Physiological Stress Response to Static Exercise

University of Wisconsin-Madison
Physiology 435
Lab 603, Group 5
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Abstract:

Too few Americans are getting enough exercise, thereby increasing their risks for several major chronic diseases and shortening overall lifespan. Previous research has shown that the use of oral, audio, or visual external stimuli may increase an individual's threshold for the intensity of an exercise, therefore aiding in increased exercise duration. In this study, the distraction methods consisting of a video, music, and chewing gum during a wall-sit exercise were compared against a control wall-sit in terms of blood pressure, pulse, oxygen saturation, and duration measurements. While blood pressure, pulse, and oxygen saturation status increased in mean percent change for all forms of distraction compared to the control, heart rate was the only physiological measurement to show a statistically significant change. Moreover, music as a method of distraction had the greatest effect on the change in heart rate.

Introduction

Few Americans are getting enough exercise, and, in doing so, are increasing their risks for several major chronic diseases, as well as shortening overall life span. Estimates show that only about one in five of American adults (21%) meet the 2008 physical activity guidelines (Ward et al. 2016). Additionally, less than three in ten high school students get at least 60 minutes of physical activity every day (CDC, 2014). These statistics are alarming because there are countless well-documented physiological and psychological benefits of exercise that most Americans are not receiving. Exercise has therapeutic effects and is commonly used to help treat coronary artery disease, hypertension, diabetes mellitus, and obesity, as well as psychological disorders such as depression (Sallis and Hovell, 1990). One reason why exercise may be performed less frequently than recommended for good health is because of the unpleasant aspects of exertion, including perspiration, fatigue, and discomfort. The purpose of this research is to investigate the use of distraction techniques during exercise, which may help to alleviate some of the negative aspects of exertion that are experienced, thereby aiding individuals in exercising for a longer duration.

It has been shown that individuals engaged in physical activity have an enhanced performance when exposed to an external stimulus. Pennebaker and Lightner (1980) concluded that the presence of an external stimulus draws attention away from the physiological sensation of the exercise, which affects the rate of perceived exertion. In this experiment, the effects of oral, audio, and visual external stimuli will be analyzed.

Previous research has shown significant improvement in exercise performance after oral administration of peppermint essential oil, which is a hybrid of both spearmint (Mentha Spicata) and water mint (Mentha Aquatica) (Meamarbashi, 2014). Peppermint had a lowering effect on heart rate and the systolic BP of participants and increased results obtained from standing vertical jump and standing long jump tests compared with the control group. Nonetheless, Allen and Smith (2015), did not observe benefits from mint flavoring, but, rather, benefits from chewing gum. Results of the study indicate that chewing gum increases alertness in the absence of cognitive performance tasks and increases hedonic tone, regardless of whether the gum was mint flavor. Based on the results of the previous two studies, it is suggested that a combination of both mint flavoring and chewing gum may be a better alleviator of an individual's focus on exercise discomfort, than either component alone.

Studies examining audio and visual distractions have shown mixed results regarding decreasing attention to the discomfort of exercise. White and Potteiger (1996) found that not only do visual distractions result in the highest level of perceived exertion when compared to audio, but also that visual stimuli seemed to increase the attentiveness to the discomfort of the exercise. Despite these findings, Johnson and Breakwell (1998) found that visual stimuli cause an attentional shift which serves to reduce the perceived level of pain experienced during physical exertion. Copeland and Franks (1991) measured differences in heart rate and exhaustion time when presented with music. They found that the maximum heart rate values were higher in the trial without music compared to the trials with music, which supports the hypothesis that auditory stimuli contribute to enhanced endurance performance.

