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How Physical Activity Impacts Sustained Attention.

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ABSTRACT

In this paper, I sought to understand the effects of physical activity on sustained attention to learn whether exercise is a useful tool for people who require continuous focus on a single task (e.g., students). Previous research has found that increases in attention are associated with physical activity variables such as the duration of exercise performed, when the exercise is performed in relation to the mental task that followed, and the intensity of the physical activity. In my correlational study, I tested the strength of these relationships by examining naturalistic daily changes in their variables longitudinally over a period of four weeks. I measured duration of exercise, the interval between exercise and attention task, intensity of exercise in terms of heart beats per minute through my Fitbit watch, and I measured attention by the percentage of errors and average reaction time on the Continuous Performance Task (CPT) test. Data from this correlational study showed no statistical correlation between attention and any of the exercise variables but did show a trend towards significance for the exercise duration variable. The findings in this study suggest that the relationship between exercise and attention may not be as strong as predicted for people in their day-to-day life.

1. Introduction

1.1 Research Problem

Staying on task for long periods of time can be difficult and may require deep focus to avoid distraction and procrastination. Checking devices for notifications and task switching between studying and scrolling on social media are common concentration interruptions. To ensure sustained attention, it is helpful to know of the lifestyle factors that could help boost focus. This study aims to look at the potentiality of physical activity as an attention-enhancing tool for students and knowledge workers alike.

1.2 Literature Review

One factor previously found to predict increased attention is having the physical activity be performed for more than five minutes (Altermann & Gropel, 2023; Fenesi et al., 2018). For example, in an experimental study by Fenesi et al. (2018), having two 5-minute calisthenics breaks within one 50-minute lecture improved university level students' attention when compared to students who instead got a mind wandering break, or no break at all. With that, students who took exercise breaks also found that, subjectively, the content was easier to understand (Fenesi et al., 2018). Altermann and Gropel (2023) studied the

effects of 25-minute endurance, strength, or coordination exercise on the attention of high school students. This study showed that physical activity improved attention regardless of the type of movement, noting that exercising for longer stints (25 minutes when compared to 10- or 15-minute exercises) may enhance activation of attention focused brain areas. Based on these results, the researchers suggested that exercise improves attention in bursts as low as five minutes long, but in exercises performed for longer bursts, the brain gets a bigger, longer lasting increase in blood flow that benefits attention specific tasks to a greater degree.

Another factor previously found to predict increased focus is having the exercise follow the mental task almost immediately (Atakan & Atakan, 2024). For example, in a correlational study by Atakan and Atakan (2024), 10th grade students performed Pilates or plyometric exercises for 30 minutes followed shortly by a standardized attention test (d2-test), and then a 40-minute math test. This study gave students a 5-minute break between the physical activity and the attention test and math test. Atakan and Atakan (2023) specified that 5 minutes was chosen because the longer the brain has between exercise and testing, the less benefit is received by exercising. Increased blood flow activates the areas of the brain responsible for increased focus and attention, while stopping the exercise decreases the blood flow back to a resting, unfocused state. In this study, the authors found that 30 minutes of moderate intensity Pilates or plyometric exercises improved students' attention test scores as well as their mathematics test scores when compared to the non-exercise group. Based on these results, the researchers suggested that having the attention task start shortly after the exercise is completed will ensure that the brain's blood flow is still elevated, and the attention areas of the brain are more activated.

A third factor previously found to predict increased attention is making sure the exercise is of at least moderate intensity (Altermann & Gropel, 2023). For example, in the randomized controlled study by Altermann and Gropel (2023), three different exercises were studied for increased attention: endurance, strength, and coordination exercises. High school students performed one type of exercise for 25 minutes at a moderate or high intensity and then completed a standardized attention test (d2-test). The results showed that all three types of exercise improved attention to a similar degree. Because different exercises require different skill levels and can use different muscle groups, the authors noted that the overall benefit of exercising in this study comes from the intensity of the exercise performed. Since all three exercise groups reached similar intensity levels, similar increases in blood flow to the brain were recorded. Based on these results, the researchers suggested that exercise improves attention regardless of the type of exercise if it is of moderate or high intensity.

1.3 Hypotheses

Based on the above literature review, I predicted the following hypotheses:

- Hypothesis #1: If exercise duration increases then attention will increase.
- Hypothesis #2: If the interval between exercise and attention task decreases then attention will increase.
- Hypothesis #3: If exercise intensity increases then attention will increase.

