UNIVERSITY OF CENTRAL OKLAHOMA

Edmond, Oklahoma

Jackson College of Graduate Studies

Effects of Exercise on Decision-Making under Stress

A thesis submitted in partial fulfilment of the requirements

for the degree of

MASTER OF ARTS IN PSYCHOLOGY

By

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Edmond, Oklahoma

2021

Effects of Exercise on Decision-Making under Stress

Thesis Title

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01-13-2021

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A THESIS APPROVED FOR

Master of Arts in Psychology

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Abstract

Prolonged exposure to stress can be very damaging to an individual both physically and mentally. Stress can have a negative impact on thoughts, behaviors, and feelings. Stress can also inhibit a person's ability to make decisions. Past studies have demonstrated that physical activity can combat the negative effects of stress on the mind and body. The purpose of the present study was to investigate whether long-term exercise and immediate exercise can mitigate the effects of stress on decision-making. Participants were prescreened and categorized into physically active or sedentary groups. Both groups completed the cold pressor stressor task, after which half of each group exercised immediately on a stationary bike. All participants then completed a financial decision-making task. Blood pressure was recorded at various points during the procedure. It was hypothesized that those who were generally more physically active or who engaged in immediate exercise would respond more accurately on the financial decision-making task compared to those who were generally sedentary or those who did not exercise immediately prior to the task. An analysis of variance test indicated no statistically significant effects of either variable on decision-making. The results did not support the hypothesis. Separate comparisons of systolic and diastolic blood pressure measurements did not reveal any statistically significant differences either. Implications, limitations, and future directions are discussed, including the impact of factors such as the COVID-19 pandemic, sample size, age, and the use of automated blood pressure monitors.

Keywords: stress, exercise, decision-making, blood pressure

ACKNOWLEDGMENTS

I would like to gratefully acknowledge everyone who has played a role in my academic experiences. First, I owe an enormous debt of gratitude to my family. They have been a constant source of comfort through the struggles of this thesis.

Secondly, I would like to thank my thesis advisor and mentor Dr. Tephillah Jeyaraj-Powell, who encouraged me throughout my academic journey and worked so hard to help me with the project.

I would also like to express my appreciation for my committee members, Dr. Thomas Hancock and Dr. Lauren Loucks for offering patient advice and guidance throughout the research process.

Thank you all for your unwavering support.

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Chapter 1

Introduction

Stress is something everyone encounters frequently and often starts with the experience of life's hassles, frustrations, or demands. Broadly speaking, stress can be defined as a condition that disturbs the physiological and psychological balance of an individual (Franklin et al., 2012). Stress can include a feeling of emotional or physical tension (Tomiyama, 2019) and can come from any thought or event that makes a person feel angry, frustrated, or anxious. It is also how the brain and the body respond to a challenge. Any type of demand such as performance at school or work, a significant change in life, or a more traumatic event can trigger stress (Russell et al., 2015).

Stress can also affect cognitive functioning (Scott et al., 2015). It can cause acute and chronic changes in certain brain areas which can in turn incite long-term damage. Studies have demonstrated people with higher stress levels had worse visual perception and global cognitive function (Scott et al., 2015). This means that stress can impair an individual's mental processes that lead to information acquisition, perception, and comprehension. Stress can also impair many memory functions such as long-term delayed memory recall (Mandolesi et al., 2018).

Since stress is so common, it has been a popular goal of researchers to find effective ways to mitigate its negative effects. Research has demonstrated numerous ways to deal with stress, one of the most common being physical activity or exercise (Tanner et. al, 2019). Exercise can improve one's overall mood and this in turn promotes stress reduction. For example, regular exercise can increase self-confidence and decrease symptoms associated with anxiety and depression (Mebin et al., 2020).

Physical activity can also increase cognitive functioning (Mandolesi et al., 2018). Exercise is related to increased performance in working memory and cognitive flexibility, as well as the speed of information processing. Researchers have also demonstrated that physical activity prevents mild cognitive impairment by improving blood flow (Mebin et al., 2020). Thus, all these effects of exercise can also impact stress levels.

The first part of this chapter begins with a description of stress and the body's response to a stressor followed by other physiological and psychological effects of stress. The second part of this chapter provides a literature review regarding the effects of physical activity on the body and its various systems. This includes a deeper examination of the research on how stress and physical activity independently impact cognitive processes like decision-making. The last section presents a new study exploring how physical activity could reduce the negative effects of stress on decision-making. The primary goal of the proposed study was to specifically look at the effects of long-term and immediate exercise on decision-making in a stressful situation.

Stress and the Physiology of the Stress Response

Hobfoll (2011) defined stress as a mental or emotional strain that results from adverse circumstances. Stress occurs when certain environmental demands exceed the perception of one's ability to cope (Fink, 2016). In other words, a person is considered to undergo stress when they believe they cannot efficiently deal with a difficult circumstance. Stress is mentally viewed as a threat and this perception of a threat results in anxiety, discomfort, emotional tension, and difficulty in adjustment. Fink's perspective proposed that the stress response involved the experience of negative emotions, which induced hormonal or cardiovascular changes (Mendelson, 2013). From a physiological perspective, stress is the reaction that can be observed after the perception of aversive circumstances (Ramesh, 2011).

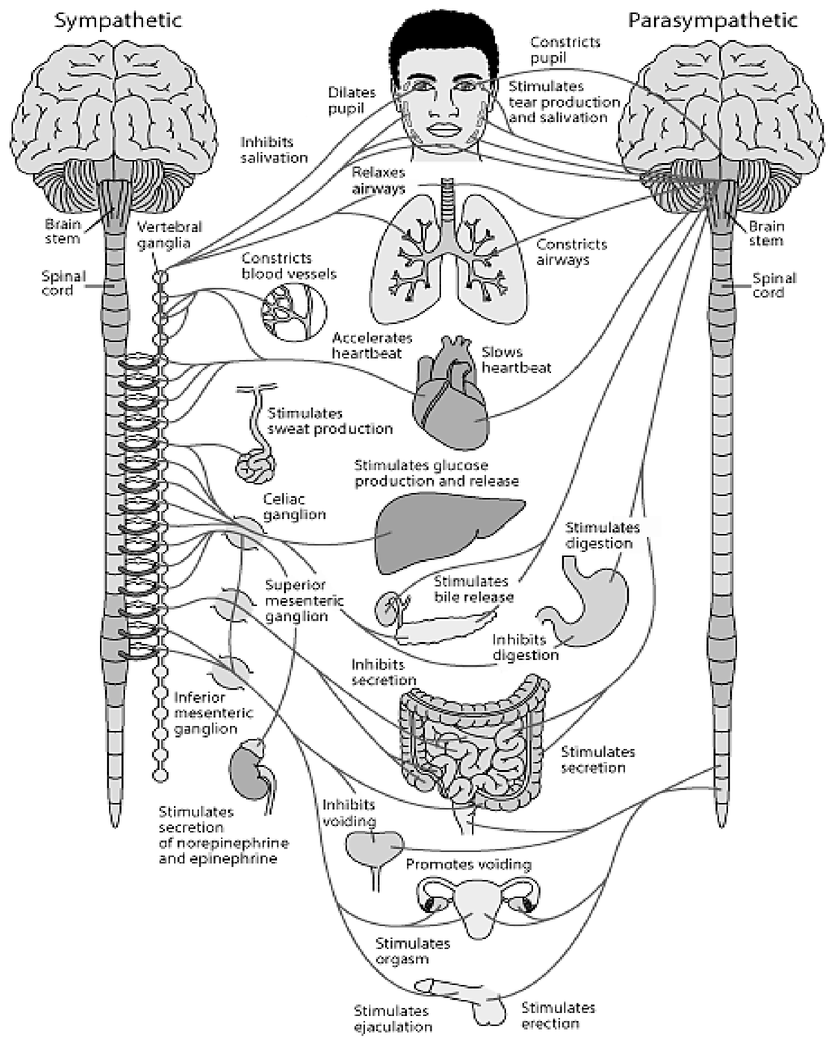
The body activates two pathways in response to stress: 1) the sympathetic response and 2) the hypothalamic-pituitary-adrenal (HPA) axis.

Without conscious effort, the autonomic nervous system (Figure 1) controls different physical reactions such as heart rate, respiratory rates, and digestion (Seaward, 2017). It does this by directing the action of cardiac muscle, gland secretion, and skeletal muscles (Parati & Esler, 2012). The autonomic system has two branches, the parasympathetic branch and the sympathetic branch. Stress activates the latter (Greenberg, 2012), which in turn activates what is known as the “fight or flight” response (Carlson & Brickett, 2017). This is a set of physiological responses that prepares people for the strenuous efforts that need to be taken in order to engage in a fight during a threatening situation or run away from it. This fight or flight response is essential to survival as it helps individuals react to threats effectively and automatically (Greenberg, 2012).

