# Use of an Acute Vigorous Exercise Intervention to Improve Academic Success on Exams in Undergraduate STEM Students

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## Abstract

This study aimed to determine if an acute bout of exercise could improve academic performance when compared to sedentary behavior within a 2-hour window before a college exam. The participants of this study completed two bouts of an intervention on two separate occasions, exercise and sedentary, then completed each of the two class exams, followed by a short survey to gain insight on motivation and anxiety. A 2-way ANOVA was used to determine a time or group effect as this study was completed over a 15-week semester and found no significant difference between the group's exam scores over time, as well as no group effect of the acute bout of exercise on their exam performance. Pre- and post-surveys, as well as post-exam surveys collected data relating to IPAQ, MSLQ, and GRIT which found significant correlations between IPAQ and perceived exam preparedness with $P$=0.041. As expected in academia, each exam's scores were positively related to final course grades with $P$=0.0275 on exam 1 and $P$=0.0179 on exam 2. Finally, a $P$=0.048 was found between final course grades and scores from the extrinsic motivations section of the MSLQ on the post-study survey. Results and lessons learned from this pilot study should be used towards creating a larger-scale study in the future.

*Keywords: BMI, exercise, education, motivations, GRIT*

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## Introduction

The United States Department of Health and Human Services reported less than half of adolescents (aged 12-21) met the requirements for physical activity proposed by the Center for Disease Prevention (National Institutes of Health, 2013). The CDC states that adolescents and young adults should participate in 60 minutes or more of moderate-to-vigorous physical activity daily for at least five or more days of the week (Center for Disease Control, 2022). Sedentary behavior can have many negative effects on a person's life, especially during developmental phases. The health risks of sedentary behavior include but are not limited to obesity, cardiovascular diseases, and Type 2 diabetes as well as adverse effects on mental health like depression, anxiety, and self-esteem (Minck et al., 2000; Ondrak et al., 2007; Liao et al., 2013). Along with health concerns, literature suggests decreased academic performance is another risk factor associated with physical inactivity. Many studies have associated improved academic performance to a higher level of physical fitness/activity (Bass et al., 2013; Castelli et al., 2007; Dwyer et al., 2001; Janak et al., 2014; London & Castrechini, 2011; Stevens et al., 2008; Tremblay et al., 2000; Van Dusen et al., 2011).

### Statement of the Problem

A fall in academic success was reported by Kuhfeld et al. (2022) after students returned to the classroom due to the COVID-19 pandemic, with mathematics and reading scores dropped 0.09-0.18 standard deviations. Restrictions to outdoor activities and increased time spent on the computer for virtual learning were key factors in the decline of physical activity rates during the pandemic. Some children reported spending less than 11 minutes per day performing any type of physical activity (Rossi et al., 2021). The CDC also stated that less than 53% of adults met their minimum requirements for physical activity, which leads to a great deal of concern as 42% of the

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US population is considered overweight or obese, which measures over a 12% increase in the last 20 years. As recent literature by Good and Anderson (2016) has noted, an increase in BMI shows a correlation to lower classroom success. It is possible that relationships between physical activity and academic performance could be determined by individual motivation and behavioral patterns. This relationship has not been confirmed by many studies and for this reason, this project aimed to answer the following research question:

> Can academic performance be improved through an acute bout of vigorous intensity exercise when compared to sedentary behavior?

**Purpose of the Project**

This project was aimed at determining if academic performance could be influenced by an acute bout of exercise prior to an exam. Students' exam grades were examined and correlated with their respective intervention groups – Group 1 performed the bout of exercise intervention while Group 2 performed the sedentary intervention for the first exam and then each group switched roles for the second exam later in the semester. The proposed outcome was that students with lower exam scores will be a part of the sedentary intervention or provided reports of less frequent participation in exercise. Previously published literature from Good and Anderson (2016) established that a higher BMI was associated with a lower overall grade in class, which led to extending insights into the role of exercise in higher education. Data from this study was used to find correlations that can continue to support efforts to increase exercise among higher education students. The aim was that students will begin to acknowledge the benefits of exercise, which include improved academic performance and strive to increase their level of physical activity in the future.

## Project Objectives

While neither intervention group had the ability to study test material during the 2-hours prior to their exam, the group of participants in the exercise intervention should receive higher test grades than the group participating in the sedentary intervention.

## Definition of Terms

Body Mass Index (BMI): a person's weight in kilograms divided by the square of their height in meters. BMI is used to categorize patients into health groupings. It does not diagnose fat or health. Merely for health concern watch (CDC, 2022).

Rec Sports: Recreational Sports is a department on campus at Virginia Polytechnic and State University (VT) that offers their students and faculty the opportunity to engage in physical activities to create healthy lifestyles and habits through a variety of group classes and sporting engagements (Rec Sports, 2021).

BOD POD$^{TM}$ (COSMED, Inc., Indianapolis, IN): a computerized, egg-shaped device that requires a user to sit inside to measure weight and volume to determine body density while also calculating body fat percentage (Mayo Clinic, 2022).

Vigorous Intensity Exercise: A level of exercise intensity that is 60-89% of participants' heart rate reserve (HRR), or an activity ≥ 6METs. These activities require the highest amount of oxygen to complete the exercise, for example, swimming, running, cycling, jumping (Liguori, 2021).

Heart Rate Reserve (HRR): a person's max heart rate calculated using the following equation: (220 – (age) – (resting heart rate) = HRR. HRR is more accurate than %max HR because it includes a participant's age and resting heart rate (Liguori, 2021).

## Literature Review

College students, especially during their first and second year, report higher levels of stress and anxiety as they transition into a new phase of life and navigate a new community or identity after high school. Maymon and Hall (2021) have suggested that those higher stress levels during first-year transition were found to affect physical health, information retention, educational experiences, as well as well-being and academic performance. Within the last few years, younger adults have shown an interest for healthier lifestyles and prioritizing exercise time (Chaudhary et al., 2020). In college students, reports of higher satisfaction and overall college experience were noted with those also rating the value of physical activity higher. (Stork et al., 2017). While the type of exercise is almost irrelevant, the Center for Disease Control (2022) recommends that physical activity be included in everyone's life with times and intensities varying by age. For college aged students, 18-22 years-old, the CDC website recommends that they participate in at least 150 minutes of moderate-intensity activity per week with an additional two days of muscle strengthening activities. The exercise guidelines function as a recommendation for physical activity among this age group, but there are many people who are well above and well below those rates. Few studies have investigated the link between poor academic performance and higher body mass index (BMI) among college students. Dubac et al. (2017) found a significant correlation ($P$=0.01) between participants $VO_2$ max levels and GPA, unrelated to academic motivation factors. The study supported higher-GPA values which favored a healthier physical profile.

On average, 'normal' healthy weight is determined at ranging between 18.5-24.9kg/$m^2$ and recorded to increase as a person moves through adulthood reaching a BMI average of 25.4kg/$m^2$ (Clark et al., 2013). This would still be recorded within range of healthy, but the

steady increase suggests concern for obesity further into their adult life. Aside from biological factors, there are socioeconomic factors, educational history, family history, gender differences, etc. that can result in academic performances and expected high school or college graduation. When averaged on a graph, national BMI increases with age among all possible factors. Clarke et al. (2013) examined high school and college individuals aged 19 to 30. Those expecting to graduate from college had a 34% reduced odds ratio of being overweight/obesity into adulthood, compared to those that did not expect to graduate college. Franz and Feresu (2013) assessed seventy-seven college-aged participants and found a negative correlation between both GPA and ACT scores with BMI. While these studies name a few scenarios of childhood obesity concerns, there are many more; Chandola (1958), Batty et al. (2006), Lawlor et al. (2006), Marioni et al. (2012), and Rosenblad (2012) that suggest a relationship between lower intelligence in youth and higher BMI, obesity, and weight gain in adulthood.

Academic performance and its influencing factors have been studied for many years and certain results, while limited by frequency, suggested that some activities in a student's lifestyle are beneficial while there were some activities that can hinder their ability to achieve full academic potential. For example, some benefits may arise due to the increase of cerebral oxygenation passed through the body and brain during exercise. Bellar et al. (2014) reported a positive cognitive change due to the activated neurons in the brains of nursing students during aerobic and weightlifting activities. In this specific study, the group participating in weightlifting had limited improvements while the aerobic participants recorded greater neurotropic developments. In Pearson's $x^2$ analysis, they observed differences in GPA with aerobic activity resulting in $P \leq 0.001$ when correlated with higher GPA. These results were suggested to be caused by the increased level of cerebral oxygenation released into the cells of the brain. While

there can be many more driving factors in association with academic performance the improvements by this exercise intervention should increase the facilitation of exercise routines among more college students.