2. Methods

2.1 Participant

The sole author of this paper served as the participant in this study. The participant is a 28-year-old female. The participant is an undergraduate student at Camosun College who completed the current study as an assignment for Psyc 215-001A ("Biological Psychology") due to their interest in physical activity as a tool for increasing attention. The participant partakes in moderate intensity exercise in the form of running, elliptical training, or using the stair climber machine once a week. They also partake in daily walks once or twice a day as part of their job as a dog walker.

2.2 Materials and Procedures

I performed a correlational study to test concurrently all my hypotheses by examining naturalistic daily changes in their variables longitudinally. I always kept a study journal with me over this study's four-week period to record self-observations of the following 4 variables: (1) exercise duration, (2) interval between exercise and attention, (3) exercise intensity, and (4) attention.

2.2.1 Exercise Duration

To measure exercise duration, the participant used their Fitbit application on their Fitbit watch to track how long they exercised for. During the study period, the participant's form of exercise was running and walking. The participant used the activity button on their Fitbit watch that corresponded to the type of exercise they were about to perform and hit the start button to track their exercise duration immediately before beginning their exercise. The participant ended the exercise on their Fitbit watch immediately after finishing their exercise. The participant then logged the exercise activity information available in their Fitbit application in their study journal. The total duration of exercise performed during the day was added at the end of each day and logged in the study journal. If exercise had not been performed on one of the correlational study days, the participant recorded the exercise duration for that day as zero.

2.2.2 Interval Between Exercise and Attention

To measure the interval between exercise and performing an attention task, the participant used the clock on their watch to track how many minutes passed between the last exercise performed and the attention task. The number of minutes was recorded in the participant's study journal. If exercise had not been performed before the attention task was to be completed, the participant recorded the lack of exercise in the study journal and that day's interval data was not analyzed.

2.2.3 Exercise Intensity

To measure the intensity of the exercise performed, the participant tracked their heart rate using their Fitbit watch. The Fitbit application tracks beats per minute (BPM) and labels the intensity of the exercise as follows: below 109BPM is light, 109-135BPM is moderate, 136-170BPM is vigorous and above 171BPM is peak intensity. The intensity levels are based on the participant's logged weight (54 kilograms) and height (167 centimeters). The time spent in each level of intensity throughout the exercise was logged in the participant's study journal. The average intensity level of the exercise was tracked by looking at the average heart rate in BPM on the Fitbit application and then recorded in the study journal. The average intensity level of exercise throughout the entire day was also measured by adding each exercise's

average BPMs and dividing by how many exercises were performed. If exercise was not performed, the participant left that day blank in their journal.

2.2.4 Attention

To measure attention, the participant performed the Continuous Performance Task (CPT) test (Conners, 1985) on their tablet at two intervals every day for 28 days. The CPT test measures sustained attention and distractibility. During the test, the participant is shown randomized letters (A-Z). The participant is to hit the spacebar on all letters except for the letter X. The participant completed the test at 7:00am and 8:00pm every day. The percentage of errors and average reaction time in milliseconds for the 8:00pm test were recorded in the participant's study journal.

2.3 Planned Analyses

To assess the strength and statistical significance of associations between variables predicted by the 3 hypotheses, I performed Pearson product moment correlations of the predictor variables (exercise duration, interval between exercise and attention task, and exercise intensity) with their outcome variable (increased attention). For testing Hypothesis #1, I correlated the duration of exercise performed throughout the day (in minutes) with the participant's average reaction time and percentage of errors on the CPT test performed that day. For testing Hypothesis #2, I correlated the interval between the last exercise and the attention task with the participant's average reaction time and percentage of errors on the CPT test performed that day. For testing Hypothesis #3, I correlated the average exercise intensity for the day in BPMs with the participant's average reaction time and percentage of errors on the CPT test performed that day. A correlation coefficient was considered statistically significant if the probability of its random occurrence (p) was $< .05$ (i.e., less than 5% of the time expected by chance alone).

3. Results

Exercise was performed on 28 of the 33 days of this correlational study. The results of this study (see Table 1) showed no statistically significant correlation between the different exercise variables and sustained attention. However, the correlation between exercise duration and attention did show a trend towards significance using as a measure of attention on the CPT test the percentage of errors made ($r = -0.34$, $p = 0.051$; see Figure 1) but not the average reaction time ($r = 0.03$, $p = 0.86$; see Figure 2). No significant correlation was found for the interval between exercise and attention task variable and attention scores using either using the percentage of errors made ($r = 0.15$, $p = 0.44$; see Figure 3) or the average reaction time ($r = -0.09$, $p = 0.64$; see Figure 4). Similarly, no significant correlation was found between exercise intensity and attention using either using the percentage of errors made ($r = -0.20$, $p = 0.31$; see Figure 5) or the average reaction time ($r = -0.09$, $p = 0.64$; see Figure 6). The relationship between sustained attention and exercise duration showed the most promising results, with an r-value of medium effect size and a p-value on the cusp of statistical significance.

