

The Effects of Peppermint-Flavored Chewing Gum on Parameters Related to Physical Fitness

Principal Investigators: Sam Considine, Alejandra Torres Diaz, Lizzy DeRoche, Gary Rajput,
Rachel Retsky, & Nicole Potter

University of Wisconsin-Madison, Department of Physiology

Physiology 435: Lab 603, Group 7

Word Count: 5826

Key words: Exercise, reaction time, chewing gum, blood pressure, heart rate, MAP

Abstract

Exercise is one of the first things that comes to mind when thinking about improving physical fitness. However, the effects of exercise on fitness are a function of many other factors. The purpose of this study was to explore the relationship between chewing peppermint-flavored gum during exercise and the physiological parameters that are related to physical fitness. Previous research regarding the physical and mental effects of exercise led to the selection of the three physiological parameters: blood pressure, heart rate and reaction time. Based on previous research conducted on these parameters, as well as the impact of gum chewing on productivity and stress, it was hypothesized that chewing peppermint-flavored gum while exercising would decrease blood pressure, heart rate, and reaction time. Participants were asked to perform short-duration aerobic exercise on a stationary bike while their blood pressure and heart rate were monitored. Times were also recorded for reaction a test. Following data analysis, it was found that there was no significant difference in the change in heart rate and mean arterial blood pressure while exercising with and without chewing gum. However, a significant difference was found in the measured reaction times. There was an overall increase in reaction times for the experimental group after the addition of chewing gum. Further research is necessary to show that it was in fact the chewing of the gum that attributed to the increase in the reaction times. Although the results of this study do not show a significant relationship between chewing peppermint-flavored gum and physical fitness, the increase in reaction times in the experimental group suggests that chewing gum may be a greater distraction than originally assumed.

Introduction

Fitness, as it pertains to physical activity, has been shown to provide overwhelming benefits in the improvement of physiological and metabolic parameters, as well as in the prevention of chronic disease and premature mortality (Mollaoglu, 2012). Extensive research in epidemiological and clinical settings has shown that physical activity may help curb obesity, reduce the risk of cardiovascular disease, improve inflammatory and thrombotic status, and increase overall mental well-being (American Heart Association Inc., 2018, Mollaoglu, 2012). The Centers for Disease Control and Prevention recommends that adults engage in at least 150 minutes of moderately intense or 75 minutes of vigorously intense exercise per week. The definitions of moderately and vigorously intense exercise depend on one's ability to reach 60 and 70 percent of his or her maximum heart rate and, therefore, vary between individuals and fitness levels (CDC, 2016).

Physiological parameters used to assess overall fitness include heart rate, blood pressure, and the time it takes to react to a given stimulus.

Heart rate is a cardiovascular measurement that is a widely used physical fitness indicator. Resting heart rate in a healthy adult is typically between 60 and 100 beats per minute. However, those with lower resting heart rates are said to have better cardiovascular function and be more physically fit (Laskowski, 2015). Previous studies have investigated the relationship between heart rate and exercise, and found that variation in heart rate is correlated with various exercise intensities (Karvonen, 1988). Furthermore, the graphical relationship between submaximal exercise and the heart rate of a healthy individual is said to be linear (Mikus, 2009). In addition to exercise intensity, many other factors have been found to influence heart rate, including stress, various colors, and potent odors (Barkat, 2003, Kudielka, 2003).

Similar to heart rate, blood pressure is influenced by a wide variety of factors and has proven to be an important parameter of overall fitness. During exercise, systolic blood pressure progressively increases to allow for more oxygen to be sent throughout the body, while diastolic blood pressure stays relatively constant (Kelley, 2000). Many studies focus their efforts on how physical fitness and hypertension interact. This interest can be attributed to the high prevalence of hypertension in the United States. It has been found that improved physical fitness reduces blood pressure, thus lowering the incidence of hypertension (Diaz & Shimbo, 2013). In addition, exercise involving aerobic activities, such as cycling, has been found to lower systolic blood pressure, particularly in those with higher baseline blood pressures (Kokkinos & Myer, 2010). One study found a 5 to 7 mmHg decrease in systolic blood pressure after isolated short exercise sessions

(Pescatello *et al.*, 2004). This past research indicates that isolated exercise, in the form of the short sessions of cycling, is a valid test of physical fitness and blood pressure changes.

Another important measure associated with physical fitness is reaction time. Reaction time is a measure of quickness, or the time interval between a stimulus and a response. It is considered a skill-related component of physical fitness, as it has been shown that physically active individuals tend to have faster reaction times than those who live a sedentary lifestyle (“Definitions: Health”, 2012, Jain, Bansal, Kumar, & Singh, 2015). Furthermore, reaction times have been positively linked to heart rate. One study examined the effects of cycling during a reaction time test. It was found that as heart rate approached 145 beats per minute, the reaction time decreased (Salmela & Ndoyes, 1986). Therefore, reaction time was the third parameter chosen in this experiment in order to measure physical fitness.

Research has been done examining the effects of chewing gum on cognitive ability and mental state. Chewing gum is associated with enhanced attention, as well as higher productivity in the workplace (Allen & Smith, 2015). It has been shown to improve mood and reduce anxiety and fatigue in healthy, young adults (Sasaki-Otomaru *et al.*, 2011). Further research needs to be done to understand the physiological benefits of chewing gum. One study found that peppermint essential oil lowered systolic and diastolic blood pressure, as well as heart rate upon immediate ingestion of the oil (Meamarbashi, 2014). Another study found that peppermint odor was associated with a decrease in daytime sleepiness (Norrish and Dwyer, 2004). Research has also shown that chewing gum leads to a decreased level of the sympathetic nervous system stress marker, alpha-amylase, while in a mentally stressful environment (Nakajo *et al.*, 2007). Finally, another study has found a

decreased level of salivary cortisol levels, an endocrine system stress marker, while chewing gum in a stressful situation (Scholey *et al.*, 2009).

Based on these past research findings, studying the effects of peppermint-flavored chewing gum on indicators of physical fitness was chosen as the premise of this experiment. Using an exercise bike, on which participants can perform aerobic exercise, three different indicators of physical fitness, heart rate, blood pressure, and reaction time, will be tested. It is hypothesized that participants given peppermint-flavored chewing gum while performing short-duration aerobic exercise will have a decrease in heart rate, blood pressure, and reaction time, as compared to exercising without chewing gum. These findings would indicate that chewing gum during exercise may lead to increased physical fitness.