To understand how the implementation of distractions affects the body's physiological response to stress in the form of physical exertion, three physiological measurements were taken: BP, pulse, and oxygen saturation. BP is indicated by a systolic pressure, the amount of pressure the blood is exerting on arterial walls when the heart contracts, relative to diastolic pressure, or the amount of pressure exerted by the blood when the heart is at rest. Static exercise, during which muscles are doing work without the movement of joints, has been shown to increase BP more than during dynamic exercise, where muscles and joints are moving, due to an increase in pressure transferred to the intramuscular blood vessels. Furthermore, BP increases immediately after beginning a static exercise and then increases slowly throughout the exercise (Hietanen, 1984). Additional cardiovascular responses result from increased BP, such as pulse, heart rate, and oxygen saturation of erythrocytes. Tension development in static exercise causes an increase in signals from mechanoreceptors, which in turn send signals to the nervous system. Sympathetic signals to the heart increase heart rate to send more blood to the contracting muscles (Asmussen, 1981). The demands of contracting muscles require adjustments to oxygen uptake and use, otherwise resulting in the use of anaerobic metabolism to fulfill the muscle's needs (Hietanen, 1984). For these reasons, BP, pulse, and oxygen saturation were chosen as means of measuring the body's physiological response to static exercise. In addition, the duration of the stationary exercise performance was measured. Duration indicates the body's endurance level and represents the body's ability to withstand a static exercise until muscle fatigue, or the decline in muscle tension as a result of contractile activity, sets in (Widmaier, Raff, & Strang, 2006).

Resting measurements serve as a negative control because no experimental treatment has been performed on the subjects. These measurements provide a useful baseline to compare subsequent measurements to. In this experiment, a wall-sit, which is a static exercise, performed with no distraction, acts as the positive control test because this treatment results in a known response: elevated heart rate, increased BP, and decreased oxygen saturation. These measurements can be compared to those in later tests where distractions are introduced, for which the response is unknown. A pilot test was conducted to determine the feasibility and testability of the study. Results found that physiological variables increased during the distraction trial in comparison with the control (Table 1).

Based on the body of research available, it is hypothesized that physiological responses, as measured by BP, pulse, and oxygen saturation, will be affected with the onset of stress in the form of a static exercise, compared to resting vital signs. Furthermore, it is predicted that the administration of various distraction methods will change the physiological responses and duration of static exercise compared to values obtained during exercise with no distraction to different degrees.

Materials and Methods

Following a recruitment effort for participants enrolled in Physiology 435 at the University of Wisconsin-Madison during the Spring 2017 semester, written consent was obtained from the volunteers (Appendix A). Due to the physical exertion component of this study, participants were informed that their involvement was voluntary and that they could stop at any time. After obtaining consent, a thorough survey inquiring about basic demographic information and fitness activity was administered (Appendix B). The information in this questionnaire served as a baseline of individual's perceived fitness and provided insight to potential injuries or allergic reactions that could occur during the study.

A total of 20 participants (6 male and 14 female) were included in the study with an age range between 18-23 years. Participant exercise regimens ranged from 1-10 hours of exercise per week and 1-7 days of exercise per week. The types of exercises that the participants engaged in were cardio/endurance, strength training, and yoga/flexibility. All participants reported engaging in some type of physical activity on a regular basis, with the exception of one individual.

The following equipment and materials were used throughout the experiment: exercise bike (Gold's Gym 390R Cycle Trainer, Model: GGEX61712.2, ICON Health & Fitness Inc., Logan, UT), automatic BP cuff (MODEL BP791IT, OMRON HEALTHCARE Co., Lake Forest, IL), pulse oximeter (Pulse Oximeter/Carbon Dioxide Detector Model: 9843, Nonin Medical Inc., Plymouth, MN), electronic devices for the music and video used for distraction (Model: IdeaPad Yoga 11s, Lenovo, Morrisville, NC and Model: Satellite, Toshiba, Tokyo, Japan), chewing gum (Trident Sugar Free, Spearmint), audio file "The Greatest" by Sia (https://www.youtube.com/watch?v=P6Ipeu6Z26g), and video clip from the TV show *Friends* (https://www.youtube.com/watch?v=9ym0lTeAoqM).