4. Discussion

4.1 Summary of Results

This correlational study looked at the effect of exercise on sustained focus. This

was studied by comparing exercise intensity, the interval between exercise and attentional task, and exercise duration to attention by the percentage of errors and reaction time on the CPT test. The study did not statistically support any of the hypotheses. However, the hypothesis that an increase in exercise duration would decrease the percentage of errors on the CPT test trended towards significance.

4.2 Relation of Results to Past Research

The first hypothesis stated that an increase in exercise duration will increase attention. The hypothesis was based on studies done by Altermann and Gropel (2023) and Fenesi et al. (2018) that both looked at the effects of exercise breaks on the ability to perform attention tasks. This correlational study did not support their findings in a statistically significant way, but the variable did trend towards significance. Although it did not support these research studies, this could have been due to the correlational framework of this study. Every exercise logged throughout the study was over 5 minutes long, as suggested by Fenesi et al. (2018), but failed to elicit the same outcome. Since Fenesi et al. (2018) and Altermann and Gropel (2023) both performed randomized control studies, the difference in their studies versus this naturalistic study could play a part in the difference in results. The difference in results could also stem from this study having a single participant, as there is a chance that the one participant may be an outlier.

The second hypothesis was if the interval between exercise and the attention task decreased, then attention would increase. Atakan and Atakan (2024) showed this to be the case in their study on high school students. The students who performed a bout of exercise before completing a math test did better on the test than those that did not. This correlational study's statistics leaned the right way in supporting the theory, but did not reach significance. The average interval between exercise and attention in this study was 387 minutes (6.45 hours), and ranged from a minimum of 90 minutes (1.5 hours) to a maximum of 728 minutes (12.13 hours). Visual examination of the scatterplot between these two variables in this study failed to show any pattern to the length of time between exercise and the attention task and attention performance. However, the discrepancy in results between our study and the Atakan and Atakan (2023) study could be from the timing this study chose to test attention. The CRT test was done at 8:00pm every day, which was at the end of the participant's day. Lifestyle factors including their job, studying, or general fatigue could play a role in the participant's CRT test results. Since Atakan and Atakan (2023) used high school students at their school for their study, their attention test could be done earlier in the day, eliciting different results.

The final hypothesis was that an increase in exercise intensity would also increase attention. Altermann and Gropel (2023) tested this through looking at three different types of exercises, all at the same intensity level (moderately high), and their effects on attention. Their study showed that regardless of the exercise performed, if it is of a high enough intensity, attention improves. This correlational study did not help to support their findings, perhaps due to a lack of variability in heart rate. In this study, there was only one day over the span of 4 weeks that the heart rate of the participant reached vigorous intensity (as per Fitbit's "Heart Rate Zones"). Although the majority of days the participant's heart rate was in the 'moderate' zone, it was on the

lower end of the moderate zone, with the average heart rate over the course of the study being 113BPMs. Since Altermann and Gropel's (2023) research stated their effects were seen at moderately high levels, this study may not have had enough moderately high BPM days to conclude a similar outcome.

4.3 Implications of Results

This study looked at the effects of exercise on attention in hopes of proving it to be a focus-enhancing tool. Since this study did not reach statistical significance in any of the hypotheses tested, it suggests that the theory that exercise improves attention can only be reached in a controlled, experimental study. This study was naturalistic, so the participant lived their normal life while logging their exercise and attention data. The results show that for the average person, regular exercise in a normal range of intensities may not have as big of an effect on attention as experimental studies suggest. Although exercise is shown to be pivotal for overall well-being (Beniwal, 2024), this study points to the direct effect of exercise on attention not being as strong for people outside of laboratories.

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Table 1

Correlations for Study Variables

Variables	Attention Measure Used			
	Percentage of Errors		Avg. Reaction Time	
	r	*n*	*r*	*n*
Exercise Duration & Attention	-0.34	33	0.03	33
Interval Between Exercise and Attention & Attention	0.15	28	-0.09	28
Exercise Intensity & Attention	-0.20	28	-0.09	28

* $p < .05$.

