

ABSTRACT

Title of Document: BENEFITS AND EFFECTS OF INTERACTIVE GAMING EXERCISE AS COMPARED TO TRADITIONAL EXERCISE TECHNIQUES: AN INVESTIGATION OF THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVELS AND MODE OF ACTIVITY IN COLLEGE STUDENTS

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The objective of this research project was to determine the relationship between mode of activity and motivation to exercise. Specifically, the research aimed to discover if interactive video games are effective in motivating sedentary college students to exercise. The introduction discusses the problems of physical inactivity and obesity, the increased use of video games, and a proposed solution using interactive technology. For a ten-week period, sedentary University of Maryland – College Park students joined either the traditional exercise or interactive gaming group, with heart rates and activity levels documented throughout. Together, quantitative heart rate and

activity data and qualitative participant feedback, illustrated that it was too difficult to collect significant data supporting a conclusion that one activity was a significantly better means to raise heart rates and motivate students to exercise. However, the data did support the importance of continuing research on potential benefits of interactive gaming for a sedentary population.

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COMPARED TO TRADITIONAL EXERCISE: AN INVESTIGATION OF THE
RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVELS AND MODE OF
ACTIVITY IN COLLEGE STUDENTS

By

Team F.I.T.N.E.S.S.

(Fun Interactive Techniques for New Exercise and Sport Styles)

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Dedication

We dedicate this research to the University of Maryland community, and to students nationwide, in the hopes that physical health and regular participation in physical activity will grow to be of utmost importance, no matter the form.

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Our project would not have been possible without all of the help and continuous support from the following:

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Glossary

- **Activity log** – a document where all physical activity done by an individual is recorded. Each activity performed, along with time spent, is documented. A weekly record of a person’s activities (study sessions attended, physical activities/exercise, video game usage) as well as their feelings and motivations towards exercise and toward the Team F.I.T.N.E.S.S. study.
- **Aerobic** – “with oxygen”; refers to the use of oxygen in the body’s metabolic or energy-generating processes.
- **Body Mass Index (BMI)** – the Body Mass Index is a statistical measure that compares a person’s height and weight.

$$\text{BMI} = [\text{weight (lbs)} * 703] /](\text{height (in)})^2]$$

| Category | BMI |
|----------------------|-------------|
| Severely underweight | < 16.5 |
| Underweight | 16.5 - 18.4 |
| Normal | 18.5 - 24.9 |
| Overweight | 25 - 30 |
| Obese | > 30 |

- **Cancer** - any malignant growth or tumor caused by abnormal and uncontrolled cell division; it may spread to other parts of the body through the lymphatic system.
- **Cardiovascular exercise** – physical exercise that helps strengthen the heart and lungs, through improving the oxygen system.

- **College student** – a person between the ages of 18 and 23.
- **DDR or Dance Dance Revolution** – a popular exergame, released by Konami™ in which players stand on a dance platform and hit the arrows on the pad (laid out in a cross pattern) with their feet as prompted by the screen – musical and visual cues.. Players are judged by how well they time their dance to the patterns presented to them and are allowed to choose more music to play to if they receive a passing score.
- **Depression** – a mental condition characterized by low mood, low self-esteem, and a loss of interest in normally enjoyable activities
- **Exercise** – any physical activity done to enhance or maintain physical fitness and overall health.
- **Exergaming** – a term used for video games that can also be used as a mode of physical activity.
- **Freshman 15** – term used to describe the weight gain that is typical for students in the first year of college
- **Heart disease** – refers to numerous diseases affecting the heart, including coronary heart disease, cardiomyopathy (diseases affecting the heart muscles), cardiovascular disease and heart failure.
- **Hypertension** – chronic medical condition characterized by elevated blood pressure. A blood pressure reading greater than 120/80 is considered prehypertension. More than 140/90 is termed hypertension. Increases risk of heart attack.

- **Inactive gaming** – video gaming which requires little to no significant physical activity or movement.
- **Interactive games** – a term used for video games that require motion by the user (some form of physical activity).
- **Maximum heart rate** – aka MHR or HRmax. The fastest rate at which an individual's heart will beat in one minute. During exercise, a person should use the following formula:

$$\text{HRmax} = 220 - \text{age}$$

- **MET or metabolic equivalent** – a way of expressing the energy cost of physical activities as multiples of the resting metabolic rate (metabolic rate at rest).
- **Mindless sedentary activities** – non-physical recreational activities that compete for students discretionary time, including sedentary screen time.
- **Mortality (rates)** – a measure of the number of deaths in some population per unit time.
- **Myocardial infarction** – Destruction of heart tissue due to reduced blood flow to the heart. It usually results from coronary artery disease and is more severe than angina. More commonly known as a heart attack.
- **Obese (obesity)** – having an excess of body fat to the extent that it can have an adverse effect on health. Also, having a BMI equal to or above 30.
- **Osteoarthritis** – refers to numerous diseases involving the degradation of joints, otherwise known as chronic breakdown of cartilage in the joints. The

most common form of arthritis occurring usually after middle age, and leading cause of chronic disability in the U.S.

- **Overweight** – having more body fat than is optimally healthy. Also, having a BMI equal to or above 25.
- **Physical activity** – any bodily movement produced by skeletal muscles that result in an expenditure of energy.
- **Secondary diseases** – a disease that follows or is caused by an earlier disease.
- **Sedentary** – defined as less than 150 minutes per week of moderate aerobic physical activity.
- **Sedentary screen time** – sedentary activity in which the participant is staring at a screen (watching TV, etc.)
- **Stress incontinence** – a condition in which coughing, sneezing, or other movements that increase pressure on the bladder result in the loss of small amounts of urine. Due to insufficient strength of the pelvic muscles.
- **Target heart rate** – desired range of heart rate during cardiovascular exercise that gives the heart and lungs the most benefit from a workout. Considered 60 to 85 % of the maximum heart rate (HRmax or MHR).
- **Traditional exercise** – cardiovascular/aerobic activities generally considered physical activity, including walking, jogging, running, swimming, etc.
- **Type 2 diabetes** – a disease, also known as adult onset diabetes, characterized by relative insulin deficiency in relation to high blood sugar. Increasingly correlated with obesity (obesity can exacerbate complications from type 2 diabetes).

- **Utilitarian sedentary activities** – any activity that does not involve any substantive physical exertion, but is necessary for the individual (i.e. studying, reading, writing, etc.)
- **Wii** – a home video game console released by Nintendo launched in the United States on November 19, 2006.

Abbreviations

- **3MA** – Three Minute Average
- **aboveTHR** – Above Target Heart Rate Zone
- **ACSM** – American College of Sports Medicine
- **AHA** – American Heart Association
- **BPM** – Beats per Minute
- **BMI** – Body Mass Index
- **CDC** – Centers for Disease Control and Prevention
- **CVdrift** – Cardiovascular Drift
- **ERC** – Eppley Recreation Center
- **HR** – Heart Rate
- **HRmax** – Maximum Heart Rate
- **inTHR** – In Target Heart Rate Zone
- **MET** – metabolic equivalent
- **NIDDK** – National Institute of Diabetes and Digestive and Kidney Diseases
- **NIH** – National Institutes of Health
- **PAR-Q** – Physical Activity Readiness Questionnaire
- **RHR** – Resting Heart Rate
- **SAS** – Statistical Analysis Software
- **THR** – Target Heart Rate
- **USDA** – United States Department of Agriculture
- **WHO** – World Health Organization

CHAPTER I: INTRODUCTION

Obesity

According to the World Health Organization (WHO), the Surgeon General, and the American College of Sports Medicine (ACSM), obesity is a serious disease and the rates of overweight and obese individuals in the United States have been increasing on a yearly basis, with a thirty-seven percent increase from 1998 to 2006 (Center for Disease Control, 2008). Approximately sixty-seven percent of the United States population over the age of twenty is overweight or obese and therefore, the United States ranks high in the prevalence of overweight and obese for population health. Overweight and obesity are defined by the increased amounts of fatty tissue in the body. For adults, overweight and obesity are generally determined by using weight and height to calculate “body mass index” or BMI. A person with a BMI between twenty-five and twenty-nine and nine-tenths is considered overweight, and with a BMI of thirty or higher is considered obese. However, BMI does not measure body fat, and muscle mass may distort results (CDC, 2009). Therefore, it should be used as a guideline rather than a rule.

Obesity and physical inactivity combined make up the second leading preventable cause of death in the United States and increase the risks of suffering from heart disease, cancer, type II diabetes, hypertension, and osteoarthritis (Mokdad, Marks, Stroup, & Gerberding, 2000). Obesity is also associated with psychological disorders including depression, stress incontinence, and increased mortality, which continues to increase the longer the duration of obesity (National Institute of Diabetes and Digestive and Kidney Diseases, 2007). Unfortunately, rates of overweight and obesity in children and adolescents are also increasing significantly. Eleven percent

of children ages two to five years, fifteen percent of children ages six to eleven years, and eighteen percent of adolescents ages twelve to nineteen years are overweight.

The average age of onset of overweight is 15.47 years, and of obesity is approximately 17.5 years (CDC, 2009). This is an alarming statistic considering that the younger a person is when they become overweight, the more likely it is that they will become obese within a two year period, thus having an increased risk for developing further health complications at a young age. These associated health complications have sparked an eighty-nine percent spending increase for obesity-related reactive healthcare (Steenhuysen, 2009). Furthermore, medical expenses and lost wages caused by obesity cost the country an estimated \$147 billion each year (Sturm, 2000). The \$117 billion in annual medical expenses is the equivalent of ten percent of the annual health budget, up from six and one-half percent in 1998 (Gardner, 2000). Average healthcare costs are forty percent more, and medication costs seventy-seven percent more, for a combined total of \$1,429 more, per year for an obese individual than for an individual of normal, healthy weight (Sturm, 2000).

Sedentary Lifestyles

Although being sedentary is not always an indicator of obesity, and likewise that overweight and obese individuals are not always sedentary, sedentary lifestyles are linked to cardiovascular disease and other risks associated with obesity (Vandewater, Shim, & Caplovitz, 2004). A sedentary lifestyle carries an increased risk of colon and breast cancer, high blood pressure, osteoporosis, and depression (World Health Organization, 2000). In addition, physical inactivity is one of the chief contributors of obesity, along with diet, genetic factors and environment (CDC, 2008).

According to the ACSM and American Heart Association (AHA) guidelines, a sedentary person is one who performs less than one-hundred and fifty minutes of moderately-intense exercise per week, in which the heart rate is elevated from sixty to eighty-five percent of their maximum heart rate, calculated as two-hundred and twenty minus age (ACSM, 2007). Moderately-intense exercise is any activity in which the person is exerting enough energy to raise his heart rate and break a sweat, while still able to carry on a conversation. For example, walking thirty minutes per day briskly between classroom buildings would be considered moderately-intense exercise. Interestingly enough, moderately-intense exercise is more likely than intense exercise to reduce the risk factors for heart disease and diabetes, and just thirty minutes per day, five days a week will reduce the risk of chronic disease in the average adult (Duke University, 2007). For the purposes of the study, the terms sedentary and inactive are used synonymously.

Education Strategies

On April 19, 2005 the United States Department of Agriculture added physical activity to its daily recommendations for a healthy living. Now, the familiar United States food pyramid has transformed into the MyFoodGuide Pyramid (USDA, 2007). See Appendix J. This transformed approach for educating the nation about daily health, stresses the importance of staying physically active by incorporating steps toward physical activity on the pyramid.

Additionally, the Center for Disease Control (CDC) implemented obesity prevention strategies, with a focus on combating sedentary lifestyles. Tom Harkin, an Iowa Senator and member of the Senate Health, Education, Labor and Pensions

Committee, says that “Report after report shows that if we fail to take meaningful steps now on prevention of chronic disease like obesity, healthcare costs will continue to spiral out of control (Harkin, 2009, p.1).” He also holds the opinion that reform for the U.S. Health System should undeniably include prevention and wellness efforts (Harkin, 2009). Unfortunately, with competing activities such as educational commitments, television, work, computers and gaming placing demands on time, one-quarter of the population does not fulfill the recommended minimum of one-hundred and fifty minutes of exercise per week (Atienza et al, 2006). Thus, we must improve the proactive education and prevention measures being taken to improve the health of our nation.

College Students’ Behaviors

Trends show that college graduates in the fair or poor health category, who watch at least four hours of television per day, comprise the largest percentage of all people leading a sedentary lifestyle, with inactivity levels of at least forty percent (NIH Public Access, 2009). Furthermore, many of the negative consequences and health risks associated with a sedentary lifestyle are categorized as age-related complications. In other words, young people today will become the health-plagued adults of tomorrow. Therefore, current college students’ unhealthy behaviors today contribute to future generational health disparities. Thus, the cost of obesity and physical inactivity will continue to increase in a negative and detrimental cycle. The college student population consists of future role models, and if health is not stressed as an utmost importance, this population will further contribute to the deterioration of the younger generations’ health. Therefore, Team F.I.T.N.E.S.S. would like to

increase college students' physical activity levels before the age of twenty-three years, since physical activity levels significantly drop between junior high school and college graduation (Kasperek, 2008). Although participation in school sponsored athletics is at an all-time high, students' activity levels remain minimal throughout secondary schooling (Pyle, 2003). Excluding those people who engage in extracurricular athletics, we infer that students previously used physical education as their main, or only, source of exercise. However, most college age students, eighteen to twenty-three years old, are not required to take a physical education class, and are therefore engaging in little to no physical activity. In a study by the Department of Health and Exercise Science at Furman University, out of one-hundred and twenty-five state institutions that were surveyed, only thirteen colleges and universities required a health course for graduation (Pearman et al, 1997). Additionally, poor student participation in sports and physical activity displays disinterest in exercise (Gao, 2008). To reduce the obesity epidemic by increasing the activity levels of college students, we must utilize a technique that can capture the attention of college students, while increasing their desire to exercise. We aim to do this with an interactive form of video games.

Goal, Research Problem and Research Questions

Video games are currently rising in popularity, as demonstrated by sales figures and increases in sedentary screen time (Jain, 2003). Sedentary screen time is time spent in front of a television, computer, or handheld gaming system when no physical activity is required. Consequently, the use of interactive video games is also increasing due to the growth of the market, the number of interactive games available,

and the creativity involved in the games. It is a form that we believe is a viable means for reinforcing healthy behaviors. This study aims to unveil a new modality of exercise by using the entertainment factor of video games coupled with interactivity, and the fundamentals of physical activity. The overarching research problem is the increasing rate of obesity and inactivity as a national concern, along with the motivation behind habitual exercise habits as it pertains to this increase. Our research questions are as follows:

- To what extent do interactive games increase physical activity levels as compared to traditional exercise?
- How can interactive games be used to encourage students to exercise?

Target Population

The desired population for the study is full-time college students, living within a five mile radius of campus, between the ages of eighteen and twenty-three years, who partake in less than one-hundred and fifty minutes of exercise a week. All students obtaining more than one-hundred and fifty minutes of moderately-intense activity each week are classified as physically active and leading a healthy exercise lifestyle by the ACSM; therefore they are excluded (ACSM, 2007). Additionally, the target population must live on or near campus to eliminate convenience and distance as confounding variables.

Group Designation

In the study two different types of activities are examined: interactive video games via Dance Dance Revolution and traditional exercise. Interactive video games are defined as games requiring movement and physical exertion on the part of the

user (Trout and Christie, 2007). Dance Dance Revolution (DDR) is an example of an interactive video game where the user is required to jump around and coordinate their feet with arrows displayed on the television screen to be successful. Traditional exercise includes aerobic activities that raise the heart rate and increase energy expenditure of the individual such as running, jogging, and walking (Haskell, Lee, & Pate, 2007).

Participant Survey

A survey of the research participants' activity will complement the experimental design. Participants are required to log all weekly aerobic activities in addition to the designated research sessions. This information is then statistically compared to reflect any differences in the quantities of performance over the duration of the study. This statistical analysis will help formulate conclusions about interactive games' efficacy in provoking a more active lifestyle, and which conditions are best for encouraging physical activity. The team hypothesizes that individuals in the interactive video game group will enjoy working out more than prior to joining the study, and will thus increase their activity levels throughout the course of the study.

Team Goals

By striving for realistic goals outlined by the team, a first step is to combat the obesity epidemic locally on the University of Maryland campus. The primary goal is to make people more active. Ultimately, a goal is to secure a recreational space on campus where students can exercise with the use of interactive games. It is a hope that a fun alternative to traditional exercise will encourage students, who are not active, to become active. Maintaining an active lifestyle assists individuals in

combating cardiovascular diseases as well as other health conditions. Additionally, our research will create new knowledge about interactive games and their efficacy in raising activity levels and serving as a valid mode of exercise. With these new schemes, the team seeks to provide a viable means to tackle obesity for not only the local population but also the community at-large.

CHAPTER II: LITERATURE REVIEW

Obesity

The concept of our study arose from concern over a serious world health problem related to the increasing prevalence of obesity among population health. Obesity is a serious and potentially fatal health problem that must be addressed as a real public health issue. Behind only tobacco use, poor health and physical inactivity resulting in obesity are the second leading cause of preventable death in the United States of America (Mokdad, 2000). The World Health Organization (WHO) provides a numerical scale for measuring obesity (WHO, 2000) known as the BMI. However, the difficulty of measuring BMI and the intrusive procedures needed to obtain this measurement, mainly obtaining weight data, make it impractical for this study. Furthermore, at the recommended loss of one to two pounds of bodyweight per week, the average amount of time that an exercise intervention would take to show significant changes in BMI would likely take at least the ten weeks of the study. Additionally, in an ideal world, BMI would provide a very clear picture of a person's risk for obesity and related health problems. However, in the real world there are too many factors, such as muscle mass and body type, that interfere with the measurement's ability to be universally effective in diagnosing obesity (Himes, 2009).

A study done by the National Longitudinal Study of Adolescent Health determined the risk of obesity among American students in grades seven through twelve by relating ten factors in accordance with their weight and achievement. The ten factors of the stratified study were gender, age, race, ethnicity, living location, parental education, family structure, prior academic achievement, individual athletic

issues and educational environment. The subjects' BMI readings were used to classify each subject according to the level of risk for obesity and then determine correlations between the ten factors being studied and the various strata of obesity risk among the student population. Based on each student's school environment, socio-demographic profile, and academic achievement, the study concluded that those adolescents without proper introduction to some form of physical activity were at a higher risk of obesity than those who had been educated in the ways of proper exercise (Crosnoe and Muller, 2004).

Research has shown that patterns of physical activity and healthy lifestyle choices established during the college years often have a greater effect on one's health throughout the rest of life. The concept of "the freshman fifteen" is well known; however, a study conducted for the *Journal of American College Health* has actually documented and quantified the typical decrease in healthy living habits that occurs among college students living on their own for the first time. According to this study, at the beginning of the freshman year, twenty-nine percent of students were not regular exercisers and by the end of their second year of college, seventy percent of the subjects had gained an average of four and one-tenth pounds each. The study also determined that this increase in weight and associated decrease in exercise and healthy eating attributed to continued problems with physical inactivity and poor nutrition throughout adulthood (Racette, Deusinger, Strube, Highstein, & Deusinger, 2006). Thus, it is critical that people learn the importance of a healthy lifestyle, particularly in their college years, because the habits developed in these formative years of independence often shape habits for the remainder of one's life.

In addition to being a dangerous medical condition in and of itself, obesity is thought to contribute to several other serious and potentially fatal medical conditions. A study conducted in Louisiana found that while there is no definite link between childhood obesity and the onset of coronary heart disease later in life, adulthood obesity could be linked to this disease. Obesity in adults is often accompanied by several risk factors of heart disease such as adverse lipid and insulin levels, and elevated blood pressure (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001). An article in *Medical Principles and Practices* details the case of a 17-year-old male who exhibited none of the risk factors for heart problems except morbid obesity. The patient was treated for a myocardial infarction and the doctors concluded that the best course of action was to implement a weight-loss program and to educate the public about the link between adolescent obesity and serious heart problems (El-Menyar, Gomaa, & Arafa, 2006). A review of the “Epidemiologic aspects of overweight and *obesity* in the United States” by Katherine Flegal noted that many of the traditional assumptions about the dangers of obesity are not entirely accurate. Flegal noted a link between obesity and diabetes and also a potentially strong link between obesity and morbidity. This contradicts the common perception that obesity can, in many ways be a long-term death sentence; however, while the study finds reason to doubt the purported link between obesity and death due to heart disease, Flegal concludes that obesity is a serious public health concern that “poses challenges for researchers and for policy makers (Flegal, 2005, p. 601).” Thus, obesity is a risk factor for many secondary diseases that may result from increased levels of obesity and many of these secondary diseases are serious medical conditions. The increased risk factor for

potentially severe medical complications only serves to highlight the importance of combating the obesity epidemic and promoting healthier lifestyles.

Physical Activity

To further support the experimental design, Team F.I.T.N.E.S.S. examined the effects of traditional exercise as compared to exercise through the use of interactive gaming. In a 2006 study entitled “Physical Activity, Exercise, and Sedentary Behavior in College Students,” Nigg and Buckworth examined the relationship between the aforementioned three factors among four-hundred and ninety-three college students enrolled in ten conditioning activity classes. Most importantly, this study was used to define the terms of our study, specifically the difference between exercise and physical activity and the various types of physical activity. Physical activity was defined as subconscious daily activities, while exercise was characterized as predetermined activity done specifically for the purpose of developing one’s health. Sedentary activity was divided into two types, utilitarian and mindless. Utilitarian sedentary activities of college students included things that did not involve any substantial physical exertion but were necessary to survive as a college student, i.e. studying. Mindless sedentary activities were non-physical recreational activities that competed for students’ discretionary time, including computer use, time spent watching television, and napping (Buckworth and Nigg, 2006).

For our traditional exercise group, many different activities were considered to provide baseline data. According to the Centers for Disease Control and Prevention (CDC), a healthy adult should perform one-hundred and fifty minutes of moderate-intensity aerobic activity every week. This includes activities such as

walking fast, doing water aerobics, riding a bike on level ground or with few hills, playing doubles tennis, or pushing a lawn mower (CDC, 2009). These activities raise heart rate and core body temperature, while using large muscle groups and working aerobically (with oxygen). Though this list is not comprehensive, it was decided that the baseline for the study's traditional exercise group would be cardiovascular exercise, specifically walking and/or running around a track. This form of exercise was most feasible due to the accessibility of numerous tracks around campus and allowing participants to exercise at their own pace and ability. On the track, participants were permitted to walk, jog, or run, based on their comfort level. Also, with heart rates serving as the primary data collected, cardiovascular exercise was a valid form of elevating and maintaining an elevated heart rate over time.

Though machines such as treadmills or elliptical trainers could have been used, it was determined that running or walking on a track would be more practical as a way to lower confounding variables. One particular confounding variable that was avoided by choosing this mode of exercise was availability. In the Eppley Recreational Center at the University of Maryland, the cardio machines were often the first devices to become occupied. However, the track was large enough to hold many people running and/or walking at the same time. By running and/or walking on the track there was no concern for exercise mode availability. Also, many people complained about boredom on a treadmill or similar cardio machine. The use of the track minimized the risk of boredom as a confounding factor by increasing the chance for interaction between coach and participant, and lessening the sense of monotony that can develop while running on a treadmill. Finally, treadmills require use of less

energy than either running or walking on the track, a factor that could ultimately have skewed the final results.

When Team FITNESS examined traditional exercise in relation to exercise motivation, it was important to reference previous studies to see if similar testing with traditional exercise sparked the participants to continue exercise in a post-study environment. In “Holistic Wellness as a Means to Developing a Lifestyle Approach to Health Behavior Among College Students” by D. Joseph Gieck and Sara Olsen, the authors examined if a regimented exercise program would increase a participant’s likeliness to continue the program after the study had ended. In the study, forty-one participants were required to take a pre-test on physical activity, document their daily walking statistics, complete five bimonthly classes on wellness for eleven weeks, and then take a post-test to determine a change in their physical activity. After the eleven weeks, the researchers noted an increase in activity levels and in the amount of time spent doing resistance training across the board. In the pretest, the average amount of time spent exercising weekly was 2.33 hours, by the end of the test, this figure was 3.33 hours and had risen to 3.53 hours one month post-test. Similarly, the amount of time participants spent resistance training rose from 1.01 to 1.67 hours weekly, by one month post-test. Also, the average number of daily steps increased from 6598 to 8975 over the eleven-week period (Gieck and Olsen, 2007). When considering studies such as this, it is important to consider the possibility of inaccurate findings due to the Hawthorne Effect (participants change their level of participation as they know they are being monitored) and the corresponding inflation of results, but these

findings indicate a significantly large increase that we can assume this study's conclusions to be accurate.

Since there was an increase in activity levels in Gieck and Olsen's experiment, Team F.I.T.N.E.S.S. hoped for similar results with interactive games. By promoting an alternative form of exercise, people who would not normally exercise might be more inclined to get up and get moving. This means it was imperative to first see if interactive games were comparable to traditional exercise and if so, to use technology to encourage sedentary people to become active.

Over the past twenty years the use of video games and the rise in obesity have been linked. In a study by Vandewater, Shim, and Caplovitz, children with higher weight status often played more video games than their lower weight status peers. Throughout the study, 2831 children between the ages of one and twelve (or their parents) kept diaries recording how often and how long they used several types of media, including television, electronic games, computers, and print media. The children were then compared based on BMI rankings, resulting in findings that higher BMI children had higher electronic gaming tendencies. However, to further create a linkage between video games and obesity, it would be necessary to examine whether this is merely a correlation between the two factors or if any causality exists between the two; however, no other media study was able to prove causality rather than mere correlation between BMI and weight status (Vandewater et al, 2004).

Furthering a lack of clarity, some studies suggested video games might not be linked as strongly to sedentary activity as some might think or suggest. "The Rhetoric of Exergaming" by Ian Bogost provides a detailed history of how video

games evolved into a possible method for activity. Bogost defines exergames as video games that combine physical input devices into the play of the game. He cites the fact that exergames have been around for decades, but technology is only just starting to further increase the amount of energy a player must exert. For instance, in the 1980's, games such as Pac Man and Pole Position "meant standing up at the cabinet and putting significant body [effort] into the play experience (Bogost, 2005, p.1)." Though video games essentially evolved into a sedentary living room activity, new technologies are shifting the landscape and curbing this trend (Bogost, 2005). Vandewater and Bogost both touch upon the potential utility of video games as methods of encouraging physical activity and exercise. Bogost, in particular details how the idea of exergaming has been around for years and improving technology has only recently allowed it to become more than a gimmick and represent a potentially effective way to use video games as an exercise tool on a large scale. The Nintendo Wii is a prime example of this as it has integrated a motion sensor in its controllers, allowing the user to directly interact with the game while expending large amounts of energy.

Through Nintendo's new use of physicality for gaming, many questioned whether the system could be used as a means for physical exercise. A study by Liverpool John Moore's University School of Sport and Exercise Science put the Wii to the test. The study demonstrated the effects of the interactive gaming system versus traditional gaming in teenagers. After only fifteen minutes of game play, the Wii demonstrated an energy expenditure of two and a half times that of regular video games (one-hundred and fifty-six percent above resting compared to sixty percent

respectively). At this rate, it would be possible to burn over 1800 calories a week if played roughly twelve hours over the course of the week (Camden, 2007).

A story from ABC News by Lee Ferran and Thomas Dilworth, showed exergaming's ability to combat the dreaded "Freshman Fifteen" for college students. The story interviewed several Wii users, who felt that by playing the different games they were able to work up a sweat in a fun way (Ferran and Dilworth, 2007).

When deciding which interactive game and system to use for this study, it was important to think about the following features: repetition, ease of learning and use, a fun factor, and how effectively it increases heart rate. Currently, the Wii is the primary gaming console for exergames, and for this reason it was selected as the system for this study. It also has many types of games from first person shooters, to sports, to dance, that all involve activity in order to use the system appropriately. After trying out many games, the team decided to use Dance Dance Revolution (DDR), an interactive game that utilizes a directional pad in which the user coordinates movements with arrows and music from the television screen. This interactive game is ideal for the study because it is easy to use, is fairly unbiased with respect to skill level, implements exciting use of color and graphics, and makes the user move in order to win. The game has numerous songs to dance to, reducing boredom from repetition. It also has several different levels of play, allowing the player to learn at their own pace. Finally, a thorough literature review provided positive findings on the game. Ian Bogost's "Rhetoric of Exergaming" describes the game as a "physically strenuous" rhythmic game. He even cites a weight lost

promotion that claims a woman lost ninety-five pounds with no exercise program other than DDR (Bogost, 2005).

Through an extensive literature review, many other studies examining the effectiveness of interactive gaming as exercise exist. Unfortunately, all of these studies focused on age ranges of fifteen years old and younger. For example, an article published in the *Archives of Pediatric and Adolescent Medicine* in 2006 addressed metabolic and physiologic responses to video game play in seven to ten year-old boys. This study found significant increases in heart rate, respiratory rate, and energy expenditure from the baseline, when the children were playing an ordinary “non-interactive” game (Tekken 3). The procedure of this study involved creating a baseline for the energy expenditure of the child, having him sit for several minutes, and then monitoring the physiological and metabolic processes of the child during and after playing the game. The study concluded that video gaming resulted in significant physiologic and metabolic effects, similar to walking and cycling; however, because gaming did not involve enough muscle groups, it could not be “considered a substitute for regular physical activities that significantly stress the metabolic pathways required for the enhancement of cardiovascular conditioning (Wang and Perry, 2006, p. 412).”

Another recent study pitted the playing of non-active video games versus active games in a study of thirteen to fifteen year old children. The method involved first having the children play the inactive game for fifteen minutes, then take a five minute rest, then play the active games three times for fifteen minutes each with breaks in between games, so in total each child played for sixty minutes. The

researchers concluded that although the energy expenditure during active games was significantly higher than in the inactive gaming, more energy is used in playing sports rather than in imitating them through Wii video games. The researchers deduced that in a typical week, substituting active games for the sedentary ones would increase energy expenditure by two percent, which can be useful for weight management. They concluded, similarly to the previous study, that exercise from interactive games was not acute enough to be recommended as an exercise regimen. One limitation of this study was that the results only applied to lean “sports competent” children of the ages twelve to fifteen; therefore, results may vary for sedentary or obese individuals (Graces, Stratton, & Ridgers, 2007).

A study performed by the Mayo Clinic examined the effectiveness of the EyeToy and Dance Dance Revolution, as compared to inactive gaming and other forms of exercise. The study found that the EyeToy, which involves a motion sensor placed on the television that detects the movements of the player with respect to objects placed on the screen, increased the energy expenditure of the children by one-hundred percent over the resting rate, compared to the only twenty-percent increase for ordinary video games. The dance pad was found to be much more effective, raising the energy expenditure by one-hundred and seventy percent from the resting rate. In the discussion of results, the researchers suggested that using activity-promoting games in place of ordinary games could be an enormous step towards reversing sedentary behavior, and perhaps even a form of obesity prevention or treatment (Lanningham-Foster et al, 2006).

For the proposed study, the team wished to examine the effectiveness of interactive gaming as it relates to sedentary college students. As college students, the team understood the struggle with committing to an exercise routine, despite competing demands for time. Between studying, working and social obligations, exercise was often categorized as a last priority. It was also important to target college students due to the rapid increase in weight often seen during the freshman year (Groppe, Simmons, Gaines, Drawdy, Saunders, Ulrich, et al. 2009). In “Selected Health Behaviors that Influence College Freshman Weight Change”, a study during the first twelve weeks of school at Cornell University revealed an increase of four and two-tenths pounds per student, on average. The average human only gains eight-tenths of a pound per year. It also noted that students with low physical activity baselines were nearly twice as likely to become obese (Kasperek, 2008). Clearly, college students need to be targeted in order to begin combating the obesity and physical inactivity epidemics plaguing the United States of America.

A study entitled “Assessing Overweight, Obesity, Diet, and Physical Activity in College Students” further encouraged the team to target college students. In the study, over seven-hundred college students ages eighteen to twenty seven were surveyed on several parameters, including fruit and vegetable intake, fiber intake and physical activity. Although the first two parameters are not related to the proposed study, the third demonstrated the lack of physical activity in college students. The study compared participants, who were less than twenty years old, to those who were over twenty years old. The trend showed that as students progressed through college, the average BMI increased and the average amount of physical activity per week

decreased. Both trends demonstrate why many college students graduate as unhealthy individuals (Huang et al, 2003).

Many of the studies which found that interactive video games were not useful as exercise tools are not completely applicable to our study. The physical activity resulting from playing interactive video games is not considered intense enough to constitute real exercise, but while this may be true for the lean, active populations on which these studies are performed, these conclusions cannot be generalized to apply to the population targeted by Team F.I.T.N.E.S.S. (Maddison et al, 2007). However, the proposed study involved a sedentary population based on studies that included children with obese BMIs, finding that active video games could be useful for weight management or treating obesity (Lanningham-Foster et al, 2006). One study concluded that gaming was equivalent to brisk walking, or skipping, which is somewhat more physically stressful for the obese and sedentary populations (Maddison et al, 2007). Because our literature review revealed no studies having been performed on the age group of eighteen to twenty-three year olds, nor any on solely sedentary children, we believe our study will create new knowledge that will benefit both our peers, and society as a whole.

Heart Rate

The American College of Sports Medicine and the American Heart Association recommend that “To promote and maintain health, all healthy adults aged 18 to 65 need moderate-intensity aerobic physical activity for a minimum of 30 minutes for 5 days each week or vigorous-intensity aerobic physical activity for a minimum of twenty minutes for three days each week (ACSM, 2007, pg. 1425).”

Both organizations further define light, moderate, and vigorous activity as less than 3.0 METs, between 3.0 and 6.0 METs, and above 6.0 METs, respectively. A MET, or metabolic equivalent is defined as an individual's energy expenditure while sitting quietly or approximately 3.5 ml·kg⁻¹·min⁻¹. To determine the METs of an activity the relative oxygen consumption for the average heart rate of an activity is divided by this standard value of one metabolic equivalent (ACSM, 2007). Unfortunately, it would be impractical to use MET's to determine the intensity of exercise because it requires extensive and invasive measurement using VO₂ max tests. In addition, this measurement is highly variable between different people and can be affected by factors such as body composition and age, meaning that the tests would have to be carefully tailored for each individual subject (Byrne, Hills, Hunter, Weinsier, & Schutz, 2005). Thus, Team F.I.T.N.E.S.S. chose not to use MET's as a method of gauging exercise intensity.

Moderate and vigorous activity are further defined by heart rate values, where moderate exercise is forty to fifty percent of the heart rate reserve and vigorous exercise is sixty to seventy percent of this value. An individual's target range is defined as follows:

$$\text{Target HR range} = [(\text{HR}_{\text{max}} - \text{RHR})] \times \% \text{HRR} + \text{RHR}$$

Where $\text{HR}_{\text{max}} = 220 - \text{age (yrs)}$, and

RHR is the individual's average HR over five consecutive minutes of rest, and

%HRR is the percentage of heart rate reserve, calculated as $\text{HR}_{\text{max}} - \text{RHR}$

(Moy, Scragg, McLean, & Carr, 2000)

The Team F.I.T.N.E.S.S. study operated under the basis of two assumptions with respect to a person's heart rate. The first is that resting heart rate and heart rate max are considered a measure of a person's fitness level. The second is that heart rate during exercise is correlated to the exertion exhibited during this time period as well as the physical condition of the individual in question; thereby heart rate is a measure of the level of exercise being performed.