The resting levels for heart rate (beats/minute), systolic and diastolic BP (mmHg), and blood-oxygen saturation (percent O_2) were measured and recorded while the participant was seated in an upright, relaxed position. This negative control data provides the vital signs of each participant before being exposed to the physiological stress experiment.

After resting measurements were obtained, the participant was instructed to engage in cycling for 5 minutes on the lowest resistance level while maintaining a speed of approximately 5-10 mph on a stationary bicycle. Next, the participant was given instructions on how to properly perform a wall-sit exercise (Appendix C). The proper technique involves the following: the angle of the femur to the tibia/fibula to be 90 degrees, the feet shoulder width apart, the back flat against the wall, and the head erect. Following the explanation of how to perform a wall-sit, the participant was asked to perform the exercise for as long as they could maintain the proper form.

Maximum heart rate, BP, and oxygen saturation were measured during the wall-sit, as well as the duration that the wall-sit was held. These positive control measurements provide an indication of the participant's stamina and endurance, as well as their physiological response signs to physical stress. The values obtained can then be compared to the values collected during the subsequent three wall-sits in which the participant was exposed to the following distractions: listening to the song, "The Greatest" by Sia (Distraction # 1), chewing Trident spearmint gum (Distraction # 2), and watching a video clip from the TV series, *Friends* (Distraction # 3). A recovery period of two minutes of pedaling on the stationary bike while maintaining a speed between 5-10 mph was provided in between each wall-sit to allow the participant to actively recover and prepare for the subsequent wall-sit (See Figure 1 for a complete timeline of events during the experiment). The order of distractions was randomized for each participant to limit any error due to muscle fatigue.

Data collected in the experiment was analyzed through a series of t-tests, comparing each distraction to the baseline measurements. The results of the t-tests and corresponding P-values determining significant comparisons between physiological responses under the three distraction methods were used to identify which distraction methods, if any, were able to affect the physiological responses related to exercise.

Results

Percent changes were calculated between the value of each physiological variable measured while performing a control wall-sit under no distraction and the value measured while performing a wall-sit under three methods of distraction, for each participant, in an effort to normalize the data. In analyzing BP, only the systolic value was used because physiological stress stimulates the sympathetic nervous system, which has a greater effect on systolic BP than diastolic BP. The average percent changes for each physiological variable can be seen in Figures 2-5. Paired t-tests were then conducted for all the physiological variables measured, as well as duration of wall-sit, by comparing these percent changes to the percentage change of the control wall-sit, which was set to a value of one. The p-values resulting from these tests can be seen in Table 2. There was a statistical significance in the percent change in heart rate across all three distraction methods: the video ($M = 0.069$, $SD = 0.074$) with $t(19) = 4.18$, $p = 0.0005$, the music ($M = 0.071$, $SD = 0.097$) with $t(19) = 3.28$, $p = 0.0039$, and the gum ($M = 0.063$, $SD = 0.088$) with $t(19) = 3.19$, $p = 0.0049$. None of the other measured variables found a significant percent change from control values during any of the distraction methods. BP: the video ($M = 0.022$, $SD = 0.194$) with $t(19) = 0.506$, $p = 0.619$, the music ($M = 0.023$, $SD = 0.15$) with $t(19) = 0.676$, $p = 0.507$, and the gum ($M = 0.048$, $SD = 0.113$) with $t(17) = 1.80$, $p = 0.089$. Oxygen saturation: the video ($M = 0.009$, $SD = 0.03$) with $t(19) = 1.20$, $p = 0.243$, the music ($M = 0.002$, $SD = 0.021$) with $t(19) = 0.395$, $p = 0.697$, and the gum ($M = 0.003$, $SD = 0.032$) with $t(19) = 0.393$, $p = 0.699$. Duration: the video ($M = 0.160$, $SD = 0.495$) with $t(19) = 1.45$, $p = 0.164$, the music ($M = -0.047$, $SD = 0.267$) with $t(19) = 0.78$, $p = 0.445$, and the gum ($M = -0.048$, $SD = 0.299$) with $t(19) = 0.711$, $p = 0.486$.