The sympathetic nervous system directs rapid involuntary responses to dangerous and stressful situations (Hall et al., 2012). Hormones boost the body’s alertness and heart rate, sending blood to the muscles. The sympathetic nervous system also plays a role in the short-term regulation of blood pressure (Joyner et al., 2010). Oxygen is rapidly delivered to the brain as breathing quickens and an infusion of glucose is shot into the bloodstream as a means of a quick energy boost (Lin et al., 2011). The response occurs so quickly that people often do not realize it has happened (Mummert, 2016). The sympathetic nervous system allows people to make quick internal adjustments and react to stressful situations without having to critically think about them.

Figure 1

Overview of the Autonomic Nervous System

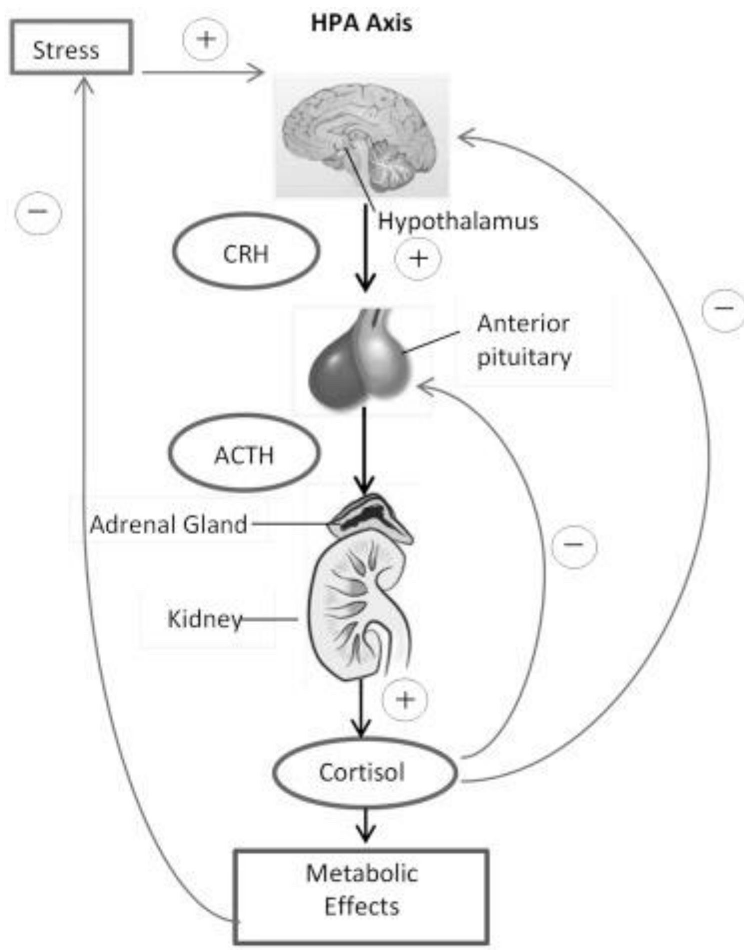


Note. From "Overview of the Autonomic Nervous System - Brain, Spinal Cord, and Nerve Disorders," by P. Low, 2018, (https://www.merckmanuals.com/home/brain,-spinal-cord,-and-nerve-disorders/autonomic-nervous-system-disorders/overview-of-the-autonomic-nervous-system).

The HPA axis is also a part of the physiological response to stress (Figure 2). The HPA axis secretes a corticotropin-releasing hormone (CRH), which activates the anterior pituitary gland to secrete adrenocorticotropic hormone (ACTH) (Seaward, 2017). This hormone stimulates the adrenal cortex for the secretion of glucocorticoids. The glucocorticoids break down proteins and convert them to glucose, which in turn increases the blood flow, helps make fats available for energy, and stimulates behavioral responses (Carlson & Brickett, 2017).

Figure 2

The Hypothalamic Pituitary Adrenal (HPA) Axis



Note. The positive and negative signs refer to activation and inhibition, respectively. From "Hormones and Schizophrenia" by J. Kulkarni, E. Gavrilidis, and R. Worsley, 2016, *Handbook of Behavioral Neuroscience, 23,* p.463-480 (https://doi.org/10.1016/B978-0-12-800981-9.00027-4).

Stress can also be differentiated into acute stress and chronic stress based on its duration. Acute stress is considered to occur for a short period of time whereas chronic stress is experiencing a stressor for a persistent and lengthy amount of time (Hammen et al., 2009). Some examples of acute stress include getting into an argument with someone, experiencing traffic when running late, presenting a topic, or taking a test (Eden, 1990). Examples of chronic stress may include being in a toxic relationship where you and your partner argue constantly, living in a high-crime neighborhood, or working a stressful career such as law enforcement (Eden, 1990).

The body is generally able to handle episodes of acute stress by activating the autonomic nervous system and the hypothalamic pituitary adrenal axis. Recovery from an acute episode of stress usually occurs rapidly. Blood pressure, heart rate, breathing rate, and levels of muscle tension may rise for a short amount of time, but will then quickly return to normal levels (Katz et al., 1981). Over time, chronic stress gradually increases resting heart rate, blood pressure, breathing rate, and levels of muscle tension (Katz et al., 1981). This requires the body to work even harder when it is at rest to function normally. As a result, chronic stress is more prone to causing illness, fatigue, and cardiovascular diseases such as heart attacks (Hammen et al., 2009).

Physiological Effects of Stress

A key aspect of stress is the way it impacts the endocrine system causing the release of various hormones in the body. Acute stress, for example, produces elevations in cortisol, one of the body's main glucocorticoids (Shields et al., 2016). Some short-term effects of glucocorticoids are essential and even beneficial to health (Ramesh, 2011). Stress can be considered a release of energy that advises an individual on what needs to be done. In other words, stress can assist with overcoming daily challenges as well as with providing the motivation to reach goals (Filaretova et al., 2013). Past research has indicated that stress can even lead to the accomplishment of tasks more efficiently (Filaretova et al., 2012).

Stress is also a vital warning system, ensuring survival when the brain perceives some type of danger or threat (Rana et al., 2016). The variety of physical reactions (such as increased heart rate and blood pressure) caused by the chemical release of epinephrine, norepinephrine, and cortisol can aid in the avoidance of stressful situations (Haussmann & Marchetto, 2010). As a result, stress enables an individual's safety.

Some stress can even aid in fortifying the immune system (Clinton et al., 2014). Stress regulates and improves heart functioning, which in turn results in improved circulation of oxygen and blood flow throughout the brain and body. Thus, stress improves immunity, thereby protecting against disease, infection, and promoting recovery from illness (Spiegel, 2012). Specifically, it appears that acute stress seems to enhance immune function while chronic stress seems to suppress it (Dhabar, 2000). The long-term effects of sustained glucocorticoids are very damaging (Falconier et al., 2017).

Another physiological impact of stress is on the health and aging of cells. Chronic stress has been found to speed up cell aging by shortening the length of telomere, a part of the chromosome important for cell replication (Epel et al., 2004).

When stress is improperly handled through inefficient or maladaptive coping mechanisms, it can contribute to many health problems. Stress has been known to increase blood pressure, which in turn can lead to various cardiovascular diseases such as heart attack or stroke (Terry et al., 1993). Carroll et al. (2012) examined the association between the systolic and diastolic blood pressure reactions to stress. Blood pressure was measured during resting baseline and mental arithmetic stress. Results demonstrated that both systolic and diastolic blood pressure reactions were positively associated with stress both in the long- and short-term capacity. Stress has also been proven to incite damage to muscle tissue, as well as cause infertility (Park, 2013). Long-term stress can lead to a suppression of the immune system and the inhibition of an inflammatory response (Carlson & Brickett, 2017).

Psychological Effects of Stress

Prolonged exposure to stress can also have a negative impact on thoughts, behaviors, and feelings (Schwabe & Wolf, 2013). Stress can cause social withdrawal due to preoccupied thinking and irrational thoughts (Scott et al., 2015). These thought patterns prove to negatively impact the sociability of an individual experiencing stress. Stress can also induce overeating or undereating due to the chronic experience of anxiety (Groesz et al., 2012). This type of eating behavior is an attempt to cope with stress, even though the coping strategy will have no positive effect on the stress (Yau & Potenza, 2013). Stress can also incite feelings of anger and sorrow due to the sensation of feeling overwhelmed (Hyun et al., 2018). Stress can manifest as increased symptoms of anxiety and depression as well as a lack of motivation and focus (Rosiek et al., 2016).

