## ABSTRACT

*Purpose*: The purpose of this study was to investigate if exercise in the form of moderate intensity interval training had an effect on memory by comparing the performance of number of words recalled during an exercise condition and a control condition.

*Methods:* The investigators tested a total of 20 participants. All participants completed an informed consent document prior to testing. Participants had three minutes to memorize a list of 15 words. This was followed by either 15 minutes of interval training or 15 minutes of sitting in a controlled environment. All participants participated in both the control and experimental conditions. A paired samples t-test was used to determine statistical significance.

*Results:* The participants were able to recall an average of 11±3 words in the control condition and an average of 9±4 words in the exercise condition. The results showed no statistical significance between control and exercise performance ($p=0.10$), nor was there any statistical significance in the performance between genders ($p=0.58$, $p=0.59$).

*Conclusion:* There was no statistical significance found between moderate intensity interval training and cognitive function, specifically short term memory. This study failed to confirm that moderate intensity interval training evokes cognitive function benefits equivalent to those demonstrated in previous studies on continuous moderate intensity aerobic exercise and high intensity interval training. Future studies should look into the effect of varying duration and intensity of the interval training to find a possible correlation.

## INTRODUCTION

College is a major transition period for most college students. Students become more independent with their academics, food choices, and time utilization. Much of an average college student's time is used to engage in sedentary activities like sitting in a classroom, studying, watching television, or surfing the internet. About 33% of college students lead sedentary lifestyles (Quartiroli & Zizzi, 2012). And if not engaging in these activities, work, social obligations, or extra-curricular activities can take up additional time. Within the college-age population, absence of exercise or irregular exercise is commonly due to a lack of time. As the typical college student is constantly immersed in a very time consuming academic schedule, finding the extra time to engage in physical activity proves to be very challenging. A study shows that during college, especially during their first two years, physical activity decreases and body weight increases (Hajhosseini et al., 2016). Another study showed that 75% of the college population engaged in moderate intensity exercise and 59% engaged in vigorous intensity exercise at least semi-regularly. But 50% of those that engaged in physical activity did not meet the minimum American College of Sports Medicine (ACSM) exercise requirements (American

College Health Association, 2015). Thus, a majority of college students exercise, but not enough to receive full health benefits. A form of exercise called can be a very beneficial type of exercise for the college age population due to its efficiency, along with other reasons. One study showed that interval training can improve cardiovascular function, quality of life, efficiency, aerobic fitness, and exercise adherence (Gayda, Dominique, & Said, 2016). It is common for college students to have busy schedules that do not offer any time to fit in one to two hours at the gym, so interval training is an efficient alternative to achieve daily exercise. Interval training can be completed in as little as ten minutes or more if desired. This smaller time frame can encourage college students who want to exercise, but cannot afford to lose an hour of their time. Along with the efficiency, interval training can improve cognitive functioning, which could also serve to benefit college students. A study found that interval training can improve the brain's ability to transition from thinking about one concept to the other, or thinking about two concepts simultaneously, when performed regularly for at least 7 weeks (Venckunas et al., 2016). Paired with the accessibility and cognitive benefits, the lack of time required for interval training allows it to be a very reasonable option for college students.

According to the National College Health Assessment (NCHA), only 20.9% of students engage in physical activity 5-7 days a week, with 23.6% of students reporting zero physical activity in the past 7 days. Many students assume that taking time off from studying to exercise will harm their academic performance, but our research team would like to examine if exercising can actually be beneficial for academics, specifically memory retention. It has been shown in recent research that four primary factors affect physical activity behavior in college students. These include professional factors, cognitive factors, social factors, and environmental factors. Of these, cognitive factors with the independent variable of self-efficacy were observed to be the primary reason college students' participated in physical activity (Young, Sturts, Ross, 2015). According to our research, there have been a substantial amount of studies done supporting how high intensity interval training can improve cognitive function (Tuskamoto et al., 2016; Alves et al. 2014). But we found mixed results for moderate intensity exercise (Tsukamoto et al., 2016; Peiffer, Darby, Fullenkamp, & Morgan, 2015).

On average, a typical aerobic exercise bout can take anywhere from 30 minutes to an hour depending on the individual's regimen, this may deter the average college student from participating in physical activity solely due to their time constraints. But interval training may exhibit the same cognitive benefits associated with aerobic exercise, in as little as 10 or 20 minutes. This may be observed as a more appealing and feasible option for the average college student with time constraints. Thus, eliminating the negative environmental factors; previously deemed by recent studies, to be amongst the primary factors deterring college students from participating in Physical Activity.