Various studies have indicated that as a result of physical fitness training, a person's resting heart rate and maximum heart rate decrease. Ultimately, this is a reflection of the heart's ability to work more efficiently via conditioning. One study titled "Effects of Aerobic Training on Heart Rate Dynamics in Sedentary Subjects" published in the *Journal of Applied Physiology*, examined the use of heart rate data as a metric for sedentary individuals and their performance (Tulppo et al, 2003). Researchers split the subjects into three groups - one control, one moderate-training, and one high-volume training. Moderate training involved six, thirty-minute sessions per week for eight weeks at an intensity of seventy to eighty percent of maximum heart rate, while high-volume was six sessions for sixty-minute durations at the same HRmax intensity. Data analysis for the study found that the participants' heart rates decreased as a result of moderate and high-volume training, from seventy to sixty-four beats per minute and from sixty-seven to sixty beats per minute, respectively. This is compared to the control group, where the heart rates remained at approximately sixty-seven beats per minute throughout.

Additional studies have demonstrated a similar decrease in maximum heart rate following a period of aerobic training. An article published in *Sports Medicine*

titled “Evidence and Possible Mechanisms of Altered Maximum Heart Rate with Endurance Training and Tapering” provides numerous examples where a participant’s maximum heart rate is reduced following a period of aerobic training (Zavorsky, 2000). See Appendix B. From this table, it can be concluded that the mean change in heart rate is an overall reduction of six beats per minute after an average of seventy-seven days of training. Of the twenty-one studies cited, only two demonstrated an upward trend, showing a slight increase in heart rate of just one beat per minute. These trends support our hypothesis that if interactive gaming can be used as aerobic training, a reduction in resting heart rate values will likely be expected.

To gauge the intensity of interactive gaming training the team assumed that trends in heart rate data are a reasonable estimate of a person’s energy expenditure. Though the ACSM defines moderate and vigorous exercise in terms of percentage of heart rate maximum, exercise can also be defined in relation to the METs of, or energy expenditure required by, an exercise. More importantly, energy expenditure can be estimated by using heart rate tracking, after adjusting for an individual’s age, gender, body mass, and fitness. In the study, “Prediction of Energy Expenditure from Heart Rate Monitoring During Sub Maximal Exercise” the researchers found, after adjusting for each participant, that a model solely based on heart rate could account for seventy-three percent of the given variation and provide an r-value of 0.857 (Keytel, 2005). This means, given a large enough sample, the adjusted equations can provide an accurate assessment of the overall intensity of the exercise, so as to compare one activity to another.

When deciding how to adjust for intensity, the team took into consideration cardiovascular drift. Cardiovascular drift, known as CVdrift, is a phenomenon characterized by “a continuous, gradual increase in heart rate after approximately ten minutes of moderate-intensity aerobic exercise, despite maintenance of a constant work-rate (Mikus, Earnest, & Blair, 2009).” A study performed at the DREW clinical exercise trial, at The Cooper Institute in Dallas, Texas, investigated the CVdrift effect in an examination of nearly thirteen-thousand exercise-training sessions. The researchers identified only one-hundred and one sessions in which the intensity was reduced, leading to the conclusion that CVdrift did not contribute to significant reductions in exercise intensity. Though CVdrift did not impact the overall intensity for the purposes of the current study, it could account for a slight elevation in heart rate.

In addition to establishing heart rate as a viable form of measurement of physical exertion, Team F.I.T.N.E.S.S. also worked to determine which, if any, commercial heart rate monitors measured values with a reasonable degree of accuracy and consistency. A study published in 2002 by researchers at North Dakota State University investigated commercial monitors. The study examined the validity of seven commercial heart rate monitors through a comparison of monitor output to electrocardiograph output at four distinct stages. These stages were at rest and on the treadmill at three different speeds, 85.7, 107.3, and 160.8 $\text{m}\cdot\text{min}^{-1}$. Each of the stages was measured for a period of ten minutes, with the monitors taking measurements every ten seconds. Researchers concluded that POLAR monitors were the best in accurately measuring the first three stages, although for higher speeds were

less accurate (Terbizan, Dolezal, & Albano, 2002). Thus, the Polar commercial heart rate monitors most effectively measured moderate exercise, with validity being compromised at the highest intensities. However, the Garmin commercial heart rate monitors measure in 5-second intervals, providing more data points throughout the course of an activity or workout session. Furthermore, at the time of purchase, the Garmin heart rate monitors were the only ones on the market that included USB and computer compatibility and a price within our budget. Thus, Team F.I.T.N.E.S.S. decided to purchase and use Garmin heart rate monitors to gain statistical advantage and analysis capabilities and save money, while sacrificing some efficacy. However, the team believed that the trade-off was beneficial due to the fact that the analysis of the heart rate data was critical to the study, and would have been nearly impossible without computer compatible heart rate monitors.

Motivation

A study conducted to measure the motivation of Mississippi Community College students' willingness to exercise during their leisure time presented interesting conclusions with regards to exercise motivation. Questionnaires were distributed to students in order to classify them as belonging to one of five different stages relating to their level of motivation to exercise. These stages were defined as pre-contemplation, contemplation, preparation, action, and maintenance, with the first two stages corresponding to individuals who did not exercise during their leisure time, the third to those who sometimes exercised during leisure time, and the last two signifying people who frequently devoted their leisure time to physical exercise. The results of this study suggest that the majority of college-aged students reside within

the third, fourth, and fifth stages of exercise motivation rather than the less active first two stages, but that still thirty-five percent of the population studied resided within the completely sedentary first and second stages (Crenshaw, 2009). These findings suggest that sedentary lifestyles are indeed a cause for concern within the college student population, but that some of these students might be within the contemplation stage and could switch to the preparation stage, in which physical activity is significantly increased with coaching and direction.

Another study, reported in the *Journal of American College Health*, delved further into the topic of exercise motivation by examining physical activity in college students as related to gender. The study aimed to compare motivation for exercise versus sport participation, using gender as a decisive feature. The results imply that those engaging in sports reported more fulfillment and enjoyment than those delegated to traditional exercise. Women were found to be more motivated by appearance issues and weight management when it came to motivation for traditional exercise rather than sport participation. Conversely, men were equally motivated by these factors for both traditional exercise and sport participation (Kilpatrick, Edward, & Bartholomew, 2006). Overall though, when taken in context, this study provides the motives for our experimental design, as it supports our claim that some college students are more likely to exercise given an entertaining alternative rather than traditional exercise.

A study by Cox, Williams, and Smith addressing the physical activity of adolescents outside of school found similar results to the previous study. By observing how eighth graders react to the availability of different types of physical

activity, the study examined the effect that a participant's enjoyment of a given activity has on that individual's willingness to engage in the task during leisure time. The results concluded that enjoyment has a direct correlation to self-determined motivation; therefore, a student is more likely to exercise if he/she enjoys the activities presented before him/her. Additionally, the study found an indirect relationship between self-determined motivation and physical activity behavior outside school, meaning that a student is most likely to exercise independently if internally motivated (Cox, 2007). Though seemingly simple conclusions, these help to provide support for the team's belief that all students can be motivated to get moving with exercise creativity.

It is our hope that the use of video games as an innovative exercise technology will help to encourage students to exercise more consistently and increase their overall levels of exercise motivation. A study conducted at the University of Eindhoven on the use of media technology to increase exercise motivation levels provides insight into the potential utility of this approach. In this study, subjects exercised using an exercise bike in front of a screen depicting a sample environment, designed to simulate cycling through a real residential neighborhood rather than simply stationary cycling. The study found that a more engaging and aesthetically-pleasing environment corresponded to higher observed levels of exercise motivation in participants (Gill, 2005). From this we can infer that the interactive nature of video games helps to increase exercise motivation levels in participants. Another interesting aspect of this study is the examination of a coaches' effect on exercise motivation. This involved subjects having a virtual coach present on the screen

periodically providing feedback throughout exercise. The effects of this interactive variable were not as straightforward as the effects of the environment on exercise motivation, but the researchers were able to determine that the presence of the virtual coach helped to calm the participants and make them feel more comfortable while exercising, as well as increasing the amount of interaction for the participants (Gill). Hence, the Team F.I.T.N.E.S.S. study in which participants are paired with group members serving as one-on-one exercise coaches should benefit from lowered anxiety levels among participants, which should lead to an increased motivation to persist with the study and continue exercising.

There is also a large amount of research that suggests confidence and self-esteem has a high correlation to exercise motivation. The aforementioned study of Mississippi Community College students found that exercise levels were significantly lower in females as opposed to males (Crenshaw). Research such as the findings of Netz and Raviv in the *Journal of Psychology* have suggested that this is due largely to issues of self-efficacy and self-esteem which are strongly tied to physical appearance (Netz, Raviv, 2004). The presence of coaches should be useful in counteracting this effect by creating a more comfortable environment in which to exercise, through positive reinforcement and encouragement, leading to corresponding increases in exercise motivation.

Finally, incentives are useful tools to increase motivation and participation in surveys and study participation. A study completed by researchers at the State University of New York, Stonybrook Campus for the *Journal of Health Psychology* found that incentives were useful in encouraging increased survey participation

(Moyer, 2008). The Team F.I.T.N.E.S.S. study similarly hoped to achieve enhanced participation through the use of incentives. At the end of the study, several Nintendo Wii game consoles were raffled to participants. The raffle was weighted according to each subject's participation level throughout the study to encourage consistent and prolonged participation. In addition, the use of Wii in the study increased its potential efficacy as an exercise tool, thus making this incentive uniquely powerful as a motivating factor.

Data Analysis

Initially, the team F.I.T.N.E.S.S. study was intended to measure the effects of traditional exercise such as jogging against the effects of interactive video games and a control group of traditional non-interactive games. Each of these groups was to contain forty subjects so that the amount of data collected for the experiment would be sufficiently large enough to render conclusions statistically significant. However, this became impractical due to limited responses from recruitment, so the group playing traditional videogames was eliminated and the size of each group of participants shrank dramatically. According to a study designed to improve techniques for modeling motor vehicle accidents, small sample sizes can badly skew data (Lord and Miranda-Moreno, 2008). This potential problem could be mitigated by using pooled samples. Often used in bioinformatics when certain species are too small in number to allow for findings to be generalized, this concept involves combining different groups of statistical information obtained under virtually identical conditions so that a larger sample size might be used. A study by Gant and Zhang investigating this technique for the purpose of examining microarray

experiments details the procedures for pooling samples in a way that minimizes the introduction of confounding variables and allows for the achievement of statistical significance (Zhang and Gant, 2008).

When determining how to collect data to track subjects' motivation levels, all quantitative notions were set aside. A 2008 study by Hershkovitz and Nachmias at Tel Aviv University demonstrated how activity logs could be used to track motivation over the course of a multi-week experiment. In this study, they examined how information obtained from logs could be used to track students' motivation to learn over the duration of an online course. They found that the information obtained from this method could be useful because it allowed for the discovery of information that could not be found in other ways of quantitative collections. For example, within our study, the heart rate data were useful but it does not relate to motivation, but the information obtained through activity logs and other open-ended media could relate to any number of factors for each individual participant, allowing for broader conclusions. However, this did have drawbacks because the broad array of potential information made available by open-ended activity logs means that the data could be extraneous and outside the scope of the study. Hershkovitz and Nachmias found that it was difficult to tailor the questions asked on the activity logs to information pertaining to a particular topic and that it was bound different for every project with its own unique understandings (Hershkovitz and Nachmias, 2008). Despite, these potential difficulties, activity logs represent a viable and potentially useful tool of information gathering for the Team F.I.T.N.E.S.S. study as they allow us to learn

about the subjects' changing levels of motivation for exercise in a way that objective, quantitative data does not.

CHAPTER III: METHODOLOGY

Overview

In order to obtain answers to our research questions, we performed a case study using a mixed-methodology approach for data collection. More specifically, the study may be categorized into two main phases. The first phase, essentially the setting-up phase, included the informing, screening and recruiting of potential study participants. This led into the second, or main, phase, during which the actual experiment and qualitative and quantitative research occurred. This two-part design was conducted twice, in two semester-long sessions during spring of 2009 and then again in fall of 2009. The following section covers in greater detail the specific procedures applied in each of these two phases, the direction of resulting data analysis, and finally an examination of potential drawbacks in the study.

Phase I: Recruiting

The first, and most vital of elements in carrying out any study involving human participants, is the recruitment of research subjects. In order for the research to be statistically significant, we set a goal of forty participants as our desired total number in both semesters. Our team based this figure on the ideal of having approximately twenty participants per semester, or two participants per team member at approximately ten team members per semester.

During the inaugural Spring 2009 semester, several different methods were used to promote awareness of our project, increase interest in the study and provide contact information to potential participants and others seeking additional information. These different recruitment methods, detailed below, had varying

degrees of return on effort. Therefore the recruitment phase during the Fall 2009 session was streamlined based on the research team's evaluation of each method, placing more emphasis on those which proved to be most successful, and in addition putting energy into other avenues of recruitment which were suggested or planned for first session but not fully executed or explored.

Recruiting Efforts and Return by Semester

| Semester | Approximate # of people spoken to: | Return Rate: |
|--------------------|---|---------------------|
| Spring 2009 | 3000 | 8 |
| Fall 2009 | 1800 | 9 |

Phase one of each session covered a roughly two week period near the beginning of each semester, during which the participants were recruited. At several points throughout this period, the status of recruiting efforts was evaluated based upon the number of prospective participants found compared to the numbers needed to meet or approximate the goals of our study. If further recruiting was deemed necessary, the recruitment phase was extended an additional week. The evaluation also took into consideration the potential issues with retention, particularly the possibility that each prospective participant could leave the project at any time, or simply not follow through on initial signs of interest. We found it necessary to expect and prepare for this, and so the aim of our recruiting efforts was to gather more interest by recruiting more participants than would actually be necessary.

Our first recruitment phase began in the Spring 2009 semester, during the first two weeks of February. At the onset, these efforts focused primarily on the distribution of informational flyers (see Figure H-26). Team members positioned themselves at high traffic buildings on the University of Maryland campus including Hornbake Library, McKeldin Library, the Stamp Student Union, and the North and South Campus Diners, offering a flyer to each passerby. Daily hours for flyer distribution varied dependent upon availability of team members, but were generally between the mid-afternoon and typical dinner hours in the evening, roughly from 3:00pm until 7:00pm. Team members were also stationed at informational tables outside of the Stamp Student Union from 12:00pm until 2:00pm, passing out flyers and answering questions about the study. In addition, flyers were posted at various locations throughout campus. Approximately 2000 flyers were passed out during Spring 2009 recruiting, and this method ultimately garnered three participants.

Informational tables secured the bulk of participants. Potential participants that visited a table received candy and a short informational survey (see Figure H-27) that would help team members determine on-site if they were within the boundaries of the target population. Members stationed at the table also answered any questions regarding the study. This method of recruiting via informational tables proved the most effective out of all methods used in the spring recruiting phase, bringing a total of ten participants to the study. However, taking into account those who dropped out from the study, recruiting in the spring semester brought in a total of eight participants who remained through Spring 2009.

The recruitment phase during the Fall 2009 semester took place during the weeks of September 1st and September 8th and operated similarly to recruiting in Spring 2009. However, the team made adjustments to recruitment methods on the basis of effectiveness from the spring. Distribution of flyers had previously proven relatively ineffective, and therefore was scaled back considerably. Approximately 1000 flyers were passed out, but no participants joined the project by this effort. Disappointingly, due to changes in campus policy, the team was unable to reserve a table at the Stamp Student Union, the most effective means for recruiting in Spring 2009. The team chose an alternative of operating an informational table at Eppley After Dark, an event promoting responsible social recreation. This is a late-night, non-traditional “exercise” event held in Eppley Recreation Center and currently includes a Wii tennis tournament.

Recruiting primarily relied upon an informational blurb sent out several times via the Honors, Scholars and Gemstone e-mail list serves at the University, as well as department e-mail list serves such as Campus Recreation Services (see Table H-14). This was accompanied by visits to GEMS100 classes to speak about the project and provide contact information for interested students. After approximately one-and-one-half weeks using these methods, recruitment still proved slow, and so in an attempt to expand numbers there was a push by team members to seek participants among friends and acquaintances (word of mouth). This last method netted some success, bringing one participant to the project. Efforts ultimately brought in nine participants that remained in the study throughout the Fall 2009 semester. Thus, the

team's overall recruiting efforts brought seventeen participants into the study, divided almost evenly between the Spring 2009 and Fall 2009 semesters.

After initial recruitment efforts, the next step in the recruitment phase was to follow up with all interested participants via email to screen for the confines of the target population. Short informational surveys were handed out by team members at tables and sent in response to e-mails expressing interest. With the information from these surveys, potential participants were screened based on age, personal activity levels, and proximity to campus. According to the confines of the target population, participants were required to be between eighteen and twenty-three years of age, partake in an average of less than one-hundred and fifty minutes of exercise per week, and live within a five mile radius of campus. For those individuals that met these requirements, further contact was made inviting them to a "meet and greet" event and determining their respective availabilities.

The third and final step in the recruitment phase was a "meet-and-greet" session held in the Center for Health and Well Being at the Eppley Recreation Center. The purpose of this event was to provide an informational meeting and lead-in to the second phase of the study. The event served to introduce study participants to their potential coaches, introduce them to the Wii and DDR, as well as generate excitement for the ten weeks ahead. During this event, participants also filled out and signed the PAR-Q and release forms necessary for study participation (see Figure H-28 and Table H-13, respectively)

From our recruitment efforts we garnered seventeen participants across both semesters. The mix of participants was close to evenly split between male and female

participants, with male participants composing fifty-nine percent of the group. The race/ethnic composition of those who remained with the study was largely of white, non-Hispanic individuals, who made up seventy percent overall, with the remainder being either African-American or Asian-American. While the participant composition included individuals aged eighteen to twenty-one years and from all class-standings at the university, seventy percent of the group were nineteen or twenty years of age and were currently of either sophomore or junior class standing. For a more detailed demographic breakdown of all participants involved in the study, see Appendix I.

Phase II: Research/Data Collection

After recruitment efforts were complete, the project transitioned into the second phase, beginning with the formation of participant groups and the start of the study portion. After the “meet-and-greet” session, the team randomly assigned participants to one of two groups: interactive gaming or traditional exercise. The interactive gaming group was the experimental group, while the traditional-exercise group functioned as the control group. Participants were distributed evenly, or as close as possible, across the two groups; however, numbers were not consistent throughout the semester due to fluctuating retention rates. By the end of the Spring 2009 semester, there were five participants in the control group and three in the experimental group. At the end of the fall semester, four participants remained in the control group and five in the experimental group. Including both semesters, the study had nine participants in the traditional exercise (control) group and eight in the interactive gaming (experimental) group.

Additionally, we assigned each participant to a member from Team F.I.T.N.E.S.S. to serve as a coach and motivator for the duration of the study. The team determined these assignments by matching the availabilities of team members and the participants. In addition to monitoring each session and collecting their participant's data, coaches provided logistical information, support, encouragement and motivation. Due to the nature of this role, the bonds formed through consistent coach-participant pairings were considered important for increasing interest and maintaining retention throughout the ten-week study. Prior to having participants engage in physical activities, Team F.I.T.N.E.S.S. coaches became CPR certified and re-certified in order to ensure the safety of all participants.

At the beginning of each research phase, the coaches trained participants to use heart-rate monitors and to take their resting heart rate. The resting heart rate of each participant was measured and recorded at the beginning, midpoint and end of the semester's study. Participants were asked to take the RHR shortly after waking up, and then report this to the coach. The RHR is an indicator of overall fitness, and thus recording it at three intervals would hopefully indicate the change in overall fitness of each participant over the course of the ten weeks. Furthermore, the team used the participant's age to determine his or her maximum heart rate, defined as two-hundred and twenty minus age. Coaches then calculated the range, sixty to eighty-five percent of maxHR, at which their participants were to exercise, which would serve as their target HR throughout the course of the study. Following each activity session, coaches would examine whether each participant was reaching his or her target heart rate range and for how long. Measuring the resting heart rate at different points

during the study also allowed us to look for improvements over time as a result of increased physical activity. The team looked at attainment of the target heart rate range and any changes in resting heart rate together, seeking to uncover any correlation between interactive gaming and the achievement of these goals. These figures were compared across the two groups with the hypothesis that trends would indicate that interactive gaming is a valid form of exercise, as effective as traditional forms of exercise.

During the course of each semester's data gathering phase, the study lasted for a ten-week period. During the ten weeks, the goal was for each participant to participate in the assigned form of activity three times per week with his or her respective coach. When scheduling conflicts arose, meetings were rescheduled to ensure continuity in participation and in the data recorded. If a team member was sick or otherwise unable to facilitate a meeting, another coach would fill in. Also during the ten-week period, activity logs were provided to each participant to be filled out weekly (see Figure H-29). Logs included a checklist of various physical activities he/she might have participated in, with space to record the duration of each activity engaged in. Logs were intended as a tool to reflect any changes in the amount and patterns of a participant's physical activity over the ten weeks, with the hope of inferring improvements in his/her activity levels, motivations or attitudes towards activity.

For both the interactive gaming and traditional exercise groups, each session lasted thirty minutes of recorded time plus any setup and/or cleanup time. The participant's heart rate was measured using a Garmin heart rate monitor, which

included a monitor attached to a chest strap and a wrist watch to produce numerical readings. At the time the study was being designed, Garmin brand heart rate monitors were able to track and record in a constant stream which could be saved and transferred, while many other monitors provided only a visual display. The monitor was used to time the session, provide a read-out of the heart rate, and store the data until it was transferred to an external hard drive. The participant's heart rate was checked and monitored regularly during each session allowing the researcher to see whether it was within the target range. Data recording the heart rate were saved onto the Garmin watch at the end of each session. The data were later used to determine individual improvements as well as differences between the two groups. The team transferred data from the heart rate monitors twice each semester, storing it on a laptop kept by one team member, and also keeping a backup copy on an external hard drive. Overall the heart rate monitors worked effectively, with the only troubleshooting issue being the shelf-life of each monitors battery, requiring replacement once per semester. Additionally, each team member kept a log of the sessions attended by their participants, noting the individual via a participant-number randomly assigned at the start of the research phase. Each log entry noted the date, starting and ending times, heart rate monitor used, and save number. This information would later be used to differentiate the heart rate information by session to follow the progress of specific participants and to more thoroughly analyze the data gathered.

The experimental group engaging in interactive gaming met in the Eppley Recreation Center, Center for Health and Well Being. The particular interactive games chosen for the purposes of the study were Dance Dance Revolution Hottest

Party and Dance Dance Revolution Hottest Party 2 on the Nintendo Wii gaming console. The activity space included a television, the gaming console, DDR interactive games, and associated dance mats provided by the research team. The research team did not control either the selection of songs to play within the game or the difficulty level selected by the participant; however, we encouraged participants to develop skills and challenge themselves while playing the game.

The control group engaging in traditional exercise met at the indoor track of the Eppley Recreation Center. Participants in this group walked, jogged or ran around the track for the thirty minute sessions according to their own comfort and abilities. To keep them motivated, coaches exercised alongside participants.

For the sake of safety, researchers encouraged their participants to take breaks as needed and drink plenty of water during sessions. Water fountains were available in the ERC and the team provided filtered water and cups in the Center for Health and Well Being. Additionally, keeping hygiene in mind, the team used sanitary wipes to wipe down and clean the heart rate monitors after each use.

Throughout the study participants were encouraged to exercise outside the bounds of the study, whether engaging in the same activity or another of their choosing. The ultimate goal of the study was to determine whether participants in the interactive gaming group would display increased desire and willingness to exercise compared to the control group.

Phase III: Data Analysis Methods

After collecting data during the Spring and Fall 2009 research phases, the research team began organizing this information over the course of the winter

semester. The first step in this process was to sort the data recorded by the Garmin heart rate monitors. Team members initially stored this information using the Garmin Training Center software, provided with the purchase of the monitors. Using the information recorded in the session logs, researchers further sorted the heart rate data by semester, participant number, and individual sessions. The sub-team in charge of data analysis converted these sorted files from the Garmin software's specific format, .tcx (Training Center XML) to the standard .xml encoding format, allowing the data to be more easily viewed, manipulated, and analyzed with other software.

At this point in the process, the raw data consisted of heart rate data for every five second interval of each thirty minute session, or three-hundred and sixty data points per session. To better manage this information, the data analysis sub-team used the original data points to produce ten, three minute averages per session. The team then created a basic program with SAS (Statistical Analysis Software) to input the available heart-rate information, and used this program to merge and further sort the data.

Next the sub-team began analyzing the data for overall trends and variations within and between the two participant groups; noting the ability of each exercise mode to keep a participant in or above his/her target heart rate range for the thirty minute duration. Specifically, the team examined the averages by session, by participant group, and by semester. The analysis team performed a Chow Test with the available data to see if it was possible to pool the information from the spring and fall semesters. The aim of this test was to determine whether the team could calculate the PROC means by group and by session, disregarding the semester split. The team

next performed a multiple regression analysis with the data. The analysis used a mixed-model regression and gave the plots of Group0, representing the control group (Traditional Exercise Group), versus plots of Group1, the experimental group (Interactive Gaming Group). Additionally, the team examined the data for a number of other factors including the percentage of time during a session spent in the target heart rate zone and the first time a participant reached their target heart rate zone for the session. A participant was only considered to be in the target heart rate zone after twenty seconds spent in or above the target zone. Finally, the team also analyzed the data for the maximum and minimum heart rates during a session, along with the time elapsed between these points.

Drawbacks and Weaknesses

Having analyzed the structure of the study there is another factor that must be addressed: the weaknesses and limitations of the setup. One major drawback was the rather intrusive and demanding nature of the study, which asked a great deal of each participant. The initial survey and weekly activity logs, requested information on individual activity levels outside of the study sessions. Participants may not have felt comfortable providing this information, or may not have remembered details clearly, and like most self-report data, the accuracy is uncertain. The activity logs, though relatively simple, may have presented an extra chore to already busy college students. The logs could be a useful source of information, but were not always submitted consistently. Also, because these were not directly recorded by members of the research team the information they offer is of unverifiable accuracy.

Study participation required thirty minutes of each participant's time, along with any time and effort involved in getting to the arranged meeting place in the ERC, three times every week, for ten weeks. Some participants may have had to travel farther depending on where they lived on or close to campus, and whether or not they had personal means of transportation. Sessions potentially may have conflicted with other priorities, and while meetings could be rescheduled, that very rescheduling process may be perceived as inconvenient. Of note is the fact that the study ran into the last weeks of each semester, coming close to finals and likely conflicting with academics. Even outside of finals, the ten-week period likely ran through other stressful times of the year, including mid-term examinations. The team scheduled sessions directly before and after, but not during, the academic break periods, specifically the Spring break in March 2009 and the Thanksgiving break in November 2009.

Additionally, the study required participants to wear the heart rate monitor watch and chest-strap throughout each session. To put on the apparatus, individuals had to position the chest strap directly above the top of the rib cage, with direct skin contact. For this reason, individuals may have had discomfort issues. Perhaps related is the reality that nine out of ten coaches were male, which may have discomforted the female participants in the study. These and the other factors mentioned above were unfortunate but unavoidable in balancing the accommodation of research participants with the need for basic controls and data collection in a scientific study.

The primary obstacle in the study was the need to recruit sufficient participants. Unless recruiting proved highly successful, which it did not, retention of

participants became even more important. Ultimately, retention rates proved to be one of the largest potential weaknesses in our research. Severe dropout rates jeopardize the validity of all results, and a research population that is too small prevents the ability to make broad conclusions. One particularly large issue is that the loss of participants in the spring led to uneven group sizes, whereby disproportions in size may have skewed results. Inconsistent attendance created almost as many problems in trying to accurately analyze data and thereby draw conclusions. Many participants either did not attend a number of sessions during the semester or left the study partway through.

To combat retention problems and further entice participation, our team offered various incentives and encouragements to participants. Each team member was charged with keeping frequent, friendly and encouraging contact with their participants, and being generally positive with regards to the study, and working to form a bond with each of his/her assigned individuals. The overall goal was to help the participant feel accountable to the coach, thereby accountable to the study. The interactive gaming setups were also made available for those participants assigned to the control group who still wished to play DDR. For each session a participant attended, their name was placed in a raffle for a Wii console, to be held at the conclusion of the semester. A final wrap-up party was held at the conclusion of each ten-week research phase, at which point the raffle for the Wii was held, and smoothie coupons were given to each participant who had attended at least fifteen of the thirty scheduled sessions. All of the participants for the semester were gathered at this meeting, which was arranged much like the format of the initial “meet-and-greet”,

with refreshments provided and the interactive gaming equipment set up for interested individuals to play.

Participant health presented another large variable which was outside the team's control. Behaviors and activity outside of the study could not be controlled, and were only potentially accounted for through the use of activity logs. Diet and nutrition were not controlled or recorded, and could potentially have affected results. The initial survey and PAR-Q forms included questions regarding the health of prospective participants, helping researchers avoid exposing them to health risks as a result of the study, but other health factors such as mental health and genetics could not be controlled. Other factors not covered by the study's data collection and initial screening procedures include extraneous lifestyle factors such as work, and academic factors such as an individual's major, course load, and grade-point average.

Beyond health, individual interest and ability or skill levels could also have affected the results acquired. As groups were assigned at random and permanently, participants had no choice in their designated group. If a participant were assigned a group that he/she was not interested in, that participant may have been less motivated to stay with the study and show up consistently. Also, some participants appeared to be already skilled or knowledgeable at Dance Dance Revolution. While this may have eased adapting to the research conditions, it may also have caused some to grow bored with the games and songs available. This was a problem during the Spring 2009 research phase, when a higher percentage of initial participants seemed to have a great deal of prior experience with the game.

Potentially, there are also alternate explanations for our findings which should be considered. As these factors were not controlled in our research, changes in diet or outside activity levels, whether in more or less healthy directions, may have affected the outcome of the study. The activity logs provided to each participant did include a section asking whether he or she had made any serious changes to diet or exercise outside the bounds of the experiment, but this information does not represent an actual control, nor is its accuracy verifiable. As mentioned above, there was the inherent potential for disparities between what was reported in activity logs and what actually occurred. Such disparities could have led researchers to reach incorrect conclusions about the experiment. At best, members of the researcher team encouraged participants to be as accurate as possible in their reporting. Ultimately, given the nature of the study, it was impossible to control for every facet of participants' lives, which needs to be taken into consideration when examining any conclusions reached.

CHAPTER IV: DATA ANALYSIS

Qualitative Data

As the goal of our study was to determine whether interactive games would increase the activity levels of the participants, the data that could indicate activity levels was the most important. The activity logs would clearly indicate activity levels, as well as the collected resting heart rate data, attendance of the sessions, and observations of the participants.

Activity Logs

The team had intended to have the participants fill out activity logs so we could analyze and find trends in their activity levels outside of the study. Unfortunately, upon receiving the activity logs, the team realized that we could not use them as we had hoped. We only received a complete set of activity logs from a two participants, and even those that we did receive were not enough to show any trends. Much of the collected activity logs indicated that the participants either did the exact same thing every week or their activity levels scattered enormously from week to week (across all groups and semesters), suggesting that there was no trend that a participant was exercising more (or less) because of our study. It was important to note that the collection of the activity logs varied in both semesters (it was electronic in Spring 2009 and on paper in Fall 2009), which could have affected the completion of the logs. The reason we changed from electronic to paper was the hope that participants would remember to fill them out if they had a piece of paper in their hand, as opposed to remembering to go online and fill them out.

Resting Heart Rates

We had also intended to collect the resting heart rates of all of the participants at three separate times during the study (beginning, middle, and end) so that we could analyze the change in resting heart rates to determine if there were any changes in the fitness levels of the participants. However, many of the participants only submitted one or two of the three desired resting heart rates, as seen below in Table 1.

Table 1: Resting Heart Rate Data

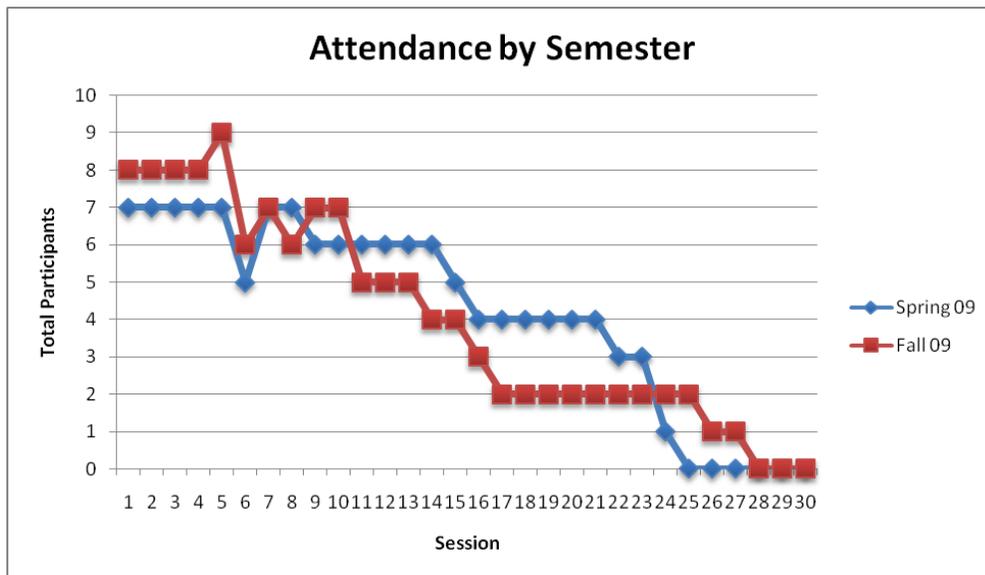
| Participant ID | Start RHR | Middle RHR | End RHR | Sessions (out of 30) |
|-----------------------|------------------|-------------------|----------------|-----------------------------|
| 04217 | N/A | N/A | N/A | 6 |
| 03975 | 80 | N/A | 75 | 11 |
| 07164 | N/A | N/A | N/A | 12 |
| 04728 | N/A | N/A | N/A | 13 |
| 02713 | 70 | 64 | 66 | 28 |
| 06614 | 58 | 58 | 57 | 17 |
| 06155 | N/A | N/A | N/A | 7 |
| 05871 | N/A | N/A | N/A | 3 |
| 09384 | 67 | 67 | 48 | 26 |
| 08793 | 72 | N/A | N/A | 18 |

This small number of data points made it fruitless to analyze the changes in resting heart rate, as it would be difficult to make a sound conclusion based on the comparison of data points between the Traditional Exercise Group and the Interactive Gaming Group. Regardless, analysis of the existing resting heart rate data that we had indicated that there were no statistically significant changes in any participants resting heart rates, as most stayed the same, although some went up, some went down, and some wavered between one and three points.

Attendance and Retention

A graph of our participant attendance by study semester is displayed below in Figure 1. Each study session number is represented on the horizontal axis, while the vertical axis shows the total number of participants who attend each respective session.