Stress and Decision-Making

The negative effect stress has on a person's ability to focus can also greatly inhibit a person's ability to make good decisions (Porcelli & Delgado, 2016). Efficient decision-making requires a person to be able to switch between different behavioral strategies. The decision-making process can be split into two different behaviors: goal-directed behaviors and habitual behavior (Dias-Ferreira et al., 2009). Goal-directed behavior is when an individual must carefully monitor and control their behavioral response in order to make a decision. This is in contrast to habitual behavior, where there is no evaluation of the consequences to responses and people respond based on particular situations or stimuli (Sebold et al., 2017). An example of habitual behavior would be if you were in a social gathering and saw a glass of water that was unattended. Everyone around you was holding a glass of water or drinking one, so you felt pressured into picking up the glass and holding it even though you do not know to whom that glass of water belongs. You drank the water in order to copy another's behavior, even though you did not consider all of the consequences of performing that behavior.

Stress can affect the executive behaviors of decision-making through the modulation of brain networks by the release of glucocorticosteroids. When people experience chronic stress, they form a bias towards the habitual behavioral response (Dias-Ferreira et al., 2009). This means that when people are stressed, they lack control and the ability to think of the consequences surrounding the choices. Instead, people choose the behaviors they have done before without considering the potential benefits or disadvantages of their decisions. This indicates how stress alters decision-making in such a way that it could even affect how people make life-altering choices, such as those involving one’s finances. Porcelli and Delgado (2016) studied how stress can modulate risk taking in financial decision-making. They instructed participants to engage in a financial decision-making task after undergoing the cold pressor task. They demonstrated that when people are stressed, they tend to rely more on automatized biases when making risky decisions. In other words, stress has negative effects on health and these effects can be worsened by an individual’s suboptimal decisions. Similar research by Starcke and Brand (2012) found that people make decisions that result in immediate rewards but at the cost of negative consequences in the long term . These studies supported the financial decision-making research conducted by Preston et al. (2007) who hypothesized that unrelated emotion and stress can disrupt decision-making, particularly when it is related to circumstances involving gambling and finances. Participants in this study were required to play the Iowa Gambling Task but only those in the experimental group were notified that they would be giving a public speech. The public speech served as the unrelated stressor portion of this experiment. The results demonstrated that those who were anticipating the speech learned the contingencies of the decision more slowly. Since the stressor was unrelated to the financial decision-making task, the stress from the speech anticipation impaired performance. This occurred because there was an interference with the financial task-related emotion that was necessary to guide advantageous choices.

Additional evidence supporting the relationship between hormones and stress is provided by Nofsinger et al. (2018) who examined testosterone and cortisol levels in finance students. They participated in three financial investment trials involving a portfolio asset allocation. Testosterone and cortisol levels were used as physiologically measures of stress. Individuals who were more stressed were found to engage in more financial risk. Thus, higher levels of testosterone and stress increased risk taking, which was interpreted as poor decision-making.

Stress is prevalent in everyone's life. Since it can significantly impact decision-making, it is important for researchers to find a factor that could mitigate the effects of stress when people are tasked to make important decisions. Research supports the hypothesis that physical activity can reduce the negative effects of stress. In the next two sections of this chapter, the effects of physical activity on the body, its interaction with other physiological systems, its effects on stress, and its relationship to cognitive function, particularly decision-making will be examined.

Effects of Physical Activity

Physical activity is any movement of the body that uses energy (Thomas et al., 2015). Physical activity that is moderate or vigorous in intensity has been demonstrated to have beneficial effects on overall mortality (including cancer-related mortality) and cardiovascular disease (Thivel et al., 2018). Regular physical activity also promotes healthy aging and growth which in turn help prevent the occurrence of many chronic diseases (Greenwood et al., 2012). It could buffer the effects of chronic stress on cell aging (Puterman et al., 2010).

Physical activity also exerts many positive effects on several aspects of mental health (Greenwood et al., 2012). Physical activity reduces depression and negative moods, and improves cognitive function (Thivel et al., 2018). The findings raise the question of whether or not the positive effects of exercise are immediate or last long-term. Rethorst, at al. (2009) examined the short-term effects of exercise in their meta-analysis. They found an increase in stroke volume (SV), heart rate (HR), cardiac output, a redistribution of blood flow, and an increase in blood pressure. The heart pumps faster and harder to circulate blood to deliver oxygen throughout the body during exercise. When this occurs, the systolic blood pressure (pressure exerted when blood is ejected into arteries) raises from the normal of 120 mm Hg to between 160 and 220 mm Hg (Rothwell et al., 2010). Exercise also seems to increase lactic acid production in the short-term (Greenwood et al., 2012).

With regards to its long-term effects, exercise was shown to produce a decrease in resting heart rate and an increase in cardiac output (Billinger et al., 2014). Regular physical activity pumps more blood with less effort, decreasing the force on the arteries and lowering blood pressure as a result (Joyner et al., 2010). Exercise also causes an increase in the number of red blood cells over time. In the respiratory system, exercise increased vital capacity and strength of the respiratory muscles while decreasing breathing rates (Edelmann et al., 2011). Over time exercise incited an increased production of energy from the aerobic energy system and tolerance to lactic acid. With regards to the muscular system, the long-term effects of exercise included the strengthening of tendons and ligaments, muscle hypertrophy, and an increase in bone density (de Labra et al., 2015).

Individuals that engage in regular exercise are less likely to suffer from stress-related disorders (Thivel et al., 2018). Past research has demonstrated that stress can be modulated by physical activity in many ways, which include the neuroendocrinal, immunological, and behavioral function systems (Greenwood et al., 2012). Physical activity increases the production of endorphins, a neurotransmitter that relieves stress and pain (i.e., an analgesic effect) (Greenwood et al., 2013). Physical activity also causes changes in antibodies and white blood cells (Stults-Kolehmainen et al., 2014). White blood cells aid in the fighting and prevention of diseases. With exercise, these antibodies circulate more rapidly, making the detection of illnesses faster and easier. Exercise may also aid in the decrease of aggressive behaviors (Greenwood et al., 2012).

As stated earlier, stress increases the chance of illness. However, aerobic exercise slows down the release of stress hormones, offering potential protection against the illness (Lucassen et al., 2010). Aerobic exercise is any type of movement that promotes cardiovascular conditioning (Lee et al., 2012). This includes brisk walking, running, swimming, or cycling. Physical activity also flushes out the bacteria from the lungs and the airways (Bauman et al., 2012). This helps reduce the chance of getting illnesses such as the cold or flu.

Fu and Levine (2013) provided convincing evidence of both the protective and therapeutic effects of exercise on the human body by evaluating people who engaged in moderate-intensity exercise at least 30 minutes per day. Some of these effects seem to be related to the impact on the autonomous nervous system. There were improvements seen in vascular function, cardiac remodeling, insulin resistance, blood volume expansion, and renal-adrenal function, all of which imply that chronic exercise training may contribute to the protection and treatment of metabolic, cardiovascular, and autonomic disorders (Fu & Levine, 2013). This demonstrated that exercise can potentially counteract the negative physiological and psychological effects of stress.

Exercise produces short- and long-term effects on the body and brain. A randomized controlled study on physical exercise and overall quality of life was done on occupationally active women (Rutanen et al., 2014). They were questioned regarding work ability and work strain. Women in the experimental group were required to engage in aerobic exercise training four times per week, 50 minutes per session for six months, and surveyed regarding physical and mental stress. Work ability was measured with the Work Ability Index (WAI). The experimental group demonstrated positive short-term as well as long-term effects on stress and work ability.

Eyigor et al. (2010) investigated the impact of exercise on physical performance, flexibility, fatigue, depression, and quality of life. This study looked at women who were being treated for breast cancer, a population who is heavily under stress. They were separated into two groups; one group performed Pilates exercises and the other group performed exercise at home. Pilates exercises were performed three times a week for eight weeks. Results showed improvements in depression, quality of life, life satisfaction, and overall happiness for the treatment group. Furthermore, these improvements were seen both during and after the eight weeks, demonstrating that the exercise has both short and long-term positive effects on stress.