Research supports cognitive function improvements following high intensity interval training (Tuskamoto et al., 2016; Alves et al. 2014). Although, research has shown mixed results for moderate intensity exercise (Tsukamoto et al., 2016; Peiffer, Darby, Fullenkamp, & Morgan, 2015). Thus, the purpose of this study was to further investigate if exercise in the form of

interval training has an effect on memory function. This research will expand upon what current research has shown, regarding the effect of physical activity, specifically interval training, has on cognitive function in college students. Doing so, will allow researchers to address the exercise barriers relating to scheduling conflicts and time restraints, which have not been addressed in previous research studies. It was hypothesized that interval training that includes intermittent bouts of walking and running will have a positive effect on memory retention.

## MATERIALS & METHODS

This study targeted college age individuals, ages 19-22, with no attention deficit disorders or cognitive dysfunctions. Also any individuals deemed "high risk" by American College of Sports Medicine (ACSM) guidelines were not allowed to participate. Interested individuals contacted the investigators of the project via the email address or phone number listed on the advertising materials. Investigators then responded to interested individuals to initiate a health screening process to ensure that it the individual was safe and eligible to participate in the study. Investigators sent an electronic copy of the *American College of Sports Medicine (ACSM) Health/Fitness Facility Pre-participation Screening Questionnaire* and requested that individuals complete the form and return it to the investigator. This questionnaire identified any major signs/symptoms/conditions that contraindicated exercise for an individual and consequently excluded the individual from participation in the research study. After investigators reviewed the questionnaire and ensured that it was safe for the individual to participate, the investigators contacted the individual to set up an appointment for them to report to the testing facility. Participants were asked to arrive at the testing location having done the following: completed a three-hour fast (no food or beverage, with the exception of water), avoided the use of nicotine for at least four hours, and avoided strenuous exercise for at least 24 hours. Participants wore athletic shoes and loose comfortable clothing.

Upon arrival to the testing site, participants were given the opportunity to express any questions or concerns regarding their involvement in the study and the investigators provided any further necessary information for the study. After all question/concerns were addressed by the investigators, participants were asked to sign two informed consent documents. One form was given to the investigator and the other consent form was given to the participants for their records. They were also given an identification code to protect their confidentiality and was used by the investigators to perform a cross-sectional study, randomly placing subjects into one of the two test conditions. The even identification codes underwent the control condition for their first visit and the exercise condition their second visit, while the odd identification codes underwent the experimental condition first and the control condition their second visit.

Exercise Condition: The participants arrived to the testing facility at their specified date and time. The participants had their blood pressure taken for baseline measurements. The participants were then seated in a quiet area and given a list of 15 random words. The

participants had 3 minutes to memorize the words. After the 3 minutes, the participants went to the track and performed a 1.5 minute walking warm-up followed by participation in moderate intensity interval training. The participants alternated running for 2 minutes and walking for 1 minute for a total of 12 minutes. An investigator was stationed at each corner of the track where the participants were performing interval training. One investigator had a stopwatch and instructed the participants when to switch from walking to running and vice versa. The participants walked and ran at their own pace while staying at moderate intensity. Participants intensity was monitored using the Borg Rating of Perceived Exertion (RPE) where the participants rated their perception of effort, fatigue, and physical exertion based on a 6 to 20 scale. According to ACSM guidelines, moderate intensity is rated between 12 to 14 on the Borg RPE scale. After the interval training, the participants performed a 1.5 minute walking cool down. Then the participants returned to the quiet area, were timed for 3 minutes, and asked to write down as many words as they could recall from the list of 15 words. One of the researchers calculated how many words the participants recalled and recorded the data, while the participants completed cool down stretching and follow-up blood pressure measurements. Participants were required to stay on site until their blood pressure returns to approximately resting levels. Participants were then dismissed.

Control Condition: The participants arrived to the testing facility at their return specified date and time. In order to standardize procedures as performed in the exercise condition, participants had their baseline blood pressure assessed. Participants then sat in a quiet classroom and were given a list of 15 words to memorize in 3 minutes. They were allowed 3 minutes to memorize the 15 words then remained seated for 15 minutes in the classroom. Once the 15 minutes passed, the participants were timed for 3 minutes and asked to write down as many words as they could recall from the list of 15 words. One of the researchers calculated how many words the participant recalled and recorded the data from the second recall. Participants were then dismissed.