Discussion

It was hypothesized that there would be a change in heart rate, BP, oxygen saturation, and duration with the implementation of various distraction methods. After calculating the percent change between the control wall-sit and the wall-sit under each distraction method, it was found that the positive changes in BP, oxygen saturation, and duration did not have statistical significance. However, in support of the hypothesis, there was a statistically significant percent change in heart rate for all three of the distraction methods when compared to the heart rates measured during the control wall-sits.

The percent change in heart rate signifies that the distraction methods used in this study had the greatest effect on heart rate. Furthermore, listening to music resulted in the greatest average percent change, supporting the hypothesis that different distraction methods changed heart rate to varying degrees. This data supports previous research which found that cardiovascular responses, such as heart rate, increase during static exercise (Hietanen, 1984). However, the results do not agree with previously mentioned literature that suggests that the use of distractions may counteract the increase in heart rate caused by exercise (Meamarbashi, 2014) (Copeland and Franks, 1991). Rather, the data suggests that certain distractions, namely music, may increase the intensity of an exercise, as seen by the statistically significant increase in heart rate. An increase in intensity could allow for more benefits to be extracted by an individual.

Duration, which is not being considered a physiological variable, yielded a different pattern of results. Similar to oxygen saturation, viewing the video resulted in the greatest percent change in duration. Interestingly, the mean percent changes for duration between the control wall-sit and performing the wall-sit while listening to music and chewing gum were negative. These results do not support the hypothesis that all the distraction methods tested would result in a longer duration, but rather suggest that only the distraction method of watching a video may enable one to hold a static exercise for longer.

There were multiple external factors recognized that could have affected our results due to random or systematic errors. For instance, on multiple occasions the BP monitor reported errors while the participants were performing the wall-sits. This error could have been due to the

BP cuff placement or a technological error with the machine. During the active recovery on the stationary bike, participants were instructed to maintain a speed of 5-10 mph; however, individuals set their own pace within this range, which could have affected their muscle recovery between wall-sits. Furthermore, individuals may have required different lengths of time for complete muscle recovery, thereby affecting their ability to perform the subsequent exercise. Another source of error could have been prematurely stopping the timer relative to the precise moment of exhaustion during the wall-sit; some participants would dictate that they needed to stop before actually relaxing from the wall-sit, resulting in a pre-emptive stopping of the timer. Additionally, there could have been a systematic error resulting from human delay in physically stopping the timer, but the extent to which the delay lasts is completely unknown since various researchers were timing the participants. The positioning of the PulseOx on the participant's finger could have potentially affected the results as well, or if the device shifted throughout the wall-sit. Another systematic error that was not controlled was the limiting of external distractions during the experiment, which was conducted in a non-private setting due to space and equipment availability. Finally, another possible limitation could be psychological stress. Every time the participants were told to stop cycling on the stationary bike, it was further communicated to them that they were going to perform another wall-sit with a various distraction. Knowing this information, the participants could experience some anxiety as they prepare themselves for greater physical exertion. This could potentially have impacts on the various measurements taken.

Further research on the validity of various distraction methods affecting physiological responses can be performed to limit the number of external sources of errors, such as conducting all parts of the study in a quiet, private setting to ensure more accurate results. Additional research can also evaluate the implementation of different distraction methods, other than those used in this study. This study could also be performed using dynamic exercise, to evaluate how various distractions change the body's physiological response to performing dynamic exercise that targets endurance. Understanding how distractions affect the physiological response to dynamic exercise could explain why this research saw an increase in heart rate using static exercise, but literature on this topic saw a decrease in heart rate when implementing distractions.

Tables and Figures

Table 1. Positive control data during pilot test of experiment.