Methods and Materials:

Participants

34 volunteer students from Physiology 435 at the University of Wisconsin-Madison were participants in this study. Participants signed a waiver and were given a brief summary of the tasks that they would be required to perform. In addition, on the waiver, participants were asked to record the average hours of sleep per night that they had gotten the week prior to participating in the study, as well as the average number of hours they exercise per week. Of the 34 participants, 24 were randomly selected to be in the experimental group and 10 were selected for the control group. In order to randomize the groups, each consent form was assigned a unique number between 1 and 34, and all of the forms were shuffled thoroughly. If the participant received a consent form with a number between 1 and 10, he or she was assigned to the control group. If the

participant received a consent form with a number between 11 and 34, he or she was assigned to the experimental group.

Equipment and Measurements

The OMRON 10 Series+ Blood Pressure Monitor and a ComFit Cuff (BP7911T, # 2014004367LG, OMRON Healthcare, Inc., Lake Forest, IL, USA) were used to record the participant's systolic, diastolic blood pressure (mmHg), and heart rate. The participant was asked to sit on a chair and place his or her left arm on the table at a forty five degree angle. The cuff was placed ½ inch above the elbow, per OMRON instructions. In order to maximize accuracy, the participant was asked to sit upright with uncrossed legs, and to roll up his or her sleeve if he or she was wearing thick clothing. The cuff was left on throughout the duration of the experiment in order to periodically monitor the participant's blood pressure. As an added precaution, the Apple Watch Series 1 (Model: MNNN2LL/A, Serial #: FHLSCCRXHF1J, Apple Inc., Cupertino, CA, USA) was placed on the left wrist of the participant and the My Watch tab was entered in order to monitor the heart rate. This precaution was taken in case the OMRON Monitor failed while measuring heart rate during the exercise part of the experiment, as a result of excessive movement of the participant. Research has shown the consistent capabilities of the Apple watch to accurately measure heart rate (Wallen *et al.* 2016). However, the measurements presented in this paper are the ones found by the OMRON Monitor. The participant exercised using the Gold's Gym Cycle Trainer 390 R exercise bike (GGEX61712, Bike #8, Gold's Gym, Dallas, TX, USA). The seat frame and pedal straps were adjusted to allow the participant to sit comfortably. The participant was instructed to maintain a slight bend in the knees to reduce the risk of injury while pedaling. Instructions and the Reaction Time I program from Lesson 11 of *BIOPAC Student Laboratory*

Manual (BIOPAC Systems, Inc., Goleta, CA, USA) were followed to measure reaction times. The participant was instructed to face away from the computer screen and push the button as directed by the BIOPAC lesson. The reaction times were measured using the Push Button Hand Switch (SS10, #12116527, BIOPAC Systems, Inc., Goleta, CA, USA) and Behringer Headphones (HPM1000, #G121485223, Behringer Inc., Willich, Germany), while being recorded with BIOPAC software (MP36, #MP36E1204002771, BIOPAC Systems, Inc., Goleta, CA, USA).

If the participant was a member of the experimental group, he or she was given one piece of Eclipse Polar Ice Sugar-Free gum for the second half of the experiment. The participant was instructed to not swallow the gum accidentally, and to actively chew the gum for the remaining duration of the experiment. After each participant completed the entire experiment, the exercise bike, blood pressure cuff, headphones, and reaction time hand switch were wiped down with Purell Hand Sanitizing Wipes for sanitary purposes.

Experimental Design

A timeline of the events of the experiment for each participant can be seen in Figure 1 and Figure 2. Each participant's resting heart rate (bpm) and systolic and diastolic blood pressure (mmHg) were measured to obtain baseline values. The participant got on the bike and, once the bike was adjusted to suit his or her height, was asked to pedal between 14 and 16 miles per hour at a resistance of 7. At this point, a timer was started. These exercise parameters were determined to be sufficient in causing moderate physical exertion after testing two group members of various fitness levels. One group member reported exercising only once per week, while the other reported exercising an average of 3-4 times per week. While pedaling, the participant's heart rate and blood

pressure were re-measured every 30 seconds until a 60 percent increase in the baseline heart rate was obtained. For example, if the participant's resting heart was 100 beats per minute (bpm), then he or she exercised until his or her heart rate reached 160 bpm. This parameter was chosen because the average 20 year old has a target heart rate (sixty percent of maximum heart rate) of approximately 120, which is 60 percent above the average baseline heart rate for 20 year olds (Hancock, 2017). The average age of all students enrolled in Physiology 435 is 21 years old. Once a 60 percent increase in heart rate was obtained, the participant was instructed to stop pedaling and the timer was stopped. The participant's heart rate, systolic and diastolic blood pressure, and time to reach a 60 percent increase in heart rate were recorded. The time recorded was used as the amount of time he or she would bike during the next round of exercise. Adjusting the bike time for each individual, based on his or her unique physical fitness, controlled for differences in fitness levels between individual participants. The change in heart rate and mean arterial blood pressure, after the two rounds of exercise, was calculated for each participant.

Following the biking, the participant was asked to sit on a chair, facing away from the computer screen, to complete the reaction test. The participant was instructed to hold the Push Button Hand Switch in his or her dominant hand and press the button every time he or she heard a static, beep noise while wearing the Behringer Headphones. The program presented the participant with a series of ten static, beep noises over a 60 second period and his or her reaction time for each noise was recorded by the BIOPAC System. The mean reaction time (measured in seconds) for each individual was calculated by the BIOPAC program. After completing the reaction test, the participant rested until the heart rate returned to 10 percent of his or her baseline.

At this point in the experiment, if the participant was in the experimental group, he or she was given a piece of mint chewing gum, while participants in the control group proceeded without chewing gum. The participant returned to the bike and pedaled at a speed between 14 and 16 miles per hour and at a resistance of 7 for the amount of time previously established to have increased his or her heart rate by 60 percent. At completion, the heart rate and systolic and diastolic blood pressure were recorded while the participant remained on the bike. Lastly, the participant was asked to complete a second reaction test in the same manner as the first reaction test. The results were recorded and compared to see if chewing gum helped to lower reaction time, heart rate and blood pressure over the participant's previously measured personal time interval.

Data Analysis

Individually, each participant's percent changes in heart rate (bpm), mean arterial blood pressure (mmHg), and mean reaction time (seconds) were calculated between the two times on the bike. Specifically, heart rate was measured following each time on the bike, and the individual percent change was calculated. The mean percent change in heart rate was then calculated for the control group, as well as the experimental group.