Figure 1: Attendance by Semester



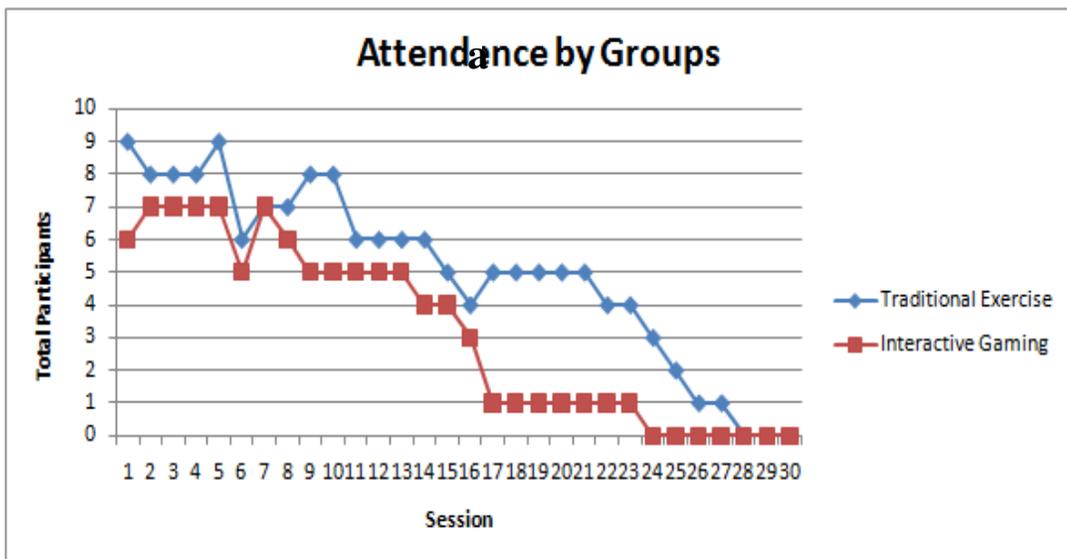
The most apparent characteristic of this graph is the steep downward trend for both semesters; in each semester, the total number of participants eventually fell to zero. This means we had no study participant complete all thirty sessions during Spring 2009 or Fall 2009. Seven participants was the highest total number of subjects who attended the same session during Spring 2009; for Fall 2009, the highest attendance was nine. Both highest totals occurred on Session 5.

We estimated the retention rate with a straight-line approximation of the slopes at their maximums and minimums since these extreme values occurred at the beginning and end of the sessions. During Spring 2009, seven participants attended Session 5, and zero participants attended Session 24. On average, we lost one

participant every 3.286 sessions. During Fall 2009, nine participants attended Session 5, and zero participants attended Session 28. This equates to losing one participant every 2.556 sessions. Though on average there was a longer period of time between participant dropouts for Spring 2009, the graphs for both semesters cross multiple times, making it difficult to determine where retention was stronger.

Similar to the above figure, Figure 2 depicts our participant attendance by study group, either the Interactive Gaming group or the Traditional Exercise Group. The focus in this graph is the group characteristic; therefore, all other distinctions, such as the semester differences, have been ignored here.

Figure 2: Attendance by Groups



Because the attendance for both the Spring 2009 semester and the Fall 2009 semester steadily decline over the sessions, attendance for each study group decreases over time as well. Another characteristic of the graph is the separation between the two lines. This gap shows that the Traditional Exercise Group's attendance was

consistently higher than the Interactive Gaming Group's attendance. Nonetheless, both groups attendance eventually hit zero by the end of the study.

We used the same straight-line approximation of the slopes at their maximums and minimums to estimate retention rates for each group. For the Traditional Exercise Group, nine participants attended Session 1, and zero participants attended Session 28. On average, one participant left our study every 3.111 sessions. For the Interactive Gaming Group, seven participants attended Session 2, and zero participants attended Session 24. Approximately 3.833 sessions passed between each participant dropout. The average retention rate the Interactive Gaming Group is nearly a full session higher than the retention rate for the Traditional Exercise Group. Even though initially we were able to recruit more students for the Traditional Exercise Group, this group had a lower retention rate than its counterpart.

Missing sessions were the most obvious problem the team had, as seen in the figures above, as most participants did not make it to all thirty sessions as the team had hoped. There were many reported reasons for missing sessions: participants would get busy with other schoolwork and not show up to their scheduled sessions (sometimes with warning, sometimes without), some would get sick or be injured and therefore could not perform as scheduled (although some participants managed to reschedule their sessions), and at times, participants would simply not show up for their scheduled time. After the break (either spring break or Thanksgiving break) this problem worsened because participants became overwhelmed with increases academic and extracurricular responsibilities. Controlling when our participants wanted to come was extremely difficult, as the team could not force them to show up.

Additionally, there were other difficulties simply scheduling the sessions, especially the DDR sessions, as the availability of the locations for the sessions was also limited.

In addition to participants missing sessions, the team also had collection errors with the heart rate monitors, which may have contributed to the lack of attendance. Occasionally, the heart rate monitors were not being read by the watches (where the data is stored until transfer), and thus the data that the team would get was blank. Also, it happened that several times the participant would accidentally or inadvertently hit the watch, which would cause it to stop recording. This would not be noticed until later on in the session when the time could not be made up. Moreover, sometimes participants would forget to turn the watch on the proper channel so their heart rate monitors would record, also resulting in no data or starting the data collection in the middle of a workout (when the error was corrected). We attempted to minimize these problems by having the participants check the time every so often to make sure the watch was still collecting data.

Observation of Participants

Although we could not get any data from the activity logs, we learned about our participants' activity levels through observation. One common story was that the interactive gaming participants tended to focus less on time than the traditional exercise participants. On many occasions these participants would not realize that their session was over and continue to play a couple more songs. However, with the traditional exercise participants, the team noticed a great deal more clock watching. Participants would keep track of how much longer they would need to run or walk, and while some seemed to enjoy the exercise, it was evident that they were very

aware of the remaining time.

As coaches we also noticed our participants trying harder to push themselves. Interactive gaming participants would try songs above their skill level to try to improve. One traditional exercise participant was committed to running for at least twenty-five minutes so as to not let down his coach. The team also noticed that guilt (of not showing up or not performing well) helped drive participants to come to more sessions and work harder.

In addition, an important finding for the team to interpret was that the motivation of the participants changed greatly throughout the course of the study. The participants often indicated that staying up late, having long days, working out, and dealing with family issues, injuries, or sickness, among other things, were the causes of their lack of effort in that day's session. This caused the participants to noticeably put in much less effort than usual and therefore their heart rates did not elevate as they previously had.

Quantitative Data

The qualitative data described above was primarily used to discuss our research questions on using interactive games to motivate college students to get active. However, to broaden our research, we decided to extract the heart rate data from the monitors to examine the relationship of how traditional exercise and interactive gaming affect an individual's heart rate.

Statistical Assumptions

As with many experiments, during the analysis of our data we were discovering it to be by no means perfect. Project errors and confounding variables

discussed later in the paper all contributed to the inability to form a perfect model of the data. However, this was not discouraging due to the common nature of such errors in experimentation. The way to correct these errors was by making several assumptions that either limit certain variables or simplify the model. For the analysis, several statistical assumptions were made for that reason.

The first assumption made by Team F.I.T.N.E.S.S. stated that the heart rate data was a good continuous approximation. Technically, since the Garmin Training Center recorded heart rate data in five-second intervals, and therefore a finite range, each point should have counted as a discrete variable. However, these points were proposed to be continuous approximations since heart rates do not drastically change in a span of five seconds under normal conditions. In the event of a medical emergency, such as a heart attack or shock, the heart rate could change instantly, but since no such problems occurred in the study, it was safe to assume no severe variations occurred within the five-second time spans.

Assuming the heart rate data to be a continuous approximation also allowed Team F.I.T.N.E.S.S. to easily analyze the data. With such a large amount of data it would have taken an enormous amount of time to analyze each five-second heart rate span. With the continuous approximation assumption, larger intervals were created based on averages because they retained the general properties of the actual data. This allowed Team F.I.T.N.E.S.S. to analyze the data more closely in a specified amount of time while finishing other aspects of the study.

Another assumption made by Team F.I.T.N.E.S.S. to ease analysis was that there were no statistical differences between the variances of the heart rates of the fall

semester compared to the spring semester in which the project ran. By combining the data from both semesters together, Team F.I.T.N.E.S.S. increased total sample size which strengthened ability to make conclusions. The main focus of the team dealt with the differences between the group variable, i.e. DDR or traditional exercise, not the semester in which the study occurred so assuming the semesters can be lumped together as one gave us a better understanding of the analysis of the data as a whole.

A third assumption Team F.I.T.N.E.S.S. made was a constant perceived exertion from one session to the next for each participant. Because the data the team dealt with was based on human participation, which can change drastically from day to day, this was a very large but necessary assumption. During any given session, there were many factors that affected how hard a participant tried and therefore how high their heart rate reached. If a person was tired, stressed, worried, or feeling any similar emotion, their actual participation effort could have varied greatly. However these variations posed a problem to the team's model, limiting any generalizations of the data from group to group. If each participant's exertion level differed from each session, it would have been impossible to directly compare the results without knowing the actual amount of energy expended, which was beyond the scope of the project. By assuming the same level of exertion from session one to session thirty, the team was able to see a more generalized trend and make conclusions for each group.

Finally, another important assumption the team made was that any missing data were "missing as random". Throughout the extent of the project, a few times data were missing for a reason. For example: heart rate monitors were not used

correctly, data were erased accidentally, or more commonly, a participant did not show up. However, in order to ease the analysis of data, the team made the assumption that there was no apparent trend for the missing data. Without a particular trend, a possible variable that would alter our results was avoided. This assumption also allowed for proper regression analysis. With data labeled as “missing as random” values were assumed for those missing data points based on the averages of similar results. This allowed the team to complete an analysis with the regression models.

As is illustrated above, when dealing with an experiment, many assumptions must be made in order to simplify the results into a system capable of being analyzed. With these assumptions, the team was able to create a realistic, generalized model of data and therefore concluded on the effectiveness of interactive gaming compared to traditional exercise.

Heart Rate Data

For analysis, the heart rate data were separated into two sets: the complete heart rate set, which looked at the data overall separated by semester, group, session, and three minute average; and the in/above target heart rate set, which looked at the percentage of time the individual was in or above the target heart rate zone for each session and then averaged out for each group. In the study, Team F.I.T.N.E.S.S. was interested in the time the participant was undergoing strenuous exercise, which correlated to the time the participant was in or above his or her target heart rate. However, analysis of the complete data was also important because the time spent below the target heart rate, although not considered strenuous exercise, is useful in

determining the effectiveness of the mode of exercise. For each of these sets, Team F.I.T.N.E.S.S. ran a series of three analyses in order to interpret the raw data. The first analysis was observational based on box charts to get an overview of the heart rate data. Next, the team analyzed the data using a t-test to compare classification averages based on groups as the session progressed. Finally, the team used a regression analysis to look for any patterns in the data.

The data the team used to perform these analyses had some notable observations regarding participation rates. One such observation was the affect of the dropout rate of participants and the participants' individual dedications to come to all thirty sessions, which confirmed the importance of the attendance data in the Qualitative Data section above. In Table 2, one can see that 3217 pieces of datum were missing out of 6120, meaning almost 53% of the data was never collected due to equipment failures, manual error, or the participant not attending a session.

Table 2: Data Availability

| | Group | | Total |
|-----------------------|--------------|----------|--------------|
| | 0 | 1 | |
| Data Missing | 1509 | 1708 | 3217 |
| Data Available | 1731 | 1172 | 2903 |
| Total | 3240 | 2880 | 6120 |

Additionally the data showed drastic participation variances between the Traditional Exercise Group with one person completing twenty-seven sessions while the Interactive Gaming Group did not have anyone coming to more than twenty three

sessions. Although this missing data was detrimental to the team’s analysis, we believed the analysis could still be performed. However, as previously mentioned in our assumptions, this missing data were “missing as random” and therefore could not be used to interpret why the Interactive Gaming Group attended fewer sessions because there is no trend in the missing data.

Another notable observation was the difference between the mean and maximum maximum average heart rates between the two groups, which can be seen below in **Figure 3**

Figure 4. At first, the Traditional Exercise Group had a maximum value of over 200 BPM (beats per minute), but these values dropped over the sessions to values in the 170 BPM range. On the other hand, the Interactive Gaming Group maintained a fairly steady maximum heart rate around the 175 BPM range. The mean data values for the Traditional Exercise Group were fairly steady around 150 BPM while the Interactive Gaming Group had continuous improvement in its mean, rising from 108 up to 150 BPM range.

Figure 3: Average Heart Rates for Traditional Exercise Group

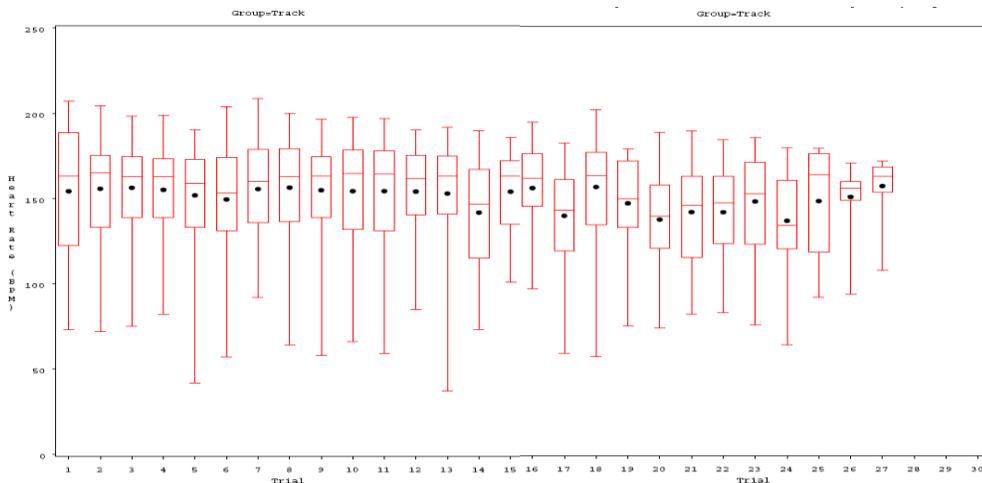
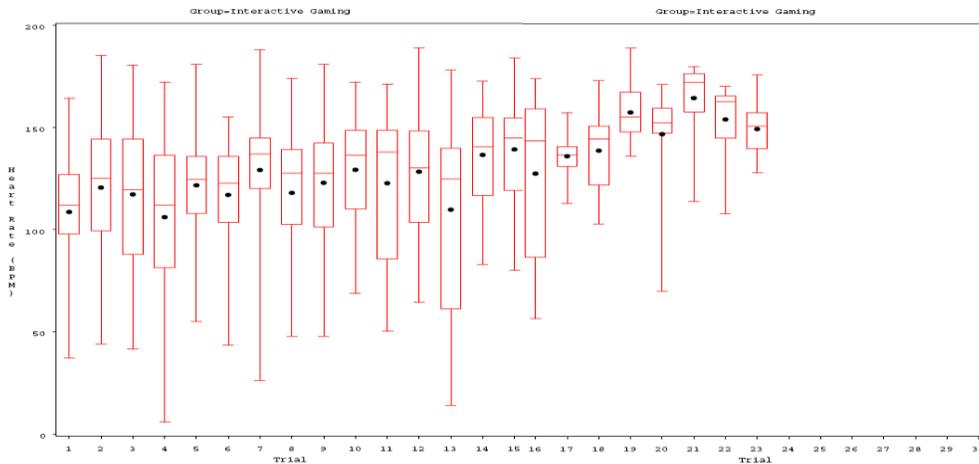


Figure 4: Average Heart Rates for Interactive Gaming Group



Both of these statistics demonstrated that the initial values for the Traditional Exercise Group showed a higher level of exertion by the participants, but by the end of the study, both groups had similar values. It was important to note though that as the study progressed there were less data points to analyze, which could have greatly altered the results, as demonstrated in the previously discussed attendance graph. Therefore, the rise in the Interactive Gaming Group's heart rate could also have been caused by the dropping out of the participants who recorded lower heart rates, increasing the average among those participants that remained.

Other observations could be made by plotting the points from the three-minute intervals as seen below in Figure 5 Figure 6. It was possible to see that over the thirty-minute period, the heart rate of the participant consistently increased. Additionally, a minor, downward hump was noted towards the middle of each session. This trend was most likely caused by the participant beginning to tire out

and reducing exertion for a brief period in time.

Figure 5: Three-Minute Intervals for Traditional Exercise Group

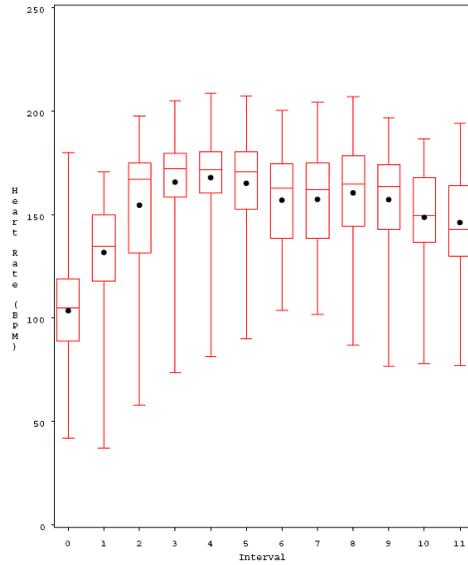
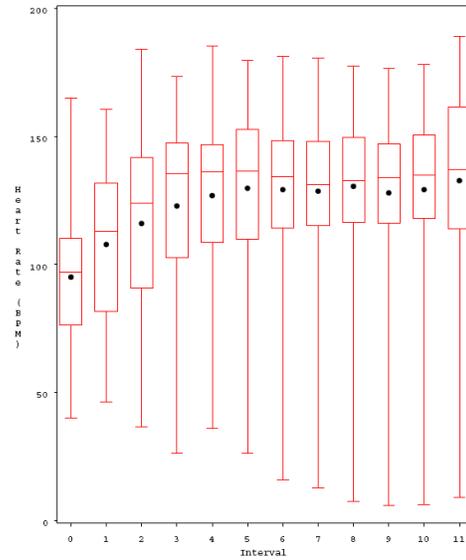
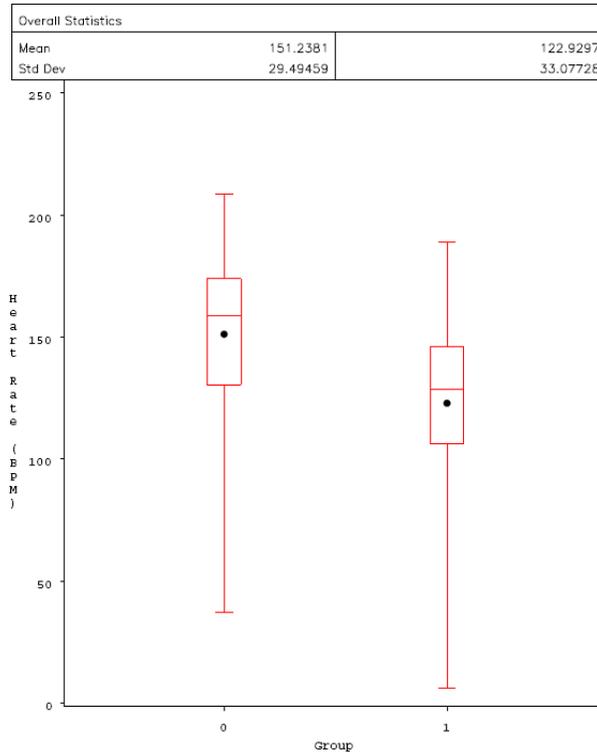


Figure 6: Three-Minute Intervals for Interactive Gaming Group



The last of the observational analysis was performed on the box charts, which were separated based on the two data sets, the complete data set and the in/above target heart rate data set. The complete heart rate set contained all the data collected. This included the data whether it was in the target heart rate zone, below it, or above it. From the descriptive statistics the mean heart rates from the Traditional Exercise Group were larger than those from the Interactive Gaming Group, as seen in Figure 7. However, it was important to note the means tended to decrease over time for those in the Traditional Exercise Group, while increasing overtime for the DDR group. Overall, the mean heart rates in the Interactive Gaming Group were still lower than those of the Traditional Exercise Group at the end of the study, but the values are converging. These effects were highly affected by dropout rates since the number of data points decreased over time as individuals left the study. With less data to analyze, and only data from committed participants, the mean was sure to increase.

Figure 7: Comparison of Heart Rates Between Groups



In order to determine whether or not the difference in means was statistically significant we performed a t-test using the average heart rates. In the first t-test we used the total average heart rate for the entire study for each group. Table 3 below, shows the results of the t-test.

Table 3: T-Test Results for Comparison of Groups

| Variabl e | Grou p | Mean | P- value |
|----------------------|-------------------|-------------|---------------------|
| realHR | 0 | 151.2 4 | <0.000 1 |
| realHR | 1 | 122.9 3 | |

With a P-value of <0.0001, with even the highest levels of confidence it would

still reject the null hypothesis that the two mean heart rates are equal. This allowed the team to accept the hypothesis that the average heart rate for the Traditional Exercise Group is in fact greater than that of the Interactive Gaming Group.

Further analysis involved t-tests comparing the average heart rates for each session between the groups to see if the averages were always greater for the Traditional Exercise Group or if there was a point where the heart rates may have converged with the Interactive Gaming Group, seen below in Table 4.

Table 4: T-Test Results for Comparison of Heart Rates between Groups for Each Session

| | | | | | | | | | | | | |
|----------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Session | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| P-value | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |

| | | | | | | | | | | | |
|----------------|--------|-------|-------|--------|-------|-------|-------|-------|-------|-------|-------|
| Session | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| P-value | <.0001 | .3446 | .0027 | <.0001 | .6859 | .0397 | .1858 | .2859 | .0095 | .1201 | .8912 |

Looking at the results for several of the sessions we noticed that the P-values are all <0.0001 until Session 14 where it reaches 0.3446. A P-value of 0.3446 would indicate that we would not reject the null hypothesis and that the two mean heart rates were equal. Looking at the next several sessions, the team noticed that the P-values began to vary, sometimes rejecting the null hypothesis while at other times accepting it. These jumps were caused by the lack of data collected in the later sessions. Looking at trial 18, we saw that there were only fifty-nine observations for the Traditional Exercise Group and twelve for the Interactive Gaming Group. This indicates that there was only one participant in the Interactive Gaming Group and five participants in the Traditional Exercise Group who completed eighteen sessions.

Thus, there are not enough data points to make any conclusions from later trials.

After performing the t-tests, the team tried some simple regression analyses to attempt to find out which variables actually affected the heart rates of the two groups. A regression equation will let the team predict the average heart rate if given different data variables: what group, trial, and interval the participant was in. The results for the simple regression test can be seen in below in Table 5.

Table 5: Regression Test Results

| Variable | Estimate | P-value |
|-----------------|-----------------|----------------|
| Group | -27.99348 | <0.0001 |
| Session | 0.08914 | 0.3058 |
| Interval | 2.26086 | <0.0001 |

The first variable taken into consideration was group. The P-value was <0.0001 therefore we knew this variable was significant. According to the chart, the estimate for the group variable was -27.99348. This meant that if you were in the Interactive Gaming Group, your heart rate would be 27.99348 beats less than if you were in the Traditional Exercise Group. This number made sense given that the t-tests showing that the Traditional Exercise Group had higher heart rates on average. The next variable was session, where the P-value was 0.3058. This meant that this variable was not significant and that the average heart rate from Session 1 to Session 30 did not vary greatly. This result was not surprising given the poor retention rate of participants as well as the short amount of time the study ran. Generally, it takes a much longer study to see a major change in heart rate. The last variable taken into consideration was interval, which represented the three-minute average heart rate intervals for each participant. The P-value for this was <0.0001 and thus the variable

was significant. With an estimate of 2.26086, as we go along in a session the average heart rate increased by 2.26086 every 3 minute interval. This followed our previous observation of an increase of the heart rate throughout each session since participants started from resting and would slowly get more intense.

Looking only at the data within the target heart rate the team could create separate box plots based on the percentage of time each individual spent within or above the target heart zone. In Figure 8 through Figure 11, we saw that the time spent in or above the target heart rate zone seems to have a consistent mean throughout the duration of the study. It was also noted that some participants never reached the target heart rate zone, while others never left it. On average, the participants spent over half of the session in or above the target heart rate range. However, it was important to again note that there may have been incomplete data which could alter the actual amount of time a participant spent in their target heart rate zone.

Figure 8: Proportion of time spent InTHR for Traditional Exercise Group

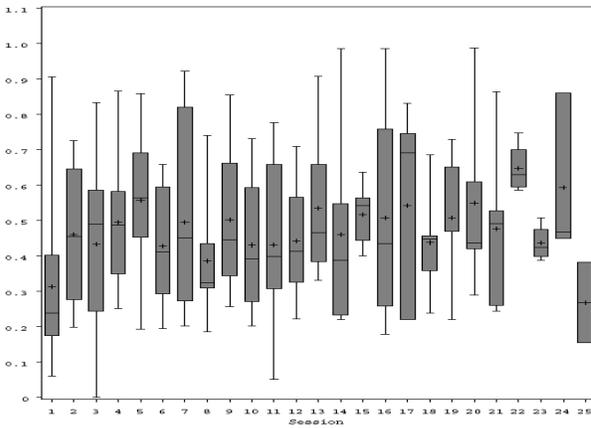


Figure 9: Proportion of time spent InTHR for Interactive Gaming Group

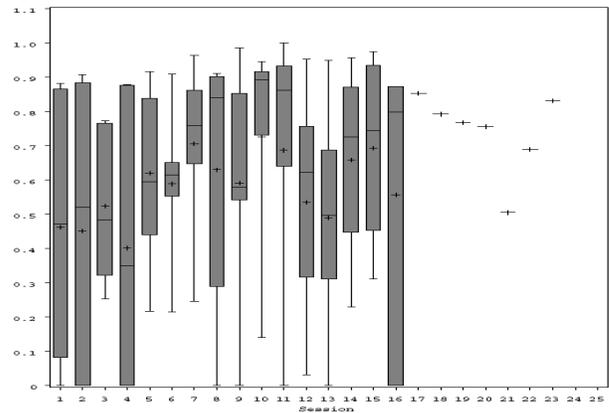


Figure 100: Proportion of time spent AboveTHR for Traditional Exercise Group

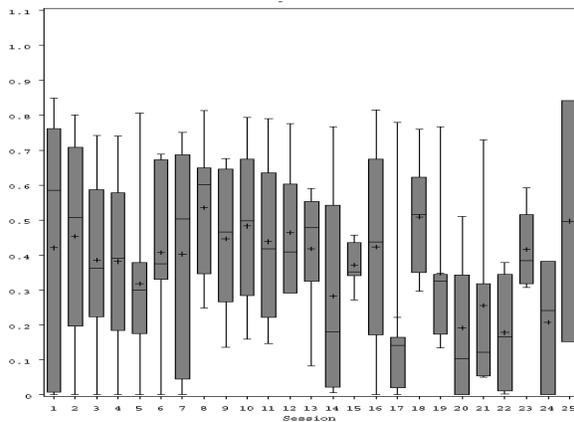
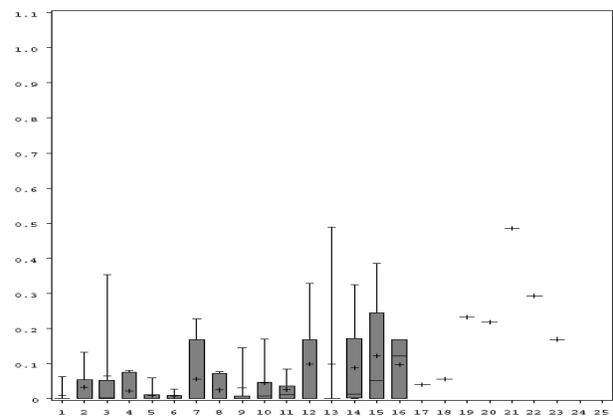


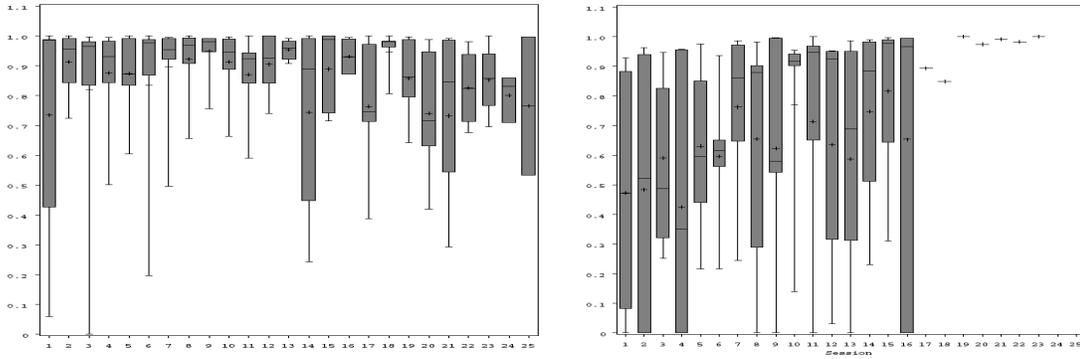
Figure 11: Proportion of time spent aboveTHR for Interactive Gaming Group



When looking at time in and above target heart rates by group the team noticed that the Traditional Exercise Group spent more time in and above their target heart rate when compared to the Interactive Gaming Group. These graphs can be seen in Figure 12 Figure 13 below. Since, on average, the Traditional Exercise Group had a higher heart rate, it made sense that this would correlate to the group lasting a longer time in or above their target heart rate. However, with this data it was a good idea not to look into the extreme points; many of these points which give one hundred percent in/above or zero percent in/above were due to problems with data collection.

Figure 11: Proportion of time spent InTHR and AboveTHR for Traditional Exercise Group

Figure 12: Proportion of time spent InTHR and AboveTHR for Interactive Gaming Group



To see if the difference between in target heart rate values and above target heart rate values was significant the team performed several more t-tests. In Table 6, one can see the results from two t-tests the team performed comparing these values as inTHR and aboveTHR. inTHR reported a P-value of 0.0012 while aboveTHR reported a value of <0.0001. This meant we could reject the null hypotheses that the differing percents between the Traditional Exercise Group and the Interactive Gaming Group were the same for both inTHR and aboveTHR.

Table 6: T-Test Results for Comparison of InTHR and AboveTHR between Groups

| Variable | Group | Mean | P-value |
|-----------------|--------------|-------------|----------------|
| inTHR | 0 | 0.4763 | 0.0012 |
| | 1 | 0.5881 | |
| aboveTHR | 0 | 0.3836 | <0.0001 |
| | 1 | 0.0598 | |

This tells us that the Traditional Exercise Group spent a greater percentage of time above their target heart rate compared to the Interactive Gaming Group.

Although both groups spent the same amount of time in their target heart rate, the Traditional Exercise Group spent a significant amount of time above their target heart rate. This explained why the average heart rate was greater for the Traditional Exercise Group as more time spent above their target heart rate would greatly increase the overall average heart rate.

Team F.I.T.N.E.S.S. also did two regressions, one for inTHR and one for aboveTHR, to see which variables affected these two values. The results for both inTHR and aboveTHR can be found seen in Table 7 below. The variable group for inTHR had a P-value of 0.0004, which was small enough to suggest that the group the participant was in had an effect on their time inTHR. The estimator was 0.12611, which meant participants in the Interactive Gaming Group spent twelve percent more time in their target heart rate than those in the Traditional Exercise Group. The P-value for session was 0.0116, not that small but still considerably small to be considered significant. Again session was a significant variable, with an estimator value of 0.00742. This was only a fraction of a percent, but when you get into Sessions 14 and 15 it can increase the time inTHR by a few percent. This indicated that as participants came and did the study, they would stay in their target heart rates for longer periods of time as the study progressed.

Table 7: T-Test Results for Comparison of InTHR and AboveTHR for Groups between Sessions

| THR | Variable | Estimate | P-value |
|------------|-----------------|-----------------|----------------|
| inTHR | Group | 0.1261 | 0.000 |

| | | | |
|--------------|--------|--------|-------|
| | | 1 | 4 |
| | Sessio | 0.0074 | 0.011 |
| | n | 2 | 6 |
| aboveT HR | Group | - | <0.00 |
| | | 0.3327 | 01 |
| | | 9 | |
| | Sessio | - | 0.445 |
| | n | 0.0018 | 9 |
| | | 2 | |

As with inTHR, the team tested two variables to see if they would fit into the regression equation for aboveTHR. The P-value for group was <0.0001, thus, as expected, it was significant. The estimator was 0.33279, meaning that if a participant was in the Interactive Gaming Group they would spend thirty-three percent less time above their target heart rate than that of someone in the Traditional Exercise Group. The P-value for trial was 0.4459, which indicated no significance from Session 1 to Session 30 in determining the time above the target heart rate.

The last test the team executed was a multiple regression test. The hope was to get a better regression equation than we did with the simple regression conducted prior to this. The team had three variables which we were examined: Group, Session, and Interval. Unfortunately, as stated earlier, over half of our observations were missing and therefore could not be used. Upon trying to run this test we received an error which stated that we did not have enough data for there to be a conclusion. The

missing data points, and lack of overall usable data made this test fail, which means we could not infer much from its failure other than we needed to collect greater quantities of data for it to work.

Through our statistical approach we were able to discover many things about our study. However, we also discovered how a lack of data can greatly affect the conclusions that can be made. Though our study was not perfect, we were able to obtain enough data and analyze it to make some general ideas relating interactive gaming to traditional exercise.

CHAPTER V: RESULTS AND DISCUSSION

Heart Rate Data

An analysis of the heart rate data through numerous statistical means led to various conclusions regarding the results of the study.

As described in the data analysis chapter, the heart rates from all sessions were reduced to three-minute intervals to determine whether a significant change in heart rate occurred throughout the ten-week progression of the study. The results found that there was no significant change in the average HR across each week of the

study. This could indicate that neither group showed an improvement in overall fitness; however, variations in intensity from week-to-week reflected differently.

The most significant conclusions were presented upon examination of the heart rate data for each group, with respect to the target heart rate zone (THR Zone). The Traditional Exercise Group spent 47.63% of training time in the THR Zone and 38.36% of training time above the THR Zone; while the Interactive Gaming Group spent 58.81% of training time in the THR Zone, but only 5.98% of training time above the zone. This distribution indicates a higher workload (intensity) for members of the Traditional Exercise Group. This significant difference amongst THR Zone training intensities between the two groups corresponds somewhat to the different activity levels for cardio fitness according to the ACSM.

One limiting factor in the analysis of the heart rate data is the issue of retention. Some of the participants only lasted just a few sessions prior to dropping out of the study. Also, even when excluding those who dropped out, little more than fifty percent of the sessions were attended in Fall 2009 and seventy-five percent of the sessions were attended in Spring 2009. This lack of consistent participation resulted in less data for analysis and possible inconclusive results, as the participants were expected to engage in the scheduled exercise, and yet were unable to do so and have this recorded. .

