the transition to remote learning due to declines in transport PA, potential increases in screen time, gym closures, and stress. Many faculty/staff were already spending greater amounts of time sitting due to work demands and may have better stress coping mechanisms due to increased age.

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Table 1. Subject characteristics between students and faculty and staff

	All Subjects (n=80)	Students (n=42)	Faculty/Staff (n=38)
Age	32.2 ± 13.6	22.2 ± 6.3	43.11 ± 10.7*
Height (cm)	169.6 ± 8.8	167.5 ± 7.0	171.8 ± 10.1
Weight (kg)	75.9 ± 21.6	67.4 ± 16.4	85.9 ± 22.8*
BMI	26.3 ± 6.8	24.0 ± 5.7	29.0 ± 7.0*

*P <0.05 compared to students

Table 2. Average step count before and after spring break in all subjects (n = 80)

	Before	After
Seven Days	8688.7 ± 3365.3	7128.2 ± 3365.3*
Thirty Days	8522.6 ± 3230.9	7085.8 ± 3599.6*
Weekend Days	8166.6 ± 3830.4	7571.7 ± 4222.9§
Weekday Days	8678.7 ± 3199.7	6903.3 ± 3487.9*

*P < 0.001 when compared to average step count before spring break
§P = 0.033 when compared to average step count before spring break

Table 3: Average step count before and after spring break in students

	Before	After
Seven Days	8442.6 ± 3025.7	6556.2 ± 2860.7*
Thirty Days	8307.4 ± 3128.3	6159.7 ± 2737.6*
Weekend Days	7543.6 ± 3291.6	6391.4 ± 3149.3*
Weekday Days	8621.6 ± 3225.9	6076.4 ± 2722.4*

*P < 0.05 compared to before spring break

Table 4: Average step count before and after spring break in faculty/staff

	Before	After
Seven Days	8960.8 ± 3727.2	7760.5 ± 3785.6*
Thirty Days	8760.4 ± 3366.5	8109.4 ± 4160.7*
Weekend Days	8750.0 ± 4305.2	8876.1 ± 4874.1
Weekday Days	8741.8 ± 3212.6	7817.2 ± 4015.9*

*P < 0.05 compared to before spring break

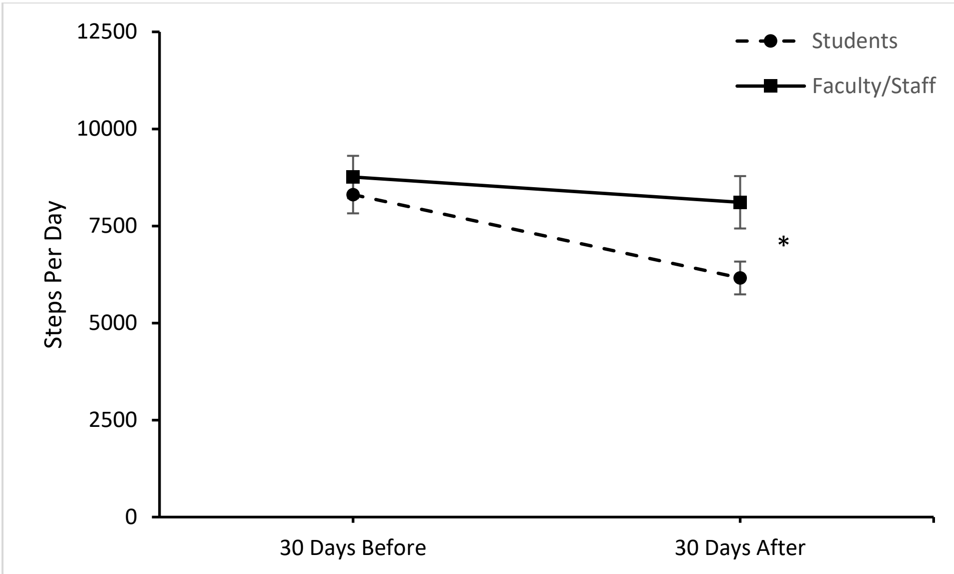

Figure 1: Average step count 30 days before and after the transition for students (n = 42) and faculty/staff (n = 38)
*P = 0.002 indicating a significant group by time interaction