Blood pressure was measured following each time on the bike. The mean arterial blood pressure (MAP) was calculated using systolic and diastolic blood pressure between the two times on the bike for each individual participant. The percent change in the MAP value was then calculated for each participant in the control group, as well as the experimental group.

Reaction time data was collected and recorded following each time on the bike. The BIOPAC Reaction Time I (Lesson 11) recorded how long he or she took to react to this sound (Figure 3). Each individual reaction test resulted in a mean reaction time (seconds) from a set of ten

reactions. The percent change in mean reaction time following the two times on the bike was calculated for each individual participant. The mean percent change in mean reaction time was then calculated for the control group, as well as the experimental group.

Positive Control

The changes in heart rate, mean arterial pressure, and reaction time were all measured with the OMRON 10 Series+ Blood Pressure Monitor and BIOPAC Systems, Inc. devices. Five group members underwent the experiment and, after achieving a 60 percent increase in heart rate at a speed between 14 and 16 miles per hour and a resistance of 7, heart rate and systolic and diastolic blood pressure were measured for each participant. Furthermore, the blood pressure and heart rate of subject one was graphed to show the effects between baseline and post-exercise data (Figure 4 and Figure 5). To get a better visual representation of the overall positive control data, the means of the data for blood pressure and heart rate were also calculated (Figure 6 and Figure 7). The same positive control data will be recorded for each participant following his or her first time on the bike. This data will be compared to his or her data after the second time on the bike.

Negative Control

In this experiment, the baseline measurements of heart rate and blood pressure were taken prior to the participant's first time on the bike. To ensure that these measurements were steady at rest, the baseline measurements were repeated with the two group members who performed the experiment. There was no variation in the baseline values measured. The baseline measurement of reaction time was taken following the participant's first time on the bike.

Results

34 subjects participated in the study. However, 5 participants were removed from the data analysis due to technical problems with the equipment. Problems with blood pressure recording device failing at the time of needed measurements caused a significant deviation in the timeline of the experimental procedure, making those data measurements unusable in the final analysis. All participants were given a brief survey as part of their consent form, which asked about average sleep and exercise. Survey results indicated that the control group reported an average of 6.95 hours of sleep per night, while for the experimental group reported an average of 6.89 hours per night. The survey results also showed that the reported average exercise was 3.7 and 3.2 hours per week for the control group and the experimental group, respectively. Finally, the average bike time in order to obtain a 60 percent increase in heart rate for the control was 0:59 seconds and 0:54 seconds for the experimental group.

Heart Rate

The percent change in heart rate was calculated for the control group ($n= 10$, $\bar{x}= 0.648$, $SD= 7.546$) and the experimental group ($n=19$, $\bar{x}= 3.659$, $SD= 12.77$) (Figure 8). Heart rate was measured until a 60 percent increase in the baseline heart rate was observed during the participant's first time on the bike. The experimental group received the gum just prior to their second time riding the bike and was instructed to chew it for the remainder of the experiment. The control group did not receive any gum. A single tail t-test revealed that there was not a statistically significant ($p= 0.251$) difference in percent heart rate change between individuals who received gum and those who did not while riding the stationary bike.

Mean Arterial Blood Pressure

Percent change in mean arterial blood pressure (MAP) was calculated for both the control group (n= 10, \bar{x} = -0.275, SD= 6.173) and experimental group (n= 19, \bar{x} = 3.951, SD= 9.906) (Figure 9). MAP was calculated from systole and diastole data. Furthermore, a single tail t-test showed that there was not a statistically significant (p= 0.116) difference in percent MAP change between individuals who received gum and those who did not receive gum.

Reaction Test

The percent change in reaction time for each participant was calculated from mean reaction times for both our control group and our experimental group. The data is summarized in Figure 10 below. Through a single tail t-test, it was found that there was a significant difference in the percent change in reaction times between control (n= 10, \bar{x} = -8.680, SD= 7.503) and experimental groups (n= 19, \bar{x} = 1.61, SD= 10.68). The p-value for the percent change in reaction time between the control and experimental groups was found to be 0.006.

Discussion

The data did not support the hypothesis that stated that the addition of chewing gum while exercising would improve the physiological parameters related to physical fitness. Instead, no significant change in the average percent changes in heart rate or mean arterial blood pressure was seen with the addition of chewing gum. If the data had supported the hypothesis, then there would have been a decrease in the percent changes in heart rate and mean arterial blood pressure, as well as a decrease in reaction time. Although previous research shows that peppermint essential oil lowers blood pressure and heart rate immediately upon ingestion of the oil, our results do not demonstrate these findings. This may be explained by the fact that chewing gum is a diluted form of peppermint, compared to fully concentrated essential oil. While there were no significant

changes in the measured heart rates and blood pressure, there was a significant difference between reaction times for individuals with and without chewing gum. However, these findings contradicted the initial hypothesis that chewing gum would decrease reaction time.

Rather, there was an increase in the observed reaction times with the addition of chewing gum. Although previous studies have found a positive correlation between gum chewing and attention level, the results from this study showed an increase in reaction times, signifying a potential decrease in individuals' attention levels (Allen & Smith, 2015). This could be due to the interference of the act of chewing with participants' abilities to fully concentrate on the task of completing the reaction test. It can be speculated that gum chewing had a negative impact on reaction time due to the fact that concentration and arousal play a key role in overall fitness (Kumar & Singh, 2015). Interestingly, every single participant in the control group did show a decrease in reaction time when the second test was administered. This could be due to possible learning that has occurred amongst these participants. Control participants completed the cycle of identical tasks twice, so during the second test, their brain may have already been primed for hearing the sound, allowing them to have a quicker reaction time.

While the hypothesis predicted that reaction time would decrease with chewing gum, the experimental data showed a statistically significant increase in reaction time. This result may be explained by the short duration of time that each participant was allowed to chew the gum for prior to taking the reaction test. One study found that the act of chewing negatively affected reaction time during early stages of an attention task. Interestingly, the beneficial effects of gum chewing on reaction time were only observed at later stages of the attention task (Tucha *et al.*, 2011). This reveals a potential flaw in the current study's experimental design, and provides a possible

explanation for the unexpected result. Thus, in order to observe a decrease in reaction time with gum chewing, it may be necessary to allow participants to chew the gum longer prior to taking the test. While research on the influence of chewing gum on blood pressure and heart rate during exercise is lacking, it is important to note that time may have impacted these measurements as well. Had the participants exercised for a longer duration of time, a significant difference in these variables may have been found with the addition of chewing gum.