Additionally, the trends across each group varied. Whereas the heart rates for the Traditional Exercise Group progressed to an early peak, followed by a gradual reduction and finally another peak before the end, the Interactive Gaming Group was much different. This group showed a large grouping of peaks and valleys over a short

period of time. Following each song, the heart rate would go down and would only increase once beginning the next song. However, this is a significant point and there are two main benefits from this finding. First, future interactive game creators can potentially limit the pauses between songs by adding a workout mode which allows users to create a continuous song playlist. Secondly, it can be beneficial to exert maximum energy in short bursts and follow it with pauses, as in sprinting or interval training. Thus, game creators can add another section to the workout mode. If users are encouraged to exert maximum effort during game-play with short pauses in between songs they will experience the benefits of increased endurance. It is also important to note that the peaks were not nearly as high as those found in the Traditional Exercise Group, so the comparable intensity was much lower. The proposed workout mode may solve this problem and encourage users to play with greater intensity.

Another limit of these results is the varied levels of intensity performed for each session and each group. For the Interactive Gaming Group, the heart rate level is raised by inexperience, so as a participant becomes more accustomed to the speed and pace of the game, the overall heart rate goes down, even as the difficulty is raised. For the Traditional Exercise Group, running intensity can be affected by boredom or monotony of the activity, an injury, and the possibility that social interaction or entertainment is lacking.

Resting Heart Rates

The results for the analysis of the resting heart rate data for all participants over the course of the study is shown to be inconclusive. The change from the

beginning to the end, initially expected to be a small reduction in the resting heart rate (at least for running) is not statistically significant. A reason for this is the method used for sampling the resting heart rate. Specifically, a self-report method can be easily neglected and/or have a high degree of error, resulting in a smaller sample of data points used for analysis.

Activity Logs

Besides measuring the participants' heart rate during training, as well as recording their resting heart rates, the study used self-report activity logs to track participant activity outside of training sessions. Each coach was responsible for distributing and collecting completed activity logs to his/her participant(s) at the beginning of each week. The logs were designed to address one of the study's most significant confounding variables, the activity outside of the coaches' control. Even if the team could not specifically control this variable, being aware of it would aid in making informed conclusions based on the study's results. Ideally, each participant would have filled out an activity log for each week, but as we will detail later in this section, such was not always the case.

Even though the data from the activity logs were not consistent enough to form a solid conclusion, it did imply trends that allowed us to compare our two exercise groups. For both the Traditional Exercise and Interactive Gaming Groups we found that the training sessions did not have a significant effect on the participants' outside physical activity. The participants in both groups essentially reverted back to their previous exercise habits outside of the study. So if a participant had already been practicing an exercise routine, he/she tended to keep the routine

while integrating the study's training sessions. Similarly, if a participant did not have a previous exercise regimen, he/she did not develop one based upon participation in the study. One significant fact to mention however is that the training sessions became an exercise routine for those without a previously established regimen. So even if these participants did not develop their own routine outside of the sessions, they were exposed to physical exercise on a consistent basis throughout the ten-week study.

The reason that the data from the activity logs proved inconclusive was that there was simply not enough of it to draw conclusions. The logs were not completed on a consistent basis, leading to an unaccounted gap in the recorded outside physical activity for many participants. Indeed much of the fault lies with the coaches, but it is difficult to ask full-time students (the participants), who are already generously volunteering their time to the study, to also record all physical activity they performed outside of the study. While it is disappointing that the activity logs did not meet the intended purpose, we cannot fault the participants as their schedules were already busy even before they volunteered to participate.

Additionally because retention was a continuous, underlying pressure, coaches worried that continued annoyance to participants regarding logs would force their early termination from the study. While all participants were given an activity log at the beginning of each week, the coaches could not show their frustration when the logs were not returned because the team had so few fully participating study members. As the team could not risk losing the participants, we did not get enough data from the activity logs and thus cannot make an adequate conclusion regarding

this data. However, in the future, it would be beneficial to sit down with participants while they fill out the activity logs to answer any questions they may have. Another potential solution would be to remind the participants of the activity log completion, holding them accountable and providing some incentive upon turning the logs in to their coach.

Confounding Variables

Along with the activity logs not working as planned, the study's results were also affected by other confounding variables for which the team could not control. The most significant of these confounding variables was participant demeanor, referring to the commitment with which each individual participant approached the study. The motivational factors were specific to each participant, so we could not adequately address each individual's motivations. Essentially, the participants had to be self-motivated to stick with a ten-week volunteer study. As coaches, we could offer encouragement and incentives, but ultimately it was the decision of the participants whether or not to come to the training sessions and with how much frequency. This variable was simply out of our control and outside of the study's parameters. Much like we could not force the participants to fill out the activity logs, we could not force them to attend the training sessions. The team could only encourage and motivate their participants to attend.

Because of the variety of the participants' schedules and the diversity of their backgrounds, it is difficult to create a general categorization of motivational factors. Still, it is beneficial to attempt a generalization of these factors in hopes of better

understanding why participants' attendance varied so widely from those who completed the entire study to those who only attended two sessions.

Motivational Factors

From the activity logs and personal interaction with the participants, we were able to determine a fairly comprehensive picture of the motivational factors affecting participants in this study. Based on the pre-study surveys we found that most of the participants agreed to join the study because they were looking to develop a steady workout regimen and felt that having a coach would help them to maintain an exercise routine. Again, it is difficult to know the full truth of the motivational factors, as the participants may have felt rude to express their desire to participate only for the incentives. Ultimately, only the participants themselves know why they chose to participate in the study with or without the vigor of full participation.

But even though the team cannot concretely define motivational factors, that does not mean we cannot contemplate the reasons for each participant's motivation. It would be imprudent to assume that the incentives and rewards did not play some role in motivating participation, but it would be just as irresponsible to assume that this was the only factor for participation. The fact is that many of the participants initially began the study seeking to develop a sustainable exercise habit. Those that decided to complete the study accomplished this goal, albeit with the help of a coach. Before the start of the study, many participants expressed concern with the overall lack of physical activity in their college lives. Many had previously been involved with athletic teams or clubs while in high school and had graduated and veered away from routine physical activity. By observing and empathizing with these concerns,

we as coaches were able to understand participant motivational factors beyond the potential rewards.

By also examining the participants who chose not to complete the study, we can understand the detrimental motivational factors of the study. Much of the accounts of coach-participant interaction suggest that the time commitment was the most significant de-motivating factor for participants. The 10-week commitment simply proved too much for some participants, which led to a lower than desired retention rate for the study. Although struggles with retention weren't unforeseen, it was difficult to fully project how many struggles with retention this project would face. Our target audience had such hectic schedules that we predicted some participants being unable to continue because of time constraints. However, what was difficult to project was the way in which each individual participant would be affected by his/her schedule. Some participants chose to continue with the study but to come less frequently. While this was beneficial in terms of accumulating data, it became difficult to draw conclusions on the individual because there were significant gaps in his/her participation. Other participants simply chose to stop coming altogether. This proved to be much more detrimental than the sporadic attendees because the team lost important end of the study data that would indicate any changes in cumulative participant health and heart rate. Depending on the point in the 10-week period that the participant stopped attending, such a development could be very frustrating as it would force all previous data to be applicable only to general group conclusions, rather than allowing the team to examine this individual's specific change. But as was such, these types of motivational factors were out of the team's

control, and unfortunately the pressures of collegiate academics sometimes took prominence over participation in the study. If the team were to redo the study, motivation would be considered as an important variable and tracked in order to allow for further analysis of individual's reasons for joining and sticking with (or not) the study.

Improving the Study

After completing the study, the team has formulated many suggestions to improve upon future research of this nature. The first and most obvious way to improve the study and subsequent results is to get more participants. Though we anticipated it being difficult to retain all the participants over the ten-week period, the retention rates were still far lower than expected. To accomplish this goal of acquiring and retaining a greater number of participants, the easiest way is to increase the amount of semesters spent gathering data from two to three. Something as simple as an extra semester would give us more results with which to base our conclusions. Ideally, we would be able to run the study during a time period in which it would be the participants' main focus. Much of the retention problems arose from scheduling conflicts, and a brief period in which the participants could focus all their energy on the study would undoubtedly prove beneficial to the overall results and conclusions. However, it is worth mentioning that such a time period is idealistic as most college students are overrun with work during the fall and spring semesters and in the summer their lives are occupied by jobs and travel. In the end, it came down to which time period the team thought we could recruit and retain the most participants.

Given that much of the campus population disappears during the summer semester, the fall and spring semesters seemed like the best possible options.

Furthermore, our overall recruiting method and style would have to change slightly as well. In passing out flyers, we mostly focused on the incentive of winning a Wii to draw people to the study. However, it would have been beneficial to focus more on the health benefits each individual could potentially receive by participating in our study. For example, if we were to ask if they would like to improve their fitness levels or have an interactive exercise station at our recruiting tables, it would be more likely that we garnered participants interested in the overall goal of our study than those motivated solely by the incentives.

After completing the study with DDR, we would suggest an exergame with more consistent activity or a variation of DDR with some adjustments. Selecting songs and waiting for them to load caused heart rates to fluctuate, often dropping out of the THR zone. An ideal mode would be a variation of the present one, but include shortcuts to speed up the song selection process. These could include a favorites list of songs that are often played since participants tended to replay songs they enjoyed several times a session. Another suggestion would be a replay and a random next option upon completion of the song. This would bypass the need to open the song load list and quickly progress to the next song. Finally, the mode would have an option to ban songs from the random selection because, like there developed favorites among participants, there were also songs that no one played due to low beats per minute or an unlikable song. This new mode would decrease the time spent waiting on the game and remove some of the fluctuations seen in the heart rate data.

Another improvement to the study aimed at obtaining and retaining participants is the addition of a greater incentive. Cash was proposed at the onset of the study, but the team chose not to offer monetary incentives for fear of skewing the participants' motivational factors. While it can be argued that the presence of any form of incentives, even a Wii raffle, would affect a participant's motivation, the additional confounding of motivation is a better alternative than having large amounts of missing data, as we experienced. After conducting the study twice, we have concluded that some form of guaranteed incentive is necessary if we want to obtain and retain more participants. And though we provided each participant who completed the study with money deposited into their Terrapin Express account, the stipend was minimal (five dollars for a smoothie), and a personal cash stipend for each participant distributed at certain points during the ten-week period would likely go a long way towards increasing retention rates. However, it is imperative that if we are offering a monetary incentive, that the recruiting efforts bring in participants who are truly interested in exercise and fitness so that they do not simply join for the money. Other forms of incentive can include class credit from the School of Public Health (provided it can be approved by the school) or more personal incentives inspired by the coaches (such as: "if we complete a difficult song, we will get smoothies afterwards"). Therefore, the incentives would be related to the goal of becoming fit.

Other ways we have determined will improve the study involve minor changes to the way we collect the data. During our post-study analysis meetings, it was determined that it would be beneficial to the results of the study to measure a

distance traveled by each participant. This can be easily accomplished by requesting that participants wear pedometers during their training sessions. By doing this, we would be able to monitor a distance traveled for participants in both the traditional exercise and interactive gaming groups, allowing us to make conclusions based on the individual and modes of exercise. Since heart rate is more a measure of intensity and how vigorously the participant exercises in the session, the heart rate data tended to be steady from one session to another. By having some count of a distance traveled during each session, we can see if there is an improvement of ability since we found there to be little change in intensity of the workout over the course of the study. We can also use this to further analyze patterns in the data. If we observe an unusual heart rate pattern in any one participant, we would be able to cross-reference his/her heart rate with his/her distance traveled and determine the cause for said pattern. Also, it would allow us to complete an entirely new level of analysis based on a comparison of heart rate data and distance traveled during training. Essentially, it would be one less mitigating factor in the study and one more variable for which we would be able to account.

Accompanying suggestions for improving the data collection methods, we have determined that it would also be beneficial to assign participants to a specific heart rate monitor to make for easier post-study sorting of data. Much of the data complications stem from it being unclear as to which participants' data was on which heart rate monitor. By assigning one coach and his/her participants to one heart rate monitor, we would ensure that each coach is personally accountable for his/her participants. Nevertheless, the complication still exists that our heart rate monitors

were not fully reliable. Ideally the team could have utilized the best heart rate monitors available, but due to budget concerns we were obligated to purchase a lesser model in bulk. Many times the coaches would report malfunctioning equipment, and often only one or two monitors would be working correctly. Ultimately the data would accumulate on the working heart rate monitors, and with ten different coaches using only a few monitors, sorting issues arose. A resolution to this problem would involve improved equipment and would require a budget increase.

Another possible way to improve the study involves dealing with the actual data, specifically the resting heart rates. By asking the participants to record their own resting heart rate outside of the training sessions, the accuracy of these heart rates were in question. The intention was to have participants record their heart rate in the morning immediately after they woke up, as this would be closest to their actual resting heart rate. But again, since we could not be there to remind them, many participants simply forgot, leaving the team with a lack of usable data. To resolve this, we have devised a system in which the coach requires the participant to undergo five minutes of pre-activity stretching while wearing a heart monitor. This method was previously used in a 2006 study conducted by Xuewen Wang and C. Arlette Perry (2006) entitled “Metabolic and Physiologic Responses to Video Game Play in 7- 10 Year Old Boys”. While not an exact science, this five minute period would provide us with a close approximation of the participant’s resting heart rate, and more importantly would ensure that we would obtain resting heart rate data for every participant. Such data would be highly beneficial to any future versions of the study.

Continuing with improving data collection methods, the team has also developed a way to increase the completion of the activity logs. A change is undoubtedly needed in the way the activity logs are distributed and completed, as the logs did not fully meet their intended purpose. To make the logs more effective, we determined that it would be sensible to supervise their completion. Having a coach present not only to give the participant each log but also to ensure its completion would lead to a higher completion rate, consequently providing us more data from which to interpret the participants' motivational factors. Essentially, each coach would be distributing the activity logs at the onset of each session, supervising their completion, and then proceeding with the actual training. The logs could possibly be completed before or after the five-minute pre-activity stretching period, or at the same point in each session to create a routine with which the participants feel comfortable. By physically monitoring the completion of the activity logs, the coach would ensure a sense of accuracy and be able to determine the effort that a specific participant put into his/her answers. It is a minor change, but it is one that would greatly improve the activity logs' significance.

In order to collect further qualitative data for study's purposes, it might also be beneficial to consider setting up one or more focus groups to learn more about participants' experiences in the study. This could also provide a means to resolve any lack of clarity regarding motivations for participation and engaging in physical activity. This sort of information would give additional support to any conclusions that might be drawn from the study.

Thoughts on Hypothesis

The team hypothesized that individuals in the Interactive Game Group would enjoy exercising more than prior to joining the experiment, and would thus increase their activity levels throughout the course of the study. Furthermore, we believed that the Interactive Game Group would increase their activity levels more than the Traditional Exercise Group. The activity levels during the study are, of course, relative to the amount of exercise activity that each individual participant engaged in prior to the study. Therefore, at the end of each ten-week session, we did not only compare across groups, but also compared each person to personal data.

Unfortunately the hypothesis was not proven over the course of the study. The Interactive Game Group had significantly poorer attendance than the Traditional Exercise Group. This, by itself, decreases the activity levels of each participant. For example, if a participant only showed up two out of the three times for a week, that would decrease his/her activity by thirty minutes for that week, and if he/she only showed up for one of the three sessions, the activity level would decrease by sixty minutes. The participants all participated in less than one-hundred and fifty minutes of activity before starting the study. The activity that each participant engaged in during study sessions usually pushed the level over one-hundred and fifty minutes for those who attended regularly. Since attendance was higher for the traditional group, their activity levels were also higher on average. The levels were higher both compared to their starting levels, but also as compared to the interactive gaming group.

Furthermore, the attitudes of the participants in the Traditional Exercise Group were, on average, more exercise-related. These are attitudes related to the activity

itself, but not necessarily related to the relationships with their respective coach (Team F.I.T.N.E.S.S. member). This is to say that the participants in the traditional group came with a hope of engaging in exercise and social activity, while those in the interactive group indicated more interest in the social aspect and the game itself. This may be due to the fact that people (our participants in particular) did not think that DDR would be an effective form of exercise, and did not necessarily put in a maximum effort. However, the participants in the traditional exercise group expected benefit, as running and walking are perceived as an effective exercise technique. Therefore, they came to their sessions anticipating a workout and wanted to exert their best effort.

Moreover, those in the Traditional Exercise Group were much more competitive during their sessions. This relates back to the attitudes toward the activity itself. Running, which most of the participants in the traditional group led up to from walking, is a competitive sport. DDR, on the other hand, is often viewed as a less competitive social activity. Our participants were clearly aware of this, as those participating in traditional exercise were progressively increasing their speed and being competitive with both their coach and with other participants on the track. Although those doing DDR would occasionally move up a level in the game, they were not competitive with their coaches. They were also not competitive with other participants, since only one interactive gaming session could occur at one time. Instead, they were social. That is not to say the traditional exercise participants were not social. In fact, both groups were about equal in this aspect, with regards to socializing before and after sessions. The main difference was that those playing

DDR were performing side-by-side with their coach for the entire thirty minute session, so increased conversation was expected. On the other hand, the traditional exercise participants were often at a different pace than their coach, and therefore not performing side-by-side on the track for the entire session. Therefore, a competitive behavior and habit was started by those in the traditional exercise group. The competitiveness factor may also relate back to the attendance, since when people initiate a competitive behavior, they are likely to continue that behavior, as it is a strong motivating factor to increase performance.

However, there are other possible reasons that the Traditional Exercise Group had higher attendance. The first, and most interesting, factor that we did not consider prior to the study is that sedentary people are often not used to engaging in exercise behavior. Therefore, once they start exercising, they may dispel negative beliefs that they originally harbored toward exercise. The social and competitive aspects that were present in our study, and in particular for the Traditional Exercise Group, were both features that allowed the participants to see that exercise can be engaging and enjoyable. The main conclusion to be drawn from this is that people who are not used to exercising need companionship, a specific time to exercise, and simply to be introduced to exercise. This conclusion is significant – there is a formula for exercise motivation, and it simply needs to be precisely applied in order to be effective. People can gain great benefits from adding exercise to their routine and with help and encouragement, will be able to do so. However, this presently applies to traditional exercise activities more than interactive exercise games. Participants in the Interactive Gaming Group would rather participate in activities such as DDR with

their friends in the privacy of their homes. Our DDR participants indicated this. The fact that they would play with their friends is the highest indicator that it is mainly considered a social activity. Thus we, as a society, must work to redefine DDR and other interactive games as both a social activity and an exercise activity. If this can be done successfully, people not currently exercising can use our conclusions involving companionship, appointment, and introduction to exercise in order to get in a habit of engaging in physical activity.

Benefits from our research

Although the team did not prove the hypothesis, there are many benefits that can be gained from our conclusions. First and most important, people unaccustomed to exercise receive many benefits from having someone to workout with. Someone who holds them accountable to showing up, but also encourages them and shows them that exercise can be fun is the type of person to introduce others to exercise.

Next, we need to more heavily promote interactive gaming as a method for people to get a “real work out”. If the perception at the start of our study was that DDR can be used as exercise, we believe that the interactive gaming participants would have received a much higher benefit from our study. Since the current idea is that DDR is just a game, we need to change people’s minds. Otherwise, people will continue to think that the only way to exercise is through more traditional activities such as running and strength-training.

Although the percentage of time in and above the target heart rate zone was significantly lower for the interactive group than the traditional group, DDR participants were still in or above their target heart rate zone over fifty percent of the

time. Despite the significant difference, all of the participants were not engaging in much, if any, activity prior to the study. Therefore, increasing their heart rate and performing moderately-intense activity a few times a week is a noteworthy improvement. All of our participants also played video games. Prior to the study, these were mainly inactive games, but after our study, many of the participants, even in the Traditional Exercise Group became more interested in interactive games. This small change is extremely beneficial for a person who does not usually engage in activity, and may be enough for weight management and improved health, even if it alone does not reach the ACSM guidelines. Participants in both groups were getting stronger at their respective activity, and this alone is enough to show that participating in either traditional exercise or interactive games is a step up from engaging in little to no activity at all.

The most significant conclusion from our study and from the above benefits is that interactive games are a good stepping point to get people interested in the concept of exercise. Since our participants related that they would prefer to play DDR in the privacy of their own homes, DDR and other interactive games should be promoted as a way to work out in the home until one is ready to get a workout partner to do more traditional exercise. Also, if interactive games are promoted as a form to get an effective workout, or at the least, more effective than no workout, people may use this as their preferred mode of exercise, and may even venture out of the home to participate in the activity with others. Since we did find that the social aspects of playing DDR were so critical to our participants, a possible solution to having the activity in public would be to have an “interactive gaming” inspired aerobic class, or

an interactive gaming room at local gyms. This would, at the very least, catch people's interest and get them into a gym setting, which we have found is another motivator to get moving in and of itself. In summary, interactive games are a good stepping stone to more vigorous exercise techniques and as a supplement to a workout program, but before a large amount of people can get interested and receive the available benefits from starting an exercise routine, the potential benefits of interactive games needs to be publicized.

Overarching Research Problem and Research Questions

The overarching research problem that inspired our study is the increasing rate of obesity and inactivity as a national concern, along with the motivation behind habitual exercise as it pertains to this increase. Although interactive games alone may not be able to solve the problems of obesity and inactivity in the United States, we believe that they can help motivate people to adopt habitual exercise habits.

Interactive games are clearly not for everybody, just as traditional exercise is not for everybody. However, if we can target people in their teens and college years, a group with among the highest percentages of people who play video games and are sedentary, we can change their habits for life, even if only minimally (Ferran, Lee, & Dilworth, 2007). This will not only benefit their health, but those who they have influence over, such as their younger siblings, peers and future families. Therefore, although traditional exercise may increase physical activity levels and raise heart rates more compared to interactive games, interactive games can still be used as an encouragement to exercise and be physically active. The goal, from here is to promote the benefits of interactive games on our campus and beyond.

Where to Go from Here

We would like to publish our results on a national basis, so that people can understand more about the psychology and motivation behind starting to exercise. This may possibly provide inspiration for good ways to start and maintain an exercise habit. It is important to note that this study can be used as the basis for further research, with specific reference to the motivational factors involved with exercise. Though we were not able to address these factors as much as we initially intended, our results can serve as the beginning of future studies and be used to further the understanding behind various exercise methods and their effectiveness. Publishing our results may best be done through writing editorials or attending conferences to present our findings. Increased awareness about the potential benefits of interactive gaming may inspire others with more resources and time to further study this subject, and hopefully start initiatives for increasing availability and knowledge of interactive games. These initiatives will ideally be able to address the limitations of our study, leading to more significant conclusions and a better overall understanding of the benefits of alternative exercise methods. Potentially, this will spark an interest in using games as an igniter for or supplement to an exercise routine. Other methods of sparking interest are to have interactive gaming rooms on campus, and even in the gym, or to have a class about the psychology behind interactive games or an activity class that involves interactive games. These techniques will likely allow people to see that interactive games can be an effective form of exercise. This may even inspire people to play them with an increased exertion of effort, increasing the amount of time spent in and above the target heart rate zone, and thus increasing the benefits received from the games.

APPENDIX

Appendix A: Frequency Tables

Table A-1: Data Recovery Statistics and Participant Frequency (by Group)

| Frequency Percent Row Pct Col Pct | Table of count by Group | | | |
|--|-------------------------|--------------|--------|-------|
| | count | Group(Group) | | Total |
| | | 0 | 1 | |
| Data Missing | 1509 | 1708 | 3217 | |
| | 24.66 | 27.91 | 52.57 | |
| | 46.91 | 53.09 | | |
| | 46.57 | 59.31 | | |
| Data Available | 1731 | 1172 | 2903 | |
| | 28.28 | 19.15 | 47.43 | |
| | 59.63 | 40.37 | | |
| | 53.43 | 40.69 | | |
| Total | 3240 | 2880 | 6120 | |
| | 52.94 | 47.06 | 100.00 | |

Table A-2: Data Recovery Statistics and Participant Frequency (by Time)

| Frequency Percent Row Pct Col Pct | Table of count by Interval | | | | | | | | | | | | | |
|--|----------------------------|--------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|
| | count | Interval(Interval) | | | | | | | | | | | | Total |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| Data Missing | 264 | 264 | 264 | 265 | 266 | 267 | 267 | 268 | 270 | 273 | 285 | 264 | 3217 | |
| | 4.31 | 4.31 | 4.31 | 4.33 | 4.35 | 4.36 | 4.36 | 4.38 | 4.41 | 4.46 | 4.66 | 4.31 | 52.57 | |
| | 8.21 | 8.21 | 8.21 | 8.24 | 8.27 | 8.30 | 8.30 | 8.33 | 8.39 | 8.49 | 8.86 | 8.21 | | |
| | 51.76 | 51.76 | 51.76 | 51.96 | 52.16 | 52.35 | 52.35 | 52.55 | 52.94 | 53.53 | 55.88 | 51.76 | | |
| Data Available | 246 | 246 | 246 | 245 | 244 | 243 | 243 | 242 | 240 | 237 | 225 | 246 | 2903 | |
| | 4.02 | 4.02 | 4.02 | 4.00 | 3.99 | 3.97 | 3.97 | 3.95 | 3.92 | 3.87 | 3.68 | 4.02 | 47.43 | |
| | 8.47 | 8.47 | 8.47 | 8.44 | 8.41 | 8.37 | 8.37 | 8.34 | 8.27 | 8.16 | 7.75 | 8.47 | | |
| | 48.24 | 48.24 | 48.24 | 48.04 | 47.84 | 47.65 | 47.65 | 47.45 | 47.06 | 46.47 | 44.12 | 48.24 | | |
| Total | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 510 | 6120 | |
| | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 8.33 | 100.00 | |

Table A-3: Data Recovery Statistics and Participant Frequency (by Session Number)

| Frequency Percent Row Pct Col Pct | Table of count by Trial | | | | | | | | | | | |
|--|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | count | Trial | | | | | | | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Data Missing | 27 | 36 | 32 | 25 | 15 | 72 | 39 | 48 | 48 | 48 | 75 | 73 |
| | 0.44 | 0.59 | 0.52 | 0.41 | 0.25 | 1.18 | 0.64 | 0.78 | 0.78 | 0.78 | 1.23 | 1.19 |
| | 8.84 | 11.2 | 9.99 | 7.8 | 4.7 | 2.24 | 1.21 | 1.49 | 1.49 | 1.49 | 2.33 | 2.27 |
| | 13.24 | 17.65 | 15.69 | 12.25 | 7.35 | 35.29 | 19.12 | 23.53 | 23.53 | 23.53 | 36.76 | 35.78 |
| Data Available | 177 | 168 | 172 | 179 | 189 | 132 | 165 | 156 | 156 | 156 | 129 | 131 |
| | 2.89 | 2.75 | 2.81 | 2.92 | 3.09 | 2.16 | 2.70 | 2.55 | 2.55 | 2.55 | 2.11 | 2.14 |
| | 6.10 | 5.79 | 5.92 | 6.17 | 6.51 | 4.55 | 5.68 | 5.37 | 5.37 | 5.37 | 4.44 | 4.51 |
| | 86.76 | 82.35 | 84.31 | 87.75 | 92.65 | 64.71 | 80.88 | 76.47 | 76.47 | 76.47 | 63.24 | 64.22 |
| Total | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 |
| | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 |

| Table of count by Trial | | | | | | | | | | | | |
|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| count | Trial | | | | | | | | | | | |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| Data Missing | 73 | 85 | 102 | 121 | 136 | 133 | 133 | 132 | 132 | 144 | 144 | 168 |
| | 1.19 | 1.39 | 1.67 | 1.98 | 2.22 | 2.17 | 2.17 | 2.16 | 2.16 | 2.35 | 2.35 | 2.75 |
| | 2.27 | 2.64 | 3.17 | 3.76 | 4.23 | 4.13 | 4.13 | 4.10 | 4.10 | 4.48 | 4.48 | 5.22 |
| | 35.78 | 41.67 | 50.00 | 59.31 | 66.67 | 65.20 | 65.20 | 64.71 | 64.71 | 70.59 | 70.59 | 82.35 |
| Data Available | 131 | 119 | 102 | 83 | 68 | 71 | 71 | 72 | 72 | 60 | 60 | 36 |
| | 2.14 | 1.94 | 1.67 | 1.36 | 1.11 | 1.16 | 1.16 | 1.18 | 1.18 | 0.98 | 0.98 | 0.59 |
| | 4.51 | 4.10 | 3.51 | 2.86 | 2.34 | 2.45 | 2.45 | 2.48 | 2.48 | 2.07 | 2.07 | 1.24 |
| | 64.22 | 58.33 | 50.00 | 40.69 | 33.33 | 34.80 | 34.80 | 35.29 | 35.29 | 29.41 | 29.41 | 17.65 |
| Total | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 | 204 |
| | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 |

| Table of count by Trial | | | | | | | |
|-------------------------|-------|-------|-------|--------|--------|--------|--------|
| count | Trial | | | | | | Total |
| | 25 | 26 | 27 | 28 | 29 | 30 | |
| Data Missing | 180 | 192 | 192 | 204 | 204 | 204 | 3217 |
| | 2.94 | 3.14 | 3.14 | 3.33 | 3.33 | 3.33 | 52.57 |
| | 5.60 | 5.97 | 5.97 | 6.34 | 6.34 | 6.34 | |
| | 88.24 | 94.12 | 94.12 | 100.00 | 100.00 | 100.00 | |
| Data Available | 24 | 12 | 12 | 0 | 0 | 0 | 2903 |
| | 0.39 | 0.20 | 0.20 | 0.00 | 0.00 | 0.00 | 47.43 |
| | 0.83 | 0.41 | 0.41 | 0.00 | 0.00 | 0.00 | |
| | 11.76 | 5.88 | 5.88 | 0.00 | 0.00 | 0.00 | |
| Total | 204 | 204 | 204 | 204 | 204 | 204 | 6120 |
| | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 3.33 | 100.00 |

Appendix B: Means by Treatment Group

Table B-1: Average Heart Rate for Three Minute Averages (for Track Group)

| Analysis Variable : realHR realHR | | | | | | | |
|-----------------------------------|-----------|-------|----|-------------|------------|-------------|-------------|
| Group | SESSION | N Obs | N | Mean | Std Dev | Minimum | Maximum |
| 0 | Session01 | 108 | 96 | 154.2490106 | 38.5189624 | 73.0000000 | 206.9444444 |
| | Session02 | 108 | 80 | 155.7254079 | 29.4631604 | 72.0000000 | 204.1944444 |
| | Session03 | 108 | 84 | 156.2892763 | 27.4134369 | 75.0000000 | 198.4166667 |
| | Session04 | 108 | 84 | 155.0770396 | 26.0585307 | 82.0000000 | 198.9166667 |
| | Session05 | 108 | 96 | 151.8552042 | 27.8230563 | 42.0000000 | 190.0000000 |
| | Session06 | 108 | 72 | 149.4591049 | 33.3670330 | 57.0000000 | 203.9722222 |
| | Session07 | 108 | 84 | 155.5365490 | 29.1283569 | 92.0000000 | 208.4722222 |
| | Session08 | 108 | 84 | 156.4009302 | 30.0202098 | 64.0000000 | 199.9722222 |
| | Session09 | 108 | 96 | 154.8350767 | 27.2974916 | 58.0000000 | 196.3888889 |
| | Session10 | 108 | 96 | 154.3117276 | 31.1109609 | 66.0000000 | 197.5277778 |
| | Session11 | 108 | 69 | 154.3199333 | 31.9430730 | 59.0000000 | 196.7777778 |
| | Session12 | 108 | 71 | 154.0905137 | 25.5186937 | 84.7777778 | 190.0833333 |
| | Session13 | 108 | 71 | 152.9106860 | 30.1689723 | 37.1250000 | 191.8055556 |
| | Session14 | 108 | 71 | 141.7587749 | 32.4191083 | 73.0000000 | 189.9444444 |
| | Session15 | 108 | 54 | 154.0291261 | 24.5290664 | 101.0000000 | 186.0000000 |
| | Session16 | 108 | 47 | 156.2102541 | 25.6329324 | 97.0000000 | 195.0000000 |
| | Session17 | 108 | 58 | 139.9336591 | 29.1265050 | 59.0000000 | 182.5769231 |
| | Session18 | 108 | 59 | 156.8558945 | 28.3459959 | 57.0000000 | 202.2500000 |
| | Session19 | 108 | 59 | 147.2308145 | 25.7867209 | 75.0000000 | 179.0000000 |
| | Session20 | 108 | 60 | 137.7081151 | 27.2681388 | 74.0000000 | 188.9722222 |
| | Session21 | 108 | 60 | 142.1051780 | 27.9237309 | 82.0000000 | 189.8333333 |
| | Session22 | 108 | 48 | 142.0466120 | 24.9447036 | 83.0000000 | 184.4444444 |
| | Session23 | 108 | 48 | 148.3170770 | 26.4828601 | 76.0000000 | 185.8333333 |
| | Session24 | 108 | 36 | 137.0024526 | 26.7419649 | 64.0000000 | 180.0277778 |
| | Session25 | 108 | 24 | 148.5776786 | 31.5798063 | 92.0000000 | 179.3888889 |
| | Session26 | 108 | 12 | 151.0393519 | 20.1067419 | 94.0000000 | 170.9444444 |
| | Session27 | 108 | 12 | 157.4166667 | 18.3823534 | 108.0000000 | 172.0000000 |
| | Session28 | 108 | 0 | . | . | . | . |
| | Session29 | 108 | 0 | . | . | . | . |
| | Session30 | 108 | 0 | . | . | . | . |

Table B-2: Average Heart Rate for Three Minute Averages (for Interactive Gaming Group)

| Analysis Variable : realHR realHR | | | | | | | |
|-----------------------------------|-----------|-------|----|-------------|------------|-------------|-------------|
| Group | SESSION | N Obs | N | Mean | Std Dev | Minimum | Maximum |
| 1 | Session01 | 96 | 81 | 108.7038054 | 27.4224831 | 37.2666667 | 164.4210526 |
| | Session02 | 96 | 88 | 120.6355948 | 32.5224522 | 44.0000000 | 185.2500000 |
| | Session03 | 96 | 88 | 117.3129228 | 34.3927717 | 41.5000000 | 180.4722222 |
| | Session04 | 96 | 95 | 106.1641447 | 41.1854628 | 6.0000000 | 172.0000000 |
| | Session05 | 96 | 93 | 121.7488889 | 23.6793078 | 55.0000000 | 181.0000000 |
| | Session06 | 96 | 60 | 117.0544899 | 24.5963953 | 43.5714286 | 155.3888889 |
| | Session07 | 96 | 81 | 129.2243237 | 31.1726016 | 26.2083333 | 188.0000000 |
| 1 | Session08 | 96 | 72 | 118.0262553 | 31.4268059 | 48.0000000 | 174.0000000 |
| | Session09 | 96 | 60 | 122.9688442 | 27.2529697 | 47.8666667 | 181.0000000 |
| | Session10 | 96 | 60 | 129.3209283 | 25.3183802 | 69.0000000 | 172.0000000 |
| | Session11 | 96 | 60 | 122.7625585 | 37.2502083 | 50.5517241 | 171.1111111 |
| | Session12 | 96 | 60 | 128.4130247 | 28.3094401 | 64.5925926 | 189.0000000 |
| | Session13 | 96 | 60 | 109.8249593 | 48.9499122 | 14.0000000 | 178.0833333 |
| | Session14 | 96 | 48 | 136.6089356 | 23.1212579 | 82.8666667 | 172.9166667 |
| | Session15 | 96 | 48 | 139.2771100 | 23.7631122 | 80.0000000 | 184.0555556 |
| | Session16 | 96 | 36 | 127.6202601 | 36.1627793 | 56.7941176 | 174.0000000 |
| | Session17 | 96 | 10 | 136.1198068 | 11.9131402 | 113.0000000 | 157.5555556 |
| | Session18 | 96 | 12 | 138.8476307 | 19.3940573 | 103.0000000 | 173.0000000 |
| | Session19 | 96 | 12 | 157.5370370 | 14.6206441 | 136.1111111 | 189.0000000 |
| | Session20 | 96 | 12 | 146.9208878 | 26.1179184 | 70.0000000 | 171.1388889 |
| | Session21 | 96 | 12 | 164.5787037 | 18.2388206 | 114.0000000 | 180.0277778 |
| | Session22 | 96 | 12 | 154.1313657 | 17.6415117 | 108.0000000 | 170.3055556 |
| | Session23 | 96 | 12 | 149.4050926 | 13.3617409 | 128.0000000 | 176.0555556 |
| | Session24 | 96 | 0 | . | . | . | . |
| | Session25 | 96 | 0 | . | . | . | . |
| | Session26 | 96 | 0 | . | . | . | . |
| | Session27 | 96 | 0 | . | . | . | . |
| | Session28 | 96 | 0 | . | . | . | . |
| | Session29 | 96 | 0 | . | . | . | . |
| | Session30 | 96 | 0 | . | . | . | . |