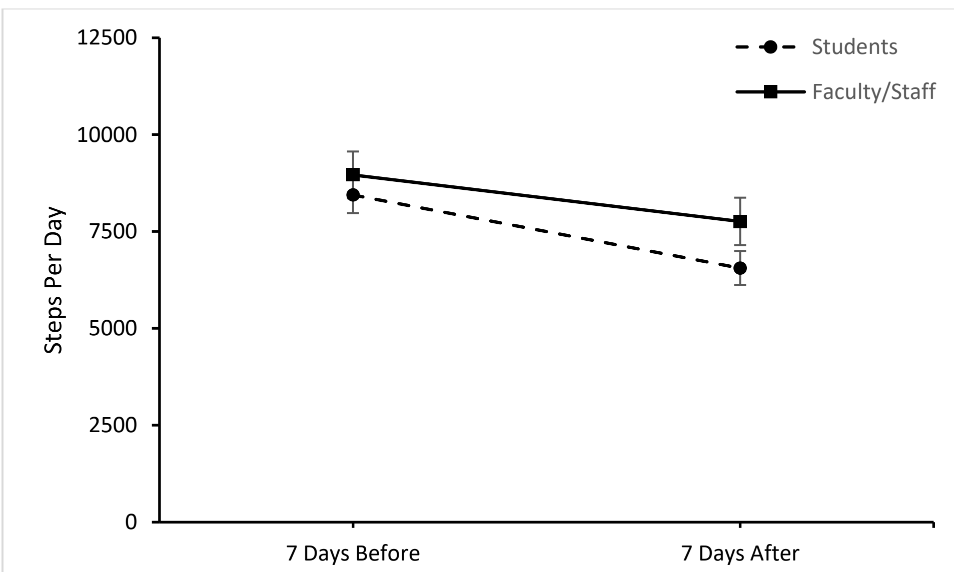

Figure 2: Average step count 7 days before and after the transition for students (n = 42) and faculty/staff (n = 38)

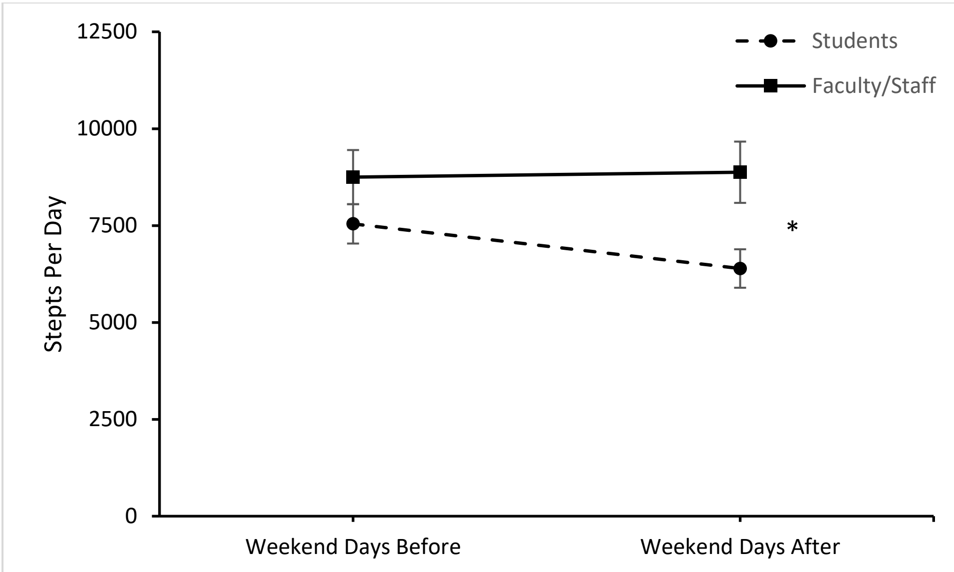

Figure 3: Average step count for weekend days before and after the transition for students (n = 42) and faculty/staff (n = 38)
*P = 0.010 indicating a significant group by time interaction