Physical Activity and Decision-Making

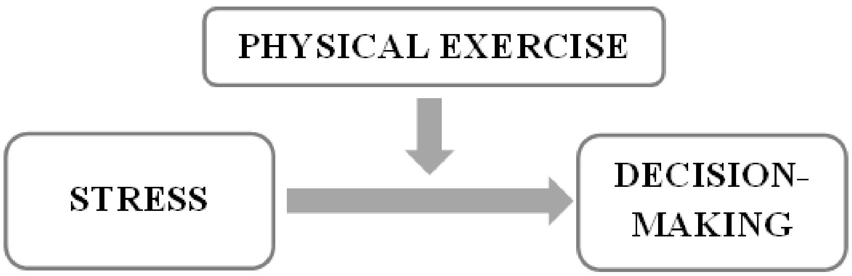
Previous studies have demonstrated a neural connection between stress and the decision-making process (Starcke & Brand, 2012). In fact, it has been well documented in animal models that exercise provides neurocognitive benefits during periods of chronic stress (Castilla-Ortega et al., 2014). Brain regions such as the prefrontal cortex that are associated with decision-making are also sensitive to stress. Since physical activity can have a positive effect on stress, and decision-making and stress are physiologically connected, physical activity could have a positive effect on decision-making. Fontana et al. (2009) tested the effects of exercise on decision-making. A group of experienced soccer players and a group of inexperienced soccer players answered seven decision-making questions regarding critical thinking scenarios found in soccer matches. The participants were expected to answer as quickly and accurately as possible while undergoing exercise of varying intensities. Results indicated that although exercise did not necessarily improve the accuracy of the decision-making, the response time for experienced soccer players and inexperienced soccer players did improve as the exercise intensity increased. Frybort et al. (2016) investigated the relationship between varying exercise intensity, motor-response time, and accuracy in an offensive game scenario in soccer. The researchers presented the participants with several videos of game situations while administering four different intensity levels on a treadmill. They found that highly intensive short-term exercise significantly decreased visual-motor response time. Though these studies looked at the effects of exercise on decision-making, they still did not factor in the effects of stress.

Tam (2014) provided explanations as to why executive cognitive functions like decision-making improve due to the cardiovascular activity derived from physical exercise. She used optical imaging of hemodynamic activity as a measure of oxygen consumption and demand in the prefrontal cortex (PFC) so that the improvement of cognitive function could be identified and associated with increased oxygen perfusion. The PFC was selected since it is involved in decision-making, especially the resolution of conflict. Tam used the Stroop task which produces such a conflict. Results supported the hypothesis that exercise increased oxygen perfusion to the PFC and showed improvements in cognitive function.

In summary, a review of existing research revealed that there was sufficient research investigating the relationships between stress and decision-making, physical exercise and stress, and physical exercise and decision-making. However, there was a lack of adequate research that simultaneously examined the relationship between these three variables. Therefore, the purpose of the present study was to examine how exercising regularly over a long-term period or on a short-term basis could mitigate the negative effects of stress on financial decision-making. Figure 3 presents the relationships between the variables under investigation.

Figure 3

Relationship between Stress, Physical Exercise, and Decision-Making



Note. The diagram depicts the cause-effect relationship between stress and decision-making, and how physical exercise might mitigate this effect.

The present study had three specific goals that lead to three experimentally testable hypotheses:

1. What are the effects of long-term physical activity on decision-making under stress?
2. What are the effects of immediate physical exercise on decision-making under stress?
3. How do differences in body condition affect an individual’s response to stress?

Hypothesis 1. Long term physical activity will have a positive effect on decision-making after a stressful situation.

It was expected that those who had been more physically active would respond more accurately on a financial decision-making task after experiencing the cold pressor task compared to those who were generally sedentary. The cold pressor task has the ability to incite high levels of stress in participants (Bond et al., 1999). This task is a cardiovascular test that is performed by immersing a hand into a bucket or container filled with ice cold water (Vaegter et al., 2015). This is usually done for 1-2 minutes. Changes in blood pressure and heart rate are measured. Elevated rates from the baseline are reliable indicators of stress (Ferracuti, et al., 1994).

Long-term exercise for an individual was defined as routinely engaging in certain amounts of exercise per week (Hallal et al., 2012). For a person to be considered “physically active”, they needed to engage in 30 minutes of moderate-intensity (anaerobic) physical activity for at least five days every week. An alternative to meet the physical activity requirements was to engage in 20 minutes of vigorous-intensity (aerobic exercise) exercise for at least three days every week.

Hypothesis 2. Immediate exercise will have a positive effect on decision-making after a stressful situation.

It was predicted that those who exercised immediately (on a stationary bike) after experiencing the cold pressor task would respond more accurately on a financial decision-making task, than those who did not exercise after the stressor. Physical activity is known to increase stress resistance (Greenwood et al., 2012). More specifically, different types of aerobic exercises have the most positive effects on coping with stress (Frybort et al., 2016). Aerobic exercise is considered to be any type of cardiovascular conditioning, examples of which include swimming, cycling, or running.

Hypothesis 3. Differences in body condition will influence how individuals experience stress and make decisions.

Body condition refers to whether individuals were generally more physically active or sedentary. Since blood pressure is increased by stress both temporarily and long-term (Carroll et al., 2011), it was used in the present study as a physiological indictor of stress. Thus, significant differences in blood pressure values (systolic and diastolic) between these two types of individuals were expected.

CHAPTER 2

Methods

Participant Selection

Participants were recruited from the University of Central Oklahoma. Initial recruitment was done online. Once informed consent (see Appendix A) was collected, potential participants were prescreened for their health and exercise conditions by completing a questionnaire (see Appendix B). The first part of this questionnaire assessed their general health condition using questions adapted from Exercise Pre-Screening Questionnaire (Physical Activity Australia, 2016) and the Physical Activity Readiness Questionnaire (Thomas et al., 1992). Any response of "yes" disqualified them from participation in the study. The second part of the questionnaire examined their level of physical activity. The participants were asked if they engaged in 30 minutes of moderate-intensity (anaerobic) physical activity for at least five days every week or 20 minutes of vigorous-intensity (aerobic exercise) exercise for at least three days every week. Examples of anaerobic and aerobic exercises were given to facilitate an understanding of the distinction between the two types. Anaerobic exercises would be weightlifting and resistance training, whereas aerobic exercise would be considered cardiovascular exercises such as running or swimming. If participants answered 'no' or 'less than that amount' to those two questions, they were considered physically "sedentary". Those who answer "yes" to the aerobic or anaerobic exercise questions were considered physically "active". Participants were screened and categorized until there were ten individuals in each category (active and sedentary) for a total of twenty participants.

Materials

- Cold pressor task: A large bowl with ice-cold water was used to induce stress. A thermometer was used to monitor the temperature of the water.
- Stopwatch: The stopwatch application on the iPhone was used to observe time intervals for each condition or task.
- Blood Pressure Monitor: A QardioArm® Smart Blood Pressure Monitor was used to record blood pressure through an iPhone application associated with the device. A statistically significant increase in blood pressure from the normal range indicated stress. Normal blood pressure range for this experiment was anything less than 120 over 80 (120/80) (O'Brien, 2005)
- Stationary bicycle: A Stamina Cardio Folding Exercise stationary bicycle (Model: 15-0181) was used to provide immediate exercise.
- Qualtrics®: The survey program Qualtrics® was used to administer the questionnaire.
- Decision-making task: This was administered as a pen-and-paper task and included questions on financial literacy adapted from Lusardi and Mitchell (2007) (see Appendix C). The research of Lusardi and Mitchell has been widely used and clinically validated by several financial decision-making researchers (Hastings et al., 2013). There were five questions that measured the ability to perform simple calculations to demonstrate an understanding of how interest and inflation work, knowledge of time discounting, and assess whether respondents suffer from money illusion. The number of accurate responses was measured.