Another limitation of this study, which may have affected the blood pressure measurements, leading to the large standard deviations of 6.173 and 9.906, was not taking into account how athletic each participant was. It has been shown that varying degrees of fitness are linked to a wide spectrum of blood pressure measurements (Palantini, 2018). Therefore, in future research on this subject, it would be beneficial to recruit participants with similar fitness levels in order to minimize the role of intrinsic fitness and isolate the effects of the chewing gum. In addition, the blood pressure measurements may have been impacted by the slight movement of a participant as she or he pedaled on the bike. At times, this movement was significant enough to cause the blood pressure monitor to result in an error message, requiring that the blood pressure and heart rate be measured a few seconds past the desired time. It is suspected that this may be a source of error in the data. However, in order to ensure the proper functioning of the monitor, an Apple Watch was placed on the left wrist of each participant, which provided heart rate readings regardless of the participant's movement. However, it is not possible to know if the blood pressure readings taken by the OMRON 10 Series+ Blood Pressure Monitor and a ComFit Cuff were accurate.

A confounding factor on reaction time in this study may have been the duration of physical exercise. In a study examining the influence of duration of physical exercise on reaction time, it was found that cognitive performance, as measured by reaction time, is reduced during initial stages of exercise while cognitive performance increased after long duration exercise. Specifically, an increased reaction time was observed after short duration exercise compared to a decreased reaction time associated with prolonged exercise duration. This association is supported by the idea that prolonged physical exercise increases arousal, due to increased blood flow to the brain (Brisswalter *et al.*, 2002). Because participants were only engaging in physical exercise for a short period of time, their cognitive performance may have been negatively impacted, resulting in an increased reaction time. Thus, future experiments may need to take into account the duration of exercise in order to determine the effect of this variable on reaction time.

The tested population was another limitation of the study. Not only was the sample size small (n=29), but the group of participants were all similar in age and did not represent a diverse population. This small population size may have resulted in the large standard deviation in the data. A large variance is seen in mean percent change in heart rate and mean arterial blood pressure. Further studies must be done to see if similar results are found in people of different ages and from different backgrounds. The results of these experiments would give a better indication on whether or not the insignificant changes seen in heart rate and mean arterial blood pressure are seen with an increase in sample size. In addition, it would be interesting to see if the increase in the reaction times would be observed in a larger population.

Overall, the results did not show a statistical significance between the experimental and control groups in terms of heart rate and blood pressure. However, data analysis found a

statistically significant correlation between gum-chewing and increased reaction time. Further research is necessary to determine if this relationship is confounded by the distraction associated with the action of chewing gum. If the action of chewing gum is truly responsible for increasing reaction time, then people should consider not chewing gum while performing tasks that require a quick reaction. In the case of fitness and exercise, this would include catching a fast pitch, dodging a tackle, or beginning a sprint.

References

- Allen, A. P., & Smith, A. P. (2015). Chewing Gum: Cognitive Performance, Mood, Well-Being, and Associated Physiology. *BioMed Research International*, 2015, 654806.
<http://doi.org/10.1155/2015/65480>
- Barkat, S., Thomas-Danguin, T., Bensafi, M., Rouby, C., & Sicard, G. (2003). Odor and color of cosmetic products: correlations between subjective judgement and autonomous nervous system response. *International Journal Of Cosmetic Science*, 25(6), 273-283.
- Brisswalter, J., Collardeau, M., Arcelin, R. (2002). Effects of acute physical exercise characteristics on cognitive performance. *Sports Medicine*, 32(2002), pp.555-566
- Centers for Disease Control and Prevention. (2015, June 4). *Measuring Physical Activity Intensity*. Retrieved March 7, 2018, from
<https://www.cdc.gov/physicalactivity/basics/measuring/index.html>
- Definitions: Health, Fitness, and Physical Activity. (2012, July 6). *The President's Council of Physical Fitness and Sports*. Retrieved March 08, 2018, from
https://web.archive.org/web/20120712201046/http://www.fitness.gov/digest_mar2000.htm

- Diaz, K. M., & Shimbo, D. (2013). Physical Activity and the Prevention of Hypertension. *Current Hypertension Reports*, 15(6), 659–668.
- Jain, A., Bansal, R., Kumar, A., & Singh, K. (2015). A comparative study of visual and auditory reaction times on the basis of gender and physical activity levels of medical first year students. *International Journal of Applied and Basic Medical Research*, 5(2), 124–127.
- Karvonen, J., & Vuorimaa, T. (1988). Heart Rate and Exercise Intensity During Sports Activities [Abstract]. *Sports Medicine*, 5(5), 303-312.
- Kelley, G. A., & Kelley, K. S. (2000). Progressive Resistance Exercise and Resting Blood Pressure : A Meta-Analysis of Randomized Controlled Trials. *Hypertension*, 35(3), 838-843.
- Kokkinos, P., & Myers, J. (2010). Exercise and Physical Activity: Clinical Outcomes and Applications. *Circulation*, 122(16), 1637-1648.
- Kudielka, B. M., Buske-Kirschbaum, A., Hellhammer, D. H., & Kirschbaum, C. (2004). Differential Heart Rate Reactivity and Recovery After Psychosocial Stress (TSST) in Healthy Children, Younger Adults, and Elderly Adults: The Impact of Age and Gender. *International Journal Of Behavioral Medicine*, 11(2), 116-121.
- Laskowski, E. R., M.D. (2015, August 22). What's a normal resting heart rate? Retrieved March 7, 2018, from <https://www.mayoclinic.org/healthy-lifestyle/fitness/expert-answers/heart-rate/faq-2005797>
- 9
- Meamarbashi, A. (2014). Instant effects of peppermint essential oil on the physiological parameters and exercise performance. *Avicenna Journal of Phytomedicine*, 4(1), 72–78.