## DATA ANALYSIS

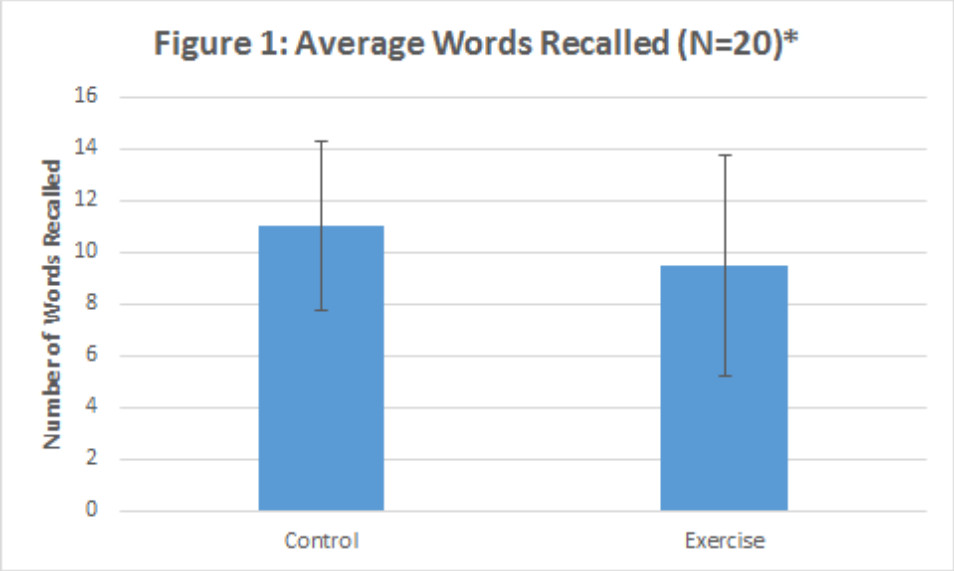
All data collected was analyzed using Statistical Package for the Social Sciences (SPSS) version 23. Descriptive statistics (mean ± SD) will be calculated for the dependent variable, number of recalled words. Dependent t-tests were performed to compare the control and experimental scores between the two groups. Statistical significance was accepted at $p<0.05$.

## RESULTS

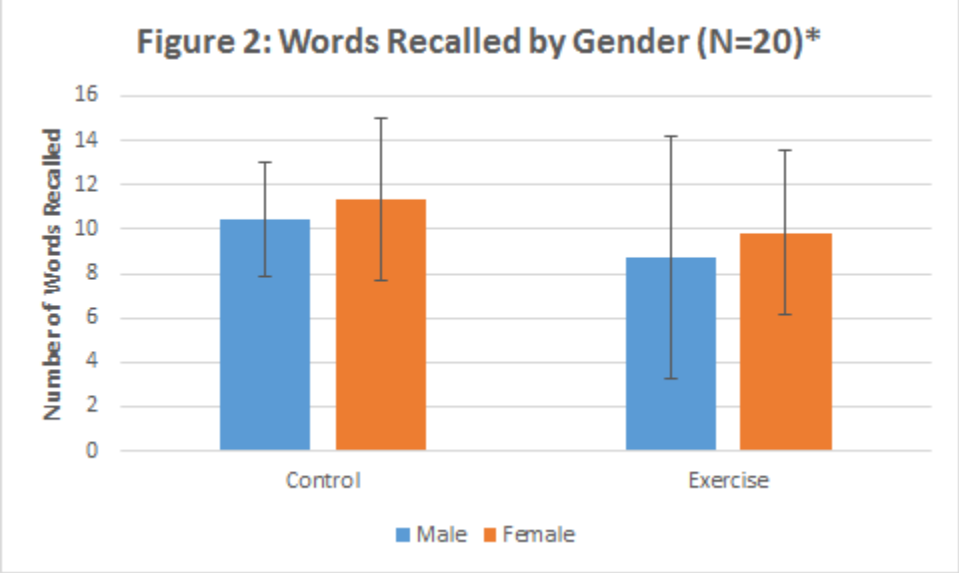
There was a total of 20 college students that showed interest in this study and none had to be dismissed due to any exclusionary criteria. No adverse events occurred during any of the individual test and participants verbally confirmed keeping set RPE parameters while exercising.