Figure 1

Association Between Exercise Duration and Attention (Percentage of Errors)

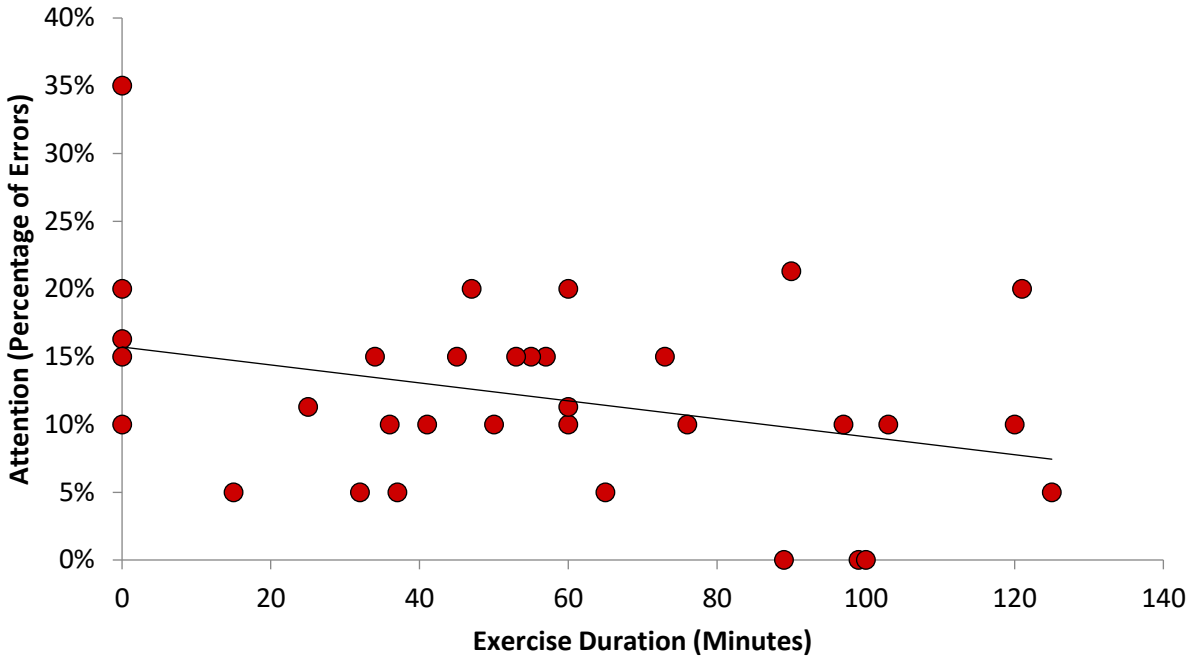

Figure 2

Association Between Exercise Duration and Attention (Average Reaction Time)