Appendix C: Boxplots

Figure C-1: Boxplot of Average Heart Rate by Group

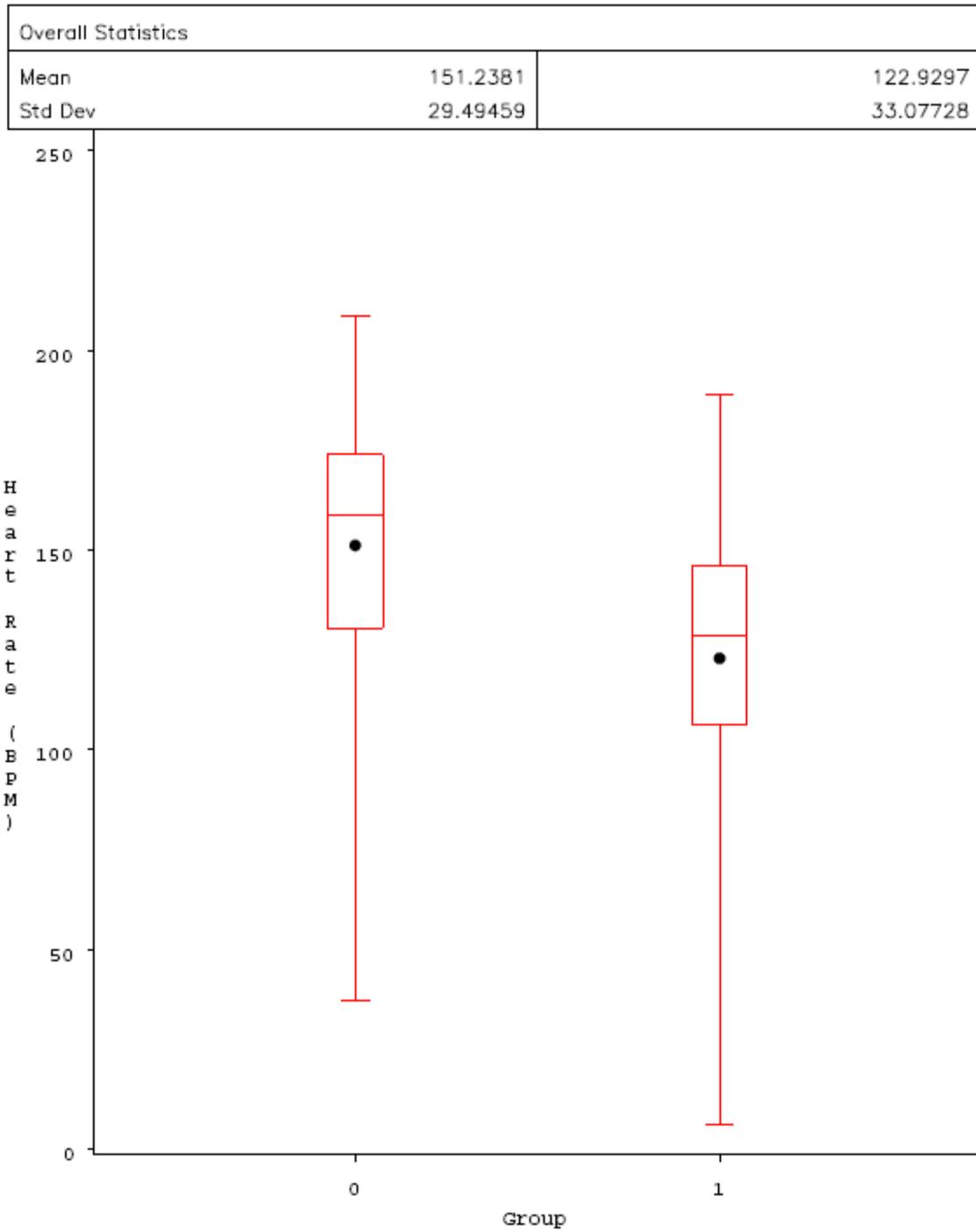


Figure C-2: Boxplots of Average Heart Rate by Interval

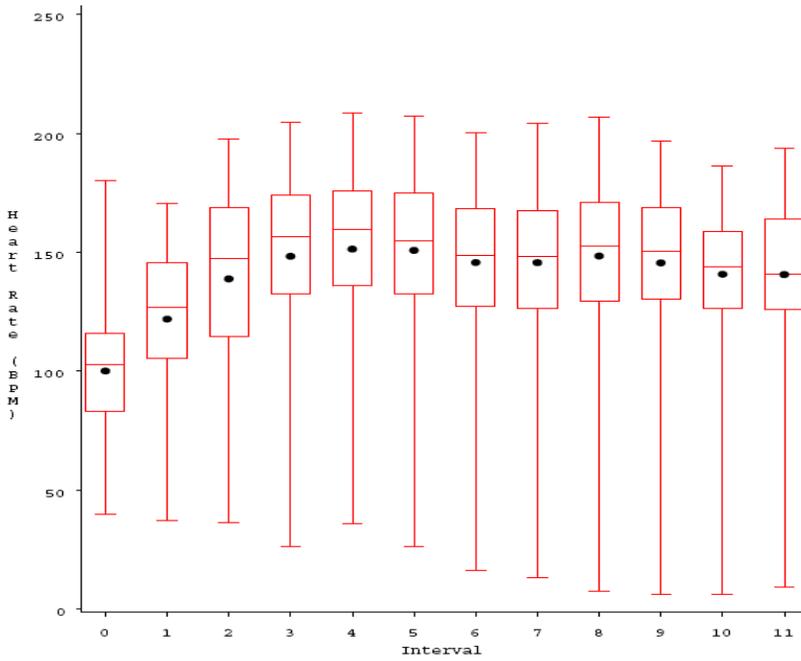


Figure C-3: Boxplots of Avg Heart Rate by Interval (Track)

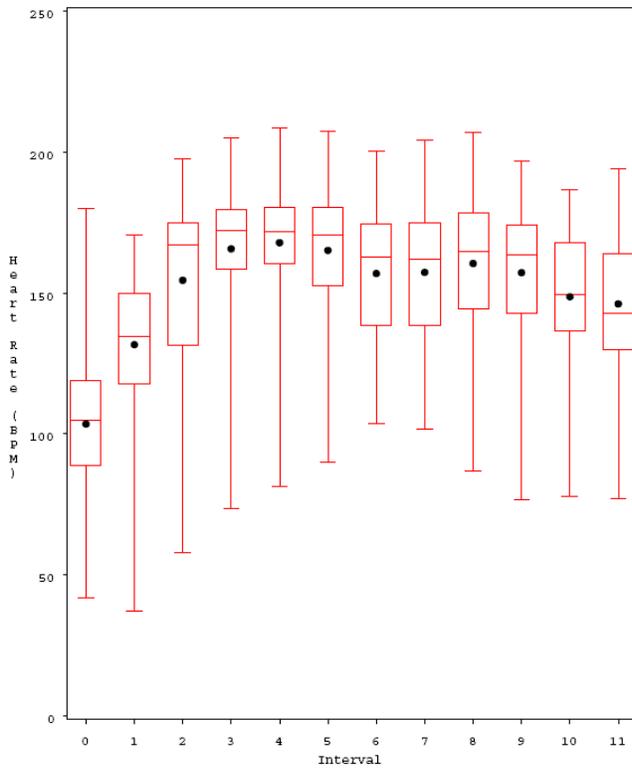


Figure C-4: Boxplots of Average Heart Rate by Interval (Inter. Gaming)

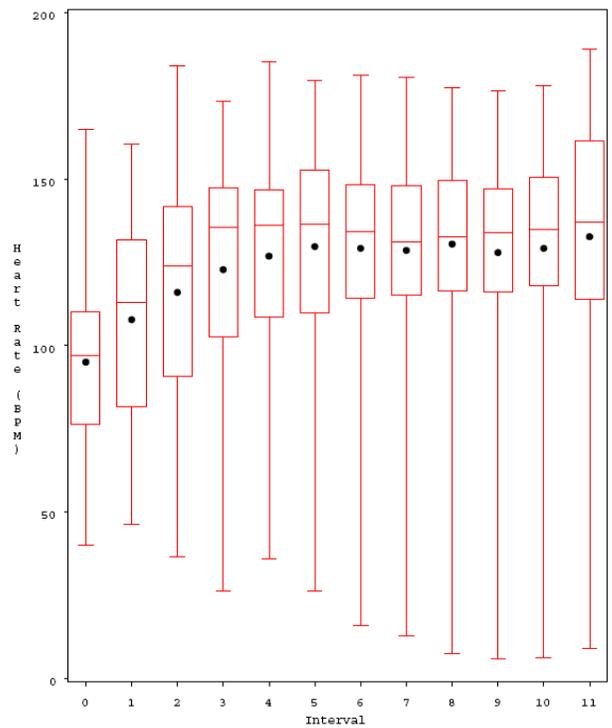


Figure C-5: Boxplots of Average Heart Rate by Trial (Group=Track)

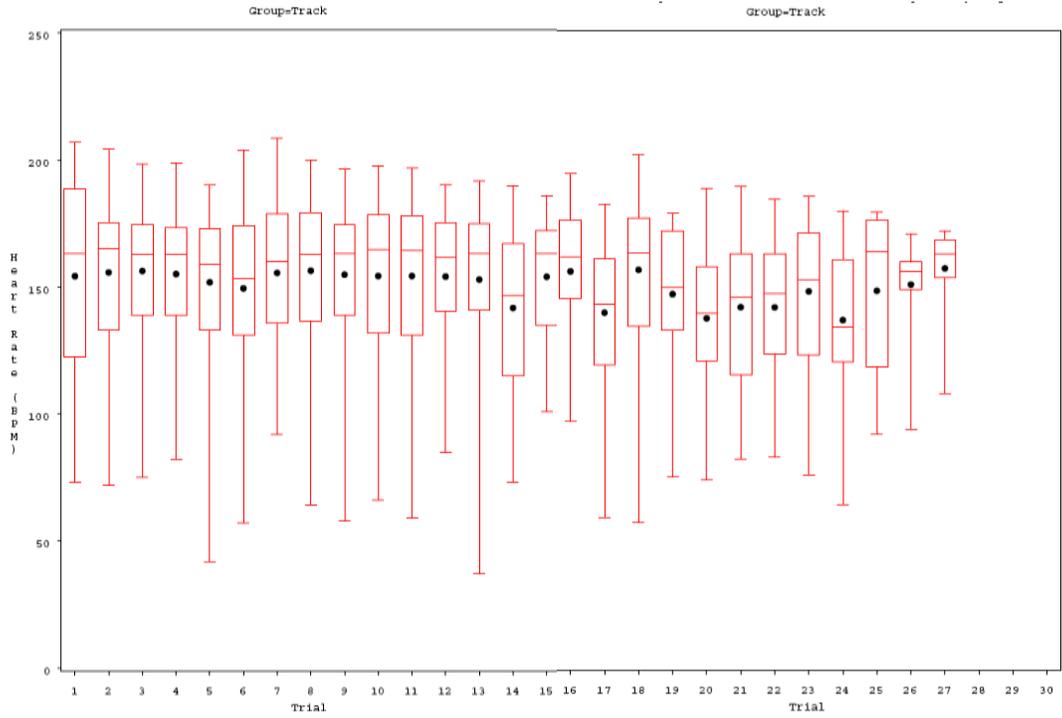


Figure C-6: Boxplots of Average Heart Rate by Trial (Group=Inter. Gaming)

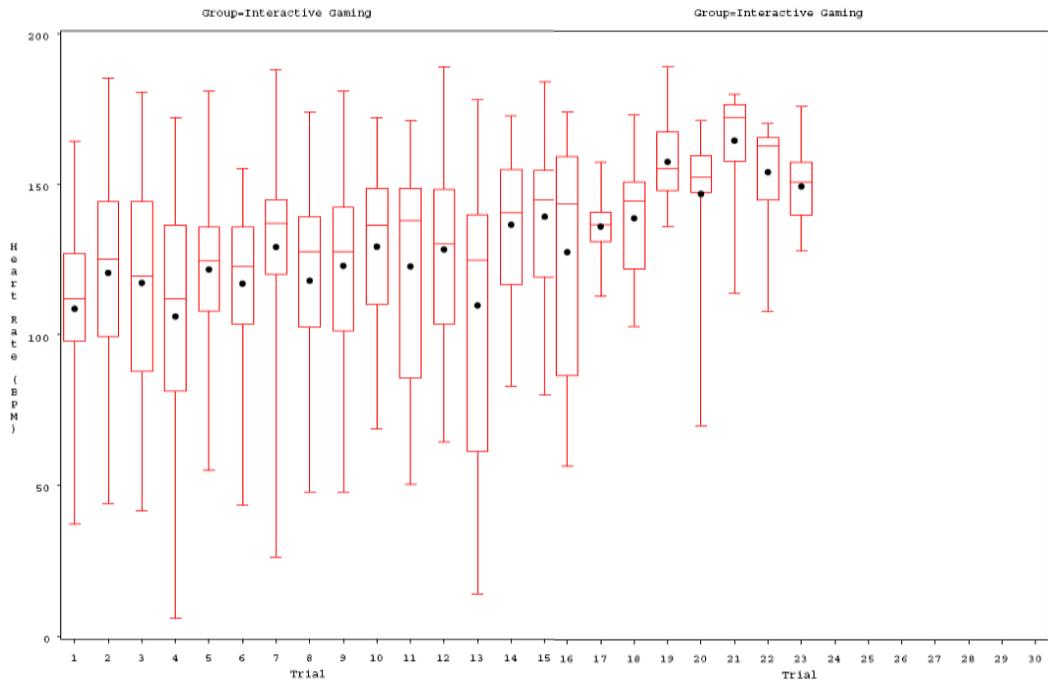


Figure C-7: Duration In Target Heart Rate Zone (as a proportion)

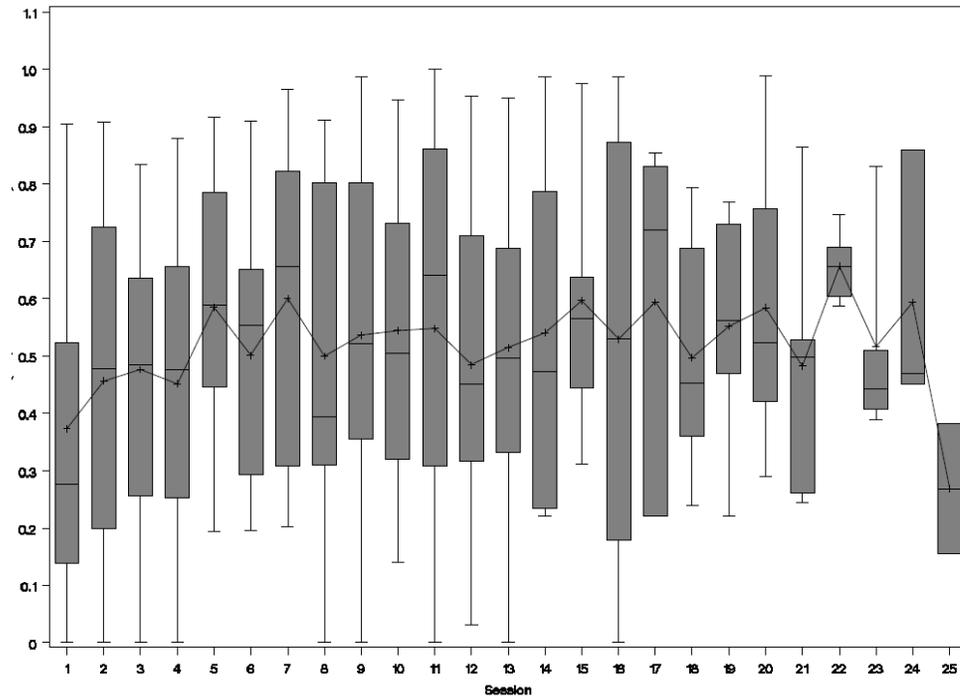


Figure C-8: Duration Above Target Heart Rate Zone (as a proportion)

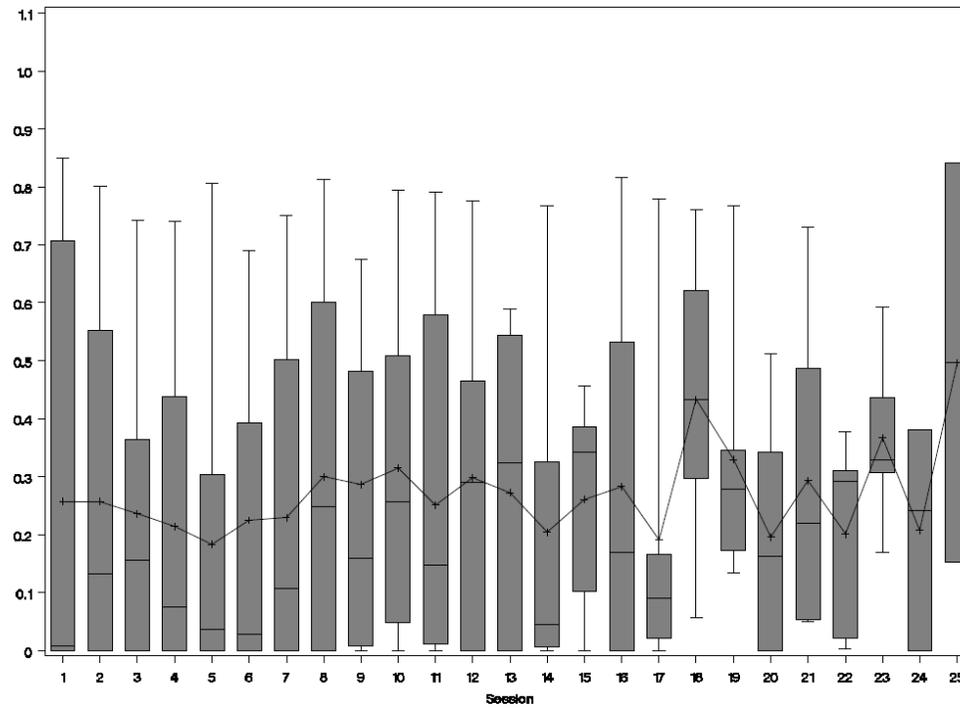


Figure C-9: Duration IN Target Heart Rate Zone (as a proportion) for Track

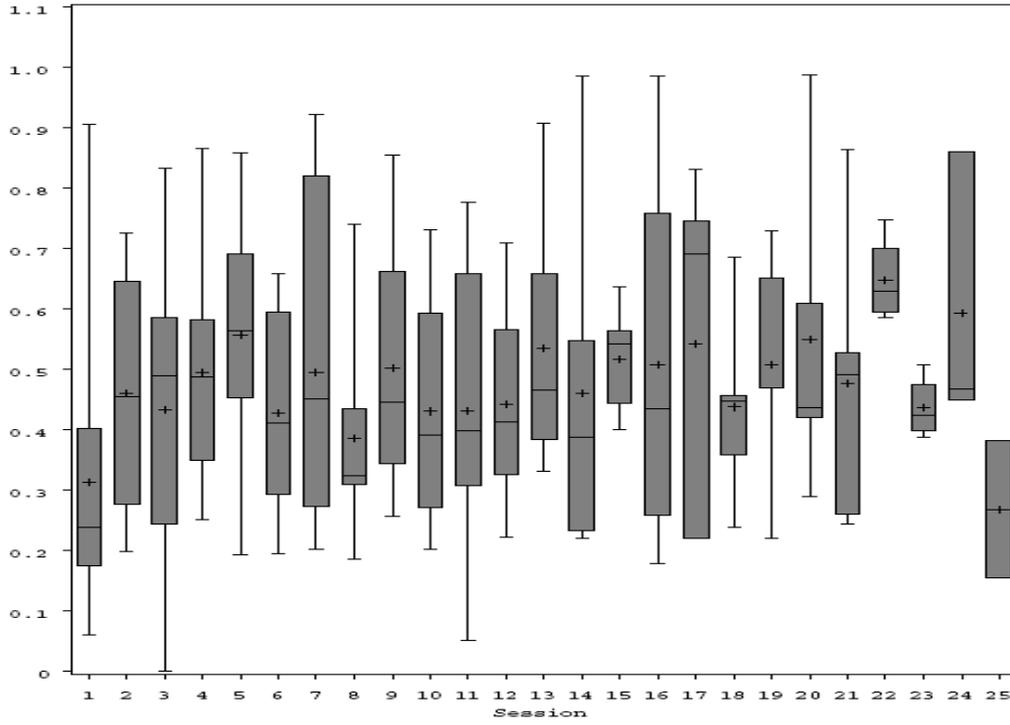


Figure C-10: Duration IN Target Heart Rate Zone (as a proportion) for Inter. Gaming

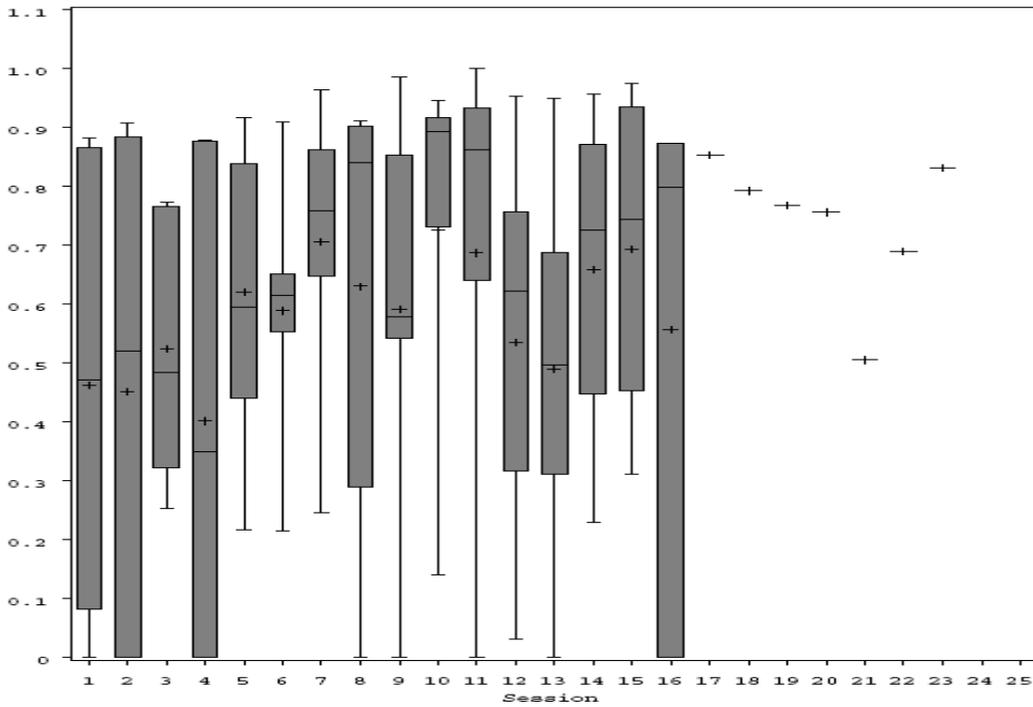


Figure C-11: Duration ABOVE Target Heart Rate Zone (as a proportion) for Track

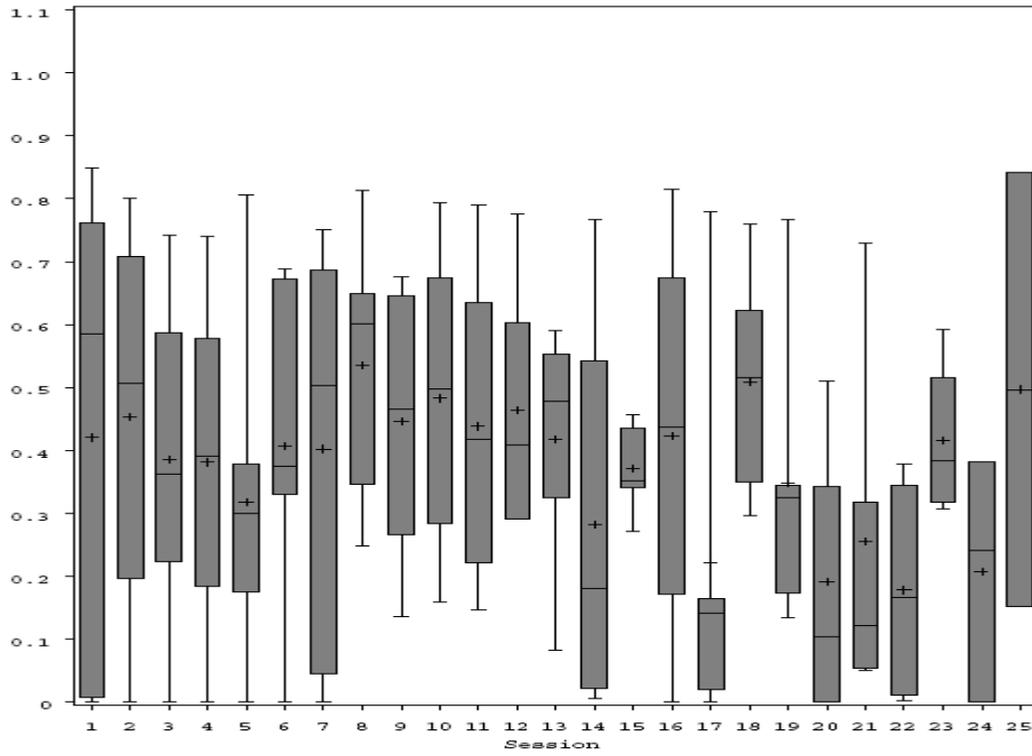


Figure C-12: Duration ABOVE Target Heart Rate Zone (as a proportion) for Inter. Gaming

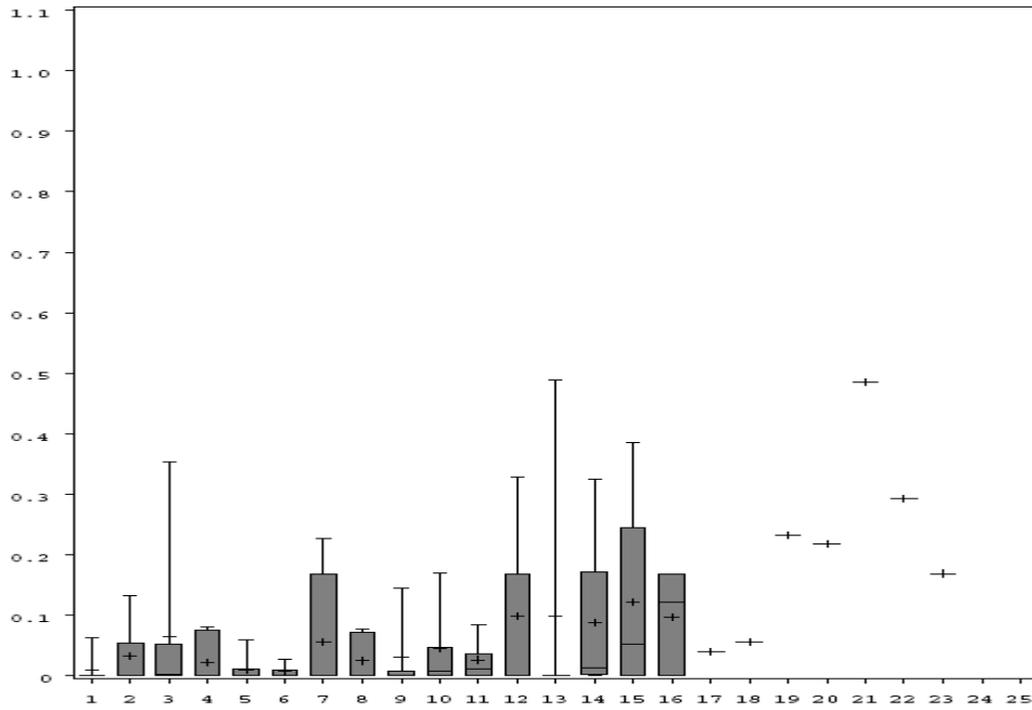


Figure C-13: Duration IN or ABOVE Target Heart Rate Zone (as a proportion) for Track

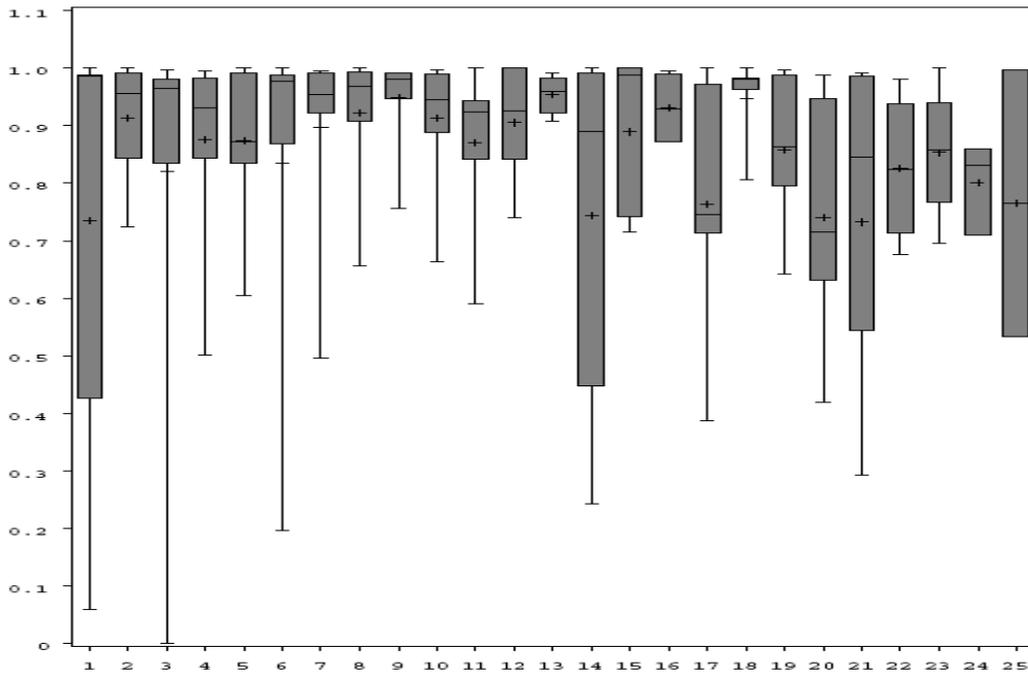
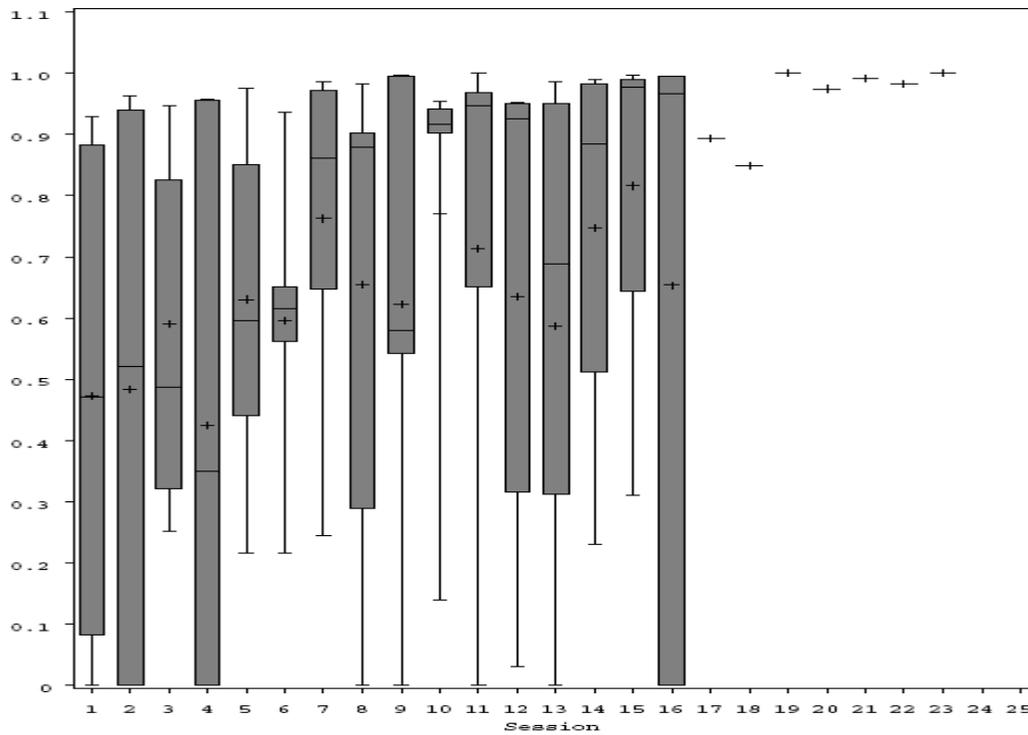


Figure C-14: Duration IN or ABOVE Target Heart Rate Zone (as a proportion) for Inter. Gaming



Appendix D: Average Heart Rate Plots by Interval

Figure D-1: Plots of Average Heart Rate over Time (Trials 1-4)