- Mikus, C. R., Earnest, C. P., Blair, S. N., & Church, T. S. (2008). Heart rate and exercise intensity during training: observations from the DREW Study. *British Journal of Sports Medicine*, 750-750.
- Mollaoglu, H., Ucok, K., Kaplan, A., Genc, A., Mayda, H., Guzel, H. I., & ... Ozbulut, O. (2012). Association analyses of depression, anxiety, and physical fitness parameters in Turkish obese adults. *Journal Of Back & Musculoskeletal Rehabilitation*, 25(4), 253-260.
- Nakajo, N., Tomioka, S., Eguchi, S., Takaishi, K., Cho, G., Sato, K. (2007). Gum chewing may attenuate salivary alpha-amylase of psychological stress responses (in Japanese). *J Jpn Dent Soc Anesthesiol*, 35, 346-353.
- Oxford University Press. (2018). Fitness [Def. 1]. In *English Oxford Living Dictionary*. Retrieved March 7, 2018, from <https://en.oxforddictionaries.com/definition/fitness>
- Palatini, P. (1988, June). Blood pressure behaviour during physical activity. Retrieved April 11, 2018, from <https://www.ncbi.nlm.nih.gov/pubmed/3041529>
- Pescatello, L.S., Franklin, B.A., Fagard, R., Farquhar, W.B., Kelly, G., & Ray, C.A., (2004). Exercise and Hypertension. *Medicine & Science in Sports & Exercise*, 36(3), 533-553.
- Salmela, J. H., & Ndoye, O. D. (1986). Cognitive Distortions during Progressive Exercise. *Perceptual and Motor Skills*, 63(3), 1067-1072.
- Sasaki-Otomaru, A., Sakuma, Y., Mochizuki, Y., Ishida, S., Kanoya, Y., & Sato, C. (2011). Effect of Regular Gum Chewing on Levels of Anxiety, Mood, and Fatigue in Healthy Young Adults. *Clinical Practice and Epidemiology in Mental Health : CP & EMH*, 7, 133–139.

- Scholey, A., Haskell, C., Robertson, B., Kennedy, D., Milne, A., & Wetherell, M. (2009). Chewing gum alleviates negative mood and reduces cortisol during acute laboratory psychological stress. *Physiol Behav*, 97, 304-312.
- Smith, A. (2012). Effects of chewing gum on stress and health: A replication and investigation of dose–response. *Stress and Health*, 29(2), 172-174.
- Torpy, J.M., Burke, A.E., & Glass, R.M. (2007). Acute emotional stress and the heart. *JAMA*, 298(3), 360.
- Tucha, L., Simpson, W. (December 2010). The role of time on task performance in modifying the effects of gum chewing on attention. Retrieved from:
<https://www.sciencedirect.com/science/article/pii/S0195666310008470>
- Wallen, M., Gomersall, S., Keating, S., Wisloff, Urlik., Coombes, J., (May 2016). Accuracy of Heart Rate Watches: Implications for Weight Management. *PLoS ONE*, 11(5)
- Welford, A.T. (1980). Choice reaction time: Basic concepts. In Welford A.T., editor. *Reaction Times* (73-128). New York: Academic Press.

Acknowledgements

We would like to thank Dr. Andrew Lokuta and the rest of the Physiology Department at the University of Wisconsin-Madison for making this study possible. We would also like to thank the participating students of Physiology 435, the Peer Learning Volunteers, and the Teaching Assistants. We would like to give special thanks to Anna Kowalkowski and Christie Lunowa, who helped to guide us through the entire process.

Figures

Time	0 Minutes	3 Minutes	9 Minutes	13 Minutes	19 Minutes
Tasks	1) Fill out consent form 2) Obtain baseline heart rate and blood pressure	3) Set up bike 4) Exercise until 60% increase in heart rate is obtained (record time) 5) Obtain heart rate and blood pressure	6) Reaction test 7) Rest until within 10% of baseline heart rate	8*) Chew gum (if in experimental group) 9) Exercise for time recorded 10) Obtain heart rate and blood pressure	11) Take reaction test

Figure 1. Timeline of events for each participant

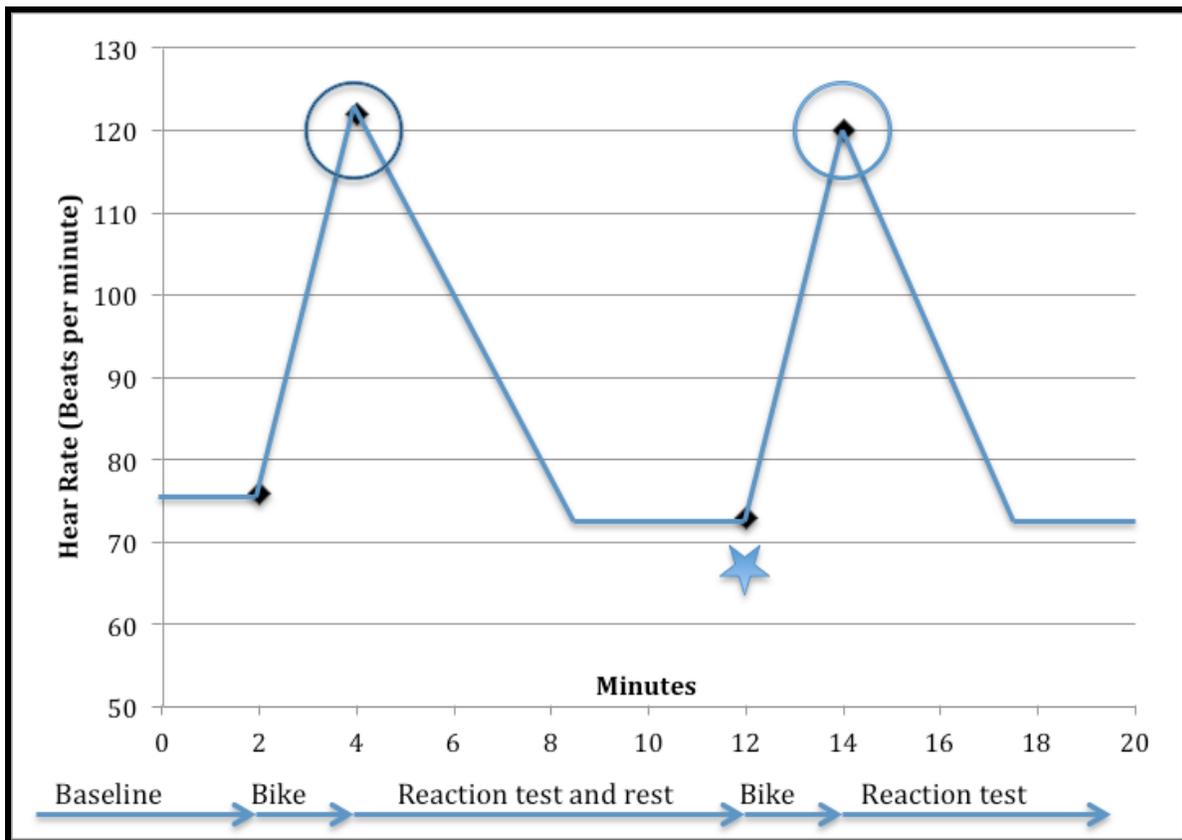


Figure 2: Example of data and timeline from one participant with heart rate collected as participant sat (baseline), after biking, following the reaction test and resting (new baseline), and after biking again. Change in heart rate was calculated between the two circled points. The star represents where the experimental group received gum or continued on without gum if in the control group.