Experiment	**BP (mmHg)**	**Pulse (beats/min)**	**O_2 Saturation (%)**	**Duration (minutes)**
Resting	117/79	74	98	N/A
Wall-sit	152/108	107	98	1:05.08
Wall-sit with Distraction #1	161/109	110	98	1:22.87

Table 2. P-values comparing the percent change between value of physiological variable measured while performing a control wall-sit under no distraction and value measured while performing a wall-sit under three methods of distraction with the percent change in the control wall-sit values, which was set to one.

		Distraction Method		
		Video	Music	Gum
Physiological Variable	Blood Pressure	0.6187	0.5071	0.0894
	Heart Rate	0.0005	0.0039	0.0049
	O_2 Saturation	0.2431	0.6973	0.6986
	Duration	0.1635	0.4450	0.4865

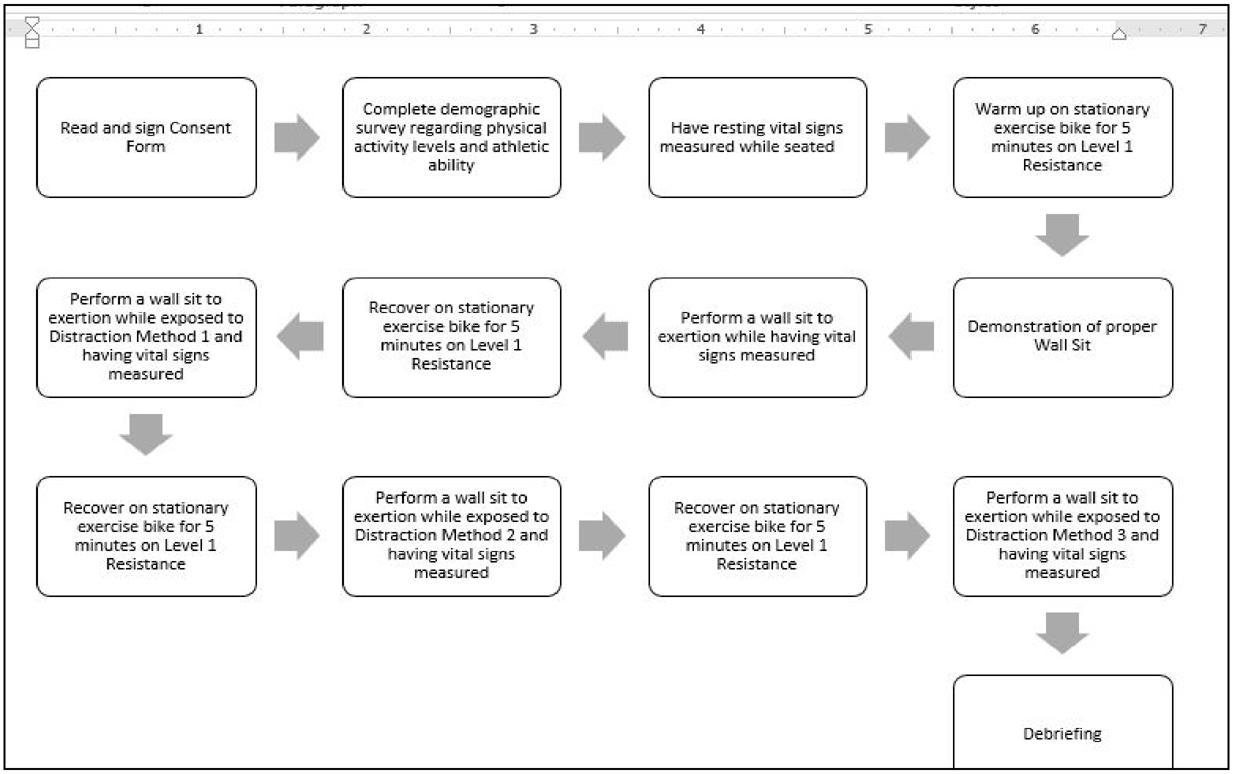

Figure 1. Timeline of events participant will experience

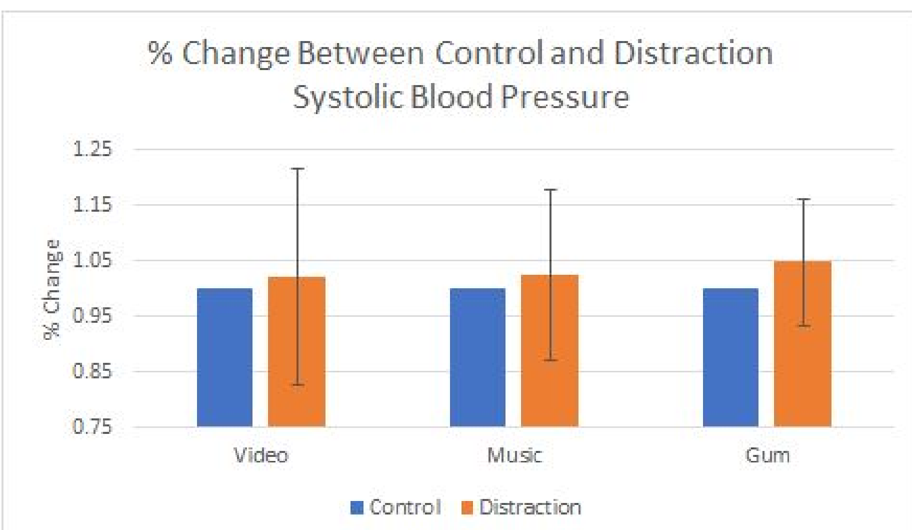

Figure 2. Average percent change between systolic BP during control wall-sit and during wall-sit while exposed to three distraction methods.

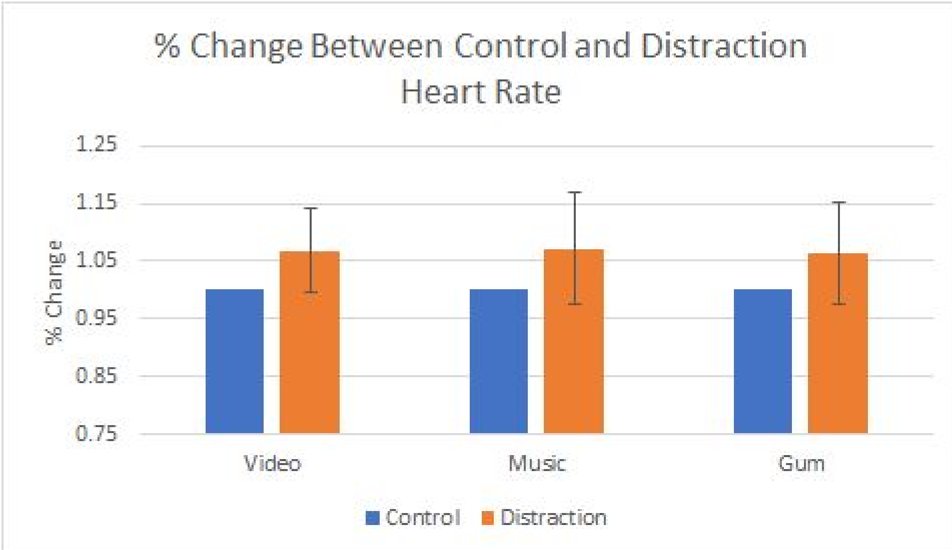

Figure 3. Average percent change between heart rate during control wall-sit and during wall-sit while exposed to three distraction methods.