Procedure

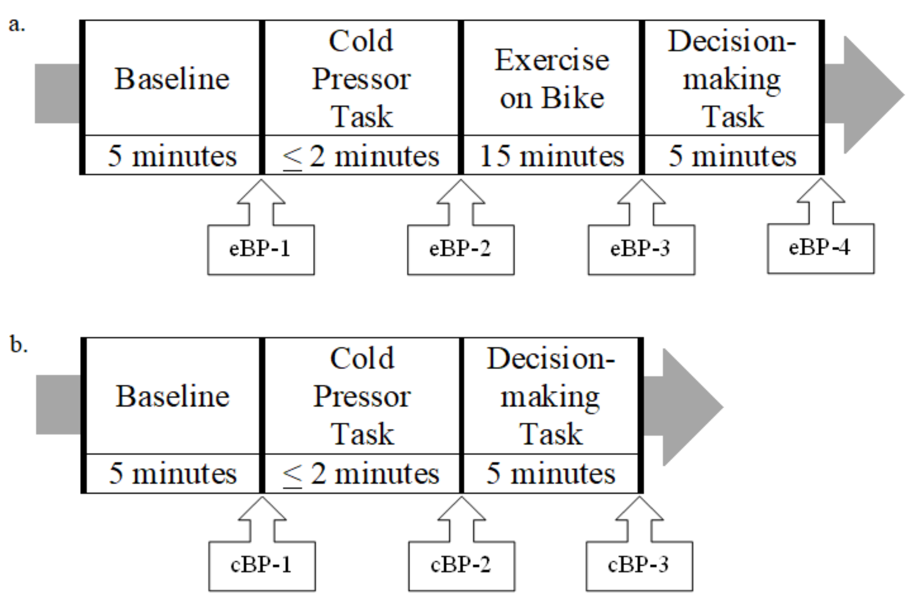
Those individuals who were prescreened and selected to participate in the experimental portion of the study arrived at the University of Central Oklahoma Psychology Laboratory. Due to the prevalence of COVID-19 during the time of data collection (i.e., November 2020), certain protocols were adopted to minimize risks (see Appendix D for details). Upon arrival, each participant was asked to read and sign the Authorization to Use or Disclose Protected Health Information for Research form (see Appendix E). This study including the COVID-19 protocols were approved by the Institutional Review Board of the University of Central Oklahoma.

Overall, there were two groups of participants that were tested at the laboratory: those who were physically active and those who were sedentary. Participants from each group were randomly assigned into the immediate exercise (experimental) condition or the no-exercise (control) condition. Each participant was connected to the blood pressure monitor and a recording of the participant's blood pressure was taken at preset time points (see Figure 4). The first recording of the blood pressure was taken to establish a baseline measurement prior to the cold pressor test (eBP-1). Each participant was then asked to sit and submerge their dominant hand in ice water for a maximum of 2 minutes at 39.2 degrees Fahrenheit. The amount of time and temperature of the water was derived from established literature (Porcelli & Delgado, 2009). Blood pressure recording (eBP-2) occurred immediately after the cold pressor task. After this, the participants who were randomly assigned to the immediate exercise condition were required to spin on a stationary bicycle for 15 minutes. Past literature indicated that this is the amount of time an individual should exercise for positive effects to be experienced (Bauman et al., 2012). The participants were expected to reach and maintain a target heart rate which was the participant's age subtracted from 220. This number was the maximum heart rate the participant should be able to achieve and was derived from Billinger and colleagues (2014). Blood pressure (eBP-3) was recorded after they completed the 15-minutes of exercise. Following the exercise, the participants moved on to complete the financial decision-making task for which they were allowed 5 minutes. A final blood pressure recording (eBP-4) was made after the task.

Those who were in the control or no-exercise condition experienced the procedure in a similar manner except that they completed the financial decision-making task immediately after experiencing the cold pressor task. (Any break between tasks would result in a sharp decline in blood pressure which is a potential confound considering the variables of interest in this study). Those in the no-exercise condition therefore had three recordings of blood pressure labeled cBP-1, cBP-2, and cBP-3.

Figure 4

Schematic Diagram of the Experimental Procedure



Note. 4a refers to the experimental or exercise group and 4b the control or no-exercise group. eBP and cBP refer to measurements of blood pressure taken during the experimental and control conditions, respectively.

Experimental Design

The present study utilized a 2 x 2 factorial design as depicted in Figure 5. The two variables of long-term physical activity and immediate exercise, along with their control conditions generated four groups, each with an independent sample size of five participants.

Figure 5

The Experimental Design

	No Immediate Exercise	Immediate Exercise
Sedentary	n = 5	n = 5
Physically Active	n = 5	n = 5

Note. The experimental design depicting independent samples and their sizes (n) under each condition.

Statistical Analyses

All statistical analyses were conducted using IBM SPSS® 24 software. A combination of 2x2 factorial ANOVA tests and independent-measures t-tests were used to make statistically significant comparisons between the groups.

CHAPTER 3

Results

Performance on the Decision-Making Task

Table 1 presents the mean accuracy scores and standard deviation for all four groups of participants. A 2x2 factorial ANOVA was used to compare the effects of physical activity level (sedentary or active) and immediate exercise (none or 15 minutes on a stationary bike) on the accuracy of responses on the decision-making task. There was no significant interaction effect, $F(1, 16) = .171$, $p = .68$. The main effect for activity level was not significant, $F(1, 16) = .476$, $p = .50$. The main effect for immediate exercise was also not significant, $F(1, 16) = .476$, $p = .50$. Figure 6 presents the results of the ANOVA.

Table 1

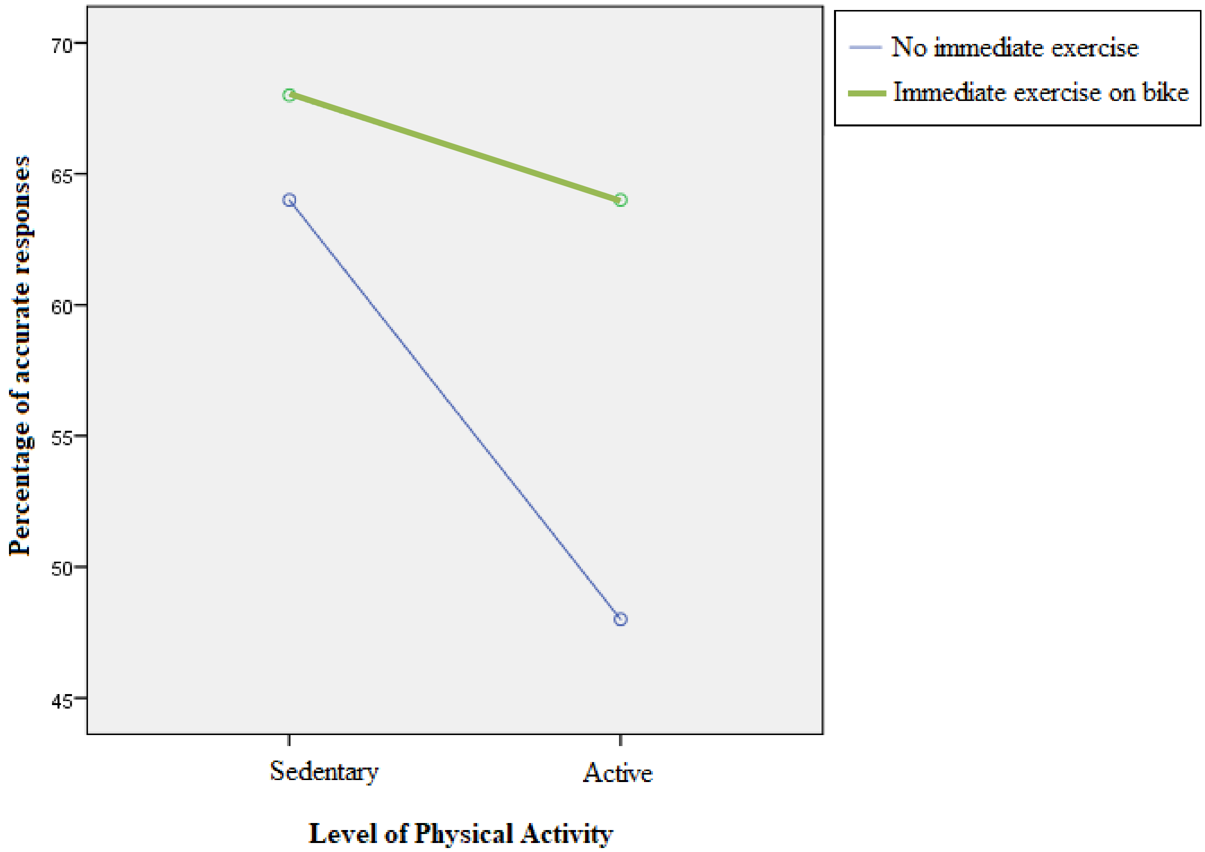
Percentage of Accurate Responses on the Decision-Making Task

	No immediate exercise		Immediate exercise	
Physical activity level	*M*	*SD*	*M*	*SD*
Sedentary	64	26.08	68	41.47
Active	48	22.80	64	35.78

Note: M = mean; *SD* = standard deviation

Figure 6

Effects of the level of physical activity and immediate exercise on accuracy



Note. This figure presents the analysis of the interaction effects of long-term physical activity and immediate exercise on accuracy of response on the decision-making task.