All the participants were between ages 18 and 22 with 35% (n=7) of the volunteers being male and 65% (n=13) being female. Of the 15 possible words to recall, the participants recalled an average of 11±3 words in the control group and 9±4 words in the exercise group. Figure 1 below provides a visual representation of the average words recalled between the control and experimental groups.

By gender, the average words recalled in the control group were 10±3 words by males and 11±4 words by females. In the exercise group, the average words recalled were 9±5 words by males and 10±4 words by females. Figure 2 below provides a visual representation of these results. The paired samples t-test did not indicate any statistical significance between exercise and cognitive function (*p=0.10*) and the independent samples t-test did not show any statistical significance between exercise and cognitive function between gender (*p=0.58, p=.059*).




*The number of words recalled ranged from 0 to 15.




*The number of words recalled ranged from 0 to 15.

## DISCUSSION

The purpose of this study was to further investigate if exercise in the form of interval training has an effect on memory function. It was hypothesized that interval training that includes intermittent bouts of walking and running will have a positive effect on memory retention. Due to no statistically significant findings revealed by the paired samples t-test comparing testing conditions, or the independent samples t-test comparing gender performance; the null hypothesis failed to be rejected.

Past studies have shown that acute continuous moderate intensity exercise improves cognitive function (Yanagisawa, et al., 2010; Alves et al., 2012) and others have indicated that high intensity interval training also improves cognitive function (Alves et al., 2014). These past studies used the Stroop test to measure cognitive function. The present study combined the successes to investigate if moderate intensity interval training could also benefit cognitive performance using a list of 15 randomly generated words rather than a Stroop test. Contrary to the hypothesis of the present study, the results indicated that cognitive function is not enhanced by low-moderate intensity interval training. This could be due to a lack of a consistently controlled environment, small sample size, and different measure of cognitive ability. The word list might not be as indicative of cognitive function as the Stroop test has proven to be, which could have skewed the results.

A possible explanation as to why this study did not line up with studies previously done is the level of hydration of the participants. It is clearly seen that dehydration impairs the cognitive function of the brain (Cian, Barraud, Melin, & Raphel, 2001; Cian et al., 2000). Tomporoski in 2003 found that submaximal aerobic exercise greatly increased cognitive function, but during continued bouts of extended, strenuous exercise leading to dehydration both information processing and memory cognition were compromised. Participants in this study were advised to hydrate before arriving to the testing site, as advised by ACSM guidelines, but there were no measures taken to ensure proper hydration levels among the participants. Differing levels of starting hydration levels as well as selected intensity could have had an effect on how quickly the participants became dehydrated.

This study did not indicate any statistical significance between interval training and cognitive function, this may be attributable to several limitations. These include the homogeneous nature of the physical activity patterns of the sample population, the setting in which the study was conducted, and the subjectivity of the RPE sale used to measure exercise intensity. Through the lack of randomized recruitment and selection of participants, the sample population serves as a limitation to this study due to the fact that only 49% of the general population is considered physically active compared to the population sample used, Therefore, a testing sample mainly composed of exercise science majors, who are known to be exponentially physically active; limits the applicability of the findings to the general population. The testing environment limitations included factors such as the disturbance of the testing setting, resultant

from sporting events occurring, on occasion, at the same time as the conduction of both exercise and controlled trials. The lack of consistency in the testing environment may have impeded the participant's mental concentration in the controlled setting, and potentially tampered with the reliability of the exercise setting. Finally, the RPE scale may serve as a limitation affecting the measurement of intensity during the exercise trials. Although the participants reported their RPE values during the experiment, the subjectivity of the RPE scale creates the potential for participant variability, which in turn directly limits the validity of data collected. Future studies investigating interval training on memory function can overcome these limitations by adapting the study's procedures. Adaptations including, a testing environment that may be easily controlled, additional methods for the measurement of exercise intensity, the recruitment of a larger sample size, and the selection of participants in such a way that ensures variety of the testing sample. Additional studies should also be conducted to further investigate interval training and mental cognition; specifically addressing the possible effects of interval training on long term memory, which was not addressed in this study.