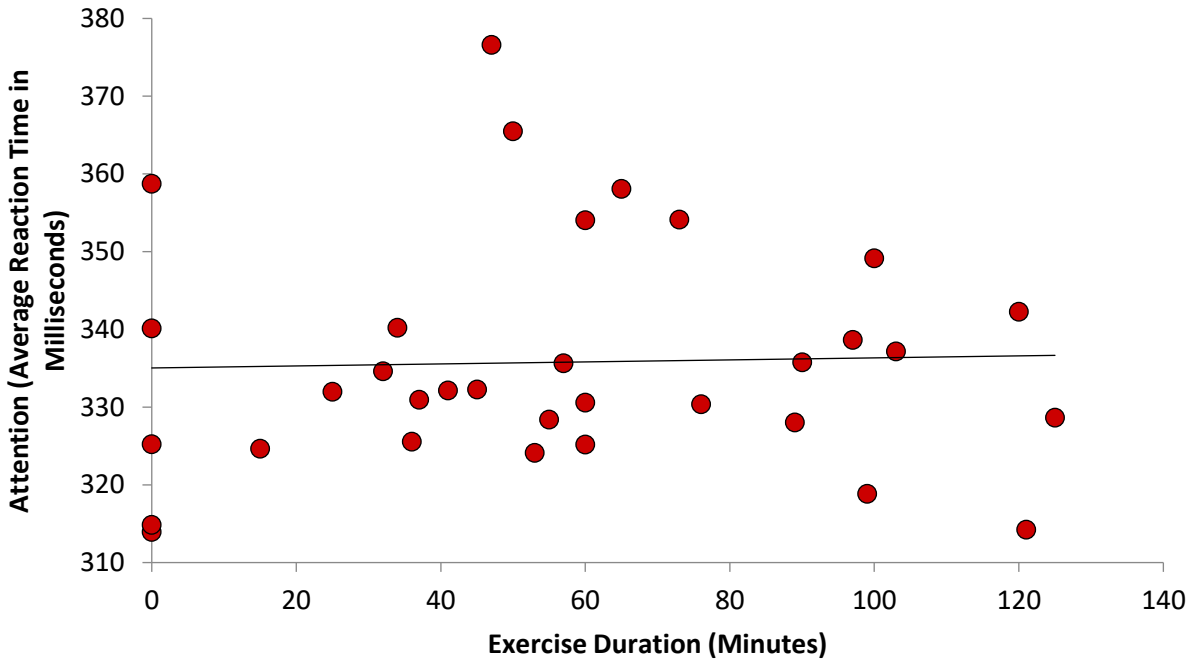

Figure 3

Association Between Interval Between Exercise and Attention and Attention (Percentage of Errors)

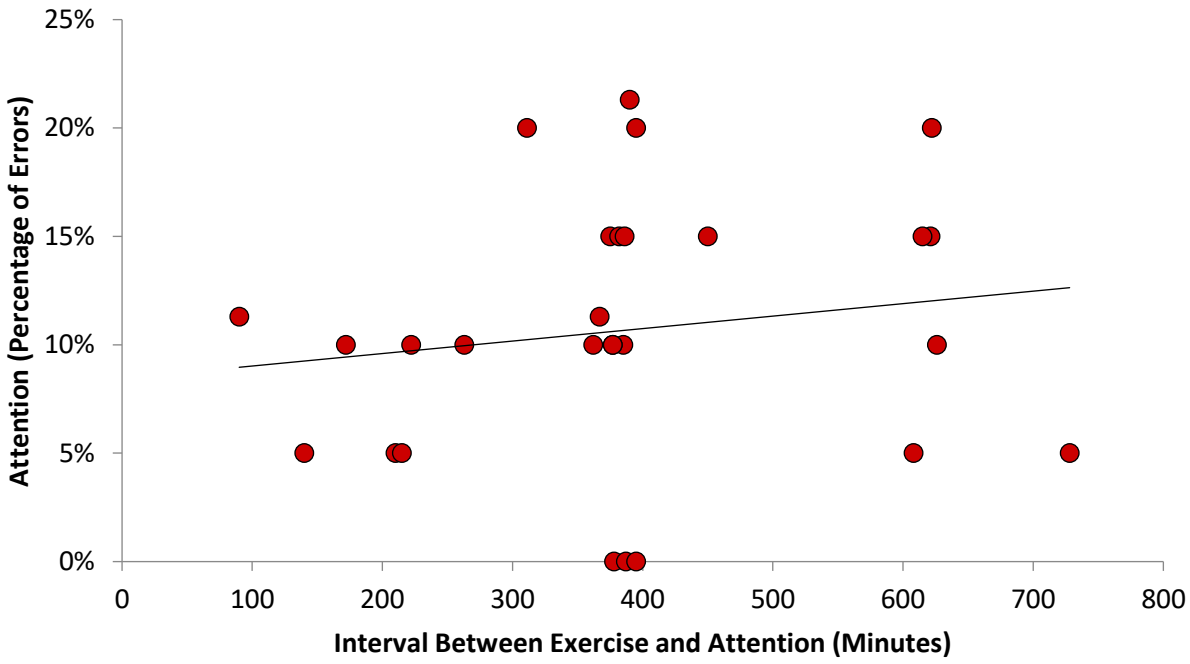

Figure 4

Association Between the Interval Between Exercise and Attention and Attention (Average Reaction Time)