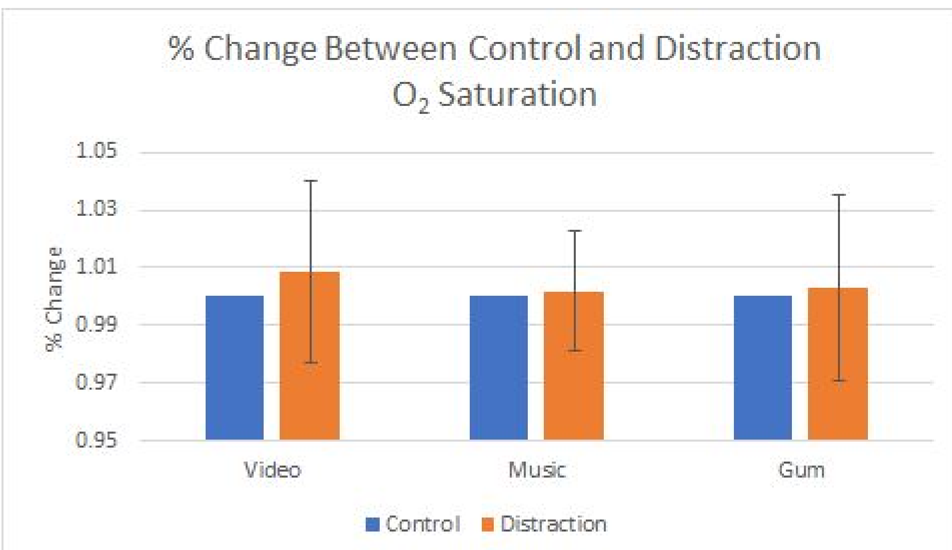

Figure 4. Average percent change between O_2 saturation during control wall-sit and during wall-sit while exposed to three distraction methods.

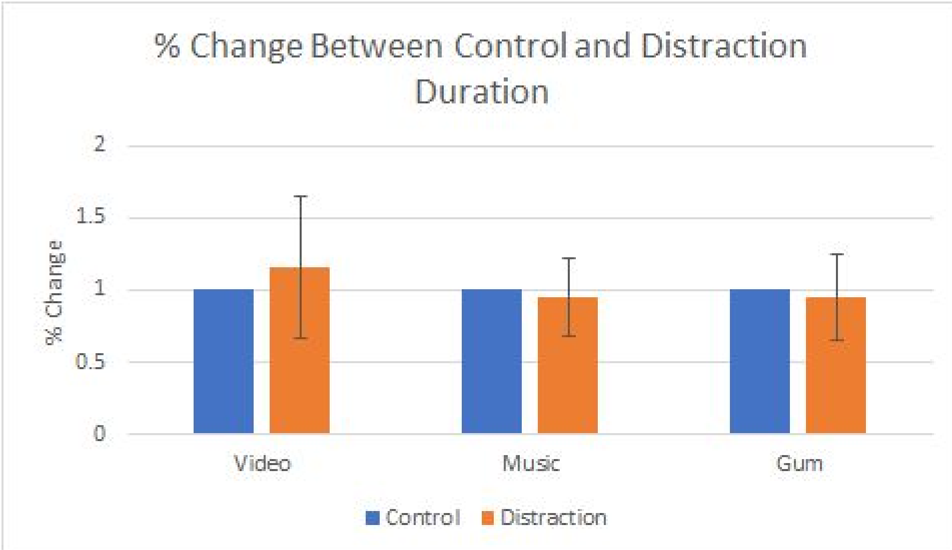

Figure 5. Average percent change between duration of control wall-sit and duration of wall-sit while exposed to three distraction methods.

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Appendix A

UNIVERSITY OF WISCONSIN-MADISON
Research Participant Information and Consent Form

Title of the Study: Physiological Stress Response to Stationary Exercise

Principal Investigators: Rachel Fader, Alex Krause, Alexandra Siverling, Parth Trivedi, and Elizabeth Zeker

DESCRIPTION OF THE RESEARCH

You are invited to participate in a research study about the physiological response to exertion.

You have been asked to participate because you are enrolled in Physiology 435.

The purpose of the research is to understand how physiological stress responses may be affected by the introduction of varying stimuli.

This study will invite the participation of all students enrolled in Physiology 435.

This research will take place within the Physiology 435 laboratory.