Although there were no statistically significant findings from the research conducted, there are still ways in which the findings can applied clinically. It can be inferred that interval training does not have an effect on cognitive functioning, specifically memory, in college age individuals, but future studies can expand upon our existing research by implementing certain changes. They could focus more on differences within the genders and how they respond cognitively to interval training. Along with this, future studies could change the type of interval training used, or the duration and intensity. A more broad population could be examined, instead of using just college students, to improve validity and accuracy within the results. After accumulating the results of our study, other studies could place a greater emphasis on determining what types of exercise, instead of interval training, have an effect on cognitive function in individuals.

## REFERENCES


Alves, C. R., Gualano, B., Takao, P. P., Avakian, P., Fernandes, R. M., Morine, D., & Takito, M. Y. (2012). Effects of Acute Physical Exercise on Executive Functions: A Comparison Between Aerobic and Strength Exercise. *Journal Of Sport & Exercise Psychology*, *34*(4), 539-549.

Alves, C. c., Tessaro, V. .., Teixeira, L. C., Murakava, K., Roschel, H., Gualano, B., & Takito, M. .. (2014). Influence of acute high-intensity aerobic interval exercise bout on selective attention and short-term memory tasks. Perceptual & Motor Skills, 118(1), 63-72. doi:10.2466/22.06.PMS.118k10w4

American College Health Association. American college health association-national college health assessment II: reference group executive summary fall 2015. Hanover, MD: American College Health Association; 2016.

American College Health Association. American college health association-national college

health assessment II: reference group executive summary spring 2015. Retrieved October 1, 2016 from http://www.acha-ncha.org/docs/NCHA-II_WEB_SPRING_2015_REFERENCE_GROUP_EXECUTIVE_SUMMARY.pdf

Aguiar, A. S., Boemer, G., Rial, D., Cordova, F. M., Mancini, G., Walz, R., ... & Prediger, R. D. S. (2010). High-intensity physical exercise disrupts implicit memory in mice: involvement of the striatal glutathione antioxidant system and intracellular signaling. *Neuroscience*, *171*(4), 1216-1227.

Cian, C., Barraud, P. A., Melin, B., & Raphel, C. (2001). Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration. *International Journal of Psychophysiology*, *42*(3), 243-251.

Cian, C., Koulmann, N., Barraud, P. A., Raphel, C., Jimenez, C., & Melin, B. (2000). Influences of variations in body hydration on cognitive function: Effect of hyperhydration, heat stress, and exercise-induced dehydration. *Journal of Psychophysiology*, *14*(1), 29.

Gayda, Mathieu, Dominique Choquet, and Said Ahmaidi. "Effects of exercise training modality on skeletal muscle fatigue in men with coronary heart disease." *Journal of Electromyography and Kinesiology* 19.2 (2009).

Hajhosseini L., Holmes T., Mohamadi P., Goudarzi V., McProud L., Hollenbeck C.B. Changes in

body weight, body composition and resting metabolic rate (RMR) in first-year university freshmen students. J Am Coll Nutri 2006; 25, 123-127.

Peiffer, R., Darby, L. A., Fullenkamp, A., & Morgan, A. L. (2015). Effects of acute aerobic exercise on executive function in older women. *Journal Of Sports Science & Medicine*, *14*(3), 574-583.

Quartiroli, A., & Zizzi, S. (2012). A tailored wellness intervention for college students using internet-based technology: A pilot study. *International Electronic Journal Of Health Education*, *15*37-50.

Tsukamoto, H., Suga, T., Takenaka, S., Tanaka, D., Takeuchi, T., Hamaoka, T., & ... Hashimoto, T. (2016). Greater impact of acute high-intensity interval exercise on post-exercise executive function compared to moderate-intensity continuous exercise. *Physiology & Behavior*, *155*224-230. doi:10.1016/j.physbeh.2015.12.021

Tomporowski, P. D. (2003). Effects of acute bouts of exercise on cognition. *Acta psychologica*, *112*(3), 297-324.

Venckunas, T. (2016). Interval running training improves cognitive flexibility and aerobic power of young healthy adults. *Journal of Strength and Conditioning Research*, *30*(8), 2114-2121.

Yanagisawa, H., Dan, I., Tsuzuki, D., Kato, M., Okamoto, M., Kyutoku, Y., & Soya, H. (2010). Acute moderate exercise elicits increased dorsolateral prefrontal activation and improves cognitive performance with Stroop test. *Neuroimage*, *50*1702-1710. doi:10.1016/j.neuroimage.2009.12.023

Young, S.J., Sturts, J.R., & Ross, C.M. (2015). Physical activity among community college

students. *The Physical Educator*, 72, 640-659.