Comparison of Blood Pressure Measurements

Prior to Experimental Manipulation

Baseline comparisons in blood pressure were made between the ten physically active and ten sedentary participants prior to the cold pressor task. Independent samples t-tests indicated no statistically significant difference in blood pressure between the physically active and sedentary participants; $t(18) = .537$, p = .60 for systolic comparisons and $t(18) = 0.122$, p = .90 for diastolic comparisons.

Blood pressure readings were also compared immediately after the cold pressor task for the physically active and sedentary participants. Once again, t-tests found no significant differences in systolic readings, $t(18) = -.673$, $p = .51$ or in diastolic readings, $t(18) = -.158$, $p = .88$.

Table 2 presents the means and standard deviations for systolic and diastolic blood pressure measurements taken before and after the cold pressor task.

Table 2

Blood pressure measurements before and after the cold pressor task.

Group	Systolic		Diastolic	
	M	*SD*	*M*	*SD*
Before cold pressor (Baseline)				
Sedentary	124.10	13.09	77.20	7.13
Active	121.30	10.02	76.80	7.54
After cold pressor				
Sedentary	120.00	11.07	77.30	12.13
Active	124.20	16.35	78.00	7.01

Note: M = mean; *SD* = standard deviation

Post-Experimental Manipulation

Following the experimental manipulation of immediate exercise on the bike, a 2x2 factorial ANOVA was conducted to compare the four groups of participants: active-bike, active-no bike, sedentary-bike, and sedentary-no bike. Separate analyses were done for systolic and diastolic blood pressure. All the means and standard deviations for the main effects are presented in Table 3.

Systolic comparisons. There was no significant interaction effect between activity level and immediate exercise on systolic blood pressure, $F(1, 16) = .125$, p = .73. The main effect for activity level was not significant, $F(1, 16) = .553$, p = .47. The main effect for immediate exercise was not significant either, $F(1, 16) = 2.629$, p = .12.

Diastolic comparisons. The main effects of activity level and immediate exercise on diastolic blood pressure produced F ratios of $F(1, 16) = .004$, p = .95 and $F(1, 16) = .359$, p = .56, respectively. These main effects were not significant. There no was significant interaction effect, $F(1, 16) = .016$, p = .90.

Finally, a similar ANOVA was done to compare blood pressure values after the four groups of participants completed the decision-making task.

Systolic comparisons. Activity level had no significant effect on systolic blood pressure, $F(1, 16) = .007$, p = .93. Immediate exercise had no significant effect either, $F(1, 16) = .087$, p = .77. There was no interaction effect between activity level and immediate exercise on systolic blood pressure, $F(1, 16) = .554$, p = .47.

Diastolic comparisons. Neither activity level nor immediate exercise had significant main effects on diastolic blood pressure with F-ratios of $F(1, 16) = .003$, p = .96 and $F(1, 16) = .048$, p = .83, respectively. No significant interaction effect was observed, $F(1, 16) = .027$, p = .87.

Table 3

Blood pressure measurements after the experimental manipulation.

Group	Systolic		Diastolic	
	M	*SD*	*M*	*SD*
After cold pressor test				
Activity level (Main effect)				
Sedentary	125.70	22.19	77.10	16.75
Active	131.80	14.44	77.50	9.23
Immediate exercise (Main effect)				
None	122.10	16.26	75.40	11.49
Exercise on bike	135.40	18.95	79.20	15.02
After decision-making task				
Activity level (Main effect)				
Sedentary	121.60	11.78	76.70	8.53
Active	122.10	13.03	76.90	6.87
Immediate exercise (Main effect)				
None	122.70	14.71	76.40	7.89
Exercise on bike	121.00	9.52	77.20	7.57

Note: M = mean; *SD* = standard deviation

CHAPTER 4

Discussion

Despite deriving hypotheses based on existing literature, the results of the present study did not support its predictions. The first hypothesis predicted that long-term physical activity would have a significant effect on decision-making after a stressful event. The results showed that those who had been more physically active and those who has been sedentary responded very similarly on the financial decision-making task after experiencing the cold pressor task.

One explanation for these results may be found in a review by Schmit and Brisswalter (2018) on executive function and fatigue during prolonged exercise. They suggested that exercise in physically fit individuals would not require much prefrontal cortex involvement and the physical arousal of exercising would initially improve cognitive function. However, prolonged exercise would require increased engagement of frontal lobe areas resulting in neurocognitive fatigue, and consequently poorer performance on tasks of executive function. Both moderate and intense exercise could induce this loss of efficiency in motor and cognitive processes and alter self-regulatory functions as well as behavioral performance. Grego et al. (2005) found that trained cyclists experienced a significant increase in brain activity after an hour of exercise indicating that more effort was needed to maintain cognitive and motor performance. While participants in the present study did not cycle for such a prolonged period of time, it is possible that dealing with the cold pressor task (as a source of acute stress) may have had an added to neurocognitive fatigue.

Another related explanation is the law of less work. In a study on decision-making processes and cognitive demand (Kool et al., 2010), participants choose freely between various actions associated with different levels of demand for controlled information processing. Results revealed a bias amongst the participants in favor of the less demanding course of action. Kool et al. implied that people choose actions that minimized the demands for exertion or work. It is possible that the participants in the present study did not want to persist on the difficult decision-making task especially after exerting considerable energy on the cold pressor task and exercising on the stationary bike.

The second hypothesis predicted that immediate exercise would have a significant effect on decision-making after a stressful situation. On the contrary, the results showed that those who exercised on the stationary bike immediately after experiencing the cold pressor task did not respond more accurately on the financial decision-making task compared to those who did not exercise after the stressor.

These results may find support in a study by Lefferts et al. (2019) who looked at the effects of acute aerobic exercise on the accuracy of decision-making in middle-aged adults with and without hypertension and found that it had no effect on tasks of executive function and memory. They did, however, find that there was an increase in the processing speed (as reflected in reduced response time) on tasks after exercise. The present study did not measure response time which may have revealed differences between those who exercised for 15 minutes on the stationary bike and those who did not.

Another factor to consider is the decision-making task itself and how people may have solved the questions. The task used in the present study required participants to access their knowledge of financial information such as compounding interest and inflation over time. If one is not frequently engaged in these types of judgments, the decision-making process would likely be more conscious, explicit, highly effortful, and slow. These are characteristics of System 2, a component of the dual-process theory (Kahneman & Frederick, 2005). Someone highly engaged in financial decision-making would respond more quickly, intuitively, and with minimal conscious effort, which in turn are characteristics of System 1. In his 2008 review, Evans examined various contrasting theories regarding how each System could lead to superior decision-making with the inclusion of factors such as the novelty of the problem, prior knowledge and experience, the time provided to complete the task, and the type of heuristics engaged by the individuals.

In the present study, participants were intentionally selected from a large pool of psychology majors, based on the assumption that they would not be as well-versed in financial calculations, as say, a business major. Given that they only had five minutes to answer the five questions on the questionnaire, some of the aforementioned factors probably played a role in how the participants responded, i.e., the accuracy of their answers. Considering that the mean accuracy scores where not significantly different across the different groups of participants, it is possible that the results were influenced by the nature of the task and the cognitive processes involved in completing the task.

The third hypothesis predicted a relationship between body condition, stress, and decision-making. Blood pressure (systolic and diastolic) was periodically recorded as a physiological measure of stress. Existing research has generally found a positive relationship between blood pressure and stress with higher values of blood pressure indicating more stress (Carroll et al., 2012). Comparisons of both systolic and diastolic blood pressure measurements were made at baseline and immediately after the cold pressor task to see if there were differences between those who were generally physically active and those who were sedentary. The positive effects of long-term physical exercise on heart rate and blood pressure have been well documented (Billinger et al., 2014; Joyner et al., 2010; Edelmann et al., 2011). It was therefore expected that those who tended to be physically active would perhaps have lower blood pressure values after the cold pressor task compared to those who were sedentary. However, the results of the present study did not reveal any significant differences between these two groups of individuals after the cold pressor task. Surprisingly, no differences were seen when those who exercised on the stationary bike were compared with those who did not. This indicated that immediate exercise did not seem to have a differential impact on physically active and sedentary individuals. In order to assess any stressful effects of the decision-making task itself, a final blood pressure reading was taken after all the participants completed the decision-making task. Once again, no significant differences were observed between the groups.

The complete lack of significant differences in blood pressure readings between the various participant groups was entirely contrary to expectations and raised certain concerns. While current research led to the expectation of seeing these differences, it was also possible that blood pressure perhaps should not have been used as the sole indicator or measure of stress. Kim et al. (2018) conducted a meta-analysis on research regarding stress and heart rate variability and concluded that heart rate variability was maybe a more objective and reliable assessment of psychological health and stress. Other researchers have used cortisol levels to reliably assess physiological changes brought on by stress (Matthews et al., 2001).