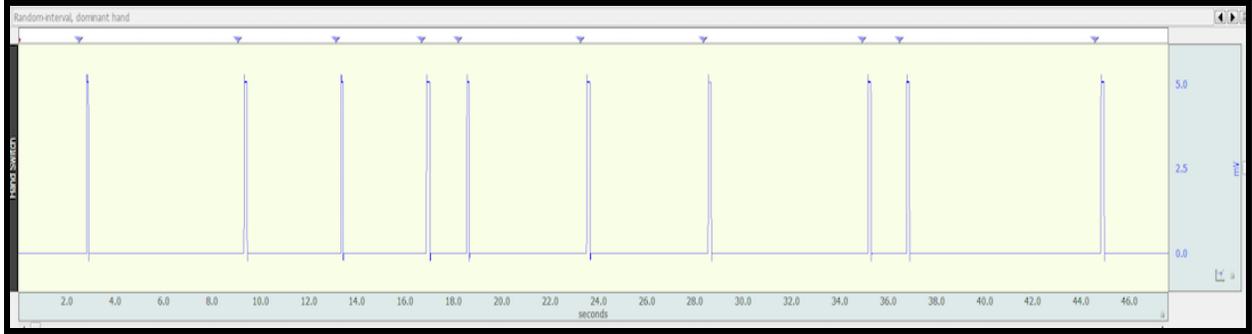


Figure 3. Reaction Test Graph from BioPac of one participant; every time the button is pressed the BioPac registers it as an increase in mV.

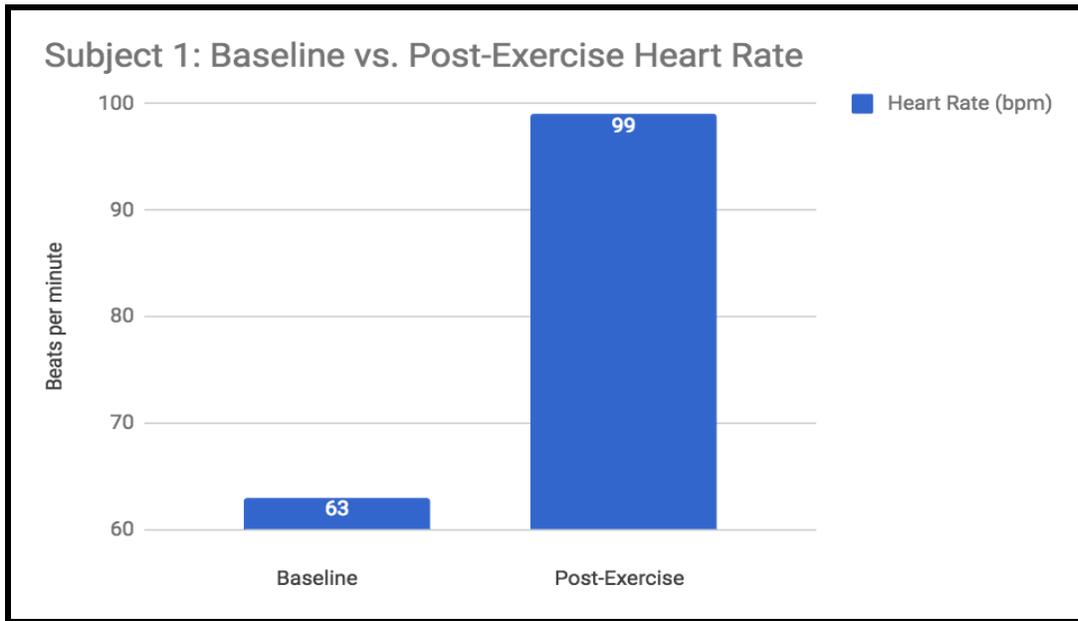


Figure 4. Subject One's baseline versus post-exercise heart rate values in beats per minute. It shows an increase of heart rate from baseline.

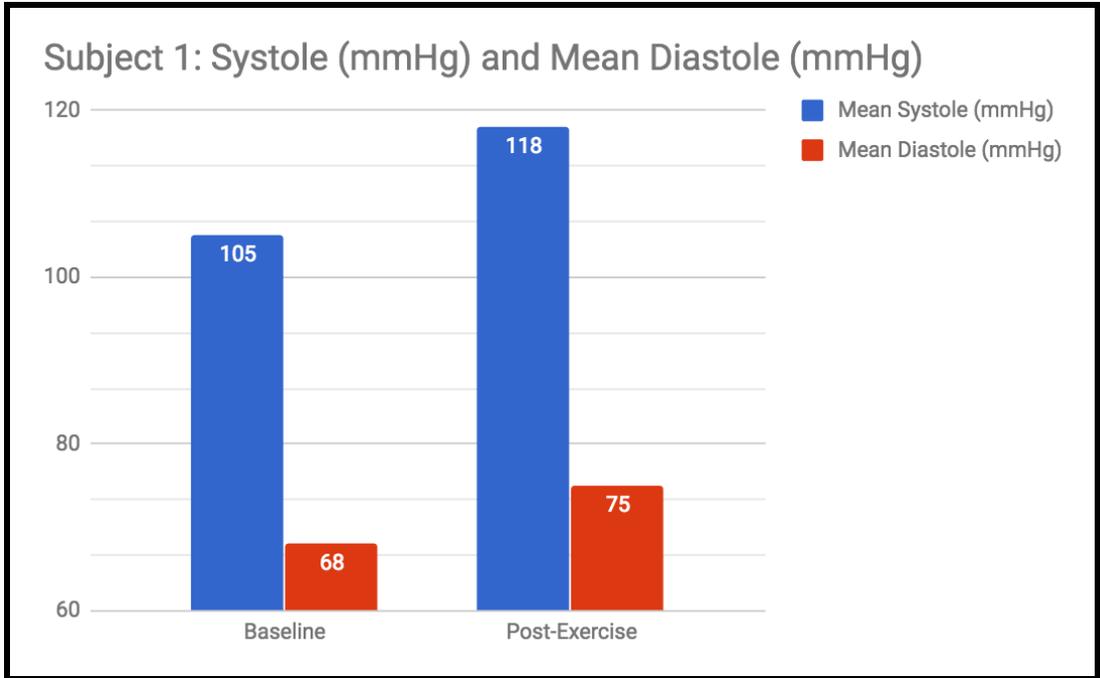


Figure 5. Subject One’s baseline versus post-exercise blood pressure values in mmHg. Both systolic and the diastolic blood pressure increased after exercising.