To achieve success in both academics and exercise requires skills that can be associated with self-control and disciplinary behaviors that college-aged students begin to navigate during their newfound independence. Jung (2013) concluded there was a strong relationship between the value of an exercise goal and the associated exercise behavior. This study correlated certain behavioral predictors with goals achieved through self-regulatory behavior all resulting in $p<0.001$. Most students do not have time management skills to tackle their academics while also prioritizing health through exercise and social time spent with friends. Boat and Cooper (2019) hypothesized that the ability to achieve academic perceived success would require self-control type behaviors. Their study aimed to determine a relationship between valued exercise goals and self-report actions of exercise. Participants were challenged in time management of two highly important life goals – academics and exercise; concluding that actual behavioral actions and outcomes could be predicted through how one's social cognition relates their perception on exercise or non-exercise goals (Boat & Cooper, 2019).

The conclusion drawn by Boat and Cooper (2019) can be related and defined within the Theory of Planned Behavior (TPB), a psychological prediction of an individual's intention to engage in a behavior at a specific time and/or place strictly regarding an ability to exert self-control (LaMorte, 2019). Psychologists and researchers have used the theory of planned behavior to predict and adjust health patterns and have learned that a lot of human behaviors manifest through intentionality. Ahmad et al. (2014) studied effects of employing the theory of planned behavior in elderly sarcopenic participants to determine and predict maintenance of their

required exercise regimes. With $R^2$=0.19, attitude was the most important component when predicting an intention towards exercise followed by perceived behavioral control. In the same study, 85% of the intention to perform exercise among the female participants was found between the perceived behavior, attitude, and subjective norms. The findings from this study have allowed physicians to continue to rate the TPB as an effective way of monitoring intentions towards certain behaviors. It is a good representation of how someone may include healthy habits into their lifestyle and note negative forces that are driving them away from reaching their full potential.

Students should be aware of the health benefits from regular exercise, and this may affect their perception of prioritization of these activities. Obesity and anxiety are large contributors to decreased life expectancy and quality of life, but they are also avoidable with healthy habits. According to a study by Warburth et al. (2006), healthy lifestyle choices had positive associations among 20% of participants as well as recorded a 29% decreased risk of developing cardio-vascular related mortality. As well as physiological benefits, exercise improves mental health and emotional well-being. Exercise can more than double the chances of having a more positive outlook on demanding situations than if not performing physical activity (Coyle et al., 2020). A student could improve their brain function through stronger mental health aspects aided by their healthy habits and lifestyles.

While exercising, the cardiovascular (heart) and pulmonary (veins and arteries) systems transport oxygen rich blood through the body and as intensity increases the supply needed increases to match the effort and needs. Ando et al. (2011) performed a modified version of the Eriksen flanker task over a 3-day period to hypothesize the maximal intensity for desired cognitive function improvements. Oxygen intake was measured during a bout of cycling exercise

followed by a set of cognitive tests. They found when VO2 levels rose around 60% of max during exercise, there were cognitive improvements caused by suggested arousals induced by that exercise. Lower intensity exercise is defined when a person's heart rate remains below 64% of their heart rate maximum (220-age). This can be achieved through activities such as light housework or showering, while more intense activities such as brisk walking or yardwork can increase the heart rate into the 64-76% heart rate max range, reaching the moderate intensity zone (Liguori, 2021). Ando et al. (2011) found a limit of 80% peak $VO_2$ before cognitive functions began to diminish. When a participant pushed past that 80% threshold the tissue mobility decreased as oxygen supply was limited due to a hyperventilation sensation in breathing mechanisms during this vigorous intensity. During hyperventilation, "an array of physiological changes is experienced that include the restriction of oxygen to the brain (vasoconstriction)" (Travel, 2021, p. 14). The results found from this study and other literature suggested the optimal range for cognitive improvements can be found when a person's heart rate exceeded 40% of their maximum load up to an intensity where they can allow their breath to avoid hyperventilation to the brain.

There are numerous factors that can influence a student's academic performance such as gender, socioeconomic status, family history, parental engagement, self-determination, and physical activity. After reviewing past literature, frequency of exercise can be associated with a person's BMI, drawing on conclusion to academic performances and physical attributes. Of these factors, physical activity (time and intensity) is the most individually controlled, meaning that if students possess the characteristics to care for their health, they could develop healthier habits and skills required to succeed in the classroom.

**Motivated Strategies for Learning Questionnaire**

The Motivated Strategies for Learning Questionnaire (MSLQ) is based on general cognitive views toward motivation and learning strategies and is provided as a guide for assessing college students' motivational orientations and use of potential learning strategies (Pichard et al., 1990). The scales used on MSLQ surveys are aimed at learning important components of self-regulated learning which can be determinants of academic performance. Self-regulated learning includes cognitive, metacognitive, behavioral, motivational, and emotions aspects of learning. According to Roth et al. (2016), the MSLQ is used the most frequently when determining self-regulating measurements and Honicke and Broadbent (2016) noted the increased use to determine self-efficacy measurements. The questionnaire can be broken down into smaller sections to help analyze behavioral patterns and effects in more specific aspects of a students' capabilities – intrinsic motivation, extrinsic motivation, expectation on exam, and anxiety for an exam. Intrinsic and extrinsic motivations are concepts that can provide a lot of insight to a person's behaviors. Ryan and Deci (2000) defined intrinsic motivations as "an important construct that reflects the natural human propensity to learn and assimilate because of interest or personal enjoyment" (p. 55) while under extrinsic motivation an action is performed because of a separable outcome unrelated to personal interests. Geller et al. (2018) concluded that in participants who were regular exercisers and ones with higher intrinsic motivation scores also scored higher for extrinsic motives. Interestingly, intrinsic motives can be independently high among participants, but if a participant records higher levels of extrinsic motivations they also have higher intrinsic motivations.

**International Physical Activity Questionnaire**

The International Physical Activity Questionnaire (IPAQ) was developed to measure health-related physical activity and many different versions are being used and tested in many

international studies. The questionnaire is self-reported, self-administered, and measures two outcomes: MET (Metabolic Equivalent Task) per week and hours reported in moderate- and vigorous- intensity activities (Hagstomer et al., 2005). Lavelle et al. (2020) found among the 58 participants the sedentary behaviors recorded on the accelerometer were comparative to the IPAQ reported time and found an underestimation of their physical activity levels. Results from this questionnaire could increase awareness among survey takers and act as a baseline for recommended ways to reach minimum physical activity rates.

**GRIT**

The author of "Grit: The Power of Passion and Perseverance", Angela Duckworth, describes that Grit is what creates outstanding achievements based on science and certain achievements are not always created through talent, but reserved for those with passion and perseverance. Duckworth and Gross (2014) explained the link between grit and self-control behaviors can help people be more successful than others when it comes down to attention, emotions, and behavior regarding temptations. Success in the aspect of grit is determined with goals especially in the face of setbacks. In a study determining potential academic achievement, Martin et al. (2021) found a mean grit score of 3.70 which is relatively high when compared to other determining factors. They also found that a higher GPA resulted in higher grit scores (total mean 3.41±0.433) concluding that effort can work as a predictor for academic outcomes, more so a determining factor in perseverance through failures – important characteristics in achievements of a college-aged student.

## Project Methodology

### Participants

Participants of this study were students in a second-year Human Nutrition, Foods, and Exercise (HNFE) course at Virginia Tech titled "Nutrition Across the Lifespan" HNFE 2014. During the first week of this class, the researchers proposed the outline of the study to all students in this class, detailing the study design, objective, requirements, and compensation. All students with interest in participation completed a survey of interest. Requirements for this study included participants completing a fitness assessment, which included body fat percentage via a BOD POD™ (COSMED USA, Inc., Indianapolis, IN) provided by Virginia Tech Rec Sports, refraining from exercise 48 hours prior to the intervention, participating in both bouts of the interventions (exercise and sedentary), wearing a monitor to track heart rate, and then completing a pre- and post- survey, as well as a survey after each of the two exams. After each survey, the students were compensated with $20 for their participation and to limit the attrition rate of the study.

Information about this study was not required to be posted on the syllabus for HNFE 2014 because student participation was completely voluntary, therefore not a requirement for the course. In this type of study, hypotheses relating exercise and academic performance were tested while a third factor was addressed in their surveys and data collection which involved motivation, emotions, and intrinsic factors that could impact results. As Williamson and Burns (2014) mentioned, with an interpretive approach to research, emotions are a valid part of the study and all things that have influence over those are important to note. For this reason, exercise limitations were considered and ensured that any student with medical conditions preventing them from participating in moderate to vigorous intensity exercise were not eligible for this

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study. Medical conditions excluding participants from this study included orthopedic limitations, cardiac concerns, or illnesses that made them feel unsafe to put their body through a vigorous intensity exercise. Participants were also excluded if they were required to perform high daily vigorous activity (such as training for a sport, Olympics, marathon, etc.) as all participants were required to refrain from vigorous intensity exercise up to 48 hours before each intervention.