Effects of the COVID-19 Pandemic

The stress experienced during a global pandemic would be considered chronic. Matthews et al. (2001) showed that chronic stress could actually inhibit acute stress responses including cortisol levels for an hour after experiencing the acute stressor. Conducting the present experiment in 2020 during the COVID-19 pandemic most likely introduced certain extraneous variables that could have influenced the participants' performance in the study. The most obvious factor would be the anxiety that millions of people have been experiencing world-wide. The National Center for Health Statistics (2020) has been conducting nation-wide surveys since the pandemic began in the United States. Data since April 2020 on individuals ranging from 18 years of age to 80 years and above reveals that the highest percentage of those reporting symptoms of anxiety are in the 18-29 age range (averaging between 40-42%). Estimates in Oklahoma for this age range averaged around 42% during the period of data collection. This is important to consider since a majority of the participants in the present study fell within this age range. Even though all precautions were taken during the experimental portion of the study, being physically present in the laboratory could have increased stress during this time.

The personal finances of many individuals were affected by the pandemic which in turn, likely contributed to their stress and anxiety. Many lost their jobs and had trouble paying their bills. According to Parker et al., (2020) from the Pew Research Center, this statistic included 35% of adults aged 18-29 years.

Another factor that could have influenced the participants were possible changes to their exercise routines due to restricted access to physical fitness facilities. No questions were asked during the experimental procedure regarding any exercise changes so whether this was truly a factor could not be determined.

Having discussed the results and the various factors that could have influenced the study, the implications of the findings can no longer be specified in a straightforward manner. Important factors to consider are the intensity and duration of the exercise, the nature of the decision-making task, and the cognitive processes involved. Measuring the physiological changes induced by stress is also complicated. These contribute to the contradictions that exist in the current research on the effects of exercise on decision-making under stress. Additionally, addressing certain limitations in the present study may provide more clarity regarding these findings.

Limitations & Future Directions

Study Sample Size

Due to the current pandemic and the necessity of conducting the experiment face-to-face, the sample size of this study was extremely limited. Only twenty participants were used in total and this could have played a role in reducing the effect of the variables, despite the ANOVA being a rather robust test. With regards to accuracy on the decision-making task, standard deviation scores revealed high variability within groups while the mean values between groups were not very different. The means did however trend towards what was predicted; hence, it is possible that with a larger sample size, one may have seen the data support the hypotheses.

Effects of Age

Despite all participants being recruited from the undergraduate psychology degree program, eighty percent of the sample fell within the age range of 18-29 years, with the remaining being between 30-60 years. Past research suggests that the older the individual, the more knowledgeable they might be about the financial literacy topics tested in the decision-making questionnaire (Taft et al., 2013). On the other hand, financial literacy has been reported to decline in adults over the age of 60, which in turn corresponds to decreases in cognition (memory and perceptual speed) (Gamble et al., 2015). While the present study, did not include any participants in this age range, even the 20% who were between 30 and 60 could have influenced the results since the total sample size was limited.

Monitoring Blood Pressure

In the present study, blood pressure was recorded using the QardioArm®, a wireless device that could be strapped to the upper arm. Research has demonstrated that this device is reliable (Mazoteras Pardo et al., 2017). In general, these types of wireless blood pressure readers are more accurate when compared to other methods of measuring blood pressure such as automated office blood pressure readings (Roerecke et al., 2019; Yoo et al., 2018). There were some contradictory findings to these claims however, particularly in children where blood pressure readings using the wireless blood pressure monitors were less accurate when compared to adults (Strergiou et al., 2017). With regards to the present study, only one reading per participant was taken at preset points during the experimental procedure. In research involving blood pressure, several readings are usually taken per participant and the average is calculated. However, a longer time interval between experimental conditions would have been required and since blood pressure values can change rapidly, it was necessary to obtain a measurement as immediately as possible.

Conclusion

In summary, neither long-term physical exercise nor immediate aerobic exercise had significant effects on financial decision-making in a stressful situation. This was evidenced by the fact that individuals who were physically active and those who were sedentary, scored very similarly on the decision-making task, regardless of whether they had engaged in immediate exercise or not (i.e., spending 15 minutes on a stationary bike) prior to the task. Blood pressure measurements were also very similar between these groups of participants, both after the cold pressor task and after immediate exercise. While the results of the present study appear to be discouraging, they are still important as they shed light on the complexities of conducting this type of exercise research. This has been made even more complicated by the COVID-19 pandemic. In fact, many people commonly use exercise as a method to alleviate stress, anxiety, and depression. It would therefore be worthwhile to redo this study with modifications to the sample size, decision-making task, and physiological measure of stress to see if changes to these factors could amplify the effects of exercise on a cognitive process such as decision-making.

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Appendix A

Informed Consent Form

(This was completed online through Qualtrics®. A paper copy was also offered to participants when they arrived at the laboratory)

Project Title: Effects of exercise on decision-making under stress.

Purpose of this research: The purpose of this project is to determine whether exercise has positive immediate and long-term effects on decision-making when an individual is placed under stress.

Procedures/treatments involved:
Prescreening: Participants will first complete two online questionnaires to assess general health condition and level of physical activity in their everyday lives. Selected participants will then be invited to come to the psychology laboratory (EDU 309) for the experimental portion of the study.

Experimental portion:
Participants will be tested one at a time in the lab. Upon arrival, they will be prescreened for COVID-19. A touchless thermometer will be used to make sure there is no fever. A blood oximeter will be used to make sure that their blood oxygen levels are within the normal range. They will also be asked questions pertaining to any symptoms of COVID-19 they may be experiencing. If they are cleared, then they will be allowed inside the lab wearing PPE such as gloves, mask, and face-shield which will all be provided. If they are not cleared, then they may be rescheduled for a later date. The experimenter will be the only other person in the testing room and will wear similar PPE.

Procedure:
A wireless blood pressure cuff will be wrapped around their upper arm to take measurements at preset intervals. First, all participants will undergo the cold pressor stressor task, which involves sitting with a hand in a bucket of ice-cold water for up to a maximum of 2 minutes. Some participants may be required to cycle on a stationary bicycle for 15 minutes. Finally, everyone will complete a short decision-making task online on a computer.

Expected length of participation: 60 minutes

Potential benefits: This study will provide valuable information regarding the effects of exercising on stress.

Potential risks or discomforts: There may be mild to moderate physical discomfort experienced during the cold pressor task. Participants may withdraw their hand from the ice bucket at any time. There may also be some physical discomfort when cycling on the stationary bike. Participants may stop at any time if they are unable to continue.

Researchers' contact: If you have any questions, you can contact the Principal Investigator Kelly Rogers (krogers22@uco.edu) or the Co-Principal Investigator Dr. Tephillah Jeyaraj-Powell (405-974-5484 or tjeyaraj@uco.edu).

Contact information for UCO IRB: For questions about this research, you may also contact the Institutional Review Board 405- 974-5497 (irb@uco.edu).

Explanation of confidentiality and privacy: All information given will be kept confidential and anonymous. No direct information of the participant's name will appear on the questionnaire responses that will be retained by the researcher, and no publication from this data will include any identifying information.

Assurance of voluntary participation: Participation is voluntary, you do not have to participate if you choose not to, and you may withdraw from the study at any time without penalty. All data will be destroyed in 5 years. Any electronic information will be kept on a password protected flash drive prior to deletion.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form.

Name of Participant (Please print): ____

Signature: _____________________________________ Date: _______________________

Appendix B

Participation Pre-Screening Questionnaire

(This was completed online through Qualtrics®)

<u>Part-1: Health Pre-screen</u>

Your responses to the following question(s) will be solely used to determine your participation in the experimental portion of this study. This information will NOT be part of the dataset and will NOT be shared with anyone other than the principal and co-principal investigators. Please answer the following question(s) about your health to the best of your knowledge.

1. Have you ever had a stroke? (yes) (no)
2. Do you ever have unexplained pains in your chest at rest or during physical exercise? (yes) (no)
3. Do you lose your balance because of dizziness or do you ever lose consciousness? (yes) (no)
4. Have you ever been diagnosed with asthma and require medication? (yes) (no)
5. Have you ever been diagnosed with type I or II diabetes? (yes) (no)
6. Do you have any major muscle or joint conditions that may limit you or be aggravated by physical activity? (yes) (no)
7. Have you ever been told that you have a heart condition? (yes) (no)
8. Do you have high blood pressure over 140/90 or low blood pressure below 100/80? (yes) (no)
9. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition? (yes) (no)
10. Are you pregnant? (yes) (no)
11. Have you ever been diagnosed with any medical conditions that may be made worse by participating in physical activity? (yes) (no)

<u>Part-2: Physical Activity Level</u>

You have met the general health conditions required to participate in this study without risk to your health.

