The Relationship Between Stress and Exercise with Fatigue and Sleep Quality as Mediating Variables

by

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Abstract

The lack of exercise in the United States is a reason for concern, especially when examining medical issues that are becoming more prevalent such as obesity, diabetes, and cancer. The majority of Americans do not adhere to the recommended guidelines regarding exercise. One of the possible explanations for this lack of exercise is stress. Stress is a natural process that is central to daily life, however, left unchecked it may become a chronic problem. Biological, psychological, and social aspects of stress may contribute to health conditions, such as obesity and chronic fatigue. Exercise is related to stress, sleep quality, and fatigue. Evidence suggests that an increase in stress may be related to an increase in fatigue and lower levels of exercise. The present study examined the relationships among stress, sleep, fatigue, and exercise. Sixty-eight undergraduate students at the University of Michigan-Dearborn completed measures concerning perceived stress, fatigue, and sleep quality and also wore a Fitbit Flex for one continuous week to record steps and sleep quality. Although several significant correlations were found between study variables, data did not support a relationship between perceived stress and exercise.

Chapter I

Introduction

Exercise is a broad term for various types of physical activity that have the potential to improve the health of people in general. Exercise can be anything from walking, to weight lifting, to running a marathon. There are many opinions regarding what types of exercise are the "best", however one thing is generally agreed upon: exercise is an underutilized health tool. For the purposes of the present study, exercise will be defined as number of steps taken per week. According to the 2015 American Time Use Survey (ATUS), a project undertaken by the Bureau of Labor Statistics, the average American civilian spends only 0.31 hours per day (18.6 minutes per day) participating in sports, exercise, and recreation. Results differ slightly when examining men and women separately, however the results are still low, averaging 0.39 hours per day for men and 0.22 hours per day for women. The Bureau of Labor Statistics (2015) also reveals that only 20.4% of the civilian population participates in sports, exercise, and recreation on a daily basis.

When compared to the guidelines set forth by the National Institute of Health (NIH), it becomes clear that Americans do not exercise at an adequate level. In addition to only 20.4% of the U.S civilian population participating in exercise on a daily basis, the U.S population on average does not exercise for adequate amounts of time. The NIH recommends that the average adult should engage in at least 60 minutes of moderate-intensity aerobic exercise per week to obtain any small health benefit. It seems that 20.4% of the population meets this suggestion, however, to obtain significant health benefits the NIH recommends that the average adult should aim for 150 minutes of moderate-intensity aerobic exercise per week, and for maximum health benefits, this suggestion increases to 300 minutes of moderate-intensity aerobic exercise. In general, the American population falls short of these suggestions.

In addition to missing out on the health benefits exercise can provide, populations that are less physically active tend to have lower consumption rates of fruits and vegetables, higher rates of influenza related hospitalizations, and higher rates of obesity (Charland, Buckeridge, Hoen, Berry, Elixhauser, Melton, & Brownstein, 2012). Furthermore, weight gain is a problem for those who do not exercise. Additional concerns due to lack of exercise include coronary heart disease (CHD), diabetes, and cancer. In general, populations that demonstrate lower rates of physical activity appear to have more health concerns overall.

In contrast, those who obtain adequate levels of exercise tend to maintain a healthy weight, and have a lower risk for depression, CHD, diabetes, cancer, and other diseases, according to the NIH. It has also been shown that increased rates of exercise strengthen the heart and improve lung functioning. In addition, the general prevention of disease, improvement of symptoms of existing chronic disease, and reduction of negative drug side effects are possible with adequate exercise (Dirks-Naylor, Griffiths, Gibson, & Luu, 2016). Since there are significant health benefits that can result from exercise, one can begin to wonder why more Americans do not engage in exercise and/or exercise long enough to reap these rewards. Several obstacles may obstruct the path to healthy living, resulting in the dismal numbers reported in the ATUS.

One potential obstacle could be exercise culture (or the lack thereof) in general. Society may be trending toward taking pills and undergoing medical interventions in order to improve well-being (Konde, Jairam, Peethambar, Noojady, & Kumar, 2016; Murray & Amin, 2014; Webster, 2017). For example, not a single pharmacy school in the U.S offered courses regarding the role of exercise in disease prevention (Dirks-Naylor et. al., 2016). The rise of the use of pharmacological interventions in the U.S. population could be one of the factors that sets Americans back in the quest for healthier living. Another significant obstacle could be the impact psychological stress has on people in general.

Theories of Stress

One of the basic stress responses is the “fight or flight” reaction to immediate stressors. This model of stress was proposed by Walter Cannon and asserts that an acute stress response occurs when an individual is confronted with immediate harm and involves a series of biochemical cascades that result in either a “fight” (defensive) reaction or “flight” (escape) reaction (Cannon & de la Paz, 1911). This mechanism that promotes the acute form of stress is the sympathetic-adrenal-medullary (SAM) system and is responsible for the fast onset of the “fight or flight” reaction to stimuli that is threatening (Kemeny, 2003). In addition to the SAM system, the immediate activation of the hypothalamic-pituitary-adrenal (HPA) system is also responsible for this acute stress reaction. It is clear that having this type of stress reaction is advantageous when escaping or confronting a threatening situation, although generally this activation is short lived and long term harmful effects on the body are not overly prominent.

Harmful effects of stress can result from the prolonged activation of the HPA system. This system promotes the long lasting reaction to stress and results in greater harm to the body. However, it should be noted that repeated activation of both the SAM and HPA systems can result in harm to the body. The SAM system and prolonged activation of the HPA system are part of another widely known model of stress, the General Adaptation Syndrome (GAS) proposed by Hans Selye. This model involves three stages of the stress response: alarm, resistance, and exhaustion (Selye, 1950). In the alarm stage, individuals experience the “fight or flight” response and an accompanying burst of energy to either defend themselves or flee the threat. The resistance stage takes this response further by asserting that the body will further propagate this initial stress response by activating the HPA system. Finally, during the exhaustion stage, the body can no longer sustain this response and is depleted of energy. Stress responses of this nature are more likely to result in physical damage. Activation of this system results in the release of cortisol (a common stress hormone) into the blood (Kemeny, 2003). Circulating cortisol is responsible for delayed stress responses, and prolonged exposure to higher levels of this hormone can result in organ and tissue damage as well as other problems such as cognitive decline and premature aging.

Departing slightly, although not completely from the previous models of stress, the stress model of allostasis was proposed by Sterling and Eyer in 1988. This model asserts that the stress regulation process is more complex than just a “fight or flight” reaction and can exist on a longer-term basis than the GAS. In general, allostasis encompasses the idea that the central nervous system is constantly monitoring the balance between internal resources in the body and external demands the environment is placing on the individual (Ganzel, Morris, & Wethington, 2010). In addition, because of the load of external stressors, the individual will compensate by adjusting internal physiological systems which allows the individual to adapt to stressors over time. This model, in particular, makes sense when considering medical phenomena where people are functioning with higher than average levels of components such as blood sugar, blood pressure, toxin levels, etc. This type of functioning promotes stability through change, meaning that although various internal and/or external variants may be changing, the body compensates in order to establish stability.

In addition to the models of Cannon, Selye, and Sterling and Eyer, stress has been conceptualized as a transactional process by which individuals perceive, process, and physically, as well as mentally, respond to stimuli that they may appraise as threatening (Lazarus & Folkman, 1984). The transactional model is congruent with the aspects of stress that are investigated throughout this paper. The effects of Lazarus' transactional process may be positive or negative. One of the key factors of this model is the influence of the appraisal of the stressors encountered. People can make three appraisals: irrelevant, benign-positive (challenging), or stressful (threatening). If an individual makes an "irrelevant" appraisal, this means the situation being appraised does not apply. If an individual makes a "benign-positive" appraisal, this means the stressor may cause distress but the person has appropriate coping resources to overcome the stressor and to grow from the experience. If an individual makes a "stressful" appraisal, then the stressor poses real harm to the individual and adequate coping resources may not be available. If a stressor is appraised as "stressful" and the individual does not have appropriate resources, then negative effects of stress may be experienced, such as sustained psychological distress with a continued stress response.

Such transactional models suggest that the stress experience is more than a physical change in response to a stimulus. The experience of stress includes biological, psychological, and social processes. Biologically, this process includes the HPA and SAM systems mentioned earlier. These pathways orchestrate organ responses to alter hormones in the body to produce crucial bodily reactions to stressors. The biological mechanisms of stress also interact with the psychosocial factors of stress, being appraisals of various life experiences and the evaluation of available coping resources. Some experiences that may evoke a prolonged stress response and tax an individual's ability to manage this stress include major life events, environmental stressors, work related stress, and social interactions. Given prolonged stress with inadequate coping resources, when large changes occur and stress levels are significantly elevated, vulnerability to health risks increases (Rahe, Mahan, & Arthur, 1970). Situations such as divorce or the death of a loved one may result in chronic stress that may contribute to sickness or cause other health problems. Similarly, catastrophes (such as the 9/11 terror attacks) can significantly alter stress levels and pose serious health consequences Even daily environmental factors can influence stress levels, such as pollution, urban crowding, discrimination, etc.