The recruitment survey identified 20 interested students, but after disqualification and attrition, only 12 students completed the study in its entirety. Among these 12 students, all were female between the ages of 18-20. The BOD POD$^{TM}$ (COSMED, Inc., Indianapolis, IN) results revealed that 58.3% of participants recorded 'normal' body fat percentages and BMIs, meaning their BMI fell between 18.5-24.9kg/m$^2$, only 8.3% recorded underweight and 25% recorded overweight. There were no participants who fell into an obese range of BMI (greater than or equal to 30 kg/m$^2$). Total mean BMI ± SD = 22.4 ± 2.53 kg/m$^2$ (see Table 1).

**Table 1**

*BMI of Each Participant from Group 1 vs. Group 2*

| Group 1 | Group 2 | Unpaired T-test |
|---|---|---|
| 22.7 | 19.64 | |
| 23.05 | 17.85 | |
| 24.6 | 21.25 | $P = 0.6728$ |
| 25.2 | 22.65 | |
| 20.15 | 25.75 | |
| 20.65 | 25.25 | |

*Note.* BMI is measured in (kg/m$^2$)

**Table 2**

*Demographics Comparing Group 1 and Group 2.*

| Category | No. Group 1 | No. Group 2 | Unpaired T-test |
|---|---|---|---|
| Gender | | | |
| Female, *n* (%) | 6 (100) | 6 (100) | |
| Male, *n* (%) | 0 | 0 | |
| Age | | | *P*=0.2131 |
| 18, *n* (%) | 0 | 1 (8.3) | |
| 19, *n* (%) | 2 (16) | 3 (25) | |
| 20, *n* (%) | 4 (33) | 2 (16) | |
| Ethnicity | | | |
| Caucasian | 2 (16) | 5 (41.7) | |
| Asian | 2 (16) | 1 (8.3) | |
| Hispanic | 2 (16) | 0 | |
| Other | 0 | 0 | |
| Number of college courses | | | *P*=0.6279 |
| 1-3 | 0 | 0 | |
| 4-6 | 5 | 4 | |
| 7+ | 1 | 2 | |
| BMI ($kg/m^2$) | | | *P*=0.6743 |
| Underweight (<18.5) | 0 | 1 | |
| Normal (18.5-24.9) | 5 | 3 | |
| Overweight (25-29.9) | 1 | 2 | |
| Obese (≥30) | 0 | 0 | |
| Body Fat % | 23.4 | 22.2 | *P*=0.8260 |
| Waist Circumference (cm) | 28.6 | 27.9 | *P*=0.6416 |
| Height (in) | 62.25 | 64.83 | *P*=0.3645 |
| Weight (lbs) | 131.25 | 132.45 | *P*=0.8660 |

*Note.* BMI, waist circumference, and body fat percentage were averaged from pre and post fitness assessment as no significant difference between each was found. Group 1 N=6, Group 2 N=6.
*=significant (*P*<0.05)

**Methodology**

Following their acceptance into the study, participants met with the research team for a briefing of consent, objectives of the study as well as expectations of participants. Informed consent is both a legal and ethical requirement when conducting research on human subjects and in this process, participants were explained the expectations of their participation and role in the study (Nijhawan et al., 2013). A consent meeting was a requirement of IRB which ensured

participants knew their efforts were voluntary and noted all expectations and requirements. At the consent participants received a unique participant number which was used for simplified random sampling to organize participants into two groups: one group served as the control group (completing a sedentary intervention) while the other group participated in a 45-minute spin class for the aerobic exercise intervention on one of the days of their class exam during the semester long HNFE 2014 class. Figure 1 represents how the intervention day flow would run. Random sampling will be used in this study because it allows for fair and effective data analysis. Random sampling allows the researchers to separate participants into equal numbered groups which keeps data analysis consistent as well as allowing the chance to obtain data from minority populations (Elfin & Negida, 2017).

**Figure 1**

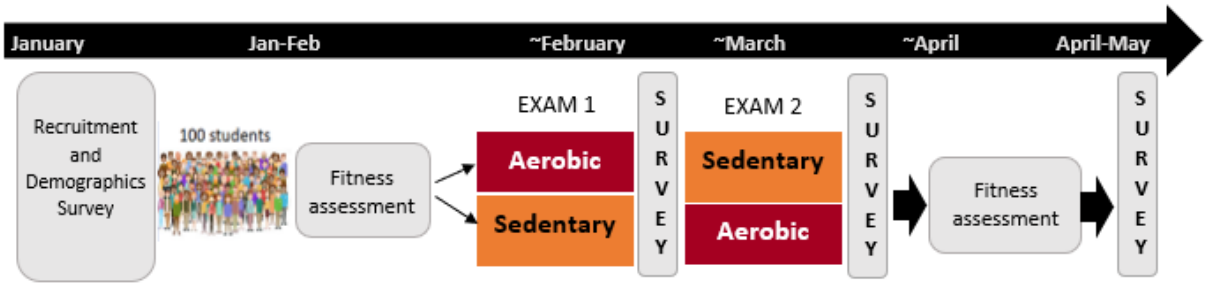
*Intervention Day Breakdown*


*Note.* Used with permission by creator, Dr. Deborah Good.

The first exam was held approximately four weeks after the initial recruitment on February 23, 2022, and during this time ‘Group 1’ participated in the sedentary intervention while ‘Group 2’ participated in the exercise intervention. Approximately 6 weeks later, on April 4, 2022, exam 2 was held and the groups switched roles; Group 1 performing the exercise intervention while Group 2 completed the sedentary intervention. See figure 2 for study design.

**Figure 2**

*Study Design Throughout The Whole 12-week Semester*




*Note.* Used with permission by creator, Dr. Deborah Good.

A control group was used to establish a cause-and-effect relationship and ensures that any change to the independent variable in a treatment group while constant in the control group can be attributed to the treatment (Thomas, 2020). The assessment of body composition which was performed by Virginia Tech Rec Sports prior to the first exam date was repeated after the final survey was collected at the end of the semester. The two assessments were used to ensure that there were no significant physical changes among students and the pre and post assessments were averaged in all following calculation. The fitness assessment involved a BOD POD™ (COSMED, Inc., Indianapolis, IN) estimate of lean body mass and fat mass, BMI, heart rate, blood pressure, waist circumference, and height/weight (Table 2).

**Intervention**

All students were asked to refrain from vigorous intensity exercise up to 48 hours prior to the intervention. They were asked to report to McComas gym an hour and half to two hours before their exam time to perform their intervention for 45 minutes, with 45 minutes between the end of the intervention and exam. The group assigned to the aerobic exercise intervention participated in a 45-minute spin class led by an instructor employed by Rec Sports in McComas Gym at Virginia Tech. The goal of the exercise intervention was to spend at least 20 minutes at

or above 70% of their HRR. Each student wore an Amazfit™ (Amazon, Seattle, WA) tracking watch during their interventions. During both the spin class and the sedentary intervention, students self-reported their heart rate before and after as well as incrementally every 10 minutes, using a heart rate monitor provided to the participants (See Appendix A) to measure if 70% HRR was achieved for the exercise group, and if there was no change of HRR in the sedentary group. After their 45-minute intervention, students had approximately 45-minutes to prepare for their HNFE 2014 class exam. After completion of that exam, they completed their post-exam survey (~5 minutes).

During each intervention period, and the 48 hours prior to the intervention period, participants were required to wear a heart rate tracking device, Amazfit Band 5 (Amazon, Seattle, WA), purchased and provided at the beginning of the study to determine their resting heart rate. While completing the exercise intervention, participants were asked to set their tracker into cycling activity mode and instructed to record responses during incremental time periods. Sedentary participants did not set their tracker to a specific activity. Heart rate responses for both groups were recorded in 10-minute increments on a card provided at the start of the intervention (see Appendix A).

**Data Collection**

A set of four surveys (pre-study, post-exam surveys (2) and post-study) were distributed online through Qualtrics™ survey software (Qualtrics, Provo, UT) and completed by the participants during the length of this study. The first survey collected included demographic information such as age, gender, ethnicity, race, GPA, credit hours completed, current exercise levels using the IPAQ (Lee et al., 2011). The first survey also included a set of questions from the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al., 1991) and used as a

measure of pre-intervention test motivation and anxiety level. The full MSLQ is comprised of 81 self-reporting questions among 15 subscales and can take between 20-30 minutes to complete, however this version of the MSLQ was abbreviated and highlighted feelings among motivations and anxiety. All items were measured on a Likert scale in a seven-point response format (1 = 'Not at all true of me' to 7 = 'Very true of me').

Surveys 2 and 3 (post-exam surveys) included the same questions on both surveys and were required to be completed after the completion of participant's HNFE 2014 exams. The two post-exam surveys asked about their participation in exercise within the previous 48 hours, as well as their preparedness and anxiety concerns about the current exam that was just completed. These questions included some of the same questions from the MSLQ but were modified slightly (Pintrich et al., 1991). The final survey was collected after the final exam was administered to assess consistency of the participants, but there was no intervention prior to the exam. This final survey included MSLQ and the results from survey 1 and 4 were averaged for results. The MSLQ is a subscale to determine levels of self-efficacy, intrinsic and extrinsic motivation levels, as well as test anxiety. The final survey also included questions from Duckworth's Grit Scale which is a 12-point Likert scale that is used for self-reflection involving passion and perseverance. All these factors were important to consider when studying reasons for academic performance. The International Physical Activity Questionnaire (IPAQ) was also included in survey 4 which was is a questionnaire used to measure health-related physical activity among a population. The scores were interpreted using an automatic scoring spreadsheet, higher scores from this self-reporting strategy suggest valid levels and patterns of physical activity in healthy participants (Cheng, 2005).