Your responses to the next set of questions will help us determine your current level of physical activity whatever that may be. Please answer the following to the best of your knowledge.

a. Do you exercise? (yes) (no)

b. Do you engage in 30 or more minutes of moderate-intensity (anaerobic-strength training) physical activity for at least 5 days every week? Examples of anaerobic exercises include weight-lifting, resistance training. (yes) (no)

c. Do you engage in 20 or more minutes of vigorous-intensity (aerobic-cardiovascular training) exercise for at least 3 days every week? Examples of aerobic exercises include swimming, cycling, jogging, rowing, brisk walking. (yes) (no)

d. Is the amount of exercise that you engage in less than the amounts previously described? (yes) (no)

Appendix C

Decision-making Task

1. Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?
    - (i) ____More than $102
    - (ii) ____Exactly $102
    - (iii) ____Less than $102
    - (iv) ____Do not know
    - (v) ____Refusal

2. Suppose you had $100 in a savings account and the interest rate is 20% per year and you never withdraw money or interest payments. After 5 years, how much would you have on this account in total?
    - (i) ____More than $200
    - (ii) ____Exactly $200
    - (iii) ____Less than $200
    - (iv) ____Do not know
    - (v) ____Refusal

3. Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
    - (i) ____More than today
    - (ii) ____Exactly the same
    - (iii) ____Less than today
    - (iv) ____Do not know
    - (v) ____Refusal

4. Assume a friend inherits $10,000 today and his sibling inherits $10,000 3 years from now. Who is richer because of the inheritance?
    - (i) ____My friend
    - (ii) ____His sibling
    - (iii) ____They are equally rich
    - (iv) ____Do not know
    - (v) ____Refusal

5. Suppose that in the year 2021, your income has doubled and prices of all goods have doubled too. In 2021, how much will you be able to buy with your income?
    - (i) ____More than today
    - (ii) ____The same
    - (iii) ____Less than today
    - (iv) ____Do not know
    - *(v)* ____Refusal

Appendix D

COVID-19 Research Protocol

Project Title: Effects of Exercise on Decision-Making under Stress

Student PI: Kelly May Rogers

Faculty Supervisor: Tephillah Jeyaraj-Powell

Materials:

1. Covid-19 Screening Questionnaire
2. Fingertip pulse oximeter
3. Non-contact infrared thermometer
4. Researcher PPE:
   - Face Shield
   - Face Mask (disposable)
   - Lab Coat
   - Non-latex Gloves (disposable)
5. Participant PPE:
   - Face Shield
   - Face Mask (disposable)
6. Hand sanitizer (with 60-95% alcohol)
7. Disinfectant spray and wipes
8. Paper towels
9. Trash bags

Procedure:

- Participants will be scheduled one at a time and with enough time in between (minimum 3 hours). Aerosolized COVID-19 can stay in the air for up to 3 hours. This also allows the researcher to change their own PPE and disinfect the research materials, equipment, and room (furniture, door handle, etc.).
- As soon as each participant arrives at the testing room, they will be asked a series of screening questions*. Anyone that responds "yes" to any of the items will not be allowed to participate that day and may be rescheduled.

- Next, they will be checked with a no-touch thermometer and pulse oximeter to make sure that they do not show these symptoms consistent with COVID-19:
    - Temperature check: Anyone with a temperature greater than 100°F will not be allowed to participate that day and may be rescheduled. Normal body temperature ranges between 97-99°F.
    - Pulse oximetry check: $SpO_2 \leq 90\%$ will be considered symptomatic for COVID-19. Normal SpO_2 is usually at least 95%, although some individuals with chronic lung disease or sleep apnea can have normal levels around 90%.
- Researcher will disinfect the area that the study is being conducted in before and after each use.
- Researcher will disinfect all equipment before and after each use.
- Researchers will also require the participants to use hand sanitizer before and after the experiment.

***COVID-19 Screening Questionnaire:**

Please respond to the following questions with Yes/No.

1) Have you experienced any of the following within the last 24 hours?
    - Fever or chills (Yes / No)
    - Cough (Yes / No)
    - Shortness of breath or difficulty breathing (Yes / No)
    - Fatigue (Yes / No)
    - Muscle or body aches (Yes / No)
    - Headache (Yes / No)
    - New loss of taste or smell (Yes / No)
    - Sore throat (Yes / No)
    - Congestion or runny nose (Yes / No)
    - Nausea or vomiting (Yes / No)
    - Diarrhea (Yes / No)

2) Are you caring for someone who has been diagnosed or tested positive for COVID-19? (Yes / No)

Appendix E

Authorization to Use or Disclose Protected Health Information for Research

This document describes how health information about you may be used and disclosed. Please review it carefully and sign acknowledging receipt of this information.

Title of Research Study: **Effects of exercise on decision-making under stress.**

Research Team: **Kelly Rogers** (Principal Investigator) and **Dr. Tephillah Jeyaraj-Powell** (Co-Principal Investigator)

Address: **100 N. University Drive, Box 85, Edmond, OK 73034**

Email: krogers22@uco.edu back up email would be tjeyaraj@uco.edu

If you decide to participate or become a part of this research study, University of Central Oklahoma (UCO) researchers may use or disclose (share) information about you that is considered to be protected health information. Protected health information is any information that can be traced back to you which concerns your past and present health and results of medical tests or diagnostic procedures. The information authorized for release may include records which may indicate the presence of a communicable or noncommunicable disease. UCO needs your authorization (permission) to use and disclose your protected health information in this research study. Protected health information will be called private information in this authorization.

Private Information To Be Used or Disclosed. If you give permission, the researchers could use and disclose your private information to the people identified in this authorization. This includes: **name and blood pressure levels.**

Purposes for Using or Disclosing Private Information. If you give permission, the researchers would use and disclose your private information to: **no one outside the research team.**

Other Use and Disclosing of Private Information. If you give permission, the researchers could also use and disclose your private information to develop new procedures or commercial products. They could disclose your private information to the research sponsor, the UCO Institutional Review Board, inspectors who check the research, and government agencies like the Food and Drug Administration (FDA) and the Department of Health and Human Services (HHS). Information used or disclosed pursuant to this authorization may be subject to redisclosure by the recipient and no longer protected by the federal law. The researchers would also disclose your private information to: **no one outside the research team.**

Confidentiality. Although the researchers will report their findings in scientific journals or meetings, they will not identify you in their reports. Maintaining the confidentiality of your private information is a priority for the researchers, but this cannot be absolutely guaranteed.

Voluntary Choice. The choice to give UCO researchers permission to use or disclose your private information for their research is voluntary. It is completely up to you. No one can force you to give permission. However, if you want to participate in the research study, you must give permission for UCO researchers to use or disclose your private information.

Access to Private Information. By signing this authorization and consenting to participate in the research study, you acknowledge and agree that your access to your private information created as a result of your participation in this research study will be withheld for so long as the research study is in progress. Your access to your private information will be reinstated upon completion of the research study you are participating in.

Canceling Permission. If you give the UCO researchers permission to use or disclose your private information, you have a right to cancel your permission whenever you want. However, canceling your permission will not apply to your private or de-identified information that the researchers have already used or disclosed. You may cancel your permission by submitting a written request to the leader of the research team or to UCO's Privacy Official.

End of Permission. Unless you cancel it, permission for UCO researchers to use or disclose your private information for their research will **never end.**

Contacting UCO. You may find out more about UCO's privacy practices and your privacy rights by reviewing UCO's Notice of Privacy Practices or by writing to:

Privacy Official
University of Central Oklahoma
100 North University Dr., Edmond, OK 73034
If you have questions call: (405) 974-5479 or E-mail: irb@uco.edu

Giving Permission. By signing this form, you give the University of Central Oklahoma (UCO) and UCO's researchers led by **Kelly Rogers** and **Dr. Tephillah Jeyaraj-Powell**, permission (authorization) to use or disclose (share) your private information (protected health information) for the research study called **Effects of exercise on decision-making under stress.**

A signed copy of this form will be provided to you. By signing below, I acknowledge receipt of a paper copy of UCO's Notice of Privacy Practices.

____

PRINTED NAME of Participant **SIGNATURE** **Date**