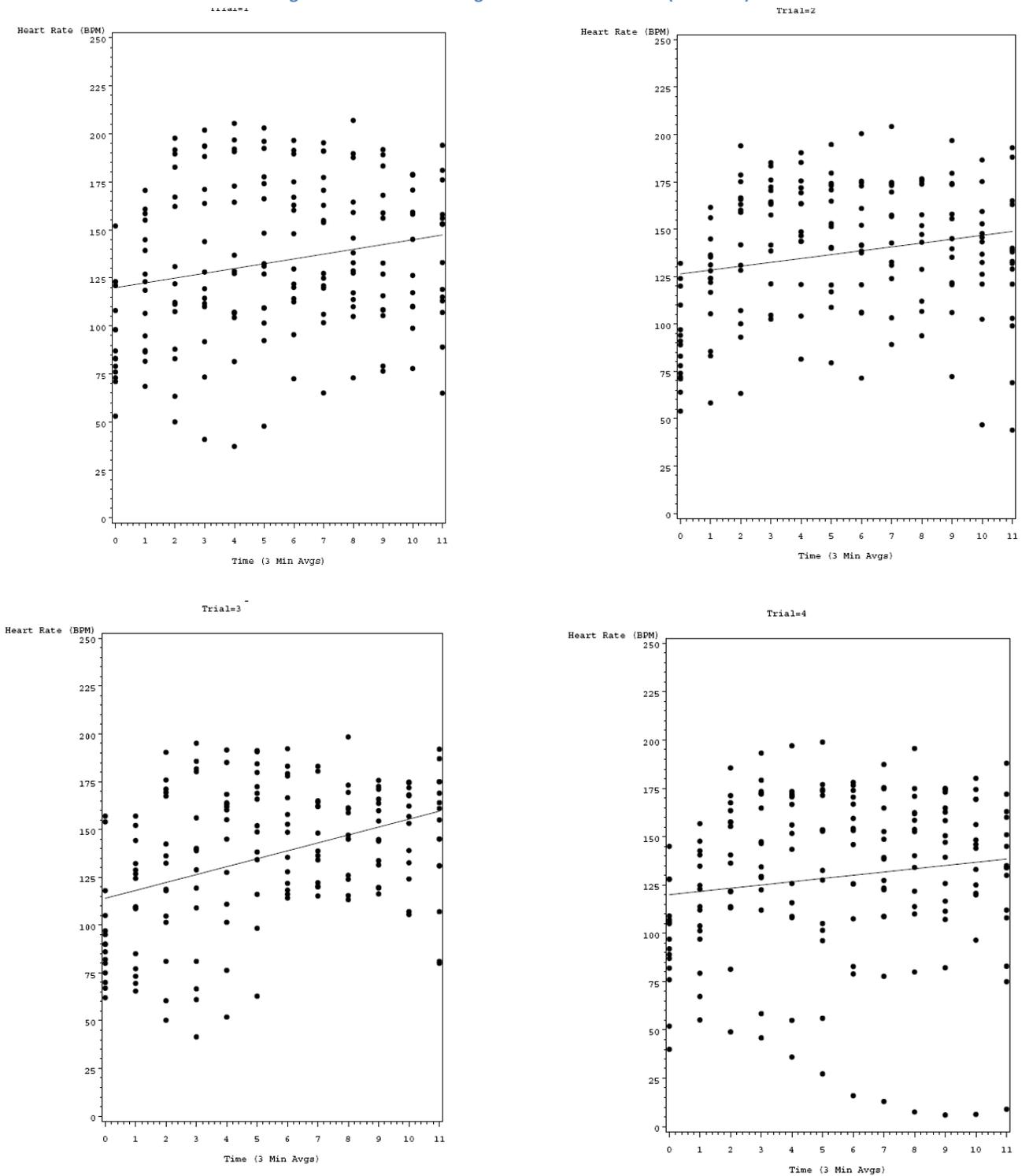


Figure D-2: Plots of Average Heart Rate over Time (Trials 5-8)

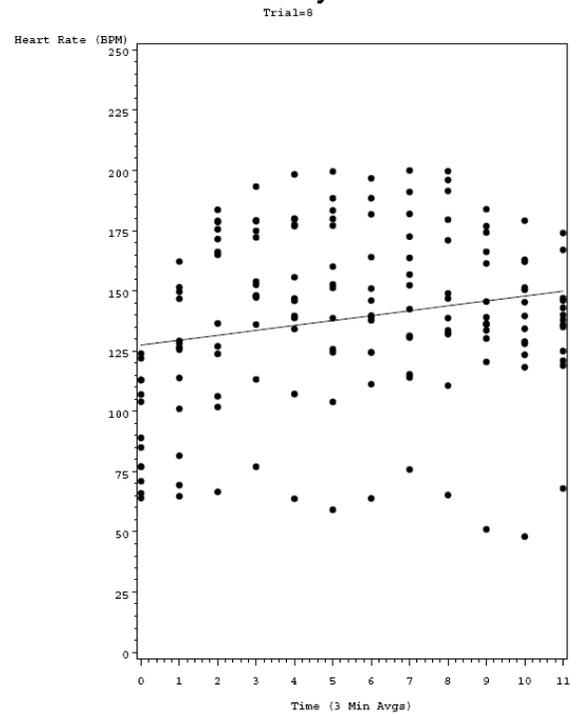
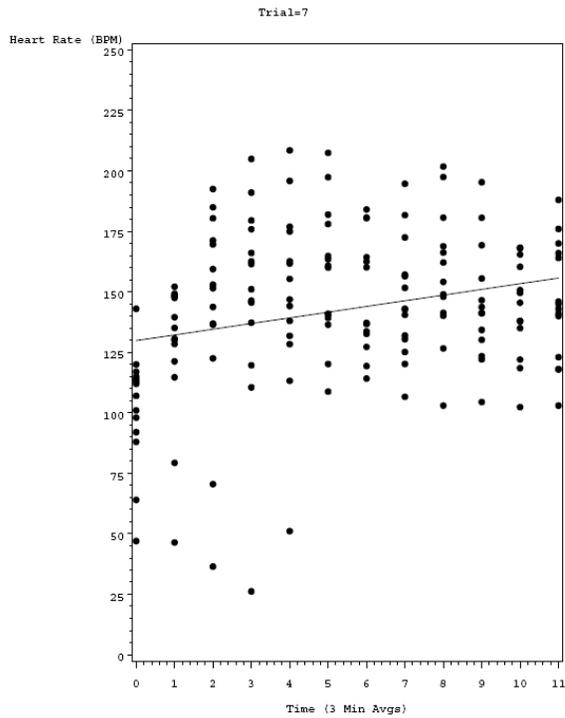
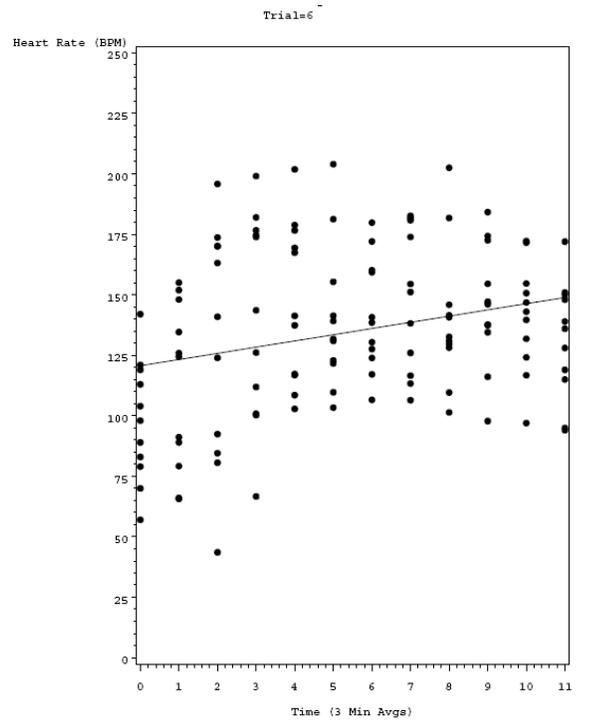
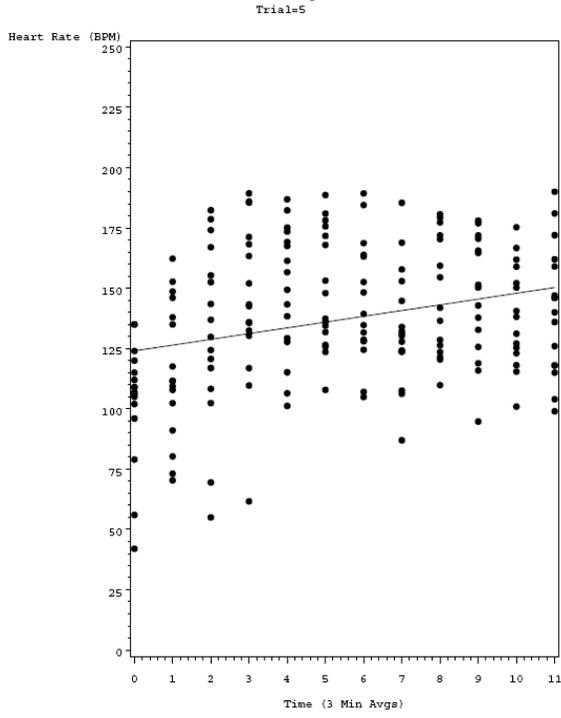


Figure D-3: Plots of Average Heart Rate over Time (Trials 9-12)

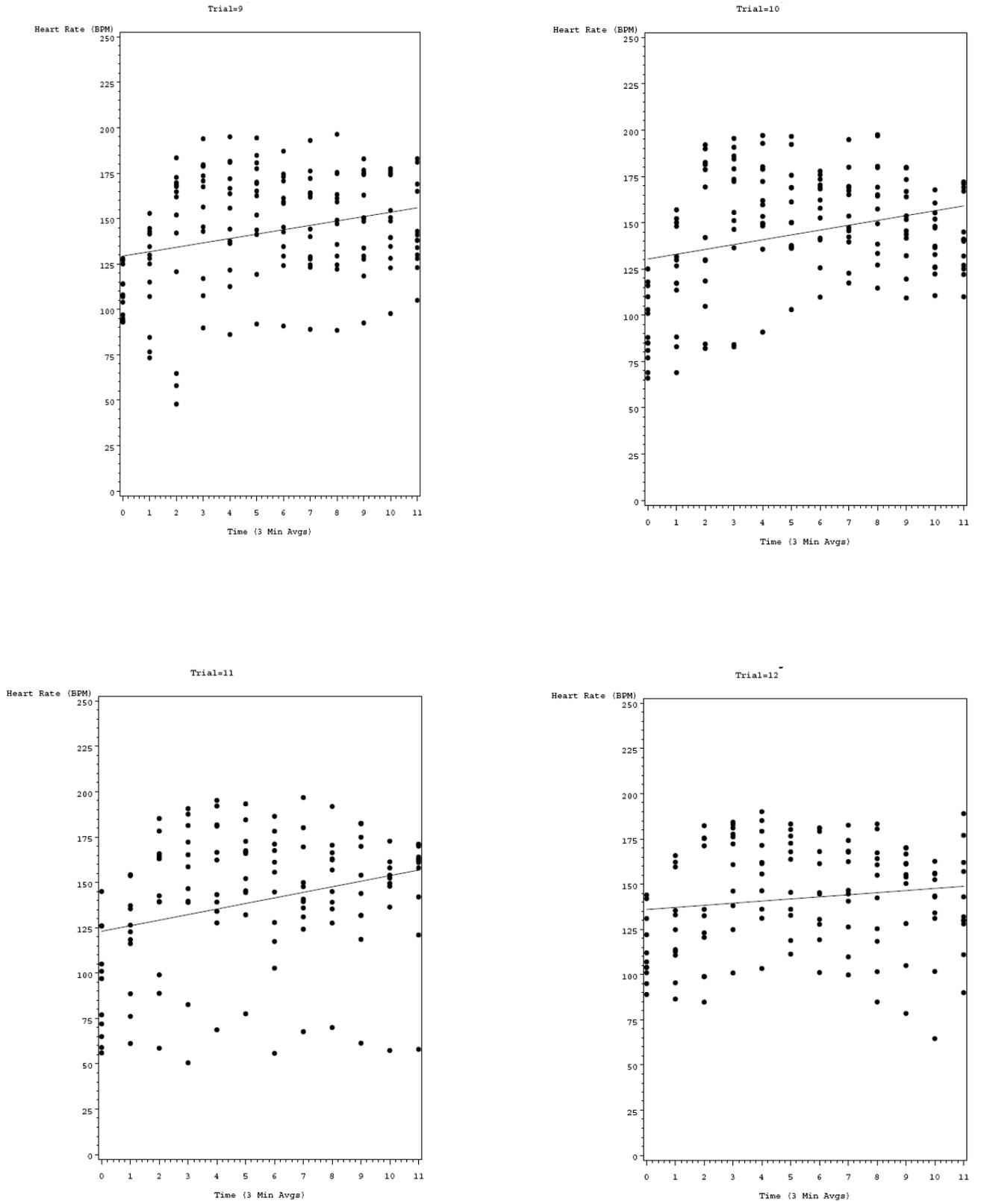


Figure D-4: Plots of Average Heart Rate over Time (Trials 13-16)

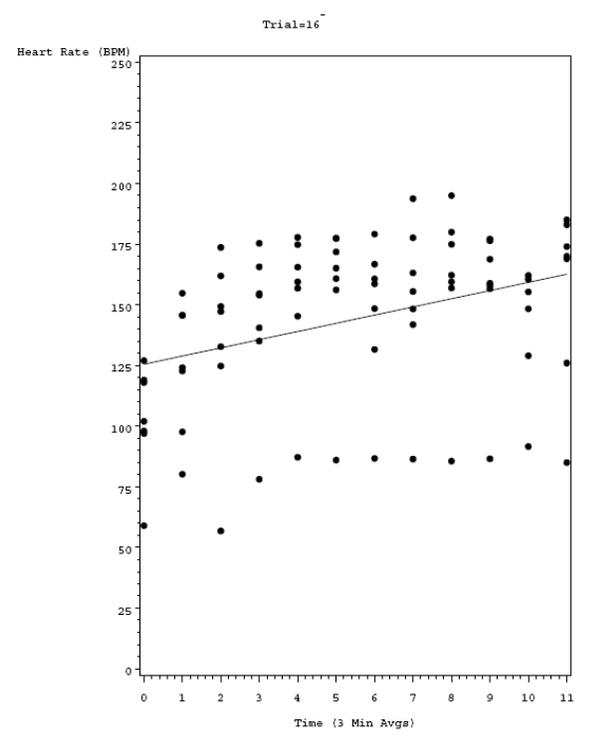
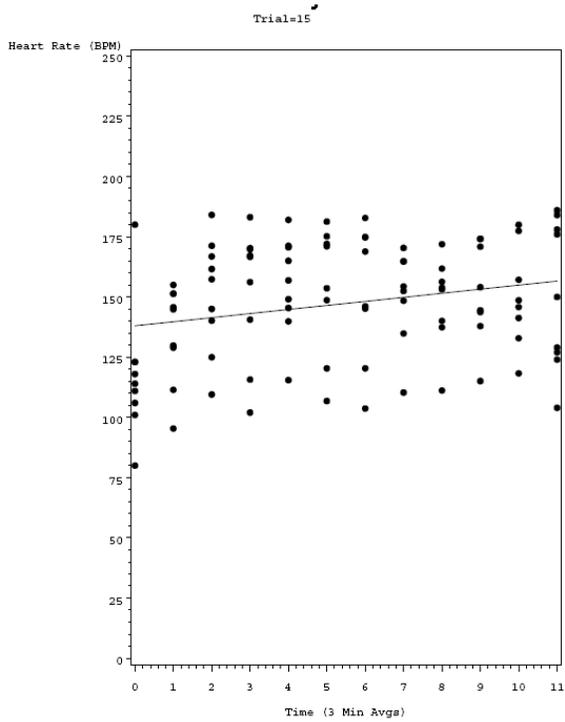
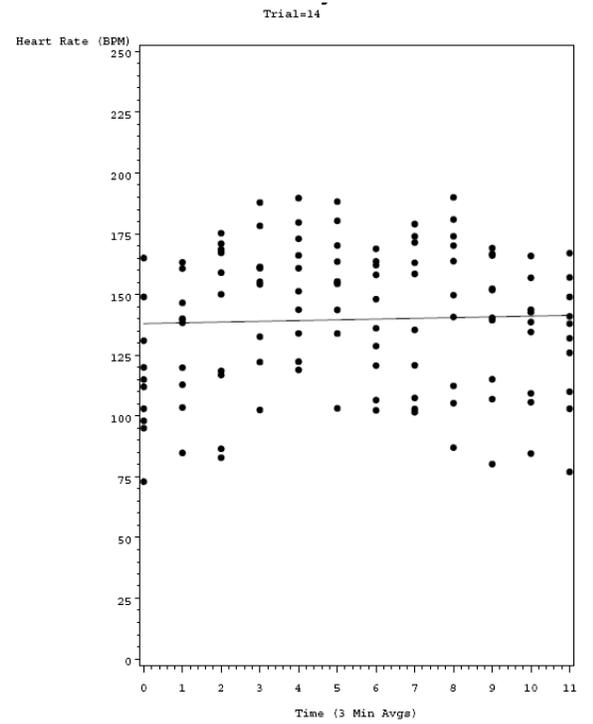
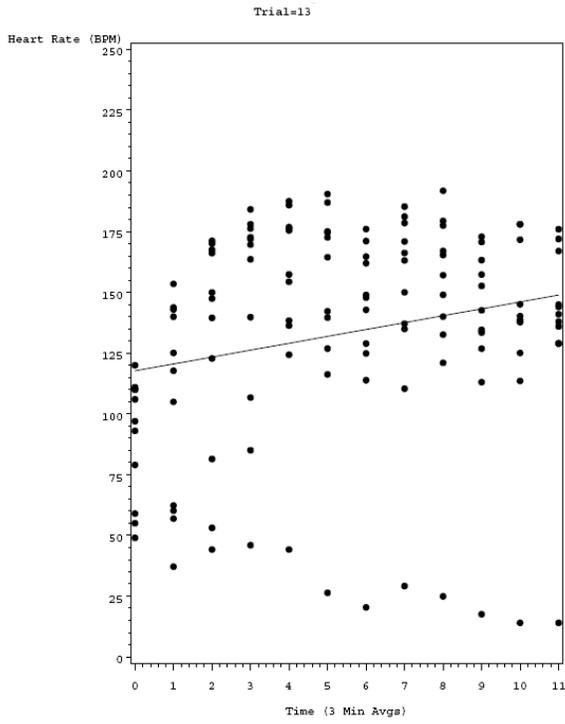


Figure D-5: Plots of Average Heart Rate over Time (Trials 17-20)

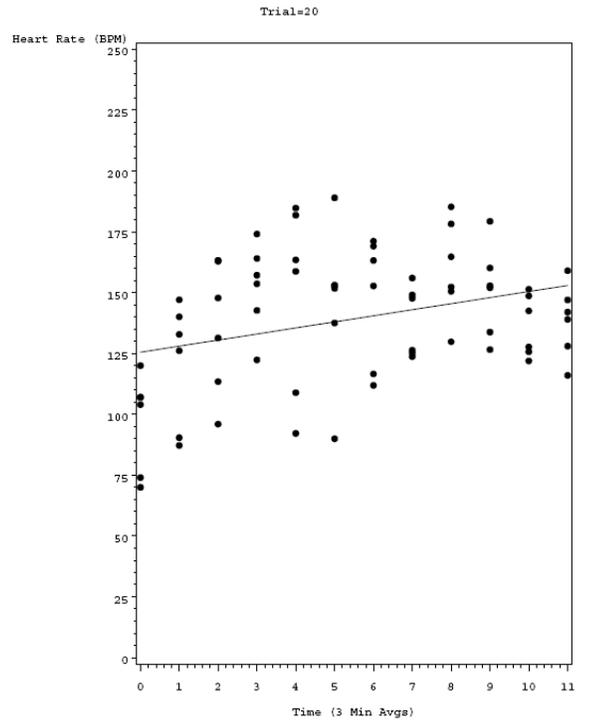
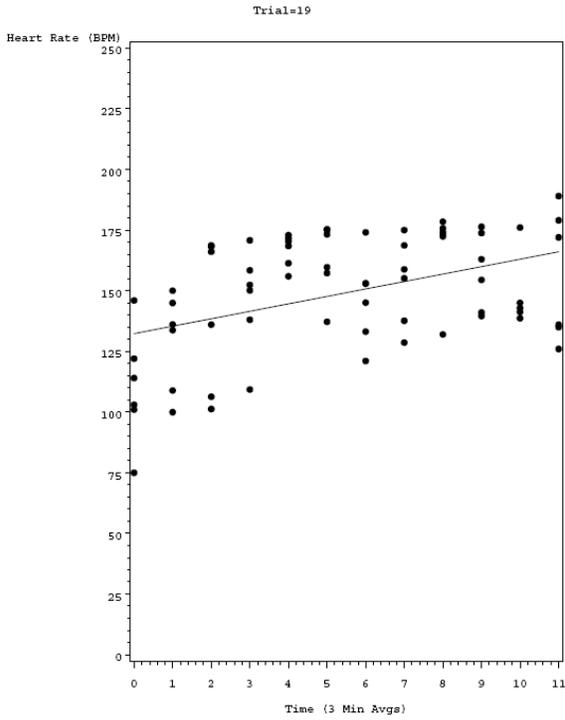
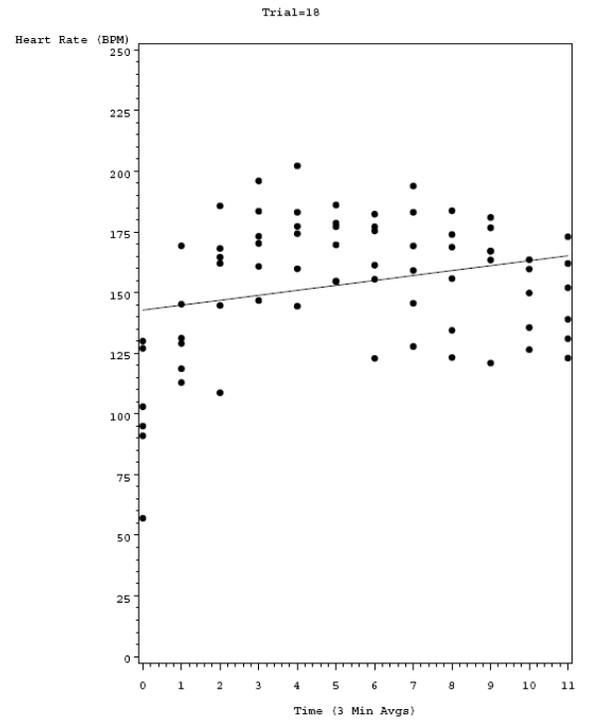
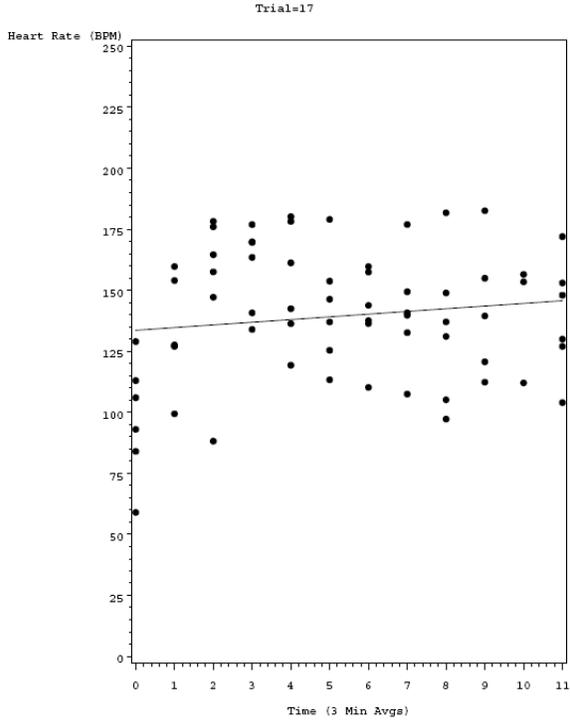


Figure D-6: Plots of Average Heart Rate over Time (Trials 21-24)

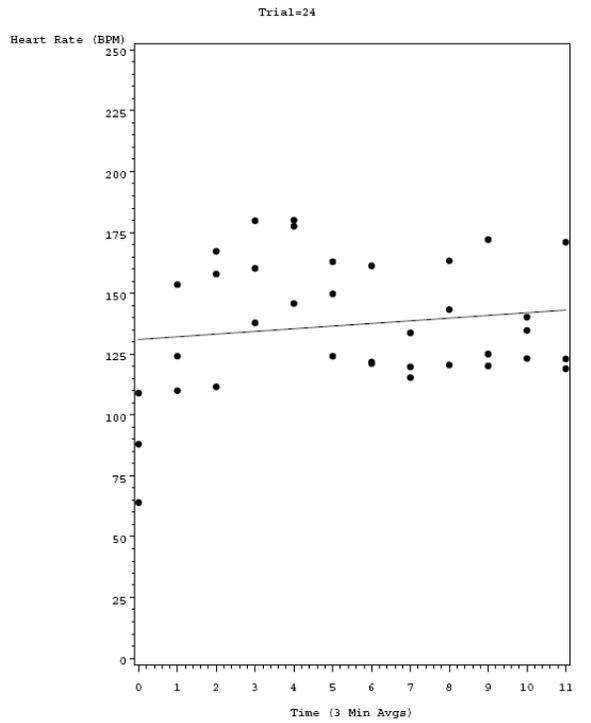
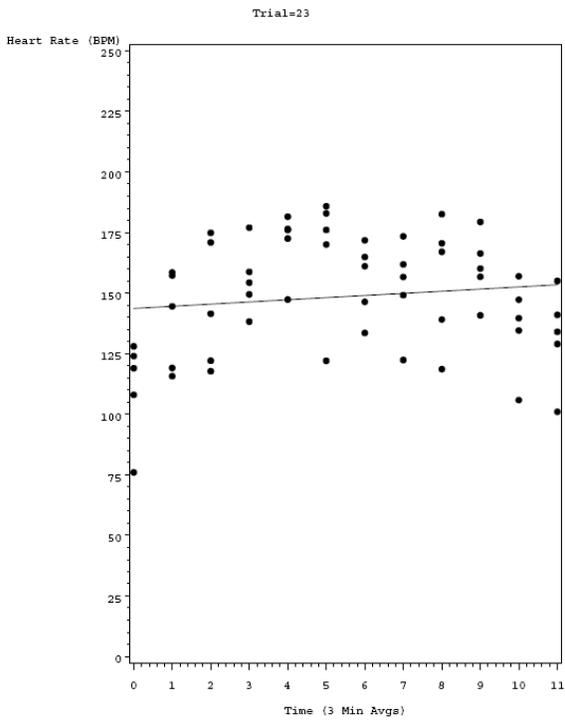
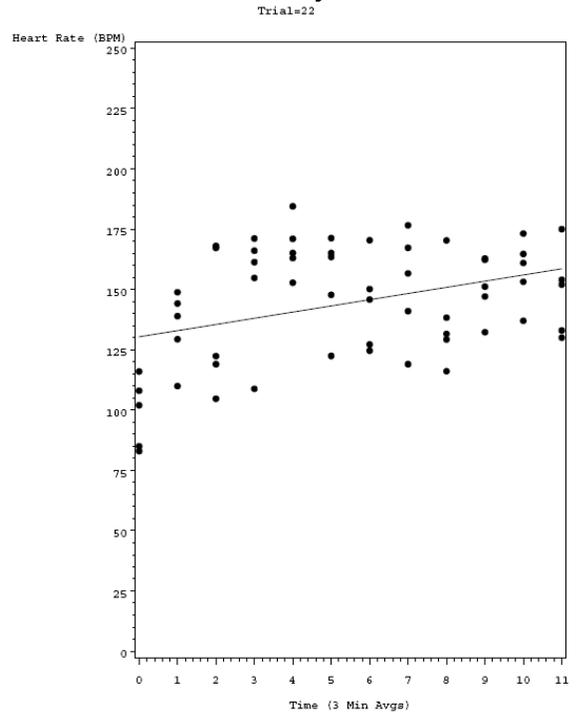
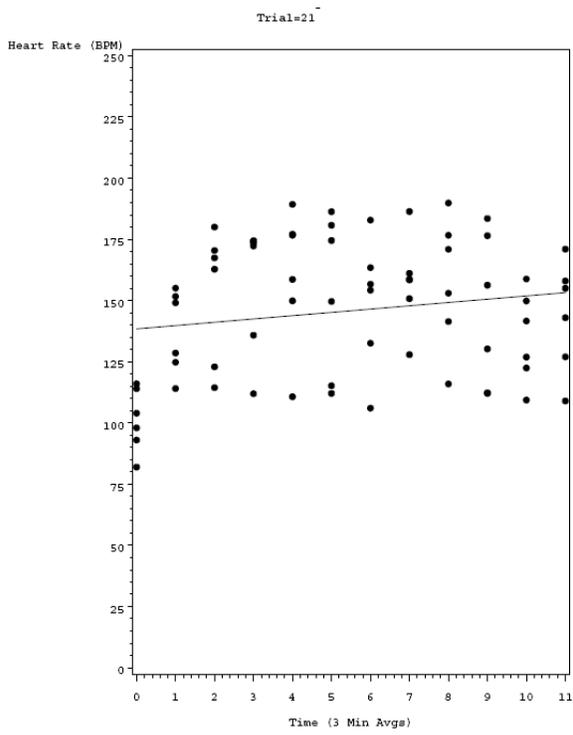
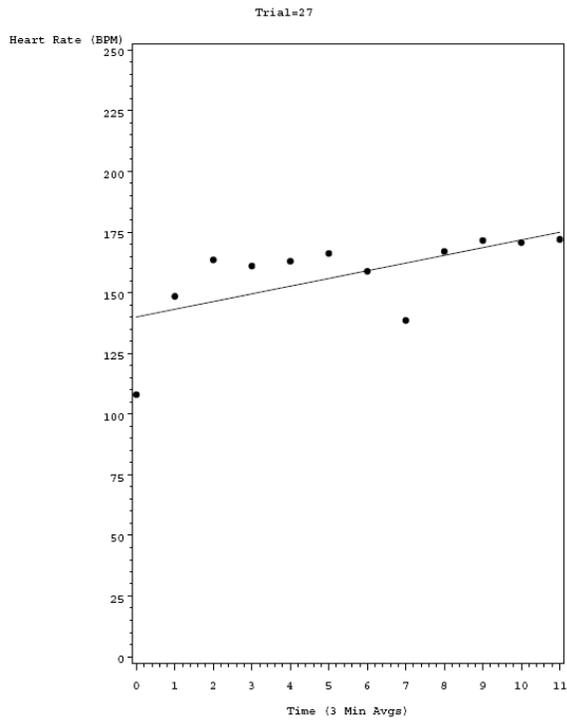
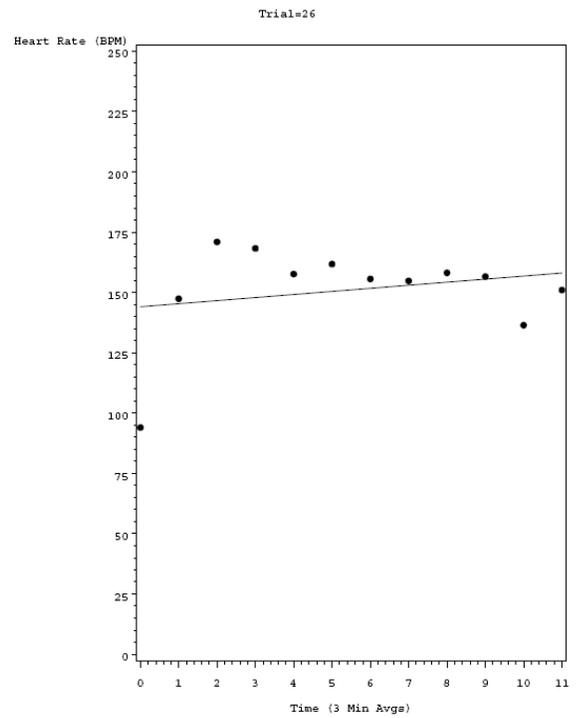
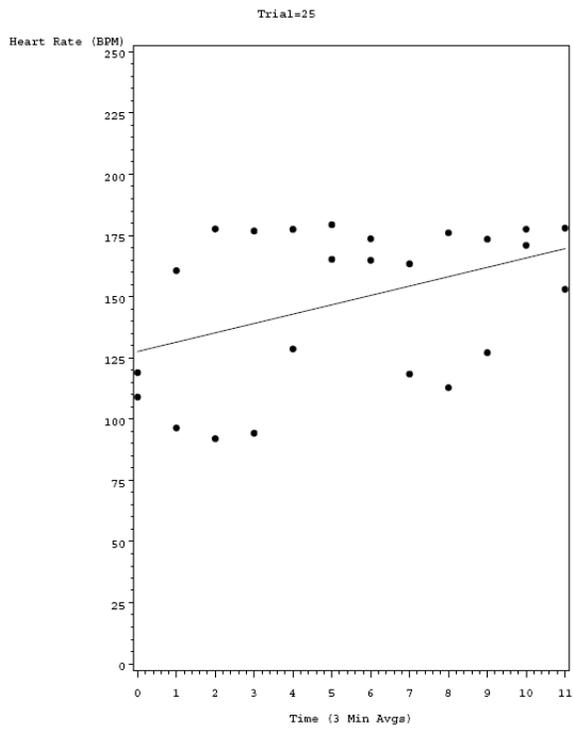


Figure D-7: Plots of Average Heart Rate over Time (Trials 25-27)



No graph for Trials 28, 29 or 30 due to missing data

Appendix E: t-test Outputs

Table E-1: t-test on Average Heart Rate (3 Min Avg) by Groups

| Statistics | | | | | | | | | | |
|------------|------------|------|---------------|--------|---------------|------------------|---------|------------------|---------|---------|
| Variable | Group | N | Lower CL Mean | Mean | Upper CL Mean | Lower CL Std Dev | Std Dev | Upper CL Std Dev | Std Err | Minimum |
| realHR | 0 | 1731 | 149.85 | 151.24 | 152.63 | 28.544 | 29.495 | 30.511 | 0.7089 | 37.125 |
| realHR | 1 | 1172 | 121.03 | 122.93 | 124.83 | 31.79 | 33.077 | 34.474 | 0.9662 | 6 |
| realHR | Diff (1-2) | | 26.01 | 28.308 | 30.607 | 30.213 | 30.991 | 31.809 | 1.1723 | |

| Statistics | | |
|------------|------------|---------|
| Variable | Group | Maximum |
| realHR | 0 | 208.47 |
| realHR | 1 | 189 |
| realHR | Diff (1-2) | |

| T-Tests | | | | | |
|----------|---------------|-----------|------|---------|---------|
| Variable | Method | Variances | DF | t Value | Pr > t |
| realHR | Pooled | Equal | 2901 | 24.15 | <.0001 |
| realHR | Satterthwaite | Unequal | 2317 | 23.62 | <.0001 |

| Equality of Variances | | | | | |
|-----------------------|----------|--------|--------|---------|--------|
| Variable | Method | Num DF | Den DF | F Value | Pr > F |
| realHR | Folded F | 1171 | 1730 | 1.26 | <.0001 |