However, stress is not a universal experience across all individuals and many different situations may arise that trigger the stress response. According to the transactional model of stress, this may be due to the many appraisals an individual can make regarding the stressor. What is perceived as threatening or challenging to one person may be perceived as irrelevant to another. Although stress is generally viewed as a negative concept, there are several mechanisms that can alleviate the harmful effects stress may impose on the body. In much the same way that the stress experience is idiosyncratic, so might the coping mechanisms selected. Certain strategies may work more efficiently for some individuals compared to others. Research evidence suggests that increased social support can decrease stress, loneliness, and even lessen fatigue (Kwag, Martin, Russell, Franke, & Kohut, 2011). The authors also suggest that physical activity and social support were mediators of the relationship between mental health and stress. Findings such as these can positively influence potential stress management and treatment programs.

These concepts and examples encapsulate the integration of biological, psychological, and social influences on the stress process. Knowing this, we can examine how stress may cause health issues and/or put people at risk for health issues, specifically fatigue. One study found that when perceived stress increased along with the perception that stress influenced health, poorer health outcomes were found (Keller, Litzelman, Wisk, Maddox, Cheng, Creswell, & Witt, 2012). This means that those who believed that their stress levels were high and that their stress levels impacted their health, had poorer health overall. This is an interesting finding because it demonstrates that psychological processes and personal insight can alter an individual's health based on whether or not that individual believes they are stressed and whether or not they believe this affects their health. A mere belief, or appraisal, can influence physical health conditions.

The Relationship Between Stress and Exercise

It has been demonstrated that exercise can lower stress levels in individuals (van der Zwan, de Vente, Huizink, Bogels, & de Bruin, 2015). In addition, while exercise can lower stress levels, there are also concurrent cognitive benefits, including increased stress-coping abilities in individuals that engaged in exercise (Collins, Hill, Chandramohan, Whitcomb, Droste, & Reul, 2009). Another study found that exercise actually reduced stress-induced cognitive impairment (Nakajima, Ohsawa, Ohta, Ohno, & Mikami, 2010). In a study examining older adults and the accumulation of a lifetime of stress, researchers found that those who were considered "low exercise engagement individuals" had greater cognitive declines due to stress compared to those who were "high exercise engagement individuals" (Head, Singh, & Bugg, 2012). In addition, this study suggests that the general benefits of exercise might include reducing the negative consequences of stress involving the hippocampus and memory (Head, Singh, & Bugg, 2012). Since exercise can strongly influence the impact of stress, generally with increased levels of exercise resulting in lowered levels of stress and/or cognitive improvements, it is possible stress can also influence exercise.

The literature examining the impact of stress on exercise is sparse compared to the literature examining the impact of exercise on stress. It is possible for stress to impair the ability/desire to exercise, perhaps through mechanisms of decreased self-control and/or a decreased self-regulatory behaviors (Oaten & Cheng, 2005; Plessow, Kiesel, & Kirschbaum, 2012). This means stress may impair one's ability to monitor and control one's own thoughts and behaviors. Extrapolating to exercise, if the ability to monitor and control thoughts and behaviors is impaired, then the ability to decide to exercise as well as engage in exercise may also be impaired. Stress can also impair one's self-control abilities at the neuronal level by enhancing the pleasure of immediate rewards and reducing the effectiveness of areas in the brain that promote behaviors relating to long term goals (Maier, Makwana, & Hare, 2015). This indicates stress may enhance the attractiveness of immediate rewards as opposed to greater, future rewards. Consistent with the transactional model of stress, it is also possible stress appraisals have an impact on exercise, although this has not been thoroughly researched at this time. It is difficult to find empirical studies that investigate stress appraisals relating directly to exercise habits, although it would make sense to conceptualize the relationship as an individual's stress appraisal having either a positive or negative impact on the ability/desire to exercise. Although individual variation is expected, it is hypothesized that challenging or threatening stress appraisals will have a negative impact on exercise habits. This is expected because the transactional model of stress describes challenging or threatening appraisals as needing attention and resources in order to cope effectively (Lazarus & Folkman, 1984). The idea is that threatening or challenging appraisals from individuals will warrant most of their attention and less resources will be available to devote to exercise. The relationship between stress and exercise may be bidirectional, however, the impact of stress on exercise will be emphasized throughout this paper.

The Integration of Fatigue and Sleep Quality

Another health condition that appears to be strongly influenced by stress is fatigue. Fatigue is the sensation of tiredness that does not seem to be alleviated by rest with or without other physical symptoms present (Lattie, Antoni, Fletcher, Penedo, Lopez, Perdomo, Sala, Nair, Fu, & Klimas, 2012). Many empirical studies demonstrate that fatigue is negatively influenced by stress and vice versa. It has been suggested that fatigue is most associated with perceived stress and perceived health status (Kocalevent, Hinz, Brahler, & Klapp, 2011). Thus, with increased stress there is an increased risk for chronic fatigue. This study also suggests that fatigue can be triggered by perceived stress and alter functioning within the individual. Knowing that the SAM and HPA systems evoke biological cascades that alter organ function which can result in damage to the body (in particular the HPA system), it is apparent that these processes can wear down the body. It has been demonstrated that increased stress leads to an increased risk for chronic fatigue, specifically because stress systems that are constantly active are going to fatigue the body (Kocalevent, Hinz, Brahler, & Klapp, 2011).

Chronic fatigue is viewed as a long term illness which results in impairment of functioning across many areas of life. This impairment can negatively impact perceived stress (reciprocally) and quality of life (Taylor, Jason, Shiraishi, Schoeny, & Keller, 2006). In addition to these impairments, two areas of functioning that are strongly influenced by fatigue are cognitive functioning and sleep. Higher levels of fatigue are associated with negative impacts on cognitive functioning (Palmer, Economou, Cruz, Abraham-Cook, Huntington, Maris, Makhija, Welsh, & Maley, 2014). In the same study, it was demonstrated that controlled sleep schedules resulted in cognitive benefits, in essence, improved sleep also improved cognitive functioning. Other empirical studies demonstrate variants of this phenomenon as well. A study by Kunert, King, and Kolkhorst (2007) examining nurses and their levels of fatigue demonstrated that poor sleep quality was a contributing factor to fatigue. In another study by Lichstein, Means, Noe, and Aguillard (1997) they described decreased sleep efficiency as a variable that actually predicts fatigue. They also found that increased levels of fatigue were prevalent among sleep disorder patients. It is clear that sleep and fatigue share a relationship. This is a significant implication because it is already believed that perceived stress influences fatigue, and if sleep influences fatigue as well it is possible that sleep and perceived stress are also related.

The Integration of Exercise, Stress, Fatigue, and Sleep Quality

The relationship between exercise and perceived stress becomes more complex with the addition of fatigue and sleep. It is believed that fatigue negatively impacts exercise in the sense that it becomes harder for the individual to exercise, and exercise is viewed as an activity that requires heightened levels of effort mentally and physically. In a study by Marcora, Staiano, and Manning (2009) where participants were given a cognitive task to induce mental fatigue and asked to exercise to exhaustion, the mentally fatigued participants disengaged from the physical exercise task quicker than the non- mentally fatigued participants. The mentally fatigued participants also reported significantly higher levels of effort required to engage in the physical exercise activity in the first place. Evidence like this suggests that fatigue acts as a mental hurdle to exercise.

Other studies have examined these exercise “barriers” and “motivators” in further detail. For instance, in a study examining cancer-related fatigue in recovering cancer patients, it was found that barriers to exercise include treatment side effects, more specifically, physical fatigue (Blaney, Lowe-Strong, Rankin, Campbell, Allen, & Gracey, 2010). These patients find it difficult to engage in exercise due to fatigue. This study also described exercise motivators as perceived exercise benefits. If exercise benefits are perceived, it may lessen the effects of the barriers to exercise. More specifically, concerning those with Chronic Fatigue Syndrome, these patients were generally physically weaker, had a decreased exercise capacity, and perceived greater levels of effort required to exercise (Fulcher & White, 2000). Since it is believed that perceived stress, sleep, fatigue, and exercise are interrelated in their influence on health conditions, methods to correct these dysfunctions should be discussed.

Treatments

Cognitive behavioral therapies (CBT) have been suggested when treating stress and fatigue. It has been found that after implementing a stress management program, negative perceptions of stress and fatigue decreased (Lattie, Antoni, Fletcher, Penedo, Czaja, Lopez, Perdomo, Sala, Nair, Fu, & Klimas, 2012). Another major cognitive therapy that has shown promising results is mindfulness-based stress reduction therapy (MBSR). This therapy involves recognizing negative thoughts and helping patients gain psychological flexibility in the sense of realizing that negative thoughts do not control their lives. It was shown that MBSR helped significantly reduce sleep disturbances, stress, mood disturbances, and fatigue (Carlson & Garland, 2005).

Although the relationship between exercise, sleep, stress, and fatigue has not been investigated extensively, it is possible that exercise itself may reduce levels of stress and fatigue. In the study by Blaney and others (2010) that identified exercise barriers and motivators, the researchers also identified exercise “facilitators” that improved outcomes in regards to stress and fatigue. This study demonstrated that certain facilitators such as having group-based, supervised, and gradually implemented exercise programs could increase participation and reduce fatigue levels.