## Data Analysis

Qualtrics™ (Qualtrics, Provo, UT) survey results were pulled and categorized by the researcher. Demographics and exam score tables were created using Excel, all other results were created using GraphPad Prism 9 (Graph Pad, San Diego, CA). A 2-way ANOVA was used to determine time effect and/or group effect between Group 1 and Group 2 as well as their 2 exam scores. Additionally, differences between groups were analyzed using the student t-tests. Simple linear regression analysis was used to correlate survey result data. Significance levels were set to an alpha of >0.05.

## Results

The recruitment process interested 32 students from the HNFE class but by the end of the study only 12 students had completed each part in its entirety. The results of the fitness assessment of the final 12 participants can be found in summary from Table 3 below. All data and results discussed were compiled from these 12 participants only as it was a requirement that students complete the whole study to be fully compensated and their information used in the final research.

**Table 3**

*Comparison of Fitness Assessment Results Between Group 1 and Group 2*

| Variable | Group 1 | Group 2 | *P* value |
|---|---|---|---|
| | Mean ± SD | Mean ± SD | |
| BMI ($kg/m^2$) | 22.73 ± 1.86 | 22.065 ± 2.84 | 0.6728 |
| % Body Fat | 23.41 ± 6.9 | 22.23 ± 9.34 | 0.8260 |
| Waist Circumference (cm) | 28.65 ± 2.79 | 27.88 ± 2.19 | 0.6416 |

*Note.* N=12. *= significance found $P<0.05$

The fitness assessments completed by Virginia Tech Rec Sports were performed a few weeks prior to the first intervention and again a few weeks after the final intervention, before the completion of their class. The data on the pre- and post- assessments did not significantly

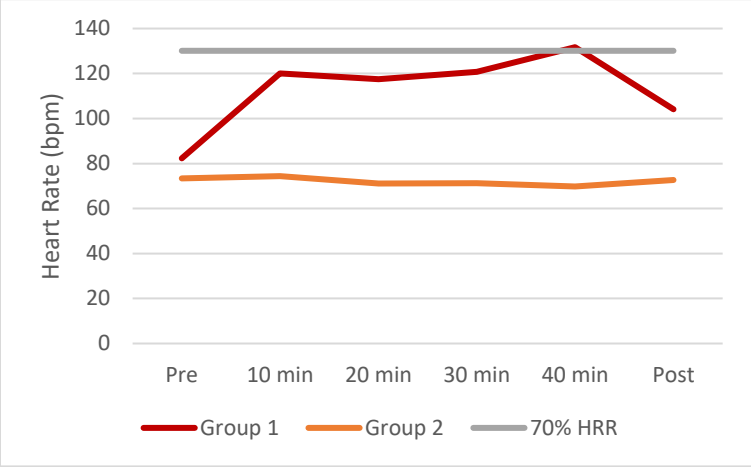
change, therefore the results were averaged. The fitness assessment layout can be viewed in Appendix B.

The heart rate responses for the exercise group during the second intervention met the requirements of vigorous intensity exercise, over 60% HRR, with a target of 70% HRR. During the first intervention, participants were wearing the heart rate tracking watch and recording the displayed heart rate response during each time mark. As shown in Figure 3, the responses for the exercise group did not reach the 70% HRR mark and this is believed to be a miscalculation of the trackers. Figure 4 shows the heart rate responses during the second intervention and participants were instructed to set their tracker to "cycling mode" to record a workout and better track heart rate. While the difference in results may not have been caused by the tracking devices, the participants self-reported feeling breathless and as thought their energy exertion was within that vigorous range.

There were no significant differences between Group 1 and Group 2 in resting heart rates with $P$=0.9183 and heart rate reserve (HRR) number during exercise with an average of 127.5 BPM for Group 1 and 130.83 BPM for Group 2 ($P$=0.5481).

**Figure 3**

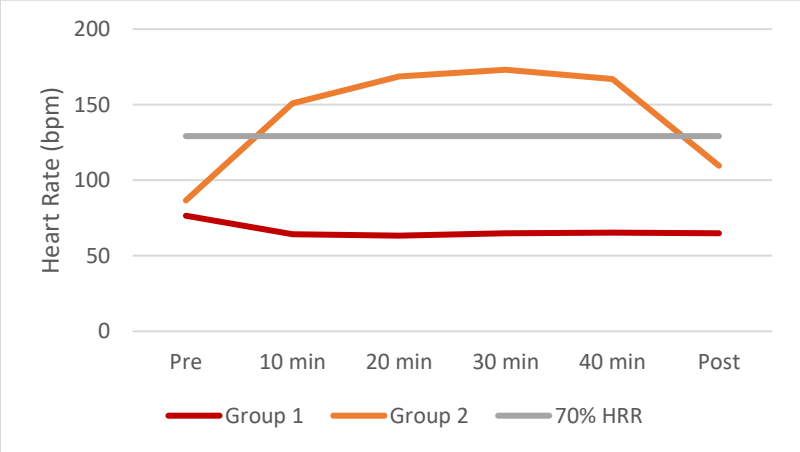
*Heart Rate Responses from the First Intervention Compared 70% HRR Max*




*Note*. Group 1 performed the exercise intervention before their exam while Group 2 participated in the sedentary intervention.

**Figure 4**

*Heart Rate Responses from the Second Intervention Compared 70% HRR Max*




*Note*. Group 1 performed the sedentary intervention before their exam while Group 2 participated in the exercise intervention. During the second intervention participant's heart rate monitor was set into 'cycling mode.'

To find significance among the participants in exam scores and treatment groups a 2-way analysis of variation was employed. There was no interaction found between the effect of the exercise group and the exam scores with a *P* value of 0.4930 represented in Figure 5. There was

also no significant between the scores from exam 1 to exam 2 with *P*=0.3634 and *P*=0.6194 was the non-significant value found between Group 1 and Group 2 over time and course of the semester disregarding the exam scores. A distribution of grades from each exam can be found in Table 4 which compares the groups averages to the total class means. Also, the 2-way ANOVA did find a significant *P*=0.0367 among the subject variance suggesting that unrelated to systematic differences of exam scores the subject variability was significant enough to contribute to the rest of the insignificant data discussed in the remainder of this report.

**Figure 5**

*Graph of Exam 1 and Exam 2 Averages Split by Group*

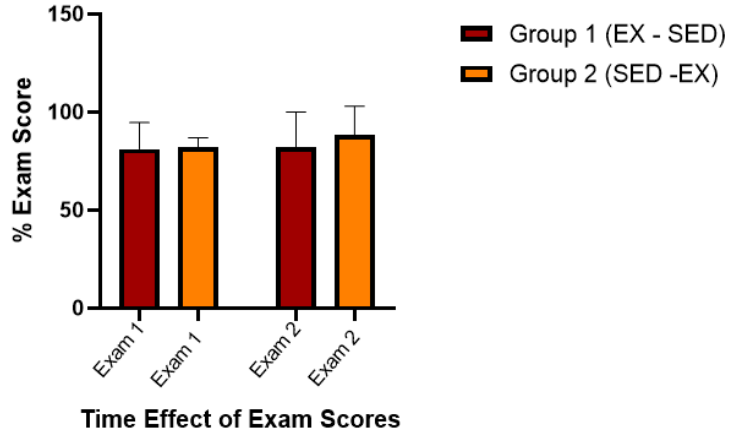



**Table 4**

*Exam Grade Averages Comparing Group 1 and Group 2 For Each Exam*

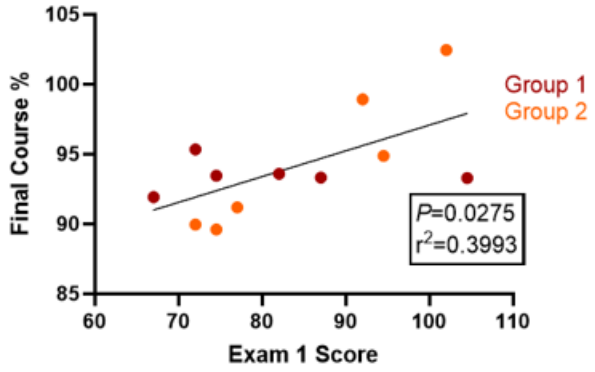
| | Group 1 (mean) | Group 2 (mean) | *P* value | Total Class (mean) |
|---|---|---|---|---|
| Exam 1 | 81.17 | 82.08 | 0.5899 | 75.14 |
| Exam 2 | 85.33 | 85.83 | 0.6441 | 80.37 |

*Note.* Group 1 participated in the exercise intervention before exam 1 and the sedentary intervention before exam 2. Group 2 participated in the sedentary intervention before exam 1 and the exercise intervention before exam 2. Group 1 N=6, Group 2 N=6, Total class N=100.