Table E-2: t-tests on Duration IN and ABOVE THR Zone (as a proportion)

| Statistics | | | | | | | | | | |
|------------|------------|-----|---------------|--------|---------------|------------------|---------|------------------|---------|---------|
| Variable | Group | N | Lower CL Mean | Mean | Upper CL Mean | Lower CL Std Dev | Std Dev | Upper CL Std Dev | Std Err | Minimum |
| inTHR | 0 | 151 | 0.441 | 0.4763 | 0.5115 | 0.1971 | 0.2193 | 0.2473 | 0.0178 | 0 |
| inTHR | 1 | 95 | 0.5235 | 0.5881 | 0.6528 | 0.2779 | 0.3175 | 0.3704 | 0.0326 | 0 |
| inTHR | Diff (1-2) | | -0.179 | -0.112 | -0.044 | 0.2403 | 0.2616 | 0.287 | 0.0343 | |
| aboveTHR | 0 | 151 | 0.3422 | 0.3836 | 0.4249 | 0.2311 | 0.2572 | 0.29 | 0.0209 | 0 |
| aboveTHR | 1 | 95 | 0.0375 | 0.0598 | 0.0822 | 0.0959 | 0.1096 | 0.1278 | 0.0112 | 0 |
| aboveTHR | Diff (1-2) | | 0.2688 | 0.3237 | 0.3786 | 0.1955 | 0.2128 | 0.2335 | 0.0279 | |

| Statistics | | |
|------------|------------|---------|
| Variable | Group | Maximum |
| inTHR | 0 | 0.989 |
| inTHR | 1 | 1 |
| inTHR | Diff (1-2) | |
| aboveTHR | 0 | 0.85 |
| aboveTHR | 1 | 0.4895 |
| aboveTHR | Diff (1-2) | |

| T-Tests | | | | | |
|----------|---------------|-----------|-----|---------|---------|
| Variable | Method | Variances | DF | t Value | Pr > t |
| inTHR | Pooled | Equal | 244 | -3.27 | 0.0012 |
| inTHR | Satterthwaite | Unequal | 150 | -3.01 | 0.0030 |
| aboveTHR | Pooled | Equal | 244 | 11.62 | <.0001 |
| aboveTHR | Satterthwaite | Unequal | 220 | 13.63 | <.0001 |

| Equality of Variances | | | | | |
|-----------------------|----------|--------|--------|---------|--------|
| Variable | Method | Num DF | Den DF | F Value | Pr > F |
| inTHR | Folded F | 94 | 150 | 2.10 | <.0001 |
| aboveTHR | Folded F | 150 | 94 | 5.51 | <.0001 |

Table E-3: t-test Comparison of First 15 Sessions and Final 15 Sessions for Duration IN and ABOVE THR Zone

| Statistics | | | | | | | | | | |
|------------|------------|-----|---------------|--------|---------------|------------------|---------|------------------|---------|---------|
| Variable | Semwhen | N | Lower CL Mean | Mean | Upper CL Mean | Lower CL Std Dev | Std Dev | Upper CL Std Dev | Std Err | Minimum |
| inTHR | 'Begin' | 192 | 0.4713 | 0.5103 | 0.5492 | 0.2489 | 0.2738 | 0.3043 | 0.0198 | 0 |
| inTHR | 'End' | 54 | 0.487 | 0.5522 | 0.6175 | 0.2009 | 0.239 | 0.295 | 0.0325 | 0 |
| inTHR | Diff (1-2) | | -0.123 | -0.042 | 0.0389 | 0.2449 | 0.2666 | 0.2926 | 0.0411 | |
| aboveTHR | 'Begin' | 192 | 0.2126 | 0.2511 | 0.2896 | 0.2458 | 0.2704 | 0.3005 | 0.0195 | 0 |
| aboveTHR | 'End' | 54 | 0.2184 | 0.2849 | 0.3514 | 0.2049 | 0.2438 | 0.3009 | 0.0332 | 0 |
| aboveTHR | Diff (1-2) | | -0.114 | -0.034 | 0.0466 | 0.2433 | 0.2648 | 0.2906 | 0.0408 | |

| Statistics | | |
|------------|------------|---------|
| Variable | Semwhen | Maximum |
| inTHR | 'Begin' | 1 |
| inTHR | 'End' | 0.989 |
| inTHR | Diff (1-2) | |
| aboveTHR | 'Begin' | 0.85 |
| aboveTHR | 'End' | 0.8417 |
| aboveTHR | Diff (1-2) | |

| T-Tests | | | | | |
|----------|---------------|-----------|------|---------|---------|
| Variable | Method | Variances | DF | t Value | Pr > t |
| inTHR | Pooled | Equal | 244 | -1.02 | 0.3078 |
| inTHR | Satterthwaite | Unequal | 95.7 | -1.10 | 0.2728 |
| aboveTHR | Pooled | Equal | 244 | -0.83 | 0.4085 |
| aboveTHR | Satterthwaite | Unequal | 92.9 | -0.88 | 0.3824 |

| Equality of Variances | | | | | |
|-----------------------|----------|--------|--------|---------|--------|
| Variable | Method | Num DF | Den DF | F Value | Pr > F |
| inTHR | Folded F | 191 | 53 | 1.31 | 0.2447 |
| aboveTHR | Folded F | 191 | 53 | 1.23 | 0.3777 |

Appendix F: Simple Regressions

Table F-1: Simple Regression Model: realHR on 'Group,' 'Trial' and 'Interval'

| | |
|--|------|
| Number of Observations Read | 6120 |
| Number of Observations Used | 2903 |
| Number of Observations with Missing Values | 3217 |

| Analysis of Variance | | | | | |
|----------------------|------|----------------|-------------|---------|--------|
| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
| Model | 3 | 737768 | 245923 | 273.32 | <.0001 |
| Error | 2899 | 2608438 | 899.77178 | | |
| Corrected Total | 2902 | 3346206 | | | |

| | | | |
|----------------|-----------|----------|--------|
| Root MSE | 29.99620 | R-Square | 0.2205 |
| Dependent Mean | 139.80941 | Adj R-Sq | 0.2197 |
| Coeff Var | 21.45506 | | |

| Parameter Estimates | | | | | | |
|---------------------|-----------|----|--------------------|----------------|---------|---------|
| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > t |
| Intercept | Intercept | 1 | 137.87743 | 1.51124 | 91.23 | <.0001 |
| Group | Group | 1 | -27.99348 | 1.16636 | -24.00 | <.0001 |
| Trial | | 1 | 0.08914 | 0.08702 | 1.02 | 0.3058 |
| Interval | Interval | 1 | 2.26086 | 0.16132 | 14.02 | <.0001 |

Regression Equation:

$$realHR = 137.88 - 27.993 \text{ Group} + 0.0891 \text{ Trial} + 2.2609 \text{ Interval}$$

Table F-2: Simple Regression Model: inTHR proportions on 'Group' and 'Session'

| | |
|--|-----|
| Number of Observations Read | 374 |
| Number of Observations Used | 234 |
| Number of Observations with Missing Values | 140 |

| Analysis of Variance | | | | | |
|----------------------|-----|----------------|-------------|---------|--------|
| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
| Model | 2 | 1.15543 | 0.57771 | 8.53 | 0.0003 |
| Error | 231 | 15.64985 | 0.06775 | | |
| Corrected Total | 233 | 16.80528 | | | |

| | | | |
|----------------|----------|----------|--------|
| Root MSE | 0.26028 | R-Square | 0.0688 |
| Dependent Mean | 0.51800 | Adj R-Sq | 0.0607 |
| Coeff Var | 50.24845 | | |

| Parameter Estimates | | | | | | |
|---------------------|-----------|----|--------------------|----------------|---------|---------|
| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > t |
| Intercept | Intercept | 1 | 0.39735 | 0.03688 | 10.77 | <.0001 |
| Group | Group | 1 | 0.12611 | 0.03509 | 3.59 | 0.0004 |
| Session | Session | 1 | 0.00742 | 0.00292 | 2.54 | 0.0116 |

Regression equation:

$$inTHR = 0.3973 + 0.1261 \text{ Group} + 0.0074 \text{ Session}$$

Figure F-1: Regression Model: inTHR proportions on 'Group' and 'Session' (Scatter Plot)

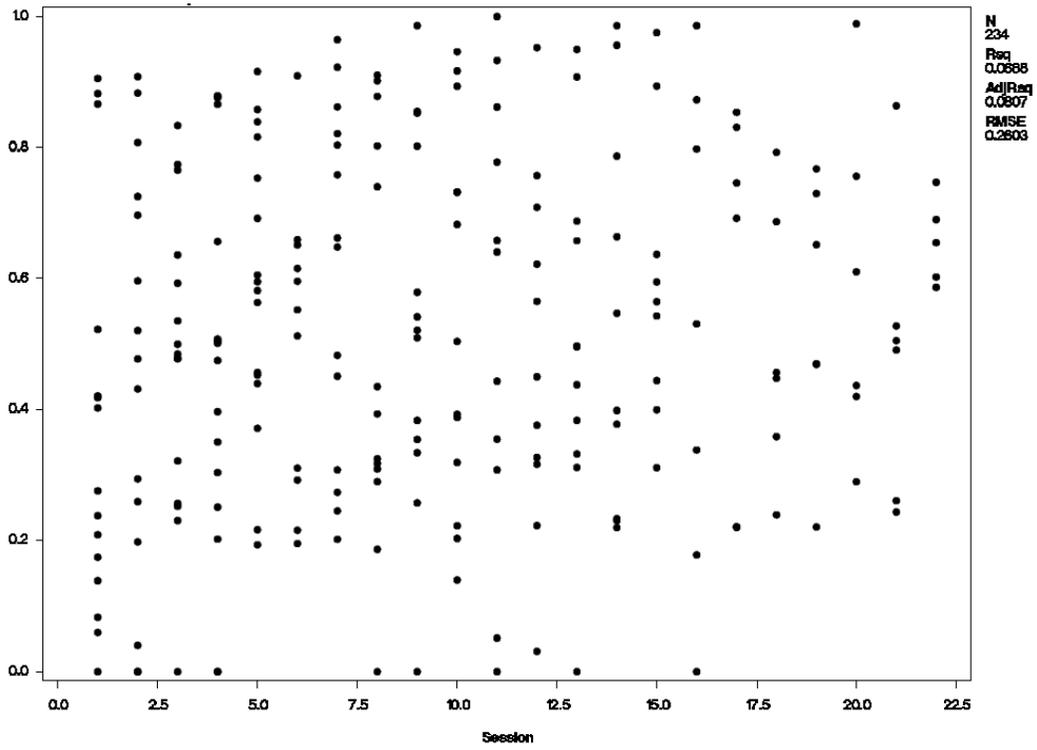


Figure F-2: Regression Model: inTHR proportions on 'Group' and 'Session' (Residual Plot)

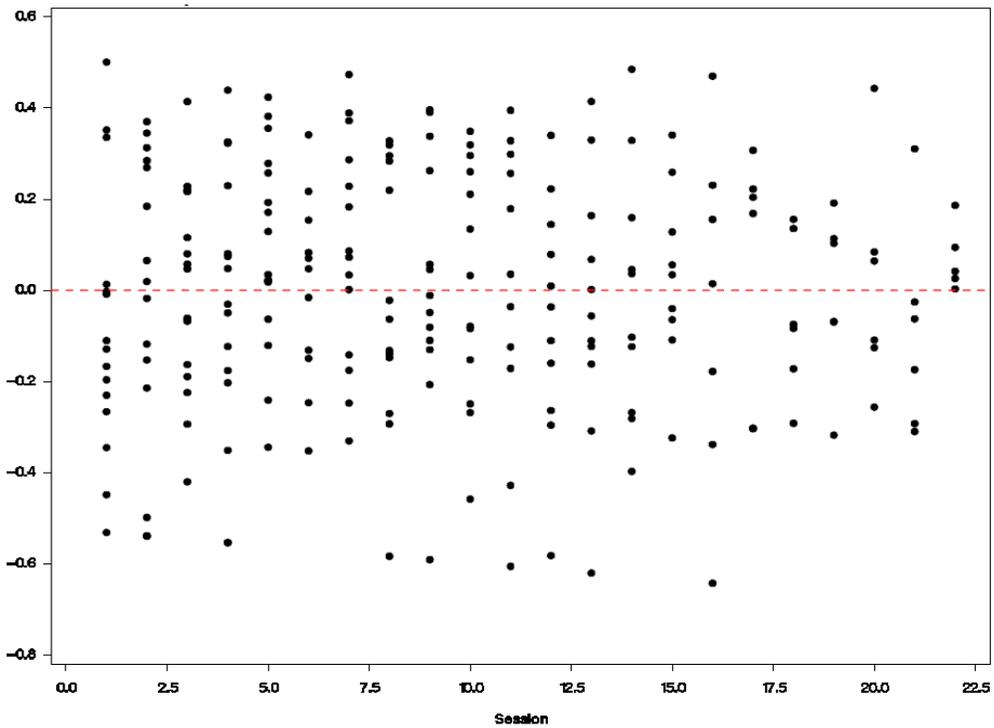


Table F-3: Simple Regression Model: aboveTHR proportions on 'Group' and 'Session'

| | |
|--|-----|
| Number of Observations Read | 374 |
| Number of Observations Used | 234 |
| Number of Observations with Missing Values | 140 |

| Analysis of Variance | | | | | |
|----------------------|-----|----------------|-------------|---------|--------|
| Source | DF | Sum of Squares | Mean Square | F Value | Pr > F |
| Model | 2 | 6.13454 | 3.06727 | 68.10 | <.0001 |
| Error | 231 | 10.40414 | 0.04504 | | |
| Corrected Total | 233 | 16.53868 | | | |

| | | | |
|----------------|----------|----------|--------|
| Root MSE | 0.21223 | R-Square | 0.3709 |
| Dependent Mean | 0.25585 | Adj R-Sq | 0.3655 |
| Coeff Var | 82.95037 | | |

| Parameter Estimates | | | | | | |
|---------------------|-----------|----|--------------------|----------------|---------|---------|
| Variable | Label | DF | Parameter Estimate | Standard Error | t Value | Pr > t |
| Intercept | Intercept | 1 | 0.40666 | 0.03007 | 13.52 | <.0001 |
| Group | Group | 1 | -0.33279 | 0.02861 | -11.63 | <.0001 |
| Session | Session | 1 | -0.00182 | 0.00238 | -0.76 | 0.4459 |

Regression equation:

$$\text{aboveTHR} = 0.4067 - 0.3328 \text{ Group} - 0.0018 \text{ Session}$$

Figure F-3: Regression Model: aboveTHR proportions on 'Group' and 'Session' (Scatter Plot)

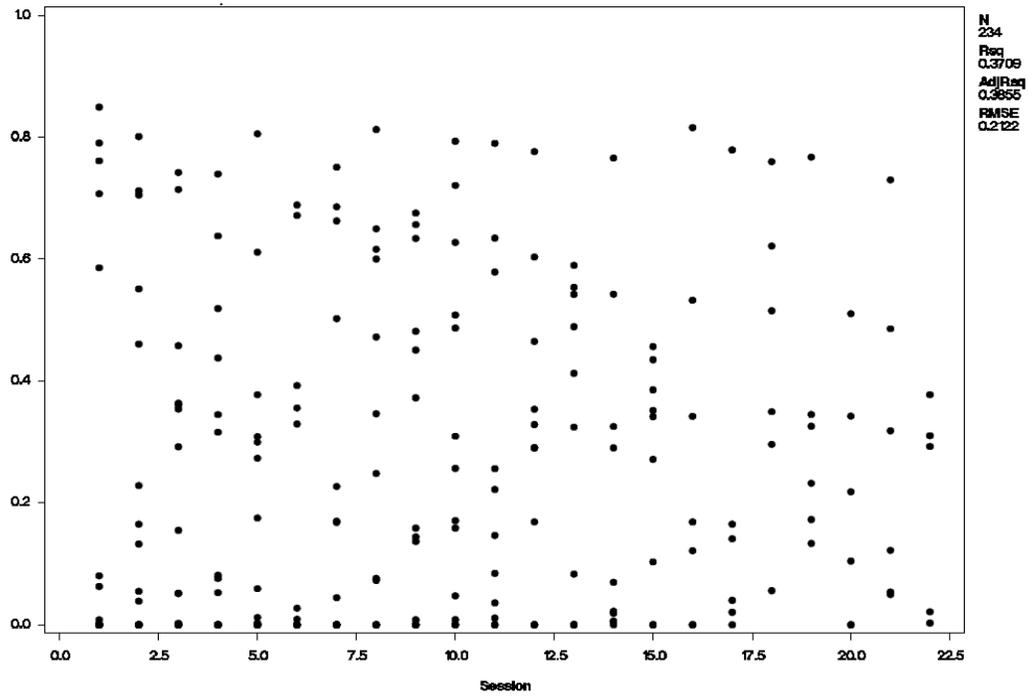
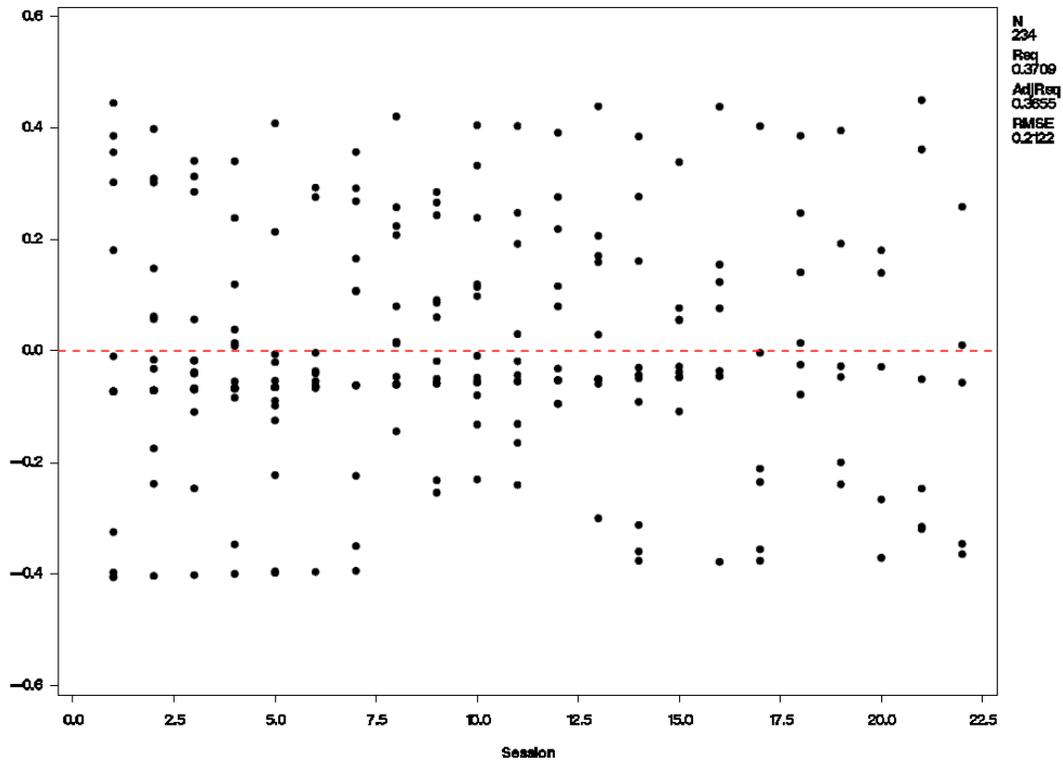


Figure F-4: Regression Model: aboveTHR proportions on 'Group' and 'Session' (Residual Plot)



Appendix G: Multiple Regressions

Table G-1: Mixed Model Multiple Regression on Average Heart Rate

The Mixed Procedure

| Model Information | |
|---------------------------|-----------------------------------|
| Data Set | GEMS.BOTHRS |
| Dependent Variable | realHR |
| Covariance Structures | Variance Components, Unstructured |
| Subject Effect | Subject |
| Estimation Method | REML |
| Residual Variance Method | None |
| Fixed Effects SE Method | Model-Based |
| Degrees of Freedom Method | Containment |

| Class Level Information | | |
|-------------------------|--------|--|
| Class | Levels | Values |
| Group | 2 | 0 1 |
| Trial | 30 | 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 |
| Interval | 12 | 0 1 2 3 4 5 6 7 8 9 10 11 |

| Dimensions | |
|-----------------------|------|
| Covariance Parameters | 79 |
| Columns in X | 440 |
| Columns in Z | 1 |
| Subjects | 1 |
| Max Obs Per Subject | 6120 |

| Number of Observations | |
|---------------------------------|------|
| Number of Observations Read | 6120 |
| Number of Observations Used | 2903 |
| Number of Observations Not Used | 3217 |

| Iteration History | | | |
|-------------------|-------------|-----------------|-----------|
| Iteration | Evaluations | -2 Res Log Like | Criterion |
| 0 | 1 | 24707.86834833 | |

WARNING: Stopped because of infinite likelihood.

Appendix H: Forms and Assorted Documents

Figure H-1: Recruiting Flyer



I WANT YOU!
To Win a Wii!

GEMSTONE TEAM FITNESS would like to invite you to participate in our study on interactive gaming!

PLAY DDR A FEW TIMES A WEEK AND ENTER FOR A CHANCE TO WIN A NINTENDO WII GAMING SYSTEM!!

INTERESTED?? REFER YOURSELF AND FRIENDS TO THE STUDY BY EMAILING THE BELOW ADDRESS

Email: GemsFitness@yahoogroups.com



Figure H-2: Activity Level Questionnaire

Gemstone: Team FITNESS

Please circle either yes or no, or rank from 1 to 5 where 1 is the lowest and 5 is the highest:

1. Are you interested in interactive games? Yes No
2. How often do you play video games? <5 5-10 10-15 15-20 20+ hrs per week
3. How many times have you used Nintendo's Wii console? Never Once or Twice Once a Month Once a Week Daily
4. Have you ever played Dance Dance Revolution? Yes No
5. How physically active are you? <30 30-60 60-120 120-180 180+ mins per week
6. Do you play any intramural or varsity sports? Yes No
7. Did you participate in any high school sports? Yes No
8. Do you use the campus recreational facilities? Yes No
9. Do you find jogging enjoyable? Yes No
10. Are your activity habits similar to your friends' habits? Yes No
11. Do you have any medical conditions that prevent you from being physically active? Yes No
12. What is your age? _____
13. Do you live on campus? Yes No
14. If no, how far off campus do you live? _____

Name:

Email:

Phone (optional):

I hereby grant Gemstone's Team FITNESS consent to contact me according to the information provided above:

Figure H-3: PAR-Q Form

Physical Activity Readiness Questionnaire (PAR-Q)

(representative of the American College of Sports Medicine standards)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly.

| No | Yes | |
|--------------------------|--------------------------|--|
| <input type="checkbox"/> | <input type="checkbox"/> | 1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor? |
| <input type="checkbox"/> | <input type="checkbox"/> | 2. Do you feel pain in your chest when you do physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 3. In the past month, have you had chest pain when you were not doing physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 4. Do you lose your balance because of dizziness or do you ever lose consciousness? |
| <input type="checkbox"/> | <input type="checkbox"/> | 5. Do you have a bone or joint problem that could be made worse by a change in your physical activity? |
| <input type="checkbox"/> | <input type="checkbox"/> | 6. Is your doctor currently prescribing drugs (for example water pills) for your blood pressure or heart condition? |
| <input type="checkbox"/> | <input type="checkbox"/> | 7. Do you know of <u>any other reason</u> why you should not do physical activity? |

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

If you answered YES to one or more questions

Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want as long as you start slowly and build up gradually. Or you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

If you answered NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

Delay becoming much more active if:

- You are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better, or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

I understand my signature signifies that I have read and understand all the information on the questionnaire, that I have truthfully answered all the questions, and that any questions/concerns I may have had have been addressed to my complete satisfaction.

Name (please print) _____

Signature _____

Date _____

Print and sign form. Then submit with Patron Application to the Foy Fitness and Recreation Center service desk.

Print Form
Reset Form

Table H-1: IRB Consent Form

| | |
|----------------------------------|--|
| Project Title | Team FITNESS |
| Why is this research being done? | <p><i>This is a research project being conducted by Team Fitness at the University of Maryland, College Park. We are inviting you to participate in this research project due to your current enrollment status as a University of Maryland student who lives on campus, between the ages of 18 and 23. The purpose of this research project is to determine the effects and benefits of interactive gaming exercise as compared to traditional modes of exercise.</i></p> |
| What will I be asked to do? | <p><i>The study involves ten weeks of participation. Each week includes three 30-minute sessions. You will participate in one of two groups of study, either in an interactive gaming group or a traditional exercise group and be paired with one of the student facilitators. The study will also involve periodic measurements, including resting heart rate. Furthermore, you will be required to fill out a weekly activity log throughout the course of the study. Once a week, your facilitator will conduct a short interview with you to determine your current attitude towards the study, along with any current progress. The research will take place on campus in a campus recreational. Throughout the study, there will be chances to receive rewards for your participation in including t-shirts, Nintendo Wii package raffles, and other small prizes.</i></p> |
| What about confidentiality? | <p><i>We will do our best to keep your personal information confidential. To help protect your confidentiality: (1) your name will not be included on the surveys or other collected data; (2) a code will be placed on the survey and other collected data; (3) through the use of an identification key, the researcher will be able to link your survey to your identity; (4) only the researcher will have access to the identification key. If we write a report or article about this research project, your identity will be protected to the maximum extent possible; (5) and in consent with federal guidelines, consent forms will be kept for 3 years after completion of the study in a secured location.</i></p> <p><i>Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.</i></p> |

| | |
|---|--|
| <p>What are the risks of this research?</p> | <p><i>There are risks from participating in this research study. As a result of physical activity or exertion, you may experience faint muscle soreness, fatigue, or any other physical injuries. However, medical assistance will be close at hand, and advice will be given on injury prevention and care. Normally, there are no long-term effects associated with any of these ailments.</i></p> |
| <p>What are the benefits of this research?</p> | <p><i>This research has the potential to help you personally by increasing your activity levels. The results may help the investigator learn more about the benefits and effects of interactive gaming exercise as compared to traditional modes of exercise. We hope that, in the future, other people might benefit from this study through improved understanding of how interactive games benefit people physically.</i></p> |
| <p>Do I have to be in this research? Can I stop participating at any time?</p> | <p><i>Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized; however, once participation is ended, your name becomes ineligible for the rewards.</i></p> |
| <p>Is any medical treatment available if I am injured?</p> | <p><i>The University of Maryland does not provide any medical, hospitalization or other insurance for participants in this research study, nor will the University of Maryland provide any medical treatment or compensation for any injury sustained as a result of participation in this research study, except as required by law.</i></p> |
| <p>What if I have questions?</p> | <p><i>This research is being conducted by Team FITNESS, an undergraduate Gemstone team at the University of Maryland, College Park. If you have any questions about the research study itself, please contact Britney Gerstner at: britneyg@umd.edu or at teamfitness2010@aol.com. If you have questions about your rights as a research subject or wish to report a research-related injury, please contact: Institutional Review Board Office, University of Maryland, College Park, Maryland, 20742; (e-mail) irb@deans.umd.edu; (telephone) 301-405-0678 This research has been reviewed according to the University of Maryland, College Park IRB procedures for research involving human subjects.</i></p> |

| | | |
|---|---|--|
| Statement of Age of Subject and Consent | <i>Your signature indicates that: you are between 18 and 23 years of age; the research has been explained to you; your questions have been answered; and you freely and voluntarily choose to participate in this research project.</i> | |
| Signature and Date | NAME OF SUBJECT | |
| | SIGNATURE OF SUBJECT | |
| | DATE | |

Table H-2: Sample Recruiting and Participant Correspondences

Email response to flier/listserv:

Hi,

My name is FACILITATOR. I am a representative of Gemstone's Team FITNESS. I would like to thank you for taking the time to contact our group and give you some more information on our project:

For our project, we will be comparing the physical differences of interactive gaming (Dance Dance Revolution on Wii) opposed to traditional exercising (walk/jog around a track). Once all the participants have been selected, they will randomly be split into one of those two groups. Three times a week, for roughly thirty minutes, you will be asked to join us at the Eppley Rec Center, depending on your availability, so that we may measure your heart rate and asses the overall fitness levels of either activity throughout the semester. Though this may seem to be a heavy time commitment there are benefits. For every session you attend, your name is entered into the Wii raffle, therefore increasing your chances of winning. Also, your assistance in this project will allow Team FITNESS to make conclusive arguments either for or against interactive gaming as a form of exercise.

Once again, thank you very much for contacting our group. I have attached a very brief questionnaire that I ask you to please fill out and return either to myself or to GemsFitness@yahoo.com as soon as possible. I look forward to hearing back from you soon and hope to see you at the start of the study!

Sincerely,
FACILITATOR
Team FITNESS

Email response to returned questionnaires:

Hi,

Thank you for taking the time to look over and fill out our questionnaire. We will be reviewing your submission, along with other participants', over the next two weeks as we continue recruiting. We are looking to begin the study on Monday Sept. 28 so we will be in contact with you with more specifics (times, dates, etc) shortly. Once again thank you for your interest in our study and we look forward to your further participation. Also, please tell any of your friends about our project who may also be interested!

Sincerely,
FACILITATOR
Team FITNESS

Email response to delayed questionnaires:

Hi,

I noticed you did not return your questionnaire and just wanted to check in and see if you were still interested in our project. I have reattached the questionnaire for you to fill out so please email me back if you are interested or not.

Sincerely,
FACILITATOR
Team FITNESS

Email response to accepted participants:

Hi,

I wanted to again thank you for time and for your desire to assist in our project. After reviewing your questionnaire we feel you would be a great candidate for our research. If you could, please fill out the attached timesheet. Please only mark an "X" through times you are not available to meet. On Monday Sept. 28 we will be having a meet and greet party at 8:15pm in the Center for Health and Well Being in the ERC with light refreshments along with a Wii hooked up to play. This will give you a chance to meet the other participants along with the team leaders. Based on your availability we will create a schedule where you will meet with one of the team leaders three times a week for ten weeks throughout the semester. Since this project would be nothing without its participants we will work in every way possible to accommodate to your personal schedule. Also, every session you attend your name will be entered into the raffle to win a new Wii at the end, so attending not only benefits us, but you as well. Once again thank you for choosing to help with Team FITNESS and I look forward to hearing back from you soon! Please let me know if you have any further questions or concerns!

Sincerely,
FACILITATOR
Team FITNESS

Email response to denied participants:

Hi,

I wanted to thank you for time and for your desire to assist in our project. After reviewing your questionnaire we regret to inform you that we will not be able to use you in our research. There were several key elements we were looking for in our participants and unfortunately we will not be needing your assistance. Once again thank you for your time and I hope you have a wonderful semester.

Sincerely,
FACILITATOR
Team FITNESS

Email response to returned time sheets:

Hi,

Thanks for filling out the time sheet. We hope to see you Monday at the meet and greet on Monday Sept. 28 at 8:15pm in the Center for Health and Well Being in the ERC. Please let me know if you will not be able to attend. We will begin formulating your weekly schedule and pairing you up with your team leader later this week. Once again, thanks for all your help and see you Monday!

Sincerely,
FACILITATOR
Team FITNESS

Email response to delayed time sheets:

Hi,

I noticed you did not return your time sheet and just wanted to check in and see if you were still interested in our project. I have reattached the time sheet for you to fill out so please email me back if you are still interested or not. Also, if you are interested please let me know if you plan on attending tonight's meet and greet. Hope to see you there!