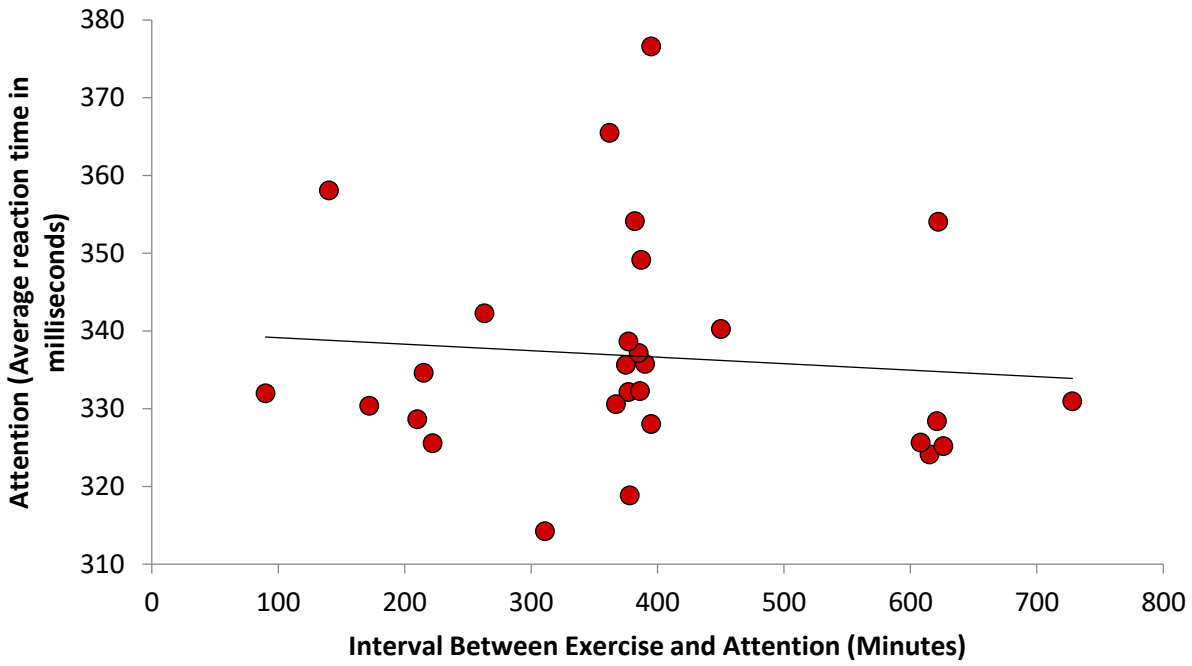

Figure 5

Association Between Exercise Intensity and Attention (Percentage of Errors)

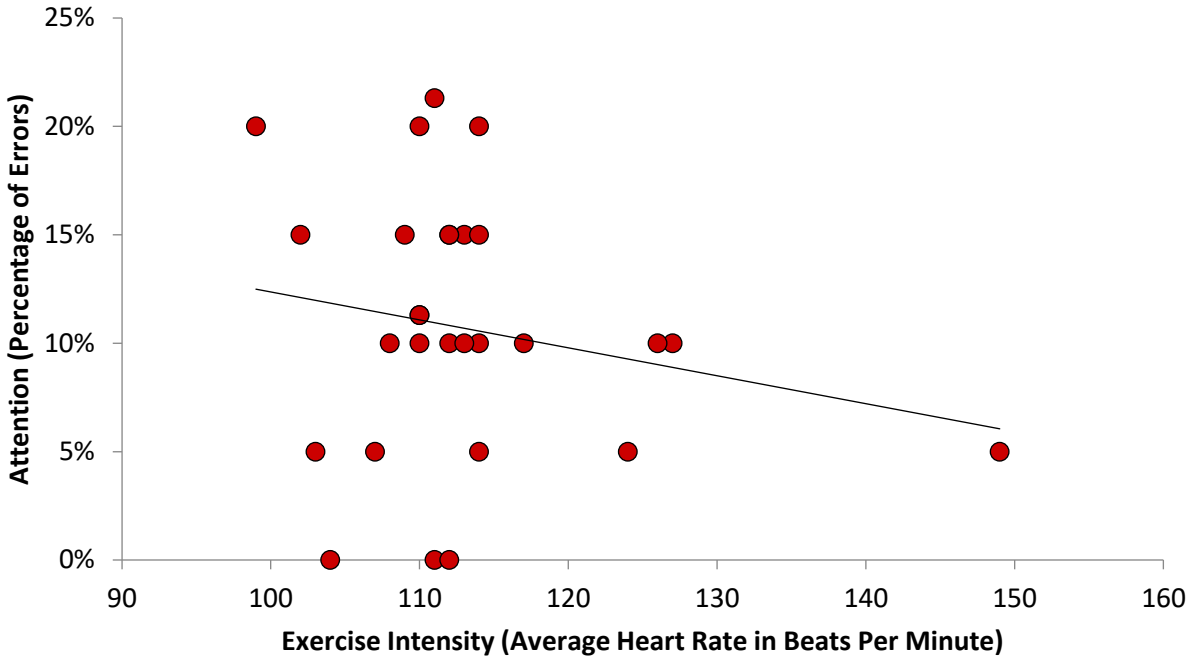

Figure 6

Association Between Exercise Intensity and Attention (Average Reaction Time)