Direction of the Current Study

The relationship between exercise and perceived stress is empirically supported, as described above. Research solidly supports the relationship between exercise and stress with increased exercise resulting in lower levels of stress. However, the relationship between stress and exercise (i.e., increased levels of stress negatively impact exercise) is not as solidly supported. Further research on this relationship may provide some insight as to why many Americans do not engage in exercise according to the guidelines set forth by the NIH. The relationship between fatigue and sleep quality is also supported, as described above, with sleep disturbances generally resulting in higher levels of fatigue. This also suggests complex relationships among stress, fatigue, and sleep quality. The relationship between exercise and stress is apparent, although the role of fatigue as a mediating variable between these two factors has not been fully investigated. It is difficult to find empirical research that examines the relationships between stress, sleep quality, fatigue, and exercise as a whole.

Since there is limited research investigating all four of these variables, the present study investigates these relationships. For the purposes of this study, exercise as a cardio construct of physical activity is investigated. Exercise is defined as number of steps per week. Walking is one of the simplest and most cost-friendly types of exercise, and many health benefits can be garnered from it, such as risk reductions for hypertension, diabetes, hypercholesterolemia, and even CHD (Williams & Thompson, 2013). Specifically concerning older adults, a 12-week walking resulted in cardiovascular health benefits (Park, Miyashita, Takahashi, Kawanishi, Hayashida, Kim, Suzuki, & Nakamura, 2014). Furthermore, research indicates that walking increases positive affect, specifically outdoor walks (Focht, 2009). Taking into account the health benefits that can be garnered from walking as well as the cost-friendly and simplistic nature of this form of exercise, walking was an attractive form of exercise to examine. Coupled with the use of the Fitbit trackers and lack of funds for more intricate equipment, tracking exercise by the measurement of daily steps made the most sense. In addition, perceived stress will be investigated as opposed to other constructs of stress because perceived stress is more closely aligned with stress appraisals and the transactional model of stress, the model of stress being used in this study. Utilizing this construct of stress allows for the incorporation of a biopsychosocial approach instead of merely counting stressful life events. Three main hypotheses are investigated in this study. Hypothesis 1: Increased levels of stress will predict lower levels of exercise, higher levels of fatigue, and poor sleep quality. Hypothesis 2: The association between stress and exercise will be partially mediated by sleep quality. Hypothesis 3: The association between stress and exercise will be partially mediated by fatigue.

Chapter II

Methods

Participants

Participants were recruited from the voluntary subject pool at the University of Michigan-Dearborn. The participants were informed about the SONA recruitment website through their psychology professors. By participating in the present study, participants were awarded undergraduate course credit for introductory psychology courses.

Exclusion criteria includes disorders/syndromes that may interfere with accurate measurements of stress and/or fatigue levels. Participants with any mental disorder, Chronic Fatigue Syndrome (CFS), any sleep disorder, and those using prescription medications that may alter sleep or fatigue levels were excluded. Participants using seasonal allergy medications were included in the study and listed in the demographic information section.

Sixty-eight undergraduate students from the University of Michigan-Dearborn participated in the present study, 33 were male and 35 were female. The ages of the participants ranged from 18-50 years old with an average age of M=19.9 years old (SD=4.29). Forty-three students were enrolled in their first academic year; 13 students in their second year; seven, in their third year; two students in their fourth year; and three students were enrolled in their fifth+ academic year. These participants identified as Caucasian (n=32), Middle Eastern (n=21), Asian/Pacific Islander=4), African American (n=6), Hispanic/Latino (n=3), and Caucasian and Asian/Pacific Islander (n=2).

Measures

Eligibility and Demographics questionnaire. (Appendix A) This form was completed by all participants in order to determine whether they were able to participate or not, based on the exclusion criteria listed above. This 11-item form also asked questions regarding age, academic year, ethnicity, gender, and employment status.

Perceived Stress Scale- 10 Item (PSS-10). (Appendix B) In order to determine participants' general stress levels, each participant completed the Perceived Stress Scale-10 (PSS-10), a ten-item questionnaire that examines people's feelings and thoughts regarding stressful things in their lives (Cohen, Kamarck, Mermelstein, 1983). This scale utilizes a 5-point Likert scale (0= never, 1= almost never, 2= sometimes, 3= fairly often, 4= very often) and asks participants to rate their thoughts and feelings over the prior week. Higher scores indicate higher levels of perceived stress. The PSS-10 demonstrates sound psychometric properties (Eun-Hyun, 2012; Mitchell, Crane, & Kim, 2008) as well as good validity (Ezzati, Jiang, Katz, Sliwinski, Zimmerman, & Lipton, 2014) across various populations. In the present study, the Cronbach's alpha value was 0.853, indicating a good level of internal consistency reliability. Within this sample, the average score on the PSS-10 was M=15.98 (SD=5.99). Perceived stress was measured at Time 1 and Time 2 in order to assess the test-retest reliability of this measure (i.e., if this measure is stable over the course of a week). To determine this, scores on the PSS measured at Time 1 are correlated with scores on the PSS at Time 2. The correlation was $r = 0.551$ and indicated that this particular measure of perceived stress was inconsistent (i.e., demonstrated poor reliability) over the one week period. Perhaps perceived stress is a relatively unstable construct, especially within the current sample. For instance, college students can be very stressed one week taking exams, etc., then be relatively less stressed the next week once those exams are finished. Perhaps the reliability would be stronger more longitudinally, compared to only a one week period of time. It is also possible that measuring a more concrete construct of stress, such as life events, would have resulted in a more stable measure over time.

Fatigue Severity Scale (FSS). (Appendix C) The Fatigue Severity Scale (FSS) was used to determine participants' overall level of fatigue. The FSS is a nine-item questionnaire that explores various aspects of fatigue, such as physical, motivational, and social domains. This scale utilizes a 7-point Likert scale (1= strongly disagree to 7= strongly agree) and asks participants to rate the degree to which they agree with various statements regarding fatigue. Higher scores indicate higher levels of fatigue. The FSS also demonstrates sound psychometric properties (Impellizzeri, Agosti, De Col, & Sartorio, 2013; Learmonth, Dlugonski, Pilutti, Sandroff, Klaren, & Moti, 2013; Lerdal & Kottorp, 2011) across diverse populations. In the present study, the Cronbach's alpha value was 0.857, indicating a good level of internal consistency reliability. Within this sample, the average score on the FSS was M=3.59 (SD=1.05). Fatigue Severity was measured at Time 1 and Time 2 in order to assess the test-retest reliability of this measure (i.e., if this measure is stable over the course of a week). To determine this, scores on the FSS measured at Time 1 are correlated with scores on the FSS at Time 2. The correlation was $r = 0.802$ and indicated that this particular measure of fatigue had good reliability over the one week period. It is likely that this construct of fatigue (physical fatigue) is relatively stable over a shorter period of time. The participants' fatigue levels did not appear to fluctuate much throughout the week.

Fitbit Flex Wireless Tracker. In order to measure participants' length and quality of sleep each night in the form of minutes asleep per week, as well as exercise in the form of number of steps taken per week, participants were given a Fitbit to wear around their wrists and instructed to leave it on for one continuous week. A Fitbit sleep index was calculated for each participant (total minutes asleep per week x average self-report sleep quality rating). Higher scores indicate higher quality of sleep. There is mixed research on the validity and reliability of the Fitbit (Evenson, Goto, & Furberg, 2015; Zambotti, Baker, Willoughby, Godino, Wing, Patrick, & Colrain, 2016), however research suggests the Fitbit generally demonstrated good validity and reliability overall, especially when compared to other wearable devices (Huang, Xu, Yu, & Shull, 2016; Storm, Heller, & Mazza, 2015). Within this sample, the average Fitbit sleep index score was M=1452.52 (SD=332.25). The average number of steps taken per week was M= 48328.88 (SD= 19523).

Self-report Sleep Diary. (Appendix D) A final measure, used to determine sleep length and quality of participants each night, was the completion of a sleep diary by each participant. This measure examines sleep quality more thoroughly and was useful in determining how participants perceived their average night of sleep. This diary asked participants to keep track of what time they physically got into bed each night, what time they actually fell asleep, how long they believed to be awake throughout the night (in minutes), what time they woke up, what time they physically got out of bed, whether or not they took sleeping medication, and a rating of how sound they believed their sleep to be (1= very restless, 2= restless, 3= average, 4= sound, 5= very sound). A sleep diary index was calculated for each participant (total minutes asleep per week x average self-report sleep quality rating). Higher scores indicates higher quality of sleep. Within this sample, the average sleep diary index score was M=1411.04 (SD=377.61).

Procedure

This was a two part study worth two subject pool credits. During the first part of the study, participants were greeted at the laboratory and asked to complete the consent form and demographics and screening form. The PI (Katie Krajewski) was the only person who administered consent as well as administration of all other materials throughout the study. Participants were allowed to ask questions about consent and the PI answered those questions to the best of her ability. If they consented, they were asked to complete a demographics and eligibility form. No participants were excluded. Those included in the study completed the Time 1 measures (PRT-PSS-10, PRT-FSS, PRT-CSS-M) and were assigned a Fitbit. The participants were instructed to wear the Fitbit continuously for one week, except for when showering, swimming, or engaging in any activity in a body of water. Participants were instructed to wear their Fitbits throughout each night as well. Participants were also instructed on how to complete a sleep diary and asked to complete the sleep diary for each night's sleep. After all consent forms and Time 1 measures were completed, Fitbits were assigned, sleep diary instructions were given, and then participants were dismissed from the meeting.