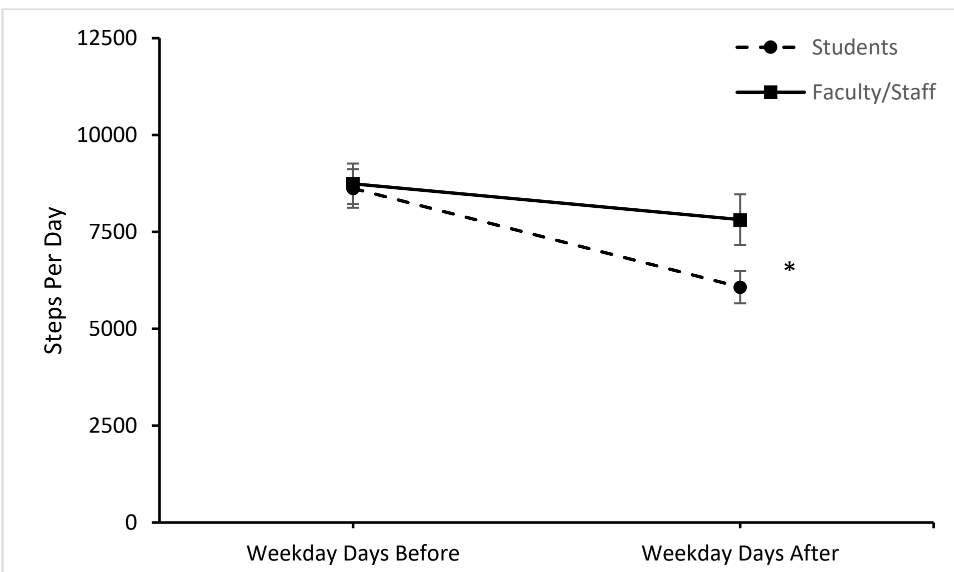

Figure 4: Average step count for weekday days before and after the transition for students (n = 42) and faculty/staff (n = 38)
*P = 0.003 indicating a significant group by time interaction

Appendix A. Informed Consent

Project Title: Physical Activity in a University Community Before and After a COVID-19 Pandemic

"Web" / "Email" Consent to Participate in Research (confidential research)

Identification of Investigators & Purpose of Study

You are being asked to participate in a research study conducted by Brynn Hudgins BS and Trent Hargens PhD, from James Madison University (JMU). The purpose of this study is to examine the impact that the COVID-19 shutdown of James Madison University after spring break 2020 impacted the physical activity habits as individuals began to work remotely and stay closer to home. This study will contribute to the researcher's completion of her master's thesis, as well as increase our understanding as to how an increase in remote working can impact the physical activity habits of university students, staff and faculty. This may have implications on long term health outcomes.

Research Procedures

This study consists of an online survey that will be administered to individual participants through Qualtrics. The researchers are recruiting individuals who own and regularly wear, Fitbit devices that track physical activity. You will be asked to access your Fitbit account and go into the history of your tracked days in that database, and then use that history to answer a series of questions on the Qualtrics survey. In short, you will be asked to provide physical activity data for the 30 prior to JMU's Spring Break 2020, as well as physical activity data for the 30 days after JMU's Spring Break 2020. Should you decide to participate in this confidential research you may access the anonymous survey by following the web link located under the "Giving of Consent" section.

Time Required

Participation in this study will require no more 60 minutes of your time.

Risks

The investigator does not perceive more than minimal risks from your involvement in this study (that is, no risks beyond the risks associated with everyday life).

Benefits

There are no direct benefits to the participant for participating in this study, other than the potential impact that a review of past physical activity habits may have on current habits. Additionally, your participation will assist a Researcher in completing her master's thesis, in a time when human subject research is at a minimum.

Confidentiality

The results of this research will be presented at scientific conferences and published in a peer reviewed journal. While individual responses are anonymously obtained and recorded online through Qualtrics, a secure online survey tool, data is kept in the strictest confidence. Responding participant's email addresses will be tracked using Qualtrics for follow-up notices, but names and email addresses are not associated with individual survey responses. The researchers will know if a participant has submitted a survey, but will not be able to identify individual responses, therefore maintaining anonymity for the survey. The results of this project will be coded in such a way that the respondent's identity will not be attached to the final form of this study. Aggregate data will be presented representing averages or generalizations about the responses as a whole. At no time will your name be identified with your individual data. The researcher retains the right to use and publish non-identifiable data. No paper data will be utilized. All electronic data will be kept on a password-protected computer in an encrypted folder. Final aggregate results will be made available to participants upon request.

Participation & Withdrawal

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind. However, once your responses have been submitted and anonymously recorded you will not be able to withdraw from the study

Questions about the Study

If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact:

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Questions about Your Rights as a Research Subject

Dr. Taimi Castle

Chair, Institutional Review Board

James Madison University

(540) 568-5929

castletl@jmu.edu

Giving of Consent

I have read this consent form and I understand what is being requested of me as a participant in this study. I freely consent to participate. The investigator provided me with a copy of this form through email. I certify that I am at least 18 years of age. By clicking on the link below, and completing and submitting this confidential online survey, I am consenting to participate in this research.

Link to Qualtrics Survey

http://jmu.co1.qualtrics.com/jfe/form/SV_eD9KU2GoLU9K5Nz

____ _______________

Name of Researcher (Printed) Date

This study has been approved by the IRB, protocol # 21-2077.

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