Sincerely,
FACILITATOR
Team FITNESS

Figure H-4: Sample Activity Log



WEEKLY ACTIVITY LOG



1. This log applies to the following week dates:

- | | |
|---------------------------------|----------------------------------|
| a. <input type="radio"/> Week 1 | f. <input type="radio"/> Week 6 |
| b. <input type="radio"/> Week 2 | g. <input type="radio"/> Week 7 |
| c. <input type="radio"/> Week 3 | h. <input type="radio"/> Week 8 |
| d. <input type="radio"/> Week 4 | i. <input type="radio"/> Week 9 |
| e. <input type="radio"/> Week 5 | j. <input type="radio"/> Week 10 |

Please list date of this week's Monday: _____

2. Participant ID# | _____

3. Trainer's Name

- | | |
|----------------------------------|------------------------------------|
| a. <input type="radio"/> Colin | f. <input type="radio"/> Matthew |
| b. <input type="radio"/> Sean | g. <input type="radio"/> Andrew |
| c. <input type="radio"/> Jojo | h. <input type="radio"/> Alexander |
| d. <input type="radio"/> Britney | i. <input type="radio"/> Justin |
| e. <input type="radio"/> Chris | j. <input type="radio"/> Joseph |

4. Target Heart Rate (220 minus age) | _____

5. I participated in a FITNESS session on the following days this week:

- | | |
|---------------------------------------|--------------------------------------|
| a. <input type="checkbox"/> Monday | e. <input type="checkbox"/> Friday |
| b. <input type="checkbox"/> Tuesday | f. <input type="checkbox"/> Saturday |
| c. <input type="checkbox"/> Wednesday | g. <input type="checkbox"/> Sunday |
| d. <input type="checkbox"/> Thursday | |

6. I enjoyed my FITNESS sessions this week!

Strongly Agree Agree Slightly Agree Neutral Slightly Disagree Disagree Strongly Disagree

7. The following are things that could make my FITNESS sessions more enjoyable and/or beneficial:

8. I slept at least 6 hours these nights this week:

- | | |
|---------------------------------------|--------------------------------------|
| a. <input type="checkbox"/> Monday | e. <input type="checkbox"/> Friday |
| b. <input type="checkbox"/> Tuesday | f. <input type="checkbox"/> Saturday |
| c. <input type="checkbox"/> Wednesday | g. <input type="checkbox"/> Sunday |
| d. <input type="checkbox"/> Thursday | |

9. I combined cardiovascular exercise, strength training exercise, and stretching in my workout on the following days this week:

- | | |
|---------------------------------------|--------------------------------------|
| a. <input type="checkbox"/> Monday | e. <input type="checkbox"/> Friday |
| b. <input type="checkbox"/> Tuesday | f. <input type="checkbox"/> Saturday |
| c. <input type="checkbox"/> Wednesday | g. <input type="checkbox"/> Sunday |
| d. <input type="checkbox"/> Thursday | |

10. I participated in _____ minutes of cardiovascular exercise this week!

11. I participated in cardiovascular exercise on the following days this week:

- | | |
|---------------------------------------|--------------------------------------|
| a. <input type="checkbox"/> Monday | e. <input type="checkbox"/> Friday |
| b. <input type="checkbox"/> Tuesday | f. <input type="checkbox"/> Saturday |
| c. <input type="checkbox"/> Wednesday | g. <input type="checkbox"/> Sunday |
| d. <input type="checkbox"/> Thursday | |

12. I participated in _____ minutes of strength training exercise this week!

13. I participated in strength training exercise on the following days this week:

- | | |
|---------------------------------------|--------------------------------------|
| a. <input type="checkbox"/> Monday | e. <input type="checkbox"/> Friday |
| b. <input type="checkbox"/> Tuesday | f. <input type="checkbox"/> Saturday |
| c. <input type="checkbox"/> Wednesday | g. <input type="checkbox"/> Sunday |
| d. <input type="checkbox"/> Thursday | |

14. I spent _____ minutes stretching my major muscle groups this week!

15. I stretched my major muscle groups on the following days this week:

- | | |
|-------------------------------------|---------------------------------------|
| a. <input type="checkbox"/> Monday | c. <input type="checkbox"/> Wednesday |
| b. <input type="checkbox"/> Tuesday | d. <input type="checkbox"/> Thursday |

- e. Friday
f. Saturday
- g. Sunday

16. I played _____ minutes of non-interactive video games this week!

17. I played non-interactive video games on the following days this week:

- a. Monday
b. Tuesday
c. Wednesday
d. Thursday
- e. Friday
f. Saturday
g. Sunday

18. I played _____ minutes of interactive video games this week!

19. I played interactive video games on the following days this week:

- a. Monday
b. Tuesday
c. Wednesday
d. Thursday
- e. Friday
f. Saturday
g. Sunday

20. I participated in the following activities this week:

- a. Aerobics (any type, including step and water)
- b. Basketball
- c. Bicycling (any type, including stationary)
- d. Bowling
- e. Boxing
- f. Circuit Training (any type)
- g. Dancing (any type)
- h. Elliptical Trainer
- i. Football
- j. Golf
- k. Gymnastics
- l. Hiking
- m. Hockey (any type)
- n. Ice skating
- o. Jogging
- p. Kayaking
- q. Martial arts (any type)
- r. Racquetball
- s. Running
- t. Skateboarding
- u. Skiing (any type, including snow or water)
- v. Ski Machine
- w. Soccer
- x. Softball
- y. Stair Step Machine
- z. Swimming
- aa. Tennis
- bb. Walking
- cc. Water Polo
- dd. Wrestling
- ee. Volleyball
- ff. Other

21. If you chose OTHER in the last question, please explain which activities you participated in below:

22. I missed one or more of my FITNESS sessions this week

YES NO

23. If you answered yes to the last question, the reason(s) for the missed session are:

- a. Stress
- b. Work
- c. School commitments (homework, exam, etc.)
- d. Doctor's appointment
- e. Rather not say
- f. Other

24. The following are any further comments I may have on the FITNESS study:

25. My initials certify that my above answers are true to the best of my knowledge:

Appendix I: Participant Demographics

Table I-1: Participant Divisions by Gender

| Gender | Number of participants: | Percentage of total: |
|--------|-------------------------|----------------------|
| Male | 10 | 59% |
| Female | 7 | 41% |

Table I-2: Participant Divisions by Race/Ethnicity

| Race | Number of participants: | Percentage of total: |
|---------------------|-------------------------|----------------------|
| African American | 3 | 18% |
| Asian | 2 | 12% |
| Hispanic | 0 | 0% |
| White, Non-Hispanic | 12 | 70% |

Table I-3: Participant Divisions by Age

| Age | Number of participants: | Percentage of total: |
|-----|-------------------------|----------------------|
| 18 | 2 | 12% |
| 19 | 6 | 35% |
| 20 | 6 | 35% |
| 21 | 3 | 18% |

Table I-4: Participant Divisions by Class Standing

| Class standing | Number of participants: | Percentage of total: |
|----------------|-------------------------|----------------------|
| Freshman | 2 | 12% |
| Sophomore | 5 | 29% |
| Junior | 7 | 41% |
| Senior | 3 | 18% |

Appendix J: Other Tables and Figures

Figure J-1: MyPyramid



Appendix K: SAS Code

Heart Rate Conversion from .xls to .sas

```

/*****
Imports all the Spring 2009 Excel Data then converts them to SAS format.
*****/

/*Import individual participant HR data from Excel into SAS 1*/

PROC IMPORT OUT=WORK.hrOLD1
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\01326.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD1
  OUT=hrNEW1 (rename=(coll=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW1 (drop = _LABEL_);
  SET hrNEW1;
RUN;

/*Sort data by session*/
proc sort data=hrNEW1;
  BY SESSION;
run;

Proc print data=hrNEW1 (obs = 15);
RUN;

/*Import individual participant HR data from Excel into SAS 2*/

PROC IMPORT OUT=WORK.hrOLD2
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\01570.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/
```

```

PROC transpose data=hrOLD2
  OUT=hrNEW2 (rename=(coll=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW2 (drop = _LABEL_);
  SET hrNEW2;
RUN;

/*Sort data by session*/
proc sort data=hrNEW2;
  BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 3*/

PROC IMPORT OUT=WORK.hrOLD3
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\02051.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD3
  OUT=hrNEW3 (rename=(coll=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW3 (drop = _LABEL_);
  SET hrNEW3;
RUN;

/*Sort data by session*/
proc sort data=hrNEW3;
  BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 4*/

PROC IMPORT OUT=WORK.hrOLD4
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\03143.xls"
  DBMS=excel REPLACE;
  SHEET="avg";

```

```

        RANGE="A1:AG13";
        GETNAMES=YES;
        MIXED=YES;
        USEDATE=YES;
        SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/
PROC transpose data=hrOLD4
    OUT=hrNEW4 (rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/
data hrNEW4 (drop = _LABEL_);
    SET hrNEW4;
RUN;

/*Sort data by session*/
proc sort data=hrNEW4;
    BY SESSION;
run;
/*Import individual participant HR data from Excel into SAS 5*/
PROC IMPORT OUT=WORK.hrOLD5
    DATAFILE= "F:\Gemstone\Separated_SPRING2009\06426.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/
PROC transpose data=hrOLD5
    OUT=hrNEW5 (rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/
data hrNEW5 (drop = _LABEL_);
    SET hrNEW5;
RUN;

/*Sort data by session*/
proc sort data=hrNEW5;
    BY SESSION;
run;

```

```

/*Import individual participant HR data from Excel into SAS 6*/

PROC IMPORT OUT=WORK.hrOLD6
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\06431.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD6
  OUT=hrNEW6 (rename=(coll=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW6 (drop = _LABEL_);
  SET hrNEW6;
RUN;

/*Sort data by session*/
proc sort data=hrNEW6;
  BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 7*/

PROC IMPORT OUT=WORK.hrOLD7
  DATAFILE= "F:\Gemstone\Separated_SPRING2009\06497.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD7
  OUT=hrNEW7 (rename=(coll=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

```

```

data hrNEW7 (drop = _LABEL_);
    SET hrNEW7;
RUN;

/*Sort data by session*/
proc sort data=hrNEW7;
    BY SESSION;
run;

/*Merge all individual data sets into on Master Data set*/
DATA allHRS;
    SET hrNEW1 hrNEW2 hrNEW3 hrNEW4 hrNEW5 hrNEW6 hrNEW7;
run;

/*Sort and print the data*/
PROC Sort data=allHRS;
    BY Group Subject SESSION;
RUN;

PROC PRINT DATA=allHRS;
run;

/*****
For Saving
*****/

/*Takes the previous data set and saves it to F: drive*/
DATA 'F:\SAS_datsets\SpringHR';
    set allHRS;
RUN;

/*This creates a new library (basically a SAS folder) in which I can refer to previous
data sets
Do this after closing then reopening the SAS program*/
libname GEMS 'f:\SAS_datsets';

PROC PRINT DATA=GEMS.SpringHR (obs =50);
run;

/*****

Exporting the File to remove XML format
*****/

PROC EXPORT DATA=GEMS.SpringHR
    outfile="f:\spr_halfway.xls"
    DBMS=EXCEL REPLACE;
run;

/*****

Now, I need to go into Excel, add the new column
and Save the "getDone.xls" file to retain the changes.

```

```

*****/

PROC IMPORT OUT=WORK.almostHR
  DATAFILE= "F:\spr_halfway.xls"
  DBMS=excel REPLACE;
  SHEET="SpringHR";
  RANGE="A1:F3601";
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

Data finalHR;
  set almostHR (Drop=HeartRate);
Run;

PROC PRINT DATA=finalHR (obs = 40);
RUN;

PROC MEANS data=finalHR;
  CLASS Group SESSION;
  var realHR;
Run;
/*Takes the previous data set and saves it to F: drive*/

DATA 'F:\SAS_datasets\REALSPRG';
  set finalHR;
RUN;

/*****/

/*This creates a new library (basically a SAS folder)
in which I can refer to previous data sets*/

libname GEMS 'f:\SAS_datasets';

PROC PRINT DATA=GEMS.REALSPRG;
run;

PROC MEANS data=GEMS.REALSPRG;
  CLASS Group SESSION;
  var realHR;
Run;

```

```

/*****
Imports all the Fall 2009 Excel Data then converts them to SAS format.
*****/

/*Import individual participant HR data from Excel into SAS 1*/

PROC IMPORT OUT=WORK.hrOLD1
  DATAFILE= "F:\Gemstone\Separated_FALL2009\02713.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD1
  OUT=hrNEW1(rename=(col1=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW1 (drop = _LABEL_);
  SET hrNEW1;
RUN;

/*Sort data by session*/
proc sort data=hrNEW1;
  BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 2*/

PROC IMPORT OUT=WORK.hrOLD2
  DATAFILE= "F:\Gemstone\Separated_FALL2009\03975.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD2
  OUT=hrNEW2(rename=(col1=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

```

```

/*Remove extra "LABEL" column*/

data hrNEW2 (drop = _LABEL_);
    SET hrNEW2;
RUN;

/*Sort data by session*/
proc sort data=hrNEW2;
    BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 3*/
PROC IMPORT OUT=WORK.hrOLD3
    DATAFILE= "F:\Gemstone\Separated_FALL2009\04217.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/
PROC transpose data=hrOLD3
    OUT=hrNEW3(rename=(col1=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW3 (drop = _LABEL_);
    SET hrNEW3;
RUN;

/*Sort data by session*/
proc sort data=hrNEW3;
    BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 4*/
PROC IMPORT OUT=WORK.hrOLD4
    DATAFILE= "F:\Gemstone\Separated_FALL2009\04728.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

```

```

PROC transpose data=hrOLD4
    OUT=hrNEW4 (rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW4 (drop = _LABEL_);
    SET hrNEW4;
RUN;

/*Sort data by session*/
proc sort data=hrNEW4;
    BY SESSION;
run;
/*Import individual participant HR data from Excel into SAS 5*/

PROC IMPORT OUT=WORK.hrOLD5
    DATAFILE= "F:\Gemstone\Separated_FALL2009\05871.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD5
    OUT=hrNEW5 (rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW5 (drop = _LABEL_);
    SET hrNEW5;
RUN;

/*Sort data by session*/
proc sort data=hrNEW5;
    BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 6*/

PROC IMPORT OUT=WORK.hrOLD6
    DATAFILE= "F:\Gemstone\Separated_FALL2009\06155.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;

```

```

        USEDATE=YES;
        SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD6
    OUT=hrNEW6(rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW6 (drop = _LABEL_);
    SET hrNEW6;
RUN;

/*Sort data by session*/
proc sort data=hrNEW6;
    BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 7*/

PROC IMPORT OUT=WORK.hrOLD7
    DATAFILE= "F:\Gemstone\Separated_FALL2009\06614.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD7
    OUT=hrNEW7(rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW7 (drop = _LABEL_);
    SET hrNEW7;
RUN;

/*Sort data by session*/
proc sort data=hrNEW7;
    BY SESSION;
run;

```

```

/*Import individual participant HR data from Excel into SAS 8*/

PROC IMPORT OUT=WORK.hrOLD8
  DATAFILE= "F:\Gemstone\Separated_FALL2009\07164.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD8
  OUT=hrNEW8(rename=(col1=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW8 (drop = _LABEL_);
  SET hrNEW8;
RUN;

/*Sort data by session*/
proc sort data=hrNEW8;
  BY SESSION;
run;
/*Import individual participant HR data from Excel into SAS 9*/

PROC IMPORT OUT=WORK.hrOLD9
  DATAFILE= "F:\Gemstone\Separated_FALL2009\08793.xls"
  DBMS=excel REPLACE;
  SHEET="avg";
  RANGE="A1:AG13";
  GETNAMES=YES;
  MIXED=YES;
  USEDATE=YES;
  SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/

PROC transpose data=hrOLD9
  OUT=hrNEW9(rename=(col1=HeartRate))
  NAME=SESSION;

  var SESSION01-SESSION30;
  BY Group Subject Interval;
  /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/

data hrNEW9 (drop = _LABEL_);
  SET hrNEW9;
RUN;

```

```

/*Sort data by session*/
proc sort data=hrNEW9;
    BY SESSION;
run;

/*Import individual participant HR data from Excel into SAS 10*/
PROC IMPORT OUT=WORK.hrOLD10
    DATAFILE= "F:\Gemstone\Separated_FALL2009\09384.xls"
    DBMS=excel REPLACE;
    SHEET="avg";
    RANGE="A1:AG13";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

/*Transpose the heart rate data and prep it for SAS analysis*/
PROC transpose data=hrOLD10
    OUT=hrNEW10(rename=(coll=HeartRate))
    NAME=SESSION;

    var SESSION01-SESSION30;
    BY Group Subject Interval;
    /* Eventually need to add "by group and subject"*/

run;

/*Remove extra "LABEL" column*/
data hrNEW10 (drop = _LABEL_);
    SET hrNEW10;
RUN;

/*Sort data by session*/
proc sort data=hrNEW10;
    BY SESSION;
run;

/*Merge all individual data sets into on Master Data set*/
DATA allHEARTS;
    SET hrNEW1 hrNEW2 hrNEW3 hrNEW4 hrNEW5 hrNEW6 hrNEW7 hrNEW8 hrNEW9 hrNEW10 ;
run;

/*Sort and print the data*/
PROC Sort data=allHEARTS;
    BY Group Subject SESSION;
RUN;

PROC PRINT DATA=allhearts;
run;

```

```

/*****
For Saving
*****/

/*Takes the previous data set and saves it to F: drive*/

DATA 'F:\SAS_datasets\FALLhr';
    set allhearts;
RUN;

proc print data='F:\SAS_datasets\FALLhr' (obs = 40);
run;

/*This creates a new library (basically a SAS folder) in which I can refer to previous
data sets
Do this after closing then reopening the SAS program*/

libname GEMS 'f:\SAS_datasets';

PROC PRINT DATA=GEMS.Fallhr (obs = 40);
run;

/*****

Exporting the File to remove XML format
*****/

PROC EXPORT DATA=GEMS.fallhr
    outfile="f:\fall_halfway.xls"
    DBMS=EXCEL REPLACE;
run;

/*****

Now, I need to go into Excel, add the new column
and Save the "getDone.xls" file to retain the changes.

*****/

PROC IMPORT OUT=WORK.almostHR
    DATAFILE= "F:fall_halfway.xls"
    DBMS=excel REPLACE;
    SHEET="fallHR";
    RANGE="A1:F3601";
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

Data finalHR;
    set almostHR (Drop=HeartRate);
Run;

PROC PRINT DATA=finalHR;
RUN;

PROC MEANS data=finalHR;
    CLASS Group SESSION;
    var realHR;
Run;
/*Takes the previous data set and saves it to F: drive*/

```

```
DATA 'F:\SAS_datasets\realFALL';
    set finalHR;
RUN;

/*****/

/*This creates a new library (basically a SAS folder)
in which I can refer to previous data sets*/

libname GEMS 'f:\SAS_datasets';

PROC PRINT DATA=GEMS.realFALL;
run;

PROC MEANS data=GEMS.realFALL;
    CLASS Group SESSION;
    var realHR;
Run;
```

Heart Rate Data Analysis SAS Code

```
libname GEMS 'f:\SAS_datasets';

/*Creates format for Group variable */
proc format;
    value groups 0="Track"
                                1="Interactive Gaming";
run;

proc format;
    value misdata 0="Data Missing"
                                1="Data Available";
run;

/*Creates Numeric Value for Sessions --> Becomes "Trials"*/
DATA Sprgwork;
    SET GEMS.realSPRG;
    SEMESTER = 0;
RUN;

DATA Fallwork;
    SET GEMS.realFALL;
    SEMESTER = 1;
RUN;

Data combined;
    SET Sprgwork Fallwork;
    Trial = INPUT(COMPRESS(SESSION,'0123456789','k'),2.);
RUN;

Data GEMS.BOTHHRS;
    retain Semester Group Subject Session Trial Interval realHR;
    set combined;
run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY SEMESTER GROUP SUBJECT Trial;
run;

PROC PRINT DATA=GEMS.BOTHHRS;
RUN;

/** if Semester = 0, then it is Spring 2009
if Semester = 1, then it is Fall 2009 **/

ods PDF body="F:\Gemstone\HR_OUTPUT\Simple Reg on 3MA HRs (All Subjs).PDF";

proc reg data=GEMS.BOTHHRS;
    model realHR = Trial Interval;
    plot realHR * (Trial Interval) / pred;
    symbol1 value=dot color=black;
    title 'Simple Regression of HR by Trial, Time (All Data)';
Run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY GROUP;
run;

proc reg data=GEMS.BOTHHRS;
    model realHR = Trial Interval;
    plot realHR * (Trial Interval) / pred;
    by group;
    format group groups.;
    symbol1 value=dot color=black;
```

```

    title 'Simple Regression of HR by Session, Time';
Run;

proc reg data=GEMS.BOTHHRS;
    model realHR = Group Trial Interval;
    plot realHR * (Trial Interval) / pred;
        symbol1 value=dot color=black;
    title 'Simple Regression of HR by Group, Session, Time';
Run;

ods PDF close;

PROC SORT DATA=GEMS.BOTHHRS;
    BY SEMESTER GROUP SUBJECT SESSION;
RUN;

proc contents data=GEMS.BOTHHRS;
run;

/** Descriptive Statistics for Fall 2009**/
PROC PRINT DATA=GEMS.BOTHHRS;
    TITLE 'Descriptive Stats of Three-Min Heart Rate Averages (3MA)';
run;

ods PDF body="F:\Gemstone\HR_OUTPUT\Descriptive Stats (both sems).PDF";

PROC SORT DATA=GEMS.BOTHHRS;
    BY SEMESTER GROUP SESSION TRIAL INTERVAL SUBJECT;
RUN;

data HRfreq;
    set GEMS.BOTHHRS;
    if realHR = '.' then count=0;
    else if realHR >= 0 then count=1;
run;

/*This displays the dropout rate basically*/

proc freq data=hrfreq COMPRESS;
    TABLES count*SEMESTER count*GROUP/nocum sparse;
    format count misdata.;
    title 'Three Min Average HR Data Frequency';
RUN;

proc freq data=hrfreq;
    TABLES count*TRIAL count*INTERVAL count*SUBJECT/nocum sparse;
    format count misdata.;
    title 'Three Min Average HR Data Frequency';
RUN;

PROC MEANS data=GEMS.BOTHHRS;
    CLASS Group SESSION;
    var realHR;
    title 'Three Min Heart Rate Averages';
Run;
ods pdf close;

ods PDF body="F:\Gemstone\HR_OUTPUT\Boxplots (both sems realHR).PDF";

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*Group;
    insetgroup mean stddev /
        header = 'Overall Statistics';
    title 'Group Box Plot Comparison of 3M Avgs';
    label realHR = 'Heart Rate (BPM)';

```

```

run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY SEMESTER GROUP SUBJECT SESSION;
RUN;

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*SEMESTER;
    insetgroup mean stddev /
        header = 'Overall Statistics';
    title 'Semester Box Plot Comparison of 3M Avgs';
    label realHR = 'Heart Rate (BPM)';
run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY Interval;
RUN;

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*Interval;
    insetgroup mean stddev /
        header = 'Stats by Interval (3 Min Averages)';

    title 'Box Plot Comparison of Heart Rate (BPM) by Interval';
    label realHR = 'Heart Rate (BPM)';
run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY Group Interval;
RUN;

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*Interval;
        by group;
        format group groups.;
    symbol2 i=BOXJT00 c=black l=2 w=2.5;

    title 'Box Plot Comparison of Heart Rate (BPM) by Interval';
    label realHR = 'Heart Rate (BPM)';
run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY Trial;
RUN;

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*Trial;
    symbol2 i=BOXJT00 c=black l=2 w=2.5;

    title 'Box Plot Comparison of Heart Rate (BPM) by Trial';
    label realHR = 'Heart Rate (BPM)';
run;

PROC SORT DATA=GEMS.BOTHHRS;
    BY Group Trial;
RUN;

PROC BOXPLOT DATA=GEMS.BOTHHRS;
    plot realHR*Trial;
        by group;
        format group groups.;
    symbol2 i=BOXJT00 c=black l=2 w=2.5;

    title 'Box Plot Comparison of Heart Rate (BPM) by Trial';
    label realHR = 'Heart Rate (BPM)';
run;

```

```

ods pdf close;

/* Creates plots of Three Min avgs by Session, then saves in PDF*/
ods PDF body="F:\Gemstone\HR_OUTPUT\3min avg plots (Both Sems).PDF" ;

PROC SORT DATA=GEMS.BOTHHRS;
    BY Trial;
RUN;

proc gplot data=GEMS.BOTHHRS;
    by trial;
    symbol1 value=dot color=black i=r1 ci = black w = 4;
    plot realHR*Interval / vaxis = 0 to 250 by 25;
    title 'Plots of HR by Interval';
    label realHR = 'Heart Rate (BPM)';
    label Interval = 'Time (3 Min Avgs)';
run;

ods PDF close;

/* Convert "SESSION" into a numeric "Trial" for regression analysis */

/*
Data GEMS.ANALhr;
    SET GEMS.GEMSHR;
    Trial = INPUT(COMPRESS(SESSION,'0123456789',"k"),2.);
RUN;

PROC SORT DATA=GEMS.ANALhr;
    BY GROUP SUBJECT SESSION;
run;

*/

ods PDF body="F:\Gemstone\HR_OUTPUT\Plain Output (both sems).PDF";

PROC PRINT DATA=GEMS.BOTHHRS;
    title '3 Min. Avg Heart Rate (in BPM) Output with Trials ';
RUN;

ods pdf close;

/**Do a t test on Group averages**/
ods PDF body="F:\Gemstone\HR_OUTPUT\t-tests on Heart Rates (both sems).PDF";

/*to check for differences between semesters*/
PROC ttest data=GEMS.BOTHHRS;
    var realHR;
    CLASS Semester;
    title 't-tests of Heart Rate (BPM) by Semester';

RUN;

PROC ttest data=GEMS.BOTHHRS;
    var realHR;
    CLASS GROUP;
    title 't-tests of Heart Rate (BPM) by Groups';

RUN;

Proc sort data=GEMS.BOTHHRS;
    by trial;
run;

```

```

PROC ttest data=GEMS.BOTHHRS;
    var realHR;
    CLASS group;
    by trial;
RUN;

ods pdf close;

/*Simple regression, though cannot say much*/

ods PDF body="F:\Gemstone\HR_OUTPUT\Simple Reg on 3MA HRs (both sems).PDF";
proc reg data=GEMS.BOTHHRS;
    title 'Simple Regression of HR by Group, Trial, Time';
    model realHR = Group Trial Interval;
    plot realHR * (Trial Interval) / pred;
        symbol value=dot color=black i=rl ci = black w = 4;
Run;

proc corr data=GEMS.BOTHHRS;
    var realHR;
    With Group Trial Interval;
RUN;
ods PDF close;

/*The true model, (mixed model regression)*/

ods PDF body="F:\Gemstone\HR_OUTPUT\Multi Reg on 3MA HRs (both sems).PDF";
PROC mixed data=GEMS.BOTHHRS;
    Title 'Basic Multiple Regression: Mixed Model for HR by Group, Trial, and
Interval';
    CLASS GROUP Trial INTERVAL;
    MODEL realHR = Group Trial Interval Group*Interval Group*Trial Interval*Trial;
    Random SUBJECT;
run;
ods pdf close;

ods PDF body="F:\Gemstone\HR_OUTPUT\Multiple Regression problems (both sems).PDF";
/*Need to do it as below but CANNOT because of missing data!!!!*/
PROC mixed data=GEMS.BOTHHRS;
    Title 'Regression: Mixed Model for HR by Group, Trial, and Interval';
    CLASS GROUP Trial INTERVAL;
    MODEL realHR = Group Trial Interval Group*Interval Group*Trial Interval*Trial;
    Random SUBJECT;
    repeated Interval / type =un subject = Subject;
    LSMEANS Trial INTERVAL GROUP;
run;
/*Need to do it as above but CANNOT because of missing data!!!!*/

ods pdf close;

```

Target Heart Rate Conversion and Analysis SAS Code

```
PROC IMPORT OUT=WORK.Targets
    DATAFILE= "F:\Gemstone\FULL target HRS.xls"
    DBMS=excel REPLACE;
    SHEET="THR sheet";
    RANGE="A1:G511";
    GETNAMES=YES;
    MIXED=YES;
    USEDATE=YES;
    SCANTIME=YES;
RUN;

data targets (drop = _LABEL_);
    SET targets;
RUN;

Proc print data=targets (obs=100);
run;

DATA 'F:\SAS_datasets\prop_THR';
    Set targets;
RUN;

/*This creates a new library (basically a SAS folder) in which I can refer to previous
data sets
Do this after closing then reopening the SAS program*/

libname GEMS 'f:\SAS_datasets';

/*Creates format for Group variable */
proc format;
    value groups 0="Track"
                                1="Interactive Gaming";
run;

/*Shows the missing data issue*/

Proc sort data=GEMS.prop_THR (obs=12);
    by Semester Group Subject;
run;

Proc freq data=GEMS.prop_THR;
    tables Semester Group Subject;
run;

PROC PRINT DATA=GEMS.prop_THR;
run;

Proc Sort data=GEMS.prop_THR;
    by session;
run;

Proc means data=GEMS.prop_THR;
    var inTHR aboveTHR;
    BY Session;
run;

/*Side Note: Chow Test to combine FALL/SPRING data for inTHR*/

/*Note below: as the number of sessions allow for the model, the p-value on the Chow
test decreases; alpha=0.01,
```

(which means as the sessions increase merging the data becomes worse and worse since more missing data)*/

```
ods PDF body="F:\Gemstone\HR_OUTPUT\Frequencies (inTHR aboveTHR).PDF";
```

```
/*To find proper Chow cut off*/
```

```
Proc freq data=GEMS.prop_THR;  
    tables Semester Group Subject;  
run;
```

```
ods pdf close;
```

```
ods PDF body="F:\Gemstone\HR_OUTPUT\Chow Tests (inTHR aboveTHR).PDF";
```

```
proc SORT data = GEMS.prop_THR;  
    BY SEMESTER;  
run;
```

```
proc autoreg data = GEMS.prop_THR;  
    model inTHR = Group Session /chow = 210;  
        where (Session <= 15);  
    TITLE 'Chow Test on Duration Proportion in THR Zone (max Sessions = 15)';  
run;
```

```
proc autoreg data = GEMS.prop_THR;  
    options horigin=5.25;  
    model inTHR = Group Session /chow = 210;  
        TITLE 'Chow Test on Duration Proportion in THR Zone (max Sessions = 30)';  
run;
```

```
/*Chow Tests for aboveTHR: Only interested in Chow values*/
```

```
proc SORT data = GEMS.prop_THR;  
    BY SEMESTER;  
run;
```

```
proc autoreg data = GEMS.prop_THR;  
    goptions hsize= 5.20in vsize= 3.75in device=pdfc ftext="swissb"  
    horigin=0 in vorigin=0 in ;  
    model aboveTHR = Group Session /chow = 210;  
        where (Session <= 15);  
    TITLE 'Chow Test on Duration Proportion Above THR (max Sessions = 15)';  
run;
```

```
proc autoreg data = GEMS.prop_THR;  
    goptions horigin=5.25 in;  
    model aboveTHR = Group Session /chow = 210;  
        where (Session <= 30);  
    TITLE 'Chow Test on Duration Proportion Above THR (max Sessions = 30)';  
run;
```

```
ods pdf close;
```

```
/*Box Plots for inTHR and aboveTHR*/
```

```
ods PDF body="F:\Gemstone\HR_OUTPUT\Boxplots (inTHR and aboveTHR).PDF"  
startpage=never;  
    goptions reset=all  
    device=pdfc  
    ftext="swissb";  
    goptions hsize=6 in vsize=4.5 in;
```

```

        title1;

PROC SORT DATA=GEMS.prop_THR;
    BY Session;
RUN;

PROC BOXPLOT DATA=GEMS.prop_THR;
    goptions horigin=1in vorigin=5.5 in ;;
    plot inTHR*Session /
        vaxis=0 to 1.1 by 0.1
        boxconnect
        cbox=BLACK
        CBOXFILL=GREY;
    where (Session <= 25);
    title 'Duration Proportion in Target Heart Rate Zone (60-85% Max HR)';
    label inTHR = 'THR Duration (Prop of Session in THR Zone)';

run;

PROC BOXPLOT DATA=GEMS.prop_THR;
    goptions hsize= 6in vsize= 4.5in device=pdfc ftext="swissb"
    horigin=1 in vorigin=0 in ;
    plot aboveTHR*Session /
        vaxis=0 to 1.1 by 0.1
        boxconnect
        cbox=BLACK
        CBOXFILL=GREY;
    where (Session <= 25);
    title 'Duration Proportion above Target Heart Rate Zone (60-85% Max HR)';
    label aboveTHR = 'THR Duration (Prop of Session)';

run;
ods pdf close;
quit;

/** Combined proportion of in or above THR Boxplots **/

ods PDF body="F:\Gemstone\HR_OUTPUT\Boxplots (only combTHR).PDF";

axis1 label=(rotate=90 "THR Duration (Prop of Session)") order=(0 to 1.1 by 0.1);
PROC SORT DATA=GEMS.prop_THR;
    BY Session;
RUN;

PROC BOXPLOT DATA=GEMS.prop_THR;
    plot combTHR*Session /
        vaxis=axis1
        cbox=BLACK
        CBOXFILL=GREY;
    format group groups.;
    where (Session <= 25);
    title 'Proportion IN or ABOVE Target Heart Rate Zone (60-85% Max HR)';

run;

ods pdf close;
quit;

/*inTHR, aboveTHR and combTHR box plots by groups*/
ods PDF body="F:\Gemstone\HR_OUTPUT\Boxplots (THR by groups).PDF";

PROC SORT DATA=GEMS.prop_THR;
    BY Group Session;
RUN;

axis1 label=(rotate=90 "THR Duration (Prop of Session)") order=(0 to 1.1 by 0.1);

```

```

PROC BOXPLOT DATA=GEMS.prop_THR;
  plot inTHR*Session /
    vaxis=axis1
    cbox=BLACK
    CBOXFILL=GREY;
  by group;
  format group groups.;
  where (Session <= 25);
  title 'Proportion in Target Heart Rate Zone (60-85% Max HR) by Groups';

run;

PROC BOXPLOT DATA=GEMS.prop_THR;
  plot aboveTHR*Session /
    vaxis=axis1
    cbox=BLACK
    CBOXFILL=GREY;
  by group;
  format group groups.;

  where (Session <= 25);
  title 'Proportion above Target Heart Rate Zone (60-85% Max HR) by Groups';

run;

PROC BOXPLOT DATA=GEMS.prop_THR;
  plot combTHR*Session /
    vaxis=axis1
    cbox=BLACK
    CBOXFILL=GREY;
  by group;
  format group groups.;

  where (Session <= 25);
  title 'Proportion IN OR ABOVE Target Heart Rate Zone (60-85% Max HR) by
Groups';

run;
ods pdf close;
quit;

/***** t-tests *****/

ods PDF body="F:\Gemstone\HR_OUTPUT\t-tests (inTHR and aboveTHR).PDF";
/*Analyzing mean differences between Spr2009 and Fall2009 for inTHR and aboveTHR*/

Proc ttest data=GEMS.prop_THR;
  var inTHR aboveTHR;
  class Semester;
  title 'Comparing THR Avg Durations between Spr09 & Fall09';

run;

/*Looking for inTHR and aboveTHR differences between DDR and Track*/

Proc ttest data=GEMS.prop_THR;
  var inTHR aboveTHR;
  class Group;
  title 'Comparing THR Avg Durations between Interactive Gaming & Track
Subjects';

run;

/*Checking to see if there exists any significant difference between beginning of
sessions and end*/

```

```

DATA WHENhr;
    set GEMS.prop_THR;
    if Session<=15 then Semwhen=0;
    else if Session>15 then Semwhen=1;
run;

proc format;
    value Gemstime 0 = 'Begin'
                1 = 'End';
run;

Proc ttest data=WHENhr;
    var inTHR aboveTHR;
    class Semwhen;
    format Semwhen Gemstime.;
    title 'Comparing THR Avg Durations between Early & Late Session';
run;

ods pdf close;
quit;

/*inTHR Multiple Regressions (Graphs then output)*/

ods PDF body="F:\Gemstone\HR_OUTPUT\Multiple Reg Graphs (inTHR).PDF" STARTPAGE=never;
goptions reset=all
device=pdfc
ftext="swissb";
goptions hsize=6 in vsize=4.5 in;
title1;

symbol1 v=dot i=rl width=2 cv=black ci=red;
proc reg data = GEMS.prop_THR noprint;
goptions horigin=1in vorigin=5.5 in ;;
model inTHR = group SESSION;
where (Session <= 22);
plot inTHR * session;
title 'Target Heart Rate Proportion Regressed by Group and Session';
label inTHR = 'THR Duration (Duration Proportion of Session)';

run;

proc reg data = GEMS.prop_THR noprint;
goptions hsize= 6in vsize= 4.5in device=pdfc ftext="swissb"
horigin=1 in vorigin=0 in ;
model inTHR = group SESSION;
where (Session <= 22);
plot residual. * Session;
title 'Residual Proportion THR Proportion by Session';

run;
ods pdf close;
quit;

ods PDF body="F:\Gemstone\HR_OUTPUT\Multiple Reg Output (inTHR).PDF";

proc reg data = GEMS.prop_THR simple;
model inTHR = group SESSION;
where (Session <= 22);
title 'Target Heart Rate Proportion Regressed by Group and Session';
run;
ods pdf close;
quit;

/*aboveTHR Multiple Regressions (Graphs then output)*/

```

```

ods PDF body="F:\Gemstone\HR_OUTPUT\Multiple Reg Graphs (aboveTHR).PDF"
STARTPAGE=never;
  goptions reset=all
  device=pdfc
  ftext="swissb";
  goptions hsize=6 in vsize=4.5 in;
  title1;

symbol1 v=dot i=r1 width=2 cv=black ci=red;
proc reg data = GEMS.prop_THR noprint;
  goptions horigin=1in vorigin=5.5 in ;;
  model aboveTHR = group SESSION;
  where (Session <= 22);
  plot aboveTHR * session;
  title 'Duration Above Target Heart Rate Proportion Regressed by Group
and Session';
  label aboveTHR = 'THR Duration (Duration Proportion of Session)';

run;

proc reg data = GEMS.prop_THR noprint;
  goptions hsize= 6in vsize= 4.5in device=pdfc ftext="swissb"
  horigin=1 in vorigin=0 in ;
  model aboveTHR = group SESSION;
  where (Session <= 22);
  plot residual. * Session;
  title 'Residual Proportion THR Proportion by Session';

run;
ods pdf close;
quit;

ods PDF body="F:\Gemstone\HR_OUTPUT\Multiple Reg Output (aboveTHR).PDF";

proc reg data = GEMS.prop_THR simple;
  model aboveTHR = group SESSION;
  where (Session <= 22);
  title 'Duration Above Target Heart Rate Proportion Regressed by Group and
Session';
run;
ods pdf close;
quit;

/*Mixed Model Regression*/
PROC mixed data=GEMS.prop_THR;
  Title 'Multiple Regression: Mixed Model of THR by Group and Session';
  CLASS GROUP SESSION ;
  MODEL inTHR = Group Session Group*Session;
  Random SUBJECT;
run;

/*Because of missing data, may not be sufficient enough to complete multiple
regression properly*/

```

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