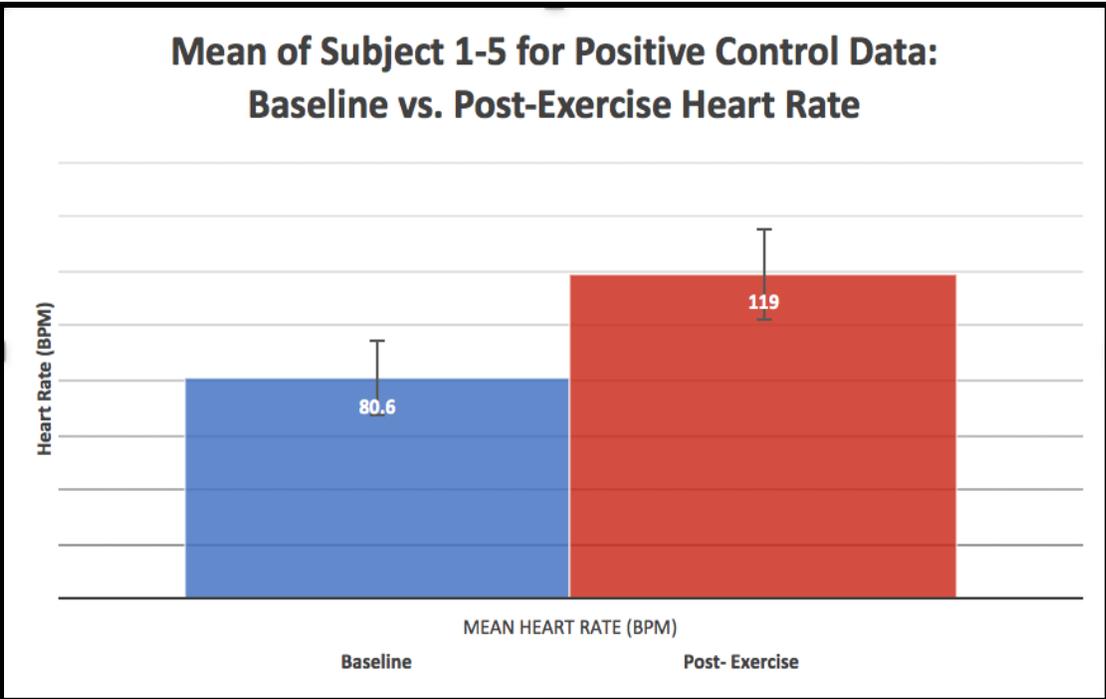


Figure 6. Mean data and standard deviation shown for blood pressure. The mean and standard deviation of all five subjects were calculated.

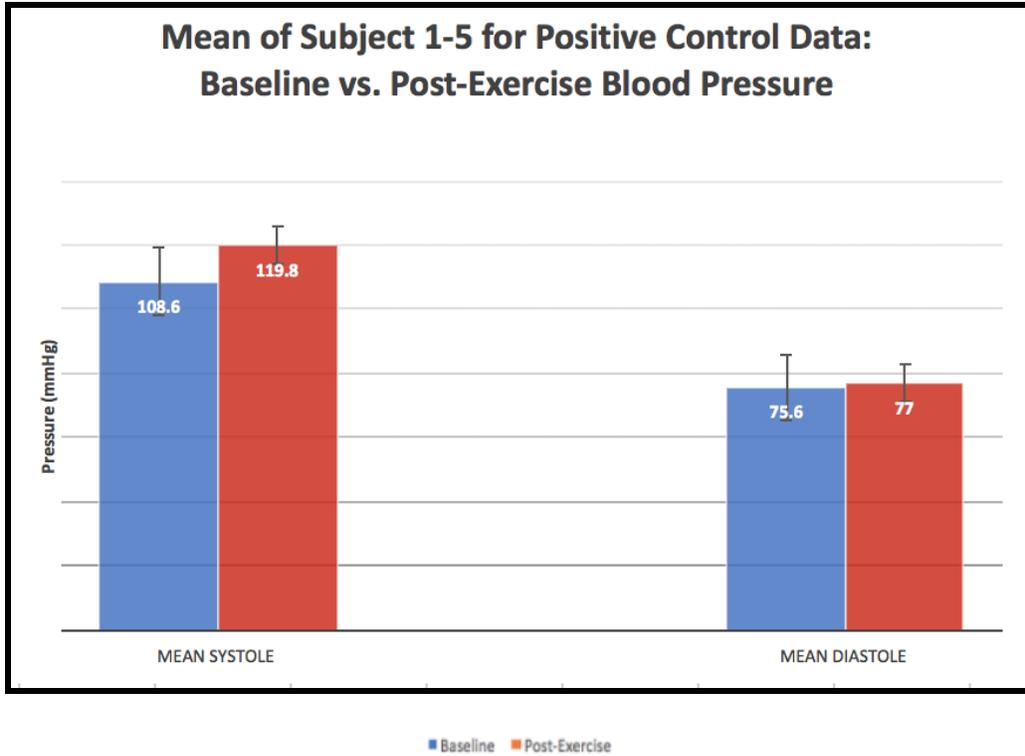


Figure 7. Mean data and standard deviation shown for heart rate. The mean and standard deviation of all five subject were calculated.