A simple linear regression was used to show a significance between collected data. As expected, significance was found between final course grade percentage and each exam grade with *P*=0.0275 for exam 1 and *P*=0.0179 for exam 2.

**Figure 6**

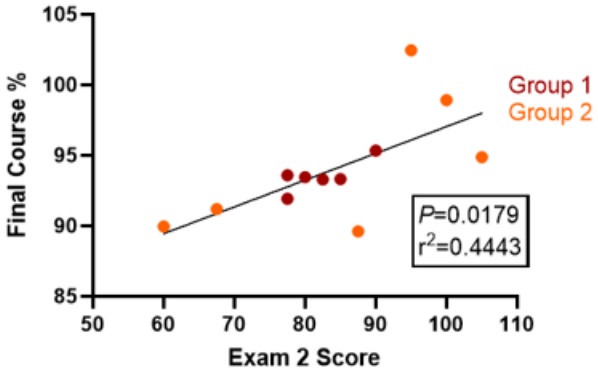
*Simple Linear Regression Showing Significance of Exam 1 Scores and Overall Course Grades*




*Note.* N=12, the entire sample group was correlated in this regression.

**Figure 7**

*Simple Linear Regression Showing Significance of Exam 2 Scores and Overall Course Grades*




*Note.* N=12, the entire sample group was correlated in this regression.

Extrinsic motivation scores were pulled and calculated from the MSLQ portion of the post-study survey and significance was found between final course grades and this section of the MSLQ. As previously mentioned, MSLQ determined ranges of motivation associated with self-

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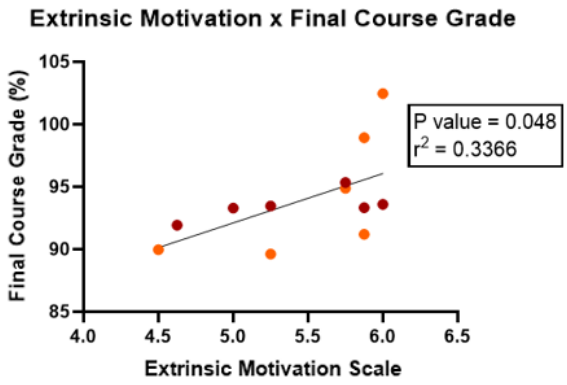
efficacy, intrinsic motivation, and extrinsic motivation. In this case, the higher extrinsic score related to a higher final course grade represented students' motivation for academic success. Significance between final course grade and extrinsic scores were found as $P$=0.048 as shown in Figure 7.

**Figure 8**

*Simple Linear Regression Showing Significance of Extrinsic Motivation with Final Course Grades*

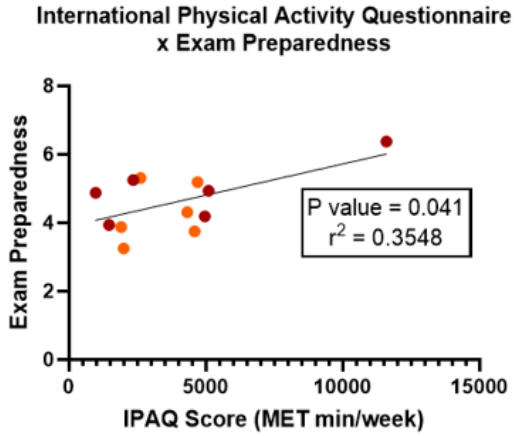



*Note.* N=12. Extrinsic motivation questions were pulled from the MSLQ section of the post-study survey.

The final correlation of significance was found between participants IPAQ scores, and the perceived exam preparation score recorded on survey's 2 and 3 (completed after each exam). Figure 8 represents the correlation and suggests that as participants recorded a higher value of exercise in MET min/week they were more prepared for their upcoming exam.

**Figure 9**

*Simple Linear Regression Showing Significance of IPAQ Score Values with Exam Preparedness*




While a few significant correlations were found in this study, a lot of other data analysis was performed and while not significant enough to confirm the hypothesis, the data could be used for consideration in future research aligning with these ideals. Table 5 (below) shows all the data compiled. The post-exam and post-study surveys recorded responses for GRIT and MSLQ sub-sections, which were important factors to correlate with final grades, IPAQ scores, and BMI.

**Table 5**

*All Data and Correlations Represented*

| | Final Course Grade (%) | | IPAQ Score | | BMI (kg/m$^2$) | |
|---|---|---|---|---|---|---|
| | $r^2$ | *P* value | $r^2$ | *P* value | $r^2$ | *P* value |
| Exam 1 score | 0.3993 | 0.0275* | 0.08637 | 0.0919 | 0.0864 | 0.3538 |
| Exam 2 score | 0.4443 | 0.0179* | 0.01274 | 0.7269 | 0.00108 | 0.9194 |
| Final Course grade | | | 0.000784 | 0.9312 | 0.3041 | 0.0631 |
| GRIT | 0.06685 | 0.4427 | 0.06929 | 0.4342 | 0.02463 | 0.6449 |
| Post-exam | | | | | | |
| Exam Preparedness | 0.003029 | 0.8651 | 0.3548 | 0.0410* | 0.00191 | 0.8927 |
| Exam Anxiety | 0.1594 | 0.1985 | 0.09498 | 0.3298 | 0.00015 | 0.9696 |
| Exam Confidence | 0.1066 | 0.3002 | 0.005149 | 0.8246 | 0.07750 | 0.3809 |
| MSLQ | | | | | | |
| Intrinsic motivation | 0.09479 | 0.3303 | 0.09487 | 0.3301 | 0.1488 | 0.2155 |
| Extrinsic motivation | 0.3366 | 0.0480* | 0.000281 | 0.9587 | 0.00349 | 0.8551 |
| Expectation on exam | 0.2132 | 0.1307 | 0.02561 | 0.6193 | 0.00058 | 0.9409 |
| Test anxiety overall | 0.001253 | 0.9130 | 0.03204 | 0.5778 | 0.05790 | 0.4512 |

*Note.* Significant correlations found when $P<0.05$*. Graphs for all correlations found in appendix.

## Discussion

Learning and academic participation are a requirement among all adolescents, but academic success is self-determined as well as determined by one's individual health and quality of life. Healthy lifestyle habits can be used as a predictor for student's academic performance. For example, attitudes and motivations towards regular exercise can be translated into study behaviors and actions required for academic success. This was supported with a significant correlation between final course grades and extrinsic motivations ($P$=0.048), and it is deemed important in noting the positive influences attitude and motivations can have on achievement. While this study did not support the hypothesis that exercise could influence academic performance when performed within the 2 hours prior to an exam, there were correlations made that could be used for consideration in future studies.

Participants were asked questions related to their level of motivation and stress leading up to their exam. The greater course success came from those with higher levels of extrinsic

motivation, and those that reported more exercise also reported higher exam preparedness. This correlation suggests that when a student feels extrinsically motivated to study they increase their ability to perform well on the exam. Similarly, exam preparedness was rated higher in those participants who reported high levels of weekly physical activity (IPAQ). Many assumptions can be made for possible causes for this relationship, but that was not studied in this trial. Unfortunately, overall course performance was not influenced by any of these factors (MSLQ, IPAQ, GRIT, and BMI) but one could assume, based on other findings and literature, that the potential emotions, attitudes, and feelings a student has during the time they study could be influenced if they were participating in regular exercise during that time. A student with a higher IPAQ score means they participate in more MET minutes/week, and this could be a key to decreasing stress and anxiety around the exam period. Fortunately, there were also no significant findings among the participants who performed the sedentary bout before the exam suggesting that academic success possibly may not be influenced in the few hours prior to an exam. If a student wants to succeed in the classroom they need to develop habits that can make them successful throughout the entire semester.

Academics and physical activity are just two of many important pieces in a college-aged student's lifestyle. These two are important factors that can have lasting implications on the student and any behavioral adjustments while being heavily influenced by peers, media, or personal motivational reasons. Students in the age range of this study (18-22 years-old) are most vulnerable for limiting health concerns relating to obesity or higher BMI and mental health concerns. Factors such as BMI or academic goals could be influencers towards people adopting certain healthier approaches to their lifestyles. Many of these factors are associated with perceived levels of individual motivations.

**Limitations**

The limitations in this study included miscommunication with participants and difficulty tracking heart rate responses. Miscommunication affected the outcome of the heart rate response collected during the first intervention and the attrition rate due to inattentiveness of students to emails and directions. After the first intervention, it was noted that the Amazfit Band 5 (Amazon, Seattle, WA) were not set into 'cycling' activity mode, therefore the heart rate readings were not as accurate for the participants in the exercise intervention (Figure 3). This was not caused by a malfunction in the device rather a lack of knowledge of the requirements for accurate readings. For the second intervention, however, the heart rate monitors were set into the correct activity mode and the results were more accurately recorded (Figure 4). This limitation did not affect the outcomes of the proposed hypothesis as the tracking device was used to ensure that the level of activity remained in the vigorous intensity zone.