Participants collected data for one week and returned to the laboratory for the second part of the study. Participants were greeted at the laboratory and asked to return the Fitbits, and turned in their sleep diaries, and completed Time 2 measures for the PSS-10, and the FSS. If participants did not attend the second lab meeting or did not return the Fitbit, the second credit was not awarded. After completion of the Time 2 measures and Fitbit collection, participants were debriefed, awarded their second subject pool credit, and dismissed.

Data Collection and Storage

Time 1 and Time 2 data were linked via participant number. Each participant was assigned a number (which was marked on each questionnaire) that corresponded to a Fitbit number. Participant number and Fitbit number were recorded in a log that did not include participant names. In order to award Sona credit, participants were asked for their names, but their names were not recorded anywhere that could be linked to their data. During data collection, surveys, consent forms, and unused Fitbits were stored in a locked laboratory. Once data were entered into SPSS, the physical surveys were destroyed. Electronic data is stored on a secure computer.

Chapter III

Results

Bivariate correlation was used to test Hypothesis 1 and the Hayes Process Model (2013) was used to test Hypotheses 2 and 3. A process analysis mediation model was used to examine fatigue as a mediator between stress and exercise. Sleep quality (operationalized with Fitbit data and with self-report sleep diaries) as a mediator between stress and exercise was also examined. Since the present study was not meant to measure an intervention, only Time 1 measures were used in all analyses. Table 1 presents descriptive statistics for the study variables.

Hypothesis 1: *Increased levels of stress will predict lower levels of exercise, higher levels of fatigue, and poor sleep quality.*

Table 2 shows the correlations between levels of stress, exercise, fatigue, and sleep quality. Scores on the PSS-10 and FSS indicate stress and fatigue were positively correlated ($r = 0.457$, $n = 68$, $p < 0.01$) suggesting that those who experienced greater levels of stress also experienced greater levels of fatigue. Scores on the PSS-10 and the Fitbit Sleep Index indicate stress and sleep quality reported by the Fitbits were negatively related ($r = -0.320$, $n = 6$, $p < 0.05$) suggesting that those who experienced greater levels of stress had poorer sleep quality. Scores on the PSS-10 and the Sleep Diary Index indicate stress and self-report sleep quality were negatively correlated ($r = -0.287$, $n = 66$, $p < 0.05$) suggesting that those who experienced greater levels of stress had poorer sleep quality. Finally, scores on the Fitbit Sleep Index and Sleep Diary Index were positively correlated *($r= 0.631$, $n= 60$, $p<0.01$)* suggesting that those who reported higher sleep quality on the self-report measure also had higher sleep quality as reported by the Fitbit, and vice versa. Exercise was not significantly correlated with stress, fatigue, or sleep quality.

Hypothesis 2: *The association between stress and exercise will be partially mediated by sleep quality.*

The Hayes Process model was used to test for mediation effects. Sleep quality was measured in two ways - using the Fitbit data and by self-report sleep diary. As seen in Table 3, the total effect of stress on exercise, mediated by sleep quality as measured by the Fitbit ($t= -0.48$, $SE= 436.50$, $p>0.05$) was not significant. The direct effect of stress on exercise ($t= -0.81$, $SE= 459.87$, $p>0.05$) was not significant nor was the indirect effect of stress on exercise ($z= 0.95$, $SE= 190.77$, $p>0.05$). As seen in Table 4 the total effect of stress on exercise mediated by sleep quality measured by the sleep diary ($t= -0.53$, $SE= 423.92$, $p>0.05$) was not significant. The direct effect of stress on exercise ($t= -0.41$, $SE= 445.18$, $p>0.05$) was not significant nor was the indirect effect of stress on exercise ($z= -0.29$, $SE= 160.66$, $p>0.05$). These results suggest that sleep quality does not mediate he relationship between stress and exercise, failing to support Hypothesis 2.

Hypothesis 3: *The association between stress and exercise will be partially mediated by fatigue.*

As seen in Table 5 the total effect of stress on exercise mediated by fatigue ($t= -0.57$, $SE= 403.20$, $p>0.05$) was not significant. The direct effect of stress on exercise ($t= -1.06$, $SE=$

451.11, $p>0.05$) was not significant nor was the indirect effect of stress on exercise ($z= 1.12$, $SE= 190.99$, $p>0.05$). These results suggest that fatigue does not mediate between stress and exercise.

Chapter IV

Discussion

Engaging in adequate levels of exercise is a problem across the United States. As reported by the 2015 American Time Use Survey (ATUS), a project undertaken by the Bureau of Labor Statistics, Americans are not exercising to the standards put forth by the National Institute of Health (NIH). The lack of exercise can contribute to many medical conditions, such as obesity, diabetes, and cardiovascular disease. Perceived stress may play a key role in this lack of exercise.

Several mechanisms of stress have been explained by various researchers. One of the basic stress responses is the “fight or flight” reaction to immediate stressors. Proposed by Walter Cannon, this model of stress asserts that a stress response occurs when an individual is confronted with immediate harm and involves a series of biochemical cascades that result in either a “fight” (defensive) or “flight” (escape) reaction (Cannon & de la Paz, 1911). This mechanism promotes the acute form of stress and involves the SAM system within the body (Kemeny, 2003) and the immediate activation of the HPA system. This activation is generally short lived and long term harmful effects on the body are not as likely with activation of this stress system, unless repeated activation occurs. However, harmful effects of stress can result from prolonged activation of the HPA system. This system promotes the long lasting reactions to stress. The SAM and HPA mechanisms are part of another widely known model of stress, the General Adaptation Syndrome (GAS) proposed by Hans Selye. This model involves three stages of the stress response: alarm, resistance, and exhaustion (Selye, 1950). The alarm stage involves the “fight or flight” response as described above. The resistance stage takes this response further by propagating this initial stress response by activating the HPA system. During the exhaustion stage, the body can no longer sustain this response and is depleted of energy. Activation of this system results in the release of cortisol (a common stress hormone) into the blood (Kemeny, 2003). Circulating cortisol is responsible for delayed stress responses, and prolonged exposure to higher levels of this hormone can result in damage to the body.

Another stress model, the stress model of allostasis, was proposed by Sterling and Eyer in 1988. This model explains that the stress regulation process is more complex and can actually exist on a longer-term basis than the GAS. Allostasis asserts that the central nervous system is constantly monitoring the balance between internal resources in the body and external demands the environment is placing on the individual with the goal of maintaining stability through change (Ganzel, Morris, & Wethington, 2010). If the load of external stressors becomes greater, the individual will compensate by adjusting internal physiological systems which allows the individual to adapt to these stressors over time. Stress has also been conceptualized as a transactional process by which individuals perceive, process, and physically, as well as mentally, respond to stimuli that they may appraise as threatening (Lazarus & Folkman, 1984). This model of stress is more congruent with the aspects of stress that are investigated throughout this paper. The basis of this model is the influence of peoples’ appraisals of the stressors they may encounter. People can make three appraisals: irrelevant, challenging, or threatening. If something is perceived as challenging or threatening, then individuals assess whether or not they have appropriate coping resources to handle the stressor. If the individual does not have appropriate resources, then the negative effects of stress will be experienced, for example, prolonged psychological distress. A transactional model of stress indicates that the stress experience is biological, psychological, and social in nature, as opposed to only physical reactions. This study was designed to examine perceived stress and how that may influence an individual's tendency to exercise. Since the goal was to examine perceived stress, the transactional model of stress which utilizes appraisals (individual perceptions) of stressors was the most appropriate model. These appraisals may also influence and/or be influenced by levels of fatigue and sleep quality. For instance, if an individual is fatigued or sleep deprived, their appraisals of stressors may be significantly different from someone who may be energized and well rested. Overall, this study was not designed to illicit a "fight or flight" reaction, so the transactional model made the most sense since it incorporates physical as well as psychological reactions to stress.

The relationship between stress and exercise may be a bidirectional relationship, however research more thoroughly supports exercise and its impact on stress as opposed to stress and its impact on exercise. A potential reason for this may be because manipulating stress levels may be more difficult compared to manipulating exercise levels, thus resulting in more thorough research investigating the impact of exercise on stress. Research generally demonstrates that higher levels of exercise results in lower levels of stress (van der Zwan, de Vente, Huizink, Bogels, & de Bruin, 2015). Some research purports that higher levels of stress will impair self-regulatory behaviors and self-control (Oaten & Cheng, 2005; Plessow, Kiesel, & Kirschbaum, 2012). One can hypothesize that impairment in these abilities may also impair the ability/desire to exercise as well, although empirical support is needed.

Sleep quality and fatigue are variables that potentially operate with stress in ways that may impact exercise. Research suggests that stress and fatigue are related. It has been suggested that fatigue is most associated with perceived stress and perceived health status (Kocalevent, Hinz, Brahler, & Klapp, 2011). Those with higher levels of stress have an increased risk for chronic fatigue. It has also been demonstrated that greater stress levels lead to an increased risk for chronic fatigue, specifically because stress systems that are constantly active will fatigue the body (Kocalevent, Hinz, Brahler, & Klapp, 2011). Sleep quality also relates to these variables. A study by Kunert, King, and Kolkhorst (2007) examining nurses and their levels of fatigue demonstrated that poor sleep quality was a contributing factor to fatigue. In a study by Lichstein, Means, Noe, and Aguillard (1997) decreased sleep efficiency predicted fatigue. It is apparent that sleep and fatigue share a relationship. Since it is suggested that perceived stress influences fatigue, and sleep influences fatigue as well, sleep and perceived stress may play a role in exercise level. Research is sparse when it comes to investigating these four variables in combination. Often studies examine parts of these relationships or only a few of these variables at a time. The goal of the present study was to assess perceived stress as a possible factor influencing exercise and to determine whether sleep quality and fatigue may act as mediating variables within that relationship.