WHAT WILL MY PARTICIPATION INVOLVE?

If you decide to participate in this research, you will be asked to perform four wall-sits until exhaustion with active recovery on a stationary bike for five minutes between each wall-sit. If you have any known injuries, physical restrictions, or health concerns, please inform the principal investigators.

Your participation will last approximately twenty minutes.

No credit will be assigned for your complete and voluntary participation. If you do not wish to participate, simply return this blank consent form.

This study involves chewing gum. Please let the principal investigators know if you have any allergies or health concerns; if so, an alternative will be provided.

ARE THERE ANY RISKS TO ME?

Because the nature of this study involves physical exertion, there are risks involved; however, the research team expects these risks to be minimal. I understand that the activities are designed to place minimal physical exertion on the musculoskeletal system and the reaction of the cardiovascular and respiratory systems to such activities cannot be predicted with complete accuracy. I understand that I am responsible for monitoring my own condition throughout the study and should any symptoms arise, I would cease my participation and inform the research team.

I, the undersigned participant, agree to indemnify and hold harmless The University of Wisconsin-Madison and any of its agents, employees, or representatives for any injury or loss suffered by me due to my participation in the activities associated with the Physiology 435 laboratory project. I hereby agree that I have been fully advised of the nature and extent of the activity that may take place and represent to you that I am physically and mentally able to participate in the activity without special accommodations or additional supervision. I understand that the activity may present the risk of injury, or even death, to me, and I have been fully advised of those possibilities. I represent to you that I fully assume the risk of any such injury or death, and I hold you, your agents, employees, and representatives harmless from any liability or death to me while engaged in this activity that is caused or contributed to by my conduct or the conduct of any other participants. If I am not able to be consulted for any reason in the case of an emergency or necessity arising during the course of the activity or as a result of the activity, I authorize you to arrange for such medical and hospital treatment as you may deem to be advisable for my health and well-being.

HOW WILL MY CONFIDENTIALITY BE PROTECTED?

While there may be printed reports as a result of this study, your name will not be used. Only group characteristics will be reported – that is results with no identifying information about individuals will be used in any reported or publicly presented work. The principal investigators will not disperse, publish, or share any identifying information. Any information collected during the study will only be used in analysis of the study.

WHOM SHOULD I CONTACT IF I HAVE QUESTIONS?

Feel free to contact a member of the research team, Alexandra Siverling, via email at asiverling@wisc.edu should you have any questions.

If you are not satisfied with the response from the research team, have more questions, or want to talk with someone about your rights as a research participant, you should contact Dr. Andrew Lokuta, 608-263-7488, ajlokuta@wisc.edu.

Your participation is completely voluntary. If you begin participation and change your mind you may end your participation at any time without penalty. If you decide not to participate or to withdraw from the study it will have no effect on your grade in this class.

Your signature indicates that you have read this consent form, had an opportunity to ask any questions about your participation in this research and voluntarily consent to participate.

Name of Participant (please print):______________________________

_______________________________ _____________________

Signature Date

Appendix B

Physiological Stress Response to Stationary Exercise

Participant Survey

What sex do you identify with?   Male   Female

What is your age?   18-20   21-23   23-25   25+

Do you have any health concerns or injuries that would affect your ability to perform exercises?

Yes   No

If so, what? ____

Do you have any allergies?

Yes   No

If so, what? ____

How many total hours per week do you exercise typically?

0   1-2   3-5   6-10   10+

How many days per week do you typically exercise?

0   1-2   3-4   5-7

What types of exercise do you regularly perform? (Circle all the apply)

Cardio/Endurance   Strength Training   Yoga/Flexibility   N/A

Other: __________________

Appendix C


ANATOMY OF A
PERFECT WALL SIT
BACK
Against the wall
STOMACH
Core tight
HIPS & KNEES
90-degree angle
FEET
Flat, about shoulder-width
ANYTIME FITNESS
Get to a healthier place.