Communication to the participants was the greatest limitation in this study. Participation numbers were high after the initial recruitment but ended with a 20% attrition bias. Participants withdrew themselves from the study if they wanted time to study for the exam rather than complete the intervention. A key factor in the comparison between the results of each intervention was that students were not able to study, but rather the intervention measured, their body's reactions to either exercise or sedentary behaviors along with their exam preparation, to determine certain outcomes. Data collected from students who withdrew themselves was not recorded in any of the results. Two students had to withdraw before the exercise intervention specifically because they did not feel well. They were either fighting an illness or did not eat enough food to complete the exercise intervention in a vigorous intensity zone. While it is

unknown, the small participation rate (N=12) could have influenced the lack of significant data, but important findings could be used towards future research in this area.

**Conclusion**

When comparing the exercise and sedentary groups there was not a significant difference between the two on their exam performance, which did not support the original hypothesis. Among the four types of surveys, a lot of data was collected in relation to attitudes and motivations associated with perceived levels of physical activity. While the original hypothesis was not supported, the information collected could be used to create a future study that could find the previously stated, expected outcomes. The IPAQ was used to help determine the physical activity levels of the participants, which in turn found that a higher level of daily exercise could help improve preparation for exam. The IPAQ results were compared to exam results, course results, and MSLQ which found no significant correlations but can prove to be important in future studies. Immediate bouts of exercise did not improve academic performance, but perhaps if the IPAQ scores were greater overall than results could vary in all other aspects. As previously stated, most young adults do not meet the requirements for physical activity stated by the CDC so if levels were increased to meet those minimum recommendations, there could be some more important findings.

Another significant difference was found from the extrinsic motivational scores in comparison to exam preparedness which suggests certain types of motivation could affect academic outcomes in terms of study behaviors and expectations. This study was able to highlight the importance that attitudes, and motivations play in physical activity levels as well as potential academic performances. Final grades were heavily influenced by extrinsic motivations suggesting the drive for higher overall grades/GPA at the conclusion of the semester which can

be achieved through other coursework requirements rather than a single exam. Motivation for that one specific exam was outweighed by the extrinsic motivation for a better GPA. Other factors such as the MSLQ, GRIT, and IPAQ provided preliminary ways to find significant data in future studies. Results showed that a student with higher IPAQ scores, meaning more MET minutes per week felt more prepared for their exams which suggested the positive influence that long term exercise could have on academic performances.

The research collected from this study did not show that exercise performed directly before an exam could immediate improvements, but that motivations and attitudes focused towards creating a healthy balance of consistent, daily exercise could show beneficial in academic success long term throughout the entire semester. More research should be completed to provide further evidence that exercise can improve academic performance in an acute intervention setting.

**Future Recommendations**

Future recommendations for this study could include a larger participant population with greater ranges of gender, age, and BMI. This study saw a homogenous sample size as all participants were female and most were Caucasian and all had a higher educational status. These demographics may not be generalizable to a larger population and a future recreation of this study should include males as well as females, students ranging in age and year level across the university, as well as different ethnic backgrounds. There could be more correlations found if the population were more diverse in these aspects. This study offered compensation for a participant's time and efforts, but that did not seem to be enough to keep a low attrition rate. There may be a lower dropout rate if the compensation was paid out at the completion of the

study rather than after each ‘checkpoint,’ in hopes that there is more incentive for participants to follow instruction and complete the entire study.

A power analysis was calculated to find a minimum number of subjects to create a viable future study. With an anticipated Group 1 mean of 95±5 (the exercise group would receive an A on their first exam) and a 10% mean decrease for Group 2, power set to 0.8 and alpha at 0.05, there should be at least 63 participants when recreating this study (Kane, 2019). By setting this power analysis, results from a trial with at least 63 participants should prove the perceived hypothesis that the group who participated in the exercise intervention would receive a higher exam score than the group who completed the sedentary arm. Expending this pilot study to a larger population of at least 63 participants is needed to draw more conclusions on whether an acute bout of exercise prior to an exam increases exam scores compared to a sedentary control.

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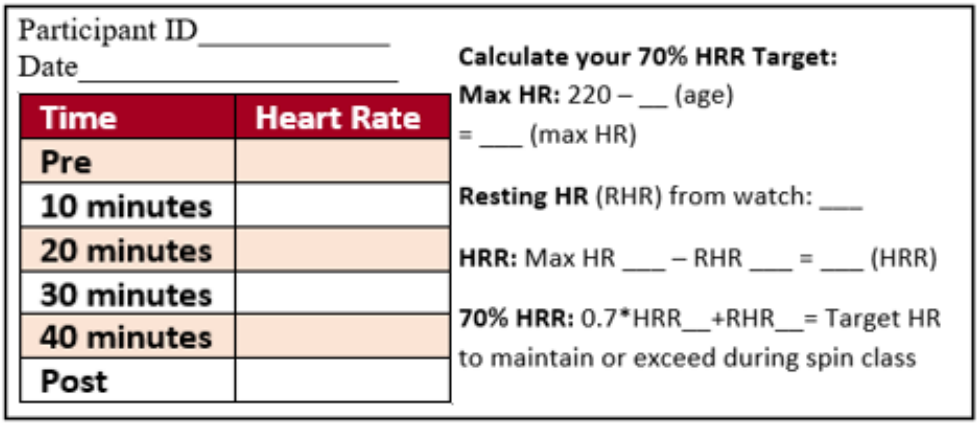
## Appendix A

## Heart Rate Response Card

This is the card that was given to each participant before the start of the intervention.



Participant ID_____
Date_____

| Time | Heart Rate |
|---|---|
| Pre | |
| 10 minutes | |
| 20 minutes | |
| 30 minutes | |
| 40 minutes | |
| Post | |

**Calculate your 70% HRR Target:**

**Max HR:** 220 – __ (age)
= ___ (max HR)

**Resting HR** (RHR) from watch: ___

**HRR:** Max HR ___ – RHR ___ = ___ (HRR)

**70% HRR:** 0.7*HRR__+RHR__= Target HR to maintain or exceed during spin class

## Appendix B

## Resting Vitals Fitness Assessment

This fitness assessment was created and completed by Virginia Tech Rec Sports, he same was used for the pre- and post-study assessments.

Resting Vitals Fitness Assessment

Trainer:_____

Participants Number: _____ Date: _____

| Test | Results |
|---|---|
| **Resting Heart Rate:** | |
| **Resting Blood Pressure:** | |
| **Waist Circumference:** | |
| **Body Fat % (Bod Pod):** | |
| **Weight (Bod Pod):** | |
| **Height:** | |
| **BMI:**<br>Weight (lb) / [Height (in)]$^2$ x 703<br>Or<br>Weight (kg) / [Height (m)]$^2$ | |

## Appendix C

### Graphs of non-significant data correlated with BMI

**Figure C1**

*Simple Linear Regression of BMI and Exam 1 Scores of Group 1 (exercise) and Group 2 (sedentary)*

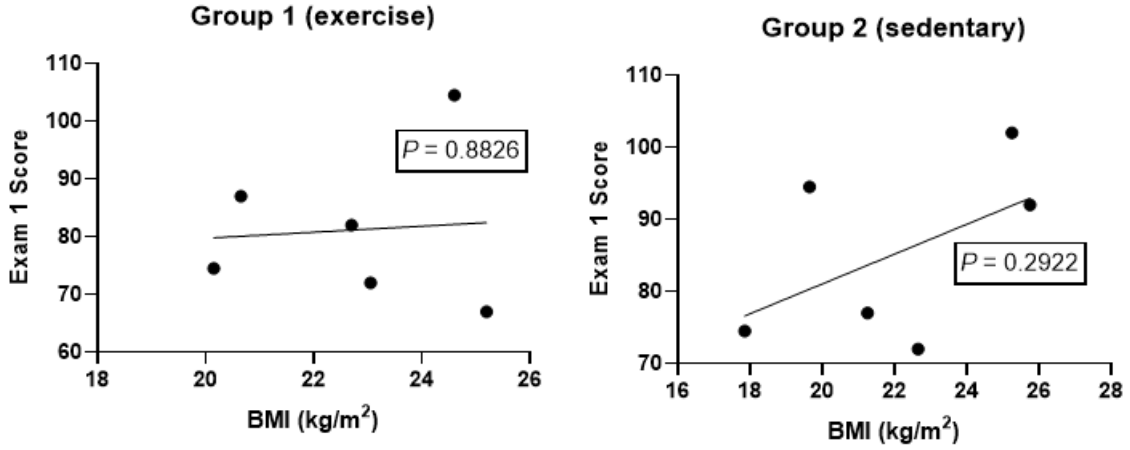



**Figure C2**

*Simple Linear Regression of BMI and Exam 2 Scores of Group 1 (exercise) and Group 2 (sedentary)*