Hypothesis 1

It was expected that increased levels of stress would predict lower levels of exercise, higher levels of fatigue, and poor sleep quality. Restriction of range is a concern with the existing data set. That is, stress and fatigue levels were low to moderate with no participant indicating high levels of stress and fatigue. There is the possibility that the participants were not experiencing a true “threat” at any point throughout the one week period, which may be why the sample had relatively lower stress scores. In addition, it appears that the sample was composed of relatively low exercisers, only obtaining an average of approximately 6,904 steps per day. This raises the possibility of a restriction of range effect throughout multiple variables, with the sample data clustering around the center of a normal distribution. Scores settling around the middle are less likely to show any type of significant relationship. It is possible that the current sample was not representative or generalizable to a larger population. This may be due to the fact that students at the University of Michigan-Dearborn have a unique college experience. Since U of M-Dearborn is a commuter campus, most of the students must drive to and from school daily and daily living stressors may be lower than the typical college student residing on campus. In addition, steps may be limited with these college students because they are driving (i.e., it is not necessary to walk back and forth to class and dormitories). Other factors may also be playing a role, such as unique stressors that are associated with commuter campuses.

The link between stress and exercise was not significant. Since this link was not significant, a mediation effect was logically impossible. Perceived stress scores and fatigue scores were significantly correlated, suggesting that those with higher levels of stress tend to have higher levels of fatigue. This is consistent with past research stating that increased stress is associated with an increased risk for chronic fatigue (Kocalevent, Hinz, Brahler, & Klapp, 2011). Overactive stress systems can eventually wear down the body and deplete coping resources, thus fatiguing the body.

In addition, perceived stress scores were significantly correlated with the Fitbit Sleep Index scores, suggesting that those with higher levels of stress had decreased sleep quality as measured by the Fitbit trackers. Perceived stress scores were also significantly correlated with the Sleep Diary Index scores, suggesting that those with higher levels of stress had decreased sleep quality as measured by the self-report sleep diary. This is consistent with past research, indicating that higher stress levels tend to decrease sleep quality, especially when examining sleep onset latency times (Zoccola, Dickerson, & Lam, 2009). Specifically through a mechanism of rumination (i.e. subjects thinking about the stressor in a prolonged manner), participants who tended to ruminate more also had longer sleep onset latency times, thus decreasing their sleep quality (Zoccola, Dickerson, & Lam, 2009). Another study suggests that higher dispositional mindfulness is associated with lower levels of perceived stress as well as better sleep quality (Brisbon & Lachman, 2017). Further studies suggest that engaging in self-relaxation training can actually improve sleep quality (Jingxian, Jiaxun, Ping, & Hui, 2013).

Finally, scores on the Fitbit Sleep Index were significantly correlated with scores on the Sleep Diary Index, suggesting that those who reported better sleep quality also demonstrated better sleep quality via the Fitbit trackers, and vice versa. This is somewhat inconsistent with past research regarding validity of subjective sleep measures. Research generally indicates that subjective sleep measures do not validly correspond with objective sleep measures when examining sleep quality (Girschik, Fritschi, Heyworth, & Waters, 2012). Although the literature on this topic is mixed and also suggests that subjective measures of sleep may predict changing sleep patterns as well as objective measures (Lockley, Skene, & Arendt, 1999). In addition, research investigating the reliability of subjective sleep measures is also mixed. One study argues that sleep that is measured subjectively for five weekday nights is reliable (Short, Arora, Gradisar, Taheri, & Carskadon, 2017) while other studies argue that subjective sleep measures and objective sleep measures are measuring different dimensions of sleep and are therefore not reliable (Aili, Astrm-Paulsson, Stoetzer, Svartengren, & Hillert, 2017).

Although this hypothesis was not supported, these correlations have interesting implications. It is possible perceived stress, fatigue, and sleep quality have stronger relationships compared to perceived stress and exercise. It is also noteworthy that both sleep indices were positively correlated. This may suggest that participants are relatively accurate at judging the quality of their sleep, within the current sample.

Hypothesis 2

It was expected that the association between stress and exercise would be partially mediated by sleep quality. Findings were not significant and this hypothesis was not supported. This indicates that sleep quality was not partially mediating the relationship between stress and exercise in the present study. Given that the relationship between level of stress (X) and exercise (Y) could not be established with the current data set, sleep quality (M) could not logically serve as a mediator between X and Y. That is, a relationship between X and Y is necessary in order to examine mediation effects between them.

Several reasons might account for these non-significant findings. The current sample was relatively homogenous and made up entirely of college students. A more diverse sample in that respect may result in different findings. Although there was some age variation, the majority of the participants were in their early to mid- 20's. More variation in that respect may also result in different findings. As mentioned above, a possible restriction of range effect may have influenced the findings. It is also possible that the Fitbit tracker was not entirely accurate at tracking sleep and steps. Research has shown that these types of trackers are not absolutely accurate, although findings have been mixed (Evenson, Goto, & Furberg, 2015; Zambotti, Baker, Willoughby, Godino, Wing, Patrick, & Colrain, 2016). It is also possible that sleep quality is unrelated to the relationship between perceived stressed and exercise. Sleep quality may not be completely unrelated to the interaction between stress and exercise, but it is possible it may not play a big enough role alone and may be interacting with several other factors.

Hypothesis 3

It was expected that the association between stress and exercise would be partially mediated by fatigue. Findings were not significant and this hypothesis was not supported. Thus, Hypothesis 3 was not supported. Fatigue did not mediate between stress and exercise in the present study. Given that the relationship between level of stress (X) and exercise (Y) could not be established with the current data set, fatigue (M) could not logically serve as a mediator between X and Y. That is, a relationship between X and Y is necessary in order to examine mediation effects between them.

Several reasons might account for this finding such as, again, the issues with the current sample described above including a restriction of range effect. A more diverse and representative sample concerning age, occupation, stress levels, and exercise levels may result in different findings. It is also possible that fatigue is unrelated to the relationship between perceived stress and exercise. Although fatigue may not be completely unrelated to this interaction, it may not play a big enough role alone and, again, may be interacting with several other factors.

Exercise as a Coping Strategy

While there is little research investigating the possibility of exercise as a coping strategy, perhaps because experimentally manipulating stress levels is a difficult thing to do, it is possible the initial conceptualization of the stress-exercise relationship in this paper is not accurate.

Instead of stress having a direct negative impact on exercise (i.e. greater levels of stress indicates lower levels of exercise), exercise may be better explained as a coping strategy.

Cross-sectional survey research indicates that 40% of the sample studied endorsed utilizing exercise as a coping mechanism for stress (Cairney, Kwan, Veldhuizen, & Faulkner, 2014). These participants were then more likely to endorse other "positive" and less harmful methods of coping (i.e not alcohol or drug usage). It is possible that exercise as a coping mechanism may be an intrinsic quality and a form of emotion-focused coping. Since the correlations between stress and fatigue as well as stress and sleep quality were significant within the current sample, yet the relationship between stress and exercise was not direct or significant and simultaneously contradicts past research, this may indicate that the relationships amongst these variables may not be strictly linear. Participants that score low on stress measures may be low exercisers while participants that score high on stress measures may be low exercisers as well, or some variation that is different than expected, perhaps fitting better within a quadratic model rather than a linear one (Chatkoff, Maier, Klein, 2010). These variables may share relationships that are not clear cut indicating interactions between one variable and another. For example, by conceptualizing exercise as a coping strategy, some highly stressed individuals may engage in exercise as a means to reduce stress levels while others may choose other forms of coping. This would result in highly stressed individuals engaging in higher levels of exercise as well as other highly stressed individuals engaging in lower levels of exercise, due to the choice of coping strategy. This highly individualized coping mechanism may be one possible explanation for the non-significant relationship between stress and exercise.

Relating this to the transactional model of stress, those who appraise a stressor as challenging may rely on exercise as one of their coping resources. Instead of the effect of stress on exercise being the outcome, exercise itself may be a coping strategy. It is important to consider the possibility of exercise as a coping strategy, especially since past research indicates many benefits regarding the use of exercise to relieve stress. In particular, exercise programs that involve a mindfulness component, yoga in this case, have demonstrated a significant reduction in the levels of stress of the participants (Tripathi & Bano, 2014). In addition, other studies have examined exercises such as martial arts, tai chi, and qigong (an ancient form of martial arts) and their effects on stress levels. It was found that exercises of this nature significantly reduce stress and anxiety levels among healthy people (Chong-Wen, Celia, Chan, Ho, Chan, & Cecilia, 2014). Furthermore, exercise programs have been found to improve both mental and physical well-being in general. Specifically, one study examined exercise therapy and its impact on the mental and physical health of those with major depression and found that exercise improves various aspects of well-being, such as stress coping strategies, body image, and general quality of life (Knapen, Vancampfort, Morien, & Marchal, 2015).