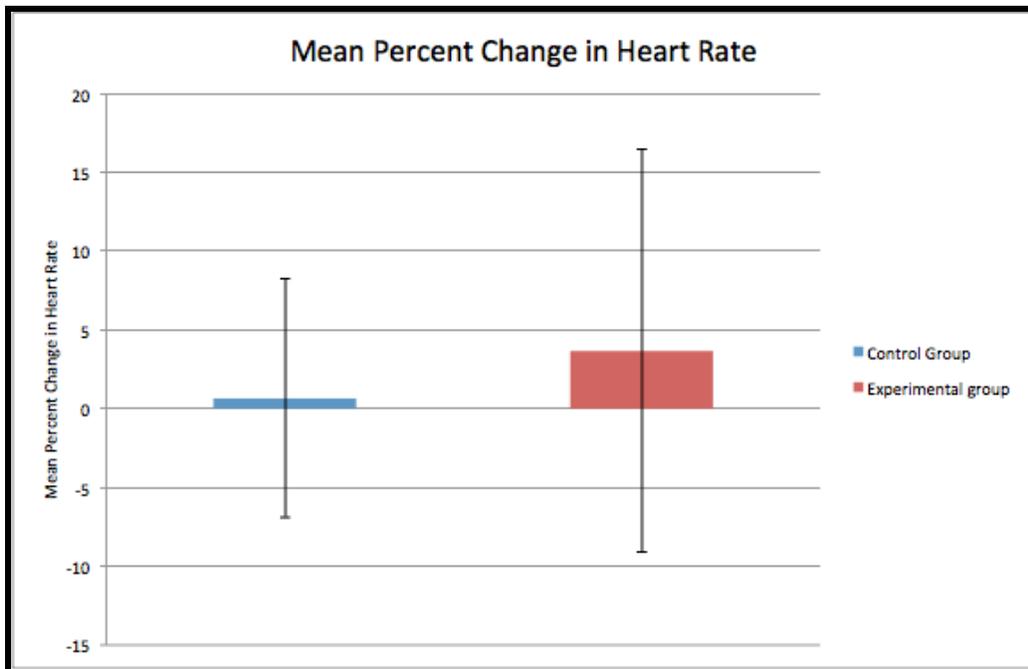


Figure 8. Mean percent change in heart rate for each group. Mean percent change for the control group, who did not receive gum, (n=10) was 0.648 +/- 7.546. The mean percent change for the experimental group (n=19), who received gum, was 3.659 +/- 12.77. Error bars represent standard deviation, p = 0.251.

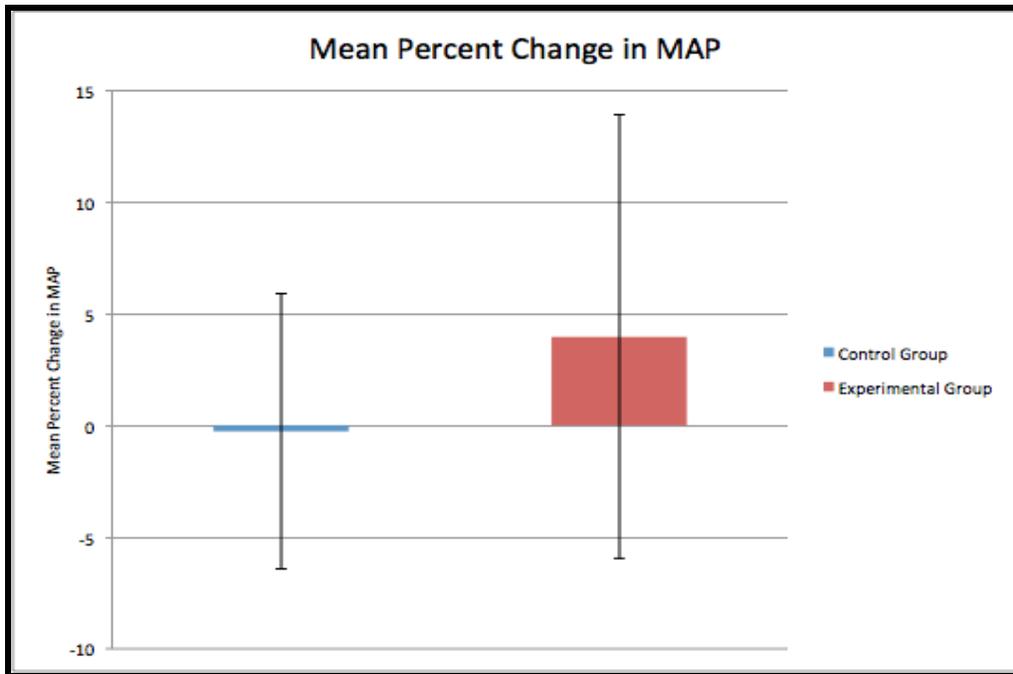


Figure 9. Mean percent change in mean arterial blood pressure (MAP) for each group. Mean percent change in MAP for the control group (n=10), who did not receive gum, was -0.275 ± 6.173 . Mean percent change in MAP for the experimental group (n= 19), who received gum, was 3.951 ± 9.906 . Error bars represent standard deviation, $p = 0.116$.

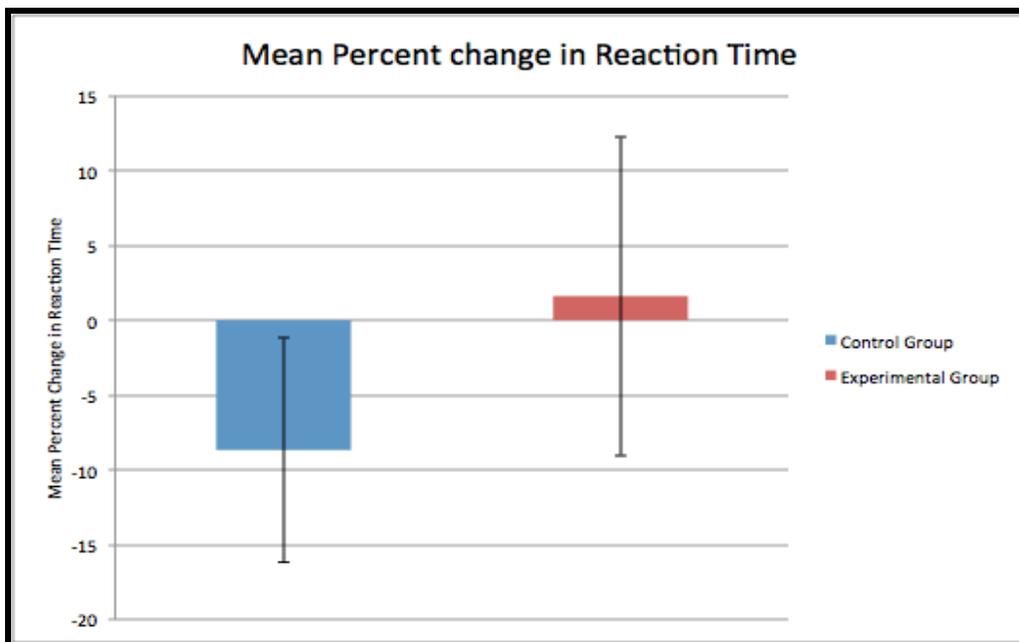


Figure 10. Mean percent change in reaction time for each group. Mean percent change in reaction time for the control group (n=10), who did not receive gum, was -8.680 ± 7.503 . Mean percent change in reaction time for the experimental group (n=19), who received gum, was 1.607 ± 10.67 . The error bar represent standard deviation, $p = 0.006$.