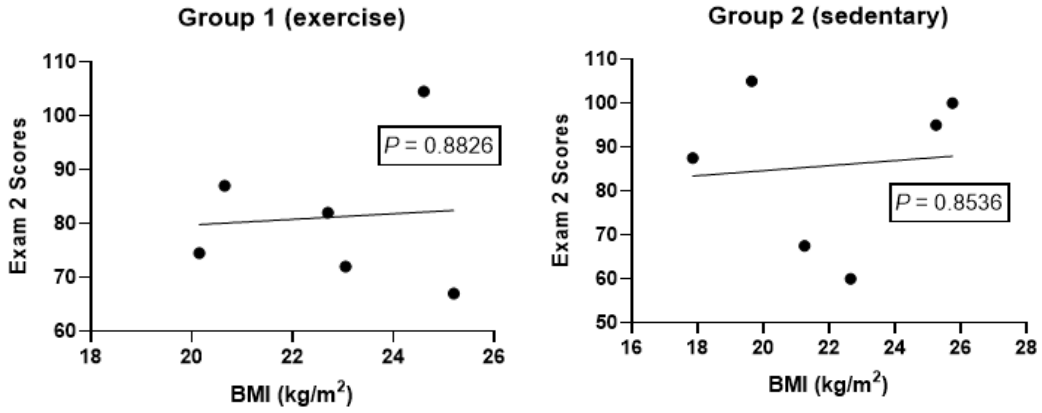


**Figure C3**

*Simple Linear Regression of BMI and GRIT*

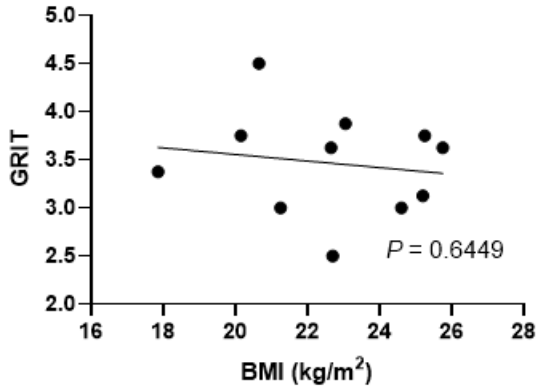



**Figure C4**

*Simple Linear Regression of BMI and Exam Preparedness*

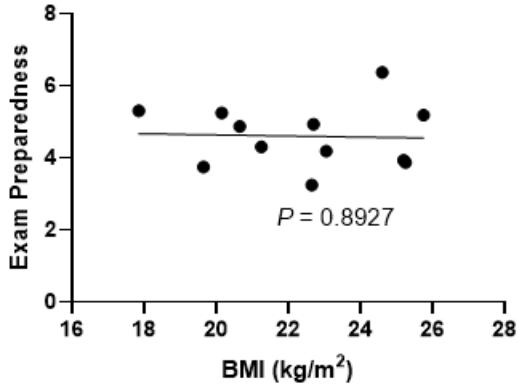



**Figure C5**

*Simple Linear Regression of BMI and Exam Anxiety*

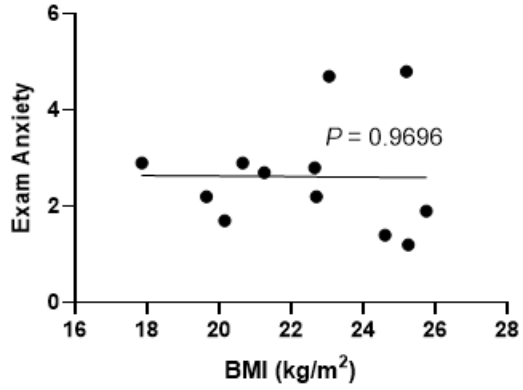


**Figure C6**

*Simple Linear Regression of BMI and Exam Confidence*

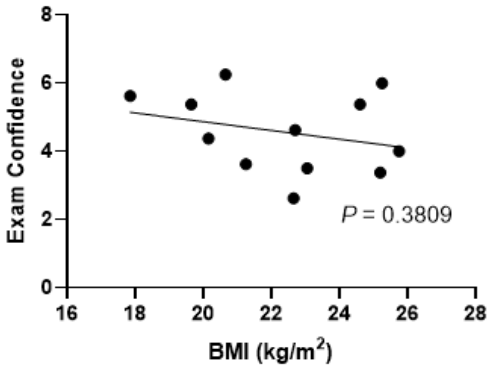



**Figure C7**

*Simple Linear Regression of BMI and Intrinsic Motivation*

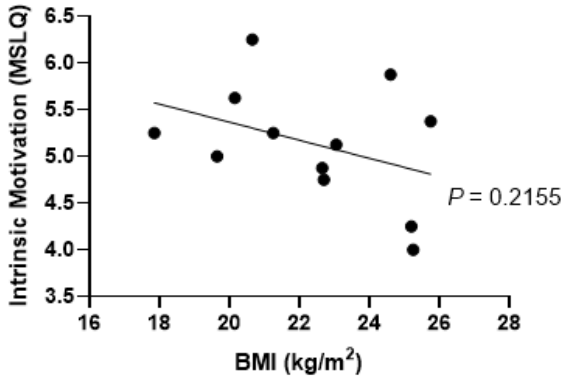



**Figure C8**

*Simple Linear Regression of BMI and Extrinsic Motivation*

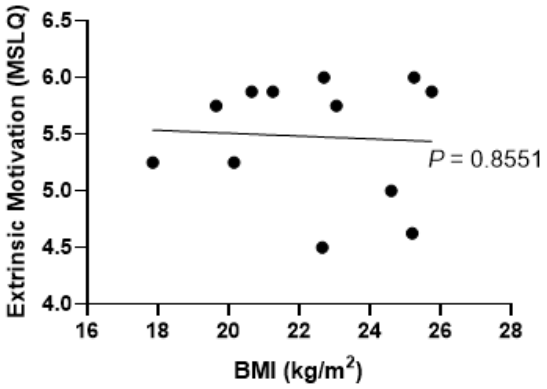


**Figure C9**

*Simple Linear Regression of BMI and Expectation For Success*

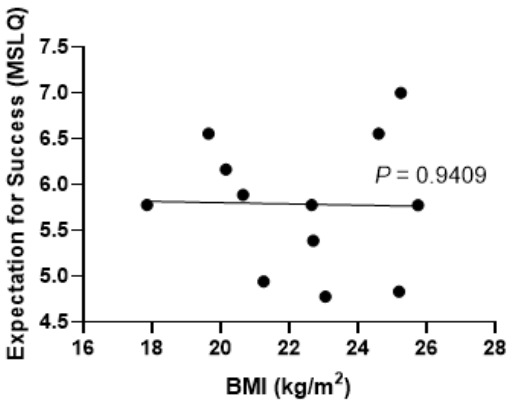



**Figure C10**

*Simple Linear Regression of BMI and General Test Anxiety*

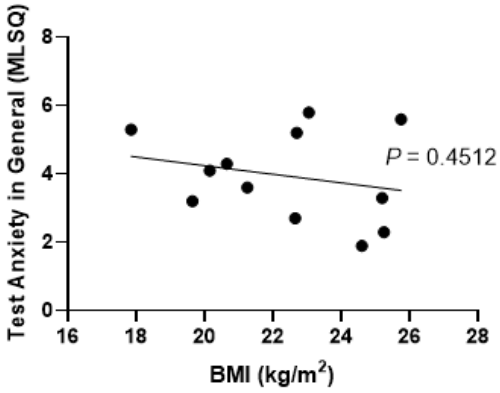
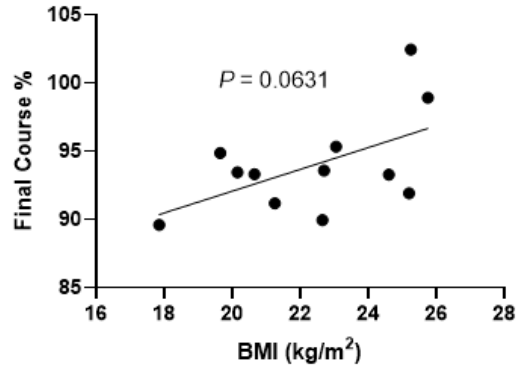