While this conceptualization may not explain perceived stress' role regarding why there is a lack of exercise in the United States, it may begin to explain the lack of a direct relationship between stress and exercise and why some stressed individuals may engage in higher levels of exercise while other stressed individuals do not. This conceptualization is more consistent with past research and the utilization of exercise as a coping strategy.

Strengths and Limitations of the Present Study

Limitations. Several limitations to the present study may have influenced the results to some degree. As mentioned above, the sample composition was relatively homogenous in the aspects of age distribution and occupation. Although there was some age variation, the majority of the sample were in their early to mid- 20's. Again, the sample was composed entirely of college students. Variation in the occupation of participants may have afforded different results. Also mentioned before, a restriction of range on the PSS and FSS scores as well as exercise levels may have influenced the results.

As mentioned above, the Fitbit trackers may not have been the most accurate at tracking sleep patterns and steps. Although the Fitbit brand trackers tend to be the most valid and reliable wearable devices, there is mixed research on the validity and reliability of wearable devices as a whole (Evenson, Goto, & Furberg, 2015; Zambotti, Baker, Willoughby, Godino, Wing, Patrick, & Colrain, 2016). Higher quality tracking devices were not able to be used in the present study due to limited funds. In addition, not all participants reliably turned the sleep mode on each night.

Finally, the choice of measures could be a limitation overall. The PSS-10 was chosen because it measures perceived stress, the exact construct of stress being investigated in this study. However, the present study could be improved by utilizing more perceived stress measures and/or examining a different construct of stress, such as concrete stressful life events. The FSS was chosen because it measures physical fatigue, which seemed most likely to influence exercise levels (i.e. those more physically fatigued would exercise less). However, the study could be improved my examining physical as well as mental constructs of fatigue. There may be a relationship between mental and physical fatigue that influence exercise. Overall, one stress and one fatigue measure may have limited the data. Using several of these measures may enrich the quality of the data and afford different findings.

Strengths. A key strength of the present study is that it is the first study, to the author's knowledge, to integrate perceived stress, exercise, sleep quality, and fatigue in one investigation. Several branches of research investigate these variables separately or combine a few of them in one study, although finding research that encompasses all four variables is difficult. Evaluating variables in this manner provides a broader scope to investigate these relationships. Another strength of the present study is that the self-report sleep measure and the Fitbit tracker were significantly correlated. The self-report sleep measure (the sleep diary) was used in order to obtain a subjective measurement of sleep quality. Likewise, the Fitbit was used to obtain an objective measure of sleep quality as well as exercise. Comparing subjective and objective measures of sleep quality was helpful in determining whether participants were accurately estimating their average nightly sleep quality. This accuracy suggests that, within the current sample, participants were able to adequately judge their sleep quality as compared to a wearable device.

Future Research and Implications for Treatment

Future research on the relationship between perceived stress and exercise with sleep quality and fatigue as mediating variables should include more representative samples of the general population. Increasing the diversity in terms of age and occupation in particular may improve the quality of the data. In addition, different wearable devices can be used to examine the differences in data between brands of trackers.

Overall, the results suggest that the relationship between perceived stress and exercise may not be explained by sleep quality and fatigue as mediating variables. This lack of mediation effects may be explained by the fact that stress and exercise were not related to one another. Other factors may be playing a role, such as motivation to exercise. Research on motivation, along with other possible factors, may provide more insight into the relationship between perceived stress and exercise. Exercise may also be conceptualized as a coping strategy. Research involving exercise conceptualized this way may indicate a different relationship between stress and exercise. Instead of stress having a direct impact on the frequency/amount of exercise, exercise may be a way for people to lower their levels of stress.

A future experimental study may involve manipulating participants' levels of stress such that there would be a group of participants that are stressed and a group of participants that are not stressed. Participants in the stressed group could be informed that they would have to provide bad feedback to a peer or perform some other stressful task in one week. Throughout the week it would be expected that the participants would be thinking about this task and, theoretically, their stress levels would increase. The non-stressed group would not need to do a stressful task in one week and would be allowed to go about their week per usual. Exercise and sleep quality could be measured with a higher quality Fitbit, and fatigue and stress could be measured with several measures instead of one measure each. Experimentally changing the participants' stress levels may allow different relationships between these variables to emerge.

Future research may also provide insight concerning the appropriate treatments for stress and fatigue. As mentioned above, CBT and MBSR treatments are popular for treating stress, fatigue, and sleep disturbances (Lattie, Antoni, Fletcher, Penedo, Czaja, Lopez, Perdomo, Sala, Nair, Fu, & Klimas, 2012; Carlson & Garland, 2005). Understanding these relationships more fully may lead to the development of new and/or more effective treatments for these common complaints.

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Tables and Figures

Table 1.

Descriptive Statistics of Study Variables

Variable	*N*	*M*	*SD*
PSS-10 (Time 1)	68	16.39	5.95
FSS (Time 1)	68	3.52	1.09
Steps per week	67	48,328.88	19,523.72
Fitbit Sleep Index	61	1,450.87	328.58
Sleep Diary Index	66	1,417.16	383.16

Note. PSS-10= Perceived Stress Scale- 10 Item, FSS= Fatigue Severity Scale, Fitbit Sleep Index= total minutes asleep per week x average sleep quality rating, Sleep Diary Index= total minutes asleep per week x average sleep quality rating.

Table 2.

Correlations between Perceived Stress, Fatigue, Exercise, and Sleep Quality

	PSS-10	FSS	Steps/Week	FBSlpInd	DSlpInd
PSS-10	-	**0.457****	-0.71	**-0.320***	**-0.287***
FSS	-	-	0.100	-0.178	-0.212
Steps/Week	-	-	-	-0.116	0.059
FBSlpInd	-	-	-	-	**0.631****
DSlpInd	-	-	-	-	-

Note. PSS-10= Perceived Stress Scale-10 Item, FSS= Fatigue Severity Scale, FBSlpInd= Fitbit Sleep Index, DSlpInd= Sleep Diary Index. **= p<0.01, *= p<0.05.

Table 3.

Mediation Analysis of Stress and Fitbit Sleep Index to Exercise

M (sleep)		**Y (exercise)**	
Antecedent		Antecedent	
Stress	17.93	Stress	-374.35
Sleep	-	Sleep	-9.08
Constant	1,739.03	Constant	68,447.99
R^2= 0.10		R^2= 0.02	
F(1,59)= 6.73, p<0.05		F(2,58)= 0.72, p>0.05	

Total effect= -211.47, SE= 436.50
t= -0.48, p>0.05
Direct effect= -374.35, SE= 459.87
t= -0.81, p>0.05
Indirect effect= 162.88, SE= 190.77
z= 0.95, p>0.05

Table 4.

Mediation Analysis of Stress and Sleep Diary Index to Exercise

M (sleep)		Y (exercise)	
Antecedent		Antecedent	
Stress	-18.26	Stress	-185.95
Sleep	-	Sleep	2.24
Constant	1,704.16	Constant	48,358.17
R^2= 0.08		R^2= 0.01	
F(1,63)= 5.49, p<0.05		F(2,62)= 0.19, p>0.05	
Total effect= -226.91, SE= 423.92			
t= -0.53, p>0.05			
Direct effect= -185.95, SE= 445.18			
t= -0.41, p>0.05			
Indirect effect= -40.96, SE= 160.66			
z= -0.29, p>0.05			

Table 5.

Mediation Analysis of Stress and Fatigue to Exercise

M (fatigue)		Y (exercise)	
Antecedent		Antecedent	
	0.0		
Stress	8	Stress	-480.34
Fatigue	-	Fatigue	2,974.58
	2.1		45,716.6
Constant	6	Constant	1
R^2= 0.20		R^2= 0.02	
F(1,65)= 16.93, $p<0.05$		F(2,64)= 0.89, $p>0.05$	

Total effect= -232.49, SE= 403.20

t= -0.57, $p>0.05$

Direct effect= -480.34, SE= 451.11

t= -1.06, $p>0.05$

Indirect effect= 247.85, SE= 190.99

z= 1.12, $p>0.05$

Figure 1.

Mediation Model of Stress and Sleep Quality to Exercise

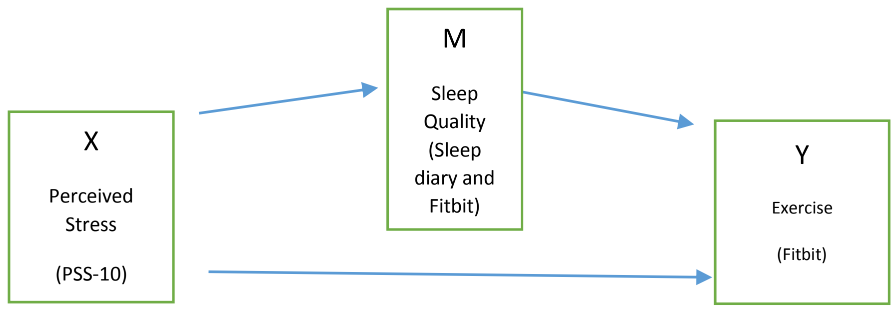
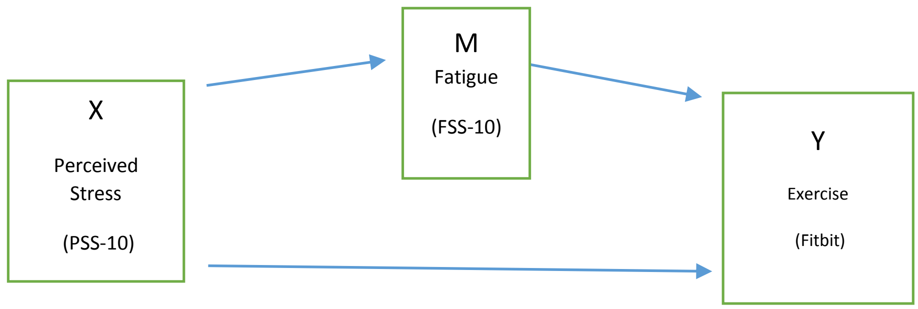


Figure 2.

