USING MET·MIN·WK^{-1} TO PRESCRIBE AEROBIC EXERCISE TO HEALTHY YOUNG FEMALES

By

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Bachelor of Science in Health Promotion

Oklahoma State University

Stillwater, Oklahoma

2008

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 2010

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EXERCISE TO HEALTHY YOUNG FEMALES

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ACKNOWLEDGMENTS

The road to individual achievement is more often than not paved with the efforts of many. Without the sacrifices, support, and encouragement that I have been blessed with over the past 26 years this, the crowning achievement of my academics, would never have been possible. It would be impossible to name everyone that I owe a debt of gratitude but I shall do my best in mentioning the few that stand out the most.

To my parents, Glenn and Suzie, I would truly be no where without your lifetime of guidance. You have both taken on many job titles over the years, Parent, Mentor, Friend, Counselor, Warden, and I want you to know that I wouldn't change a thing about the path that you have started me on. I could never repay you for your continued and never-ending patience and support. I love you both very much.

To my advisory committee, I truly appreciate the time and effort each of you have taken to direct my academic efforts. Dr. Smith, I thank you for encouraging and developing my independent interests. Dr. Warren, this wouldn't have been possible without your feedback and patience. Dr. Miller, thank you for teaching me how to be a student.

Special thanks go to Stacia Rempel, Eric Conchola, Mary Talley, Robin Purdie, Ryan Fiddler, Brennan Thompson, and Dr. Steve Edwards. This research wouldn't have

been possible if each of you hadn’t offered your help along the way, whether you may realize it or not.

Last, but certainly not least, I want to thank each of the 10 participants that volunteered their time and energy to this study. It’s refreshing to know that in today’s me-first world there’s still people out there that are willing to volunteer their efforts to help out a stranger.

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CHAPTER I

INTRODUCTION

Overview

Based on current American Heart Association and American College of Sports Medicine guidelines, it is recommended that healthy adults participate in some sort of aerobic physical activity at least three days per week (Haskell, et al., 2007). In following those same guidelines, the intensity of performance further dictates the other variables in prescribing physical activities duration and frequency. For example, a person can engage in only 20 minutes of physical activity just 3 days per week if his or her intensity level is relatively high, whereas 30 minutes of activity 5 days per week is necessary to achieve the same health benefits if physical activity intensity is lower. Furthermore, it is noted that the two different physical activity intensities may be combined to meet these minimum guidelines.

There are several different ways to quantify aerobic exercises' intensity (Thompson, Gordon, & Pescatello, 2010). An individual's heart rate can be used in different ways to prescribe appropriate exercise intensities. An age-predicted