**Figure C11**

*Simple Linear Regression of BMI and Final Course Grade*

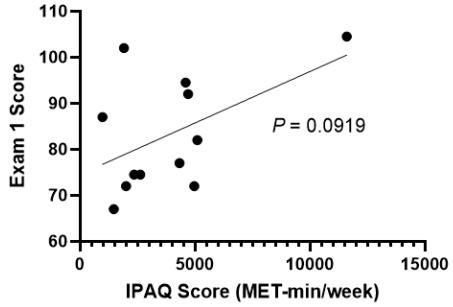


## Appendix D

## Graphs of non-significant data correlated with IPAQ scores

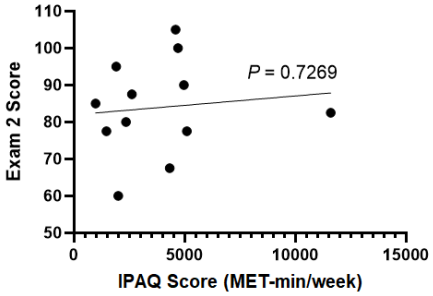
### Figure D1

*Simple Linear Regression of IPAQ and Exam 1 Scores*




### Figure D2

*Simple Linear Regression of IPAQ and Exam 2 Scores*




### Figure D3

*Simple Linear Regression of IPAQ and GRIT*

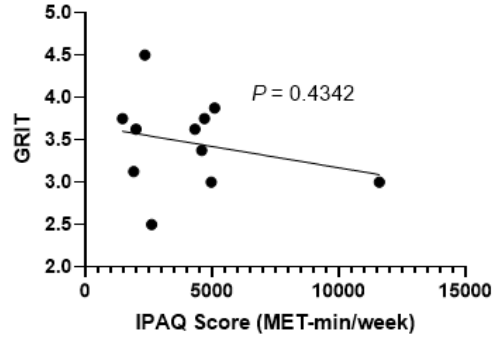


**Figure D4**

*Simple Linear Regression of IPAQ and Exam Anxiety*

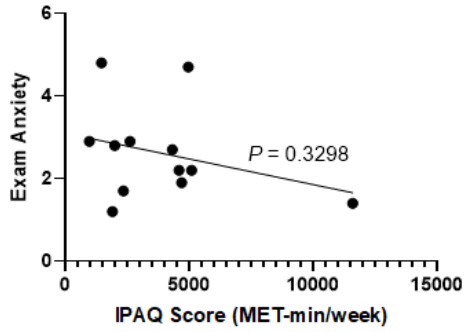



**Figure D5**

*Simple Linear Regression of IPAQ and Exam Confidence*

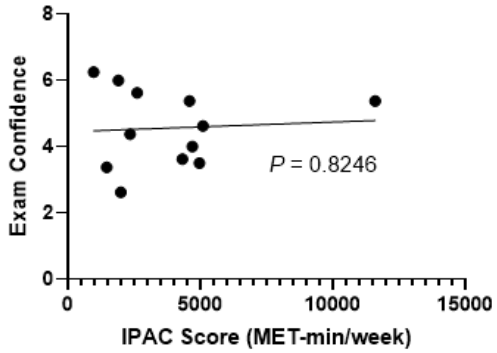



**Figure D6**

*Simple Linear Regression of IPAQ and Intrinsic Motivation*

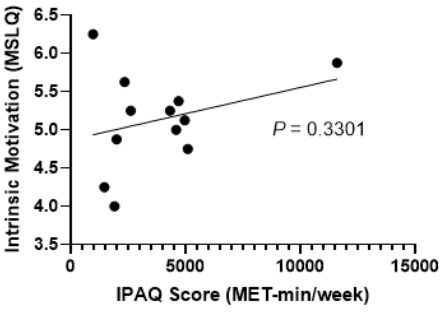


**Figure D7**

*Simple Linear Regression of IPAQ and Extrinsic Motivation*

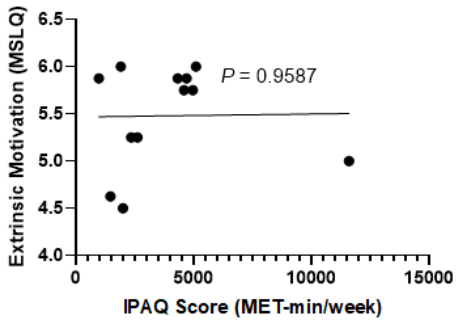



**Figure D8**

*Simple Linear Regression of IPAQ and Expectation For Success*

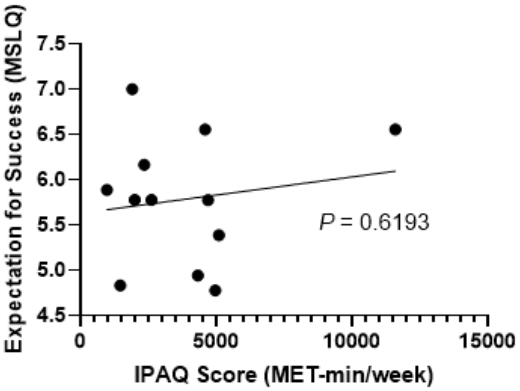



**Figure D9**

*Simple Linear Regression of IPAQ and General Test Anxiety*

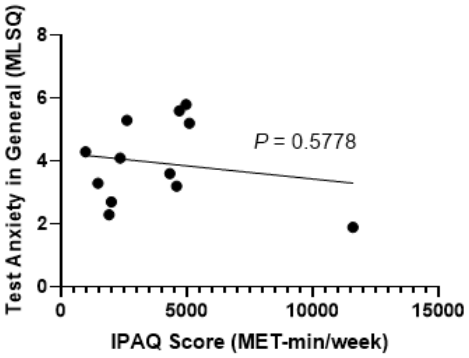
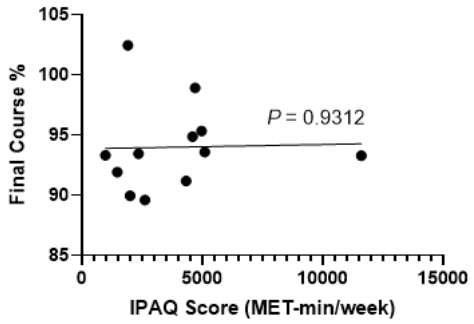


**Figure D10**

*Simple Linear Regression of IPAQ and Final Course Grade*



## Appendix E

### Graphs of non-significant data correlated with final course grades

**Figure E1**

*Simple Linear Regression of Final Course Grade and GRIT*

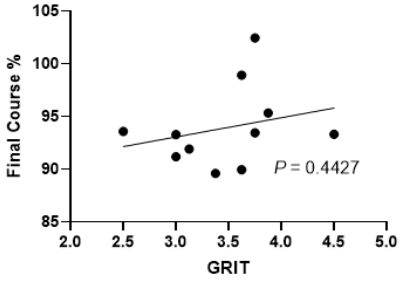



**Figure E2**

*Simple Linear Regression of Final Course Grade and Exam Preparedness*

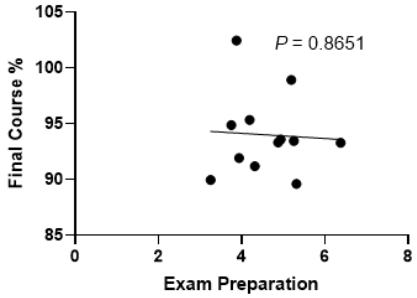



**Figure E3**

*Simple Linear Regression of Final Course Grade and Exam Anxiety*

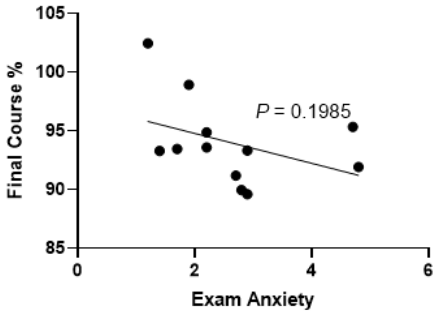


**Figure E4**

*Simple Linear Regression of Final Course Grade and Exam Confidence*

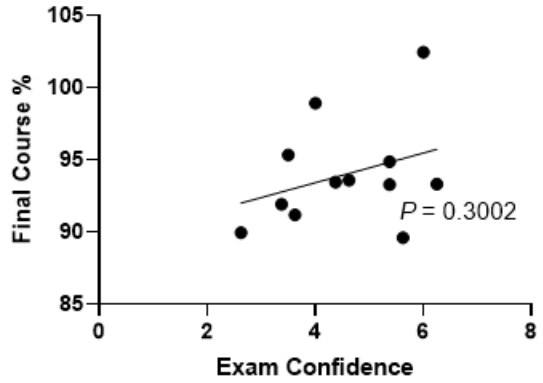



**Figure E5**

*Simple Linear Regression of Final Course Grade and Intrinsic Motivation*

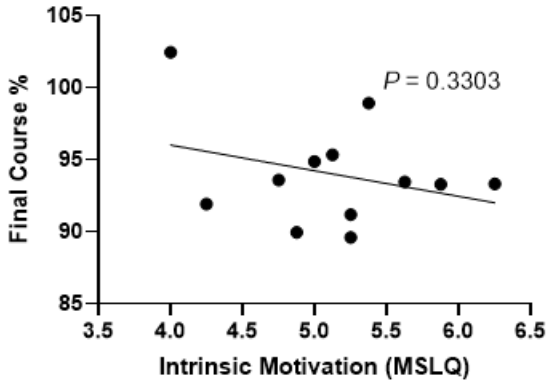



**Figure E6**

*Simple Linear Regression of Final Course Grade and General Test Anxiety*