Mediation Model of Stress and Fatigue to Exercise



Appendix A: Eligibility and Demographics Form

Eligibility

1. Are you 18 years of age or older? Yes No
2. Do you suffer from any type of psychological condition that may interfere with sleep or fatigue? Yes No
3. Do you suffer from any condition that causes chronic fatigue? Yes No
4. Do you have a diagnosed sleep disorder? Yes No
5. Are you currently taking any medications that may alter sleep or fatigue levels? Yes No
   (ex. Sleeping aids, anti-depressants, ADHD meds)
6. Are you currently taking seasonal allergy medication? Yes No

Demographics

1. Age: ______
2. Academic year in college 1st 2nd 3rd 4th 5th+
3. Ethinicity (check all that apply)

   ☐ Caucasian/White

   ☐ Hispanic or Latino

   ☐ Black or African American

   ☐ Native American or American Indian

   ☐ Middle Eastern

   ☐ Asian or Pacific Islander

☐ Other: ______________________

4. Gender: Male Female
5. Are you employed? Yes No

Appendix B: PSS-10

Instructions: The questions in this scale ask you about your feelings and thoughts during the last week. In each case, please indicate with a check how often you felt or thought a certain way.

1. In the last week, how often have you been upset because of something that happened unexpectedly?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

2. In the last week, how often have you felt that you were unable to control the important things in your life?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

3. In the last week, how often have you felt nervous and "stressed"?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

4. In the last week, how often have you felt confident about your ability to handle your personal problems?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

5. In the last week, how often have you felt that things were going your way?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

6. In the last week, how often have you found that you could not cope with all the things that you had to do?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

7. In the last week, how often have you been able to control irritations in your life?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

8. In the last week, how often have you felt that you were on top of things?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

9. In the last week, how often have you been angered because of things that were outside of your control?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

10. In the last week, how often have you felt difficulties were piling up so high that you could not overcome them?

___0=never ___1=almost never ___2=sometimes ___3=fairly often ___4=very often

Appendix C: FSS

Instructions: Circle the number that best represents your response to each question.

Scoring range: 1=strongly disagree with the statement to 7=strongly agree with the statement.

During the past week, I have found that:

1. My motivation is lower when I am fatigued. 1 2 3 4 5 6 7
2. Exercise brings on my fatigue. 1 2 3 4 5 6 7
3. I am easily fatigued. 1 2 3 4 5 6 7
4. Fatigue interferes with my physical functioning. 1 2 3 4 5 6 7
5. Fatigue causes frequent problems for me. 1 2 3 4 5 6 7
6. My fatigue prevents sustained physical functioning. 1 2 3 4 5 6 7
7. Fatigue interferes with carrying out certain duties and responsibilities. 1 2 3 4 5 6 7
8. Fatigue is among my three most disabling symptoms. 1 2 3 4 5 6 7
9. Fatigue interferes with my work, family, or social life. 1 2 3 4 5 6 7

Appendix D: Self-Report Sleep Diary

Daily Sleep Diary Instructions

Each diary contains seven days for recording one week of sleep and wake patterns.

The following daily sleep diary instructions provide specific guidelines for each question. Look at the gray colored example column on the diary as you read the instructions. The daily sleep diary instructions below are followed by the diary.

1. **Sleep Medication**: This question asks whether you took any medication last night to help you to sleep. This is a 'yes' or 'no' answer. For example, if you did not take any sleep medication last night, you would write 'no'.
2. **Bedtime**: This is the time you get into bed. For example, if you go to bed at 10:00 p.m., you should write '*10 pm*'.
3. **How long it took to fall asleep**: Provide your best *estimate* of how long it took you to fall asleep after you turned the light off and intended to go to sleep. For instance, if it took you 60 minutes to fall asleep, then please record '*60 minutes* ' OR '*1 hour*' in the diary.
4. **How long were you awake during the night**: Please estimate to the best of your knowledge how long you spent awake during the night. (For example '*90 minutes*' or '*1½ hours*').
5. **Morning Awakening**: This is the very last time you woke up in the morning. For instance, if your last awakening was 6:00 a.m. and you didn't go back to sleep, then you would record ' *6:00 am*' on the diary. If you use the alarm to wake up, record the time you woke up when the alarm first went off as your morning awakening. If you fell back to sleep briefly after the alarm went off, then record the time you woke up when the alarm went off as your morning awakening.
6. **Time you got out of bed**: This is different than morning awakening. This is the time you physically got out of bed and stayed out of bed for the rest of the day.
7. **Sleep Quality**: Please use the following 5–point scale:
   1=Very Restless; 2=Restless; 3=Average Quality; 4=Sound; 5=Very Sound. Write the number that best represents the quality of your sleep. In the example, the sleep quality was restless, so the number '2', which matches 'restless' was written in the diary.

At the bottom of the diary page, you can write any **comments** you have about your night's sleep.

DAILY SLEEP DIARY

TODAY'S DATE	**Example** 2/19/08							
1. Last night, I took sleep medication. (yes or no)	No							
2. What time did you go to bed last night?	10:00pm							
3. After turning the lights off, how long did it take you to fall asleep?	1 hour							
4. How long were you awake during the night?	1 ½ hours							
5. What time did you wake up this morning? (your last awakening in the morning)	6:00 am							
6. What time did you get out of bed and stay out of bed?	7:30 am							
7. Overall, my sleep last night was___ : 1=very restless 2=restless 3=average	2							

quality 4=sound 5=very sound								

COMMENTS:

Appendix E: Consent Form

EXPERIMENTAL SUBJECT POOL PARTICIPATION CONSENT FORM

The psychology faculty considers participation in experimental research by subjects to be an educational experience for the students as well as a most important service to the research of the University. This research project has been approved by the University of Michigan-Dearborn Institutional Review Board (IRB Dearborn). Participation is voluntary, if you choose **not** to participate as a research subject you may participate in another research related activity at no expense to your academic record or standing. If you choose not to participate in the study, withdraw from the study, or lose the Fitbit, only 1 subject pool credit will be awarded. Participants will be held responsible for the Fitbits. If a Fitbit is either lost or damaged, only 1 subject pool credit will be awarded instead of 2 credits. The purpose of this experiment is to examine the relationships between stress levels, fatigue levels, sleep quality, and exercise.

Psychology Subject Pool Subjects

As a part of your participation in an Introductory Psychology course at the University of Michigan- Dearborn, you agree to serve as a research subject for this experiment. You have had the opportunity to read the “Subject Pool Participation” description information that was provided when you registered on the SONA System website as a research participant. You will receive 2 subject pool credits for your participation in this study. You may withdraw at any time from this study, however there will be a loss of 1 research participation credit. Participants must attend both meetings in order to receive 2 credits. If only one meeting is attended, 1 credit will be awarded.

Upper Level Psychology Course Research Subjects

As part of your participation in an upper level psychology course at the University of Michigan-Dearborn you agree to serve as a research subject for this experiment. You have had the opportunity to read the “Subject Pool Participation” description information that was provided when you registered on the SONA System website as a research participant. You will receive 2 extra credit for your participation. You may withdraw at any time from this study, however there will be a loss of 1 research participation credit. Participants must attend both meetings in order to receive 2 credits. If only one meeting is attended, 1 credit will be awarded.

Description of Subject Involvement:

The procedure in this study involves wearing a Fitbit for a one week interval, filling out three questionnaires at the first meeting, filling out three questionnaires at the second meeting, and keeping a sleep diary each night during the one week interval. The risks include potential discomfort while wearing the Fitbit and a sense of lack of privacy since exercise and sleep will be tracked on the Fitbit. There is a very minimal risk of developing a skin rash on the wrist from wearing the Fitbit. This risk is minimal because we are not using the model of Fitbit that has the most issues with rashes. There is also a location tracking feature on the Fitbits, although the research team makes sure this is not enabled. There is a small risk the nature of some questions on some surveys may be distressing and counseling service information will be provided if you are distressed. Benefits include learning about your exercise patterns and sleep cycles, helping researchers understand the benefits of exercise, and helping in understanding what factors stand in the way of exercising.

We plan to publish or present the results of this study, but will not include any information that would identify you. There are some reasons why people other than the researchers may need to see information you provided as part of the study. This includes organizations responsible for making sure the research is done safely and properly, including the University of Michigan, government offices.

Contact Information:

If you have questions about the study you may contact Katie Krajewski at klkrajew@umich.edu or their faculty advisor Dr. Marie Waung at mwaung@umich.edu.

If you have questions regarding your rights as a research participant, or wish to obtain information, ask questions, or discuss concerns with someone other than the researcher(s), you may contact the Dearborn IRB Administrator at (734) 763-5084. Written questions should be directed to the Office of Research and Sponsored Programs, 2066 IAVS, University of Michigan-Dearborn, Evergreen Rd., Dearborn, MI 48128-2406, (313) 593-5468; the Dearborn IRB Administrator at (734) 763-5084, or email Dearborn-IRB@umich.edu.

Your participation will require no more than 2 hours total, including two meetings and the completion of a sleep diary each morning. The purpose and procedure as well as the benefits and risks of the study have been explained to you and the results will be made available to you upon your request. By signing this document, you are agreeing to be in the study. You will be given a copy of this document for your records and one copy will be kept with the study records. Be sure that questions you have about the study have been answered and that you understand what you are being asked to do. You may contact the researcher if you think of a question later.

I agree to participate in the study.

Signature____________________________

Name: ______________________________

Address: ____________________________

Enrolled in: Psychology _______________

Psychology Instructor_________________

To be filled in by experimenter:

Experiment: _______________________

Date: ____________________________

Experimenter: ____________________

Appendix F: Research Protocol

Research Protocol

Part 1

Recruitment and Screening

- Participants will be recruited via the SONA subject pool website.
- Psychology professors will inform their students about the SONA system and students can sign up for studies on this system in order to receive class credit.
- Regarding this study, students can view the study website and read about the study, including exclusionary criteria and benefits/risks of the study, and decide whether they want to participate or not.
- If the student want to participate in this study, they sign up for two timeslots. One timeslot is the first study meeting and the second timeslot is the second study meeting held one week after the first study meeting.
- Student should know whether they are eligible for the study by reviewing the exclusionary criteria on the study website, however, screening will take place during the first study meeting.
- SONA credit will be awarded on the SONA system accordingly.

Prior to Arrival

- PI will make sure consent forms are ready to be distributed
- PI will make sure measures are ready to be distributed
- PI will number consent forms to corresponding Fitbit numbers (this will be participant ID number)
- Have Fitbits out and ready to be distributed

Upon Arrival

- PI will greet participants at the door and have them choose a seat at a desk
- Once everyone is seated, PI will address the participants as a group:
  "**Hi my name is Katie and I'm the research PI that will be running the study. You all are here to participate in the exercise, stress, and fatigue study using Fitbit technology. In this study we are hoping to better understand how stress and exercise are related to each other. Before we start, I just want to have each of you sign a consent form I am about to give you. This form lays out the risks and benefits to participating in this study. I'll have you read it over and ask any questions that you may have."**

- PI will distribute the consent form to each participant and allow adequate time for each participant to read the document and sign. Questions will be answered at this time as well.
- If a participant does not want to participate, they will be allowed to leave at this time but will not be awarded credit.
- Those that want to participate will sign the consent form and stay:
  "**Now that you have agreed to participate, this study will involve the use of Fitbits. Part of the consent form was that you are responsible for returning your assigned Fitbit. In addition, this is a two part study, so in order to receive both credits, both lab meeting must be attended. The first part of the study is today, you all will receive one credit for today, and I will be having you complete a few surveys, assigning you a Fitbit to wear for one week, and answering any questions you may have. Before we go any further, I am going to have you complete an eligibility and demographics form."**
- PI distributes the eligibility and demographics form and allows adequate time for completion.
- Eligibility will be screened upon form completion and those not eligible will be dismissed and awarded one credit. Participants will be discreetly dismissed in order to avoid embarrassment. In addition, exclusionary criteria is posted on the SONA webpage in order to warn participants of the risk of ineligibility.
- Those that are eligible will remain to complete the pre-test measures:
  "**Now I'll be distributing the surveys that need to be completed today. There are three of them and if you have any questions about how to fill them out I will gladly help. For all the surveys you complete today I ask that you do so independently and silently in order to maintain confidentiality for everyone. After you are done filling out the surveys, I will assign each person a Fitbit to wear for the rest of the study."**
- Distribute the PRT-PSS-10, PRT-FSS, and PRT-CSS-M and allow adequate time for completion.
- Once surveys are completed, participants will be assigned Fitbits:
  "**(holding up a Fitbit for everyone to see) Each one of you will be assigned a Fitbit and we ask that you wear the Fitbit continuously for one week, with the exception of when you are showering or doing anything in a body of water. It is important to also wear them at night so data can be collected about your sleep quality. We will just be looking at your sleep, step, and active minutes data. I'll start passing these Fitbits out to all of you. The number on the Fitbit will correspond to your participant number, and this is how we will identify your data. We won't identify your data by your name. In addition, I'll be passing out a form that outlines the rules for usage of the Fitbit and explains that you are responsible for returning it. There is a space on the form for you to sign indicating you agree to the rules."**
- Distribute numbered Fitbits and rule forms to each participant and answer any questions they may have about operating a Fitbit.
- Once Fitbits are distributed, PI will distribute the sleep diary:

“**This is the sleep diary. I ask that each of you fill this out for each night’s sleep, according to the instructions on the sheet. As you can see there are 7 columns on your sheet, one column for each night you will be collecting data on the Fitbit. Please read over the instructions and let me know if you have any questions.”**

- Once all Fitbits and sleep diaries are distributed, participants will be released and instructed to return on the day they signed up for on the Sona website.

Post Departure

- PI will gather all surveys, consent forms, and extra Fitbits.
- PI will take all the materials to the storage area, Dr. Waung’s lab, and these will be locked in the lab as a means of protection.
- PI will award all participants that attended with one credit on the Sona website.

Part 2

Prior to Arrival

- PI will make sure all post-test measures are ready to be distributed
- PI will make sure debriefing forms are ready to be distributed

Upon Arrival

- PI will greet the participants at the door and invite them to sit at a desk
- Once everyone is seated, PI will address the participants as a group:
  “**Welcome back and thank you for returning! Today we are wrapping up the study. You will just need to complete a few more surveys, turn in your Fitbits, and turn in your sleep diaries. After that you will be debriefed and awarded your second credit. Now I will begin collecting Fitbits and sleep diaries.”**
- PI will collect the Fitbits and sleep diaries. Participants will be asked their names as they turn these materials in so they can be awarded the second credit on the Sona website. However their names will not be recorded anywhere that can be linked to their data.
- Once these materials are collected, the PI will distribute the post-test measures (PT-PSS-10, PT-FSS, and PT-CSS-M) and allow for adequate time for completion:
  “**These are the last round of surveys. As with the first round of surveys, I ask that each of you complete these independently and silently in order to protect everyone’s confidentiality. After you are done completing these surveys, I will pass out the debriefing forms and allow times for questions.”**
- Once surveys are completed and turned in, PI will distribute the debriefing forms, answer any questions, and dismiss the participants:
  “**These are your debriefing forms, they detail what the study was about. If you feel any sort of distress over any aspects of the study, there is information listed on the form about who to contact for counseling services if you feel you need counseling. If you have any further questions feel free to hang back and ask. I will award all of you your second credit on the Sona website. As of now we are all done. Thank you all for your participation!”**

Data Collection

- Fitbits will not be synced to mobile devices or to computers that the participants own. Instead, data will be extracted directly from the Fitbits via USB and transferred directly to the computer that is being used for the study.
- Data is de-identified. No participant names are necessary for data transfer.
- Data will be entered into the statistical program.
- Once data is transferred directly to the computer, data will be erased from each Fitbit and prepared for use for the next participant.

Appendix G: Fitbit Rules and Responsibilities Form

Rules of use:

1. Only remove the Fitbit when showering or when doing any activity in water.
2. In order to prevent skin rash, make sure no debris builds up under the band of the Fitbit.
3. Make sure to wear the Fitbit while sleeping.
4. Wear the Fitbit continuously for one week (except when in water).
5. Do not attempt to sync the Fitbit with your phone, tablet, computer, or any other electronic device. The Fitbit will only be synced with a university computer and you will not be able to view your data.
6. It is important to attend your next scheduled meeting on the day it is scheduled. If delayed, the Fitbit may lose data.
7. Handle the Fitbit with care.

Responsibilities of the participant:

The participant is responsible for using the Fitbit in accordance with these rules and for returning the Fitbit at the conclusion of the study. The Fitbits are university property and any participant that does not return their Fitbit will not be awarded the second credit for the study.

Your signature below indicates that you have read and understand these rules and responsibilities.

____

Appendix H: Debriefing Form

In this study we were examining the specific relationships between exercise, stress, fatigue, and sleep. We used the tracking abilities of the Fitbit in order to keep track of participants' sleep and number of steps they had for one week. We measured their stress levels and fatigue levels by having them fill out several surveys.

It is our hope that we can find a link between lack of exercise and stress levels. It could be that increased stress levels lead to less exercise, decreased stress levels lead to more exercise, or there could be no relationship at all. Your participation can help us find a link between these variables.

Thank you for your participation in this study. If you feel that you are distressed because of this study, please contact University of Michigan- Dearborn Counseling Services:

2157 University Center

4901 Evergreen Rd, 2157 UC

Dearborn, MI 48128

(313) 593-5430

Monday- Friday 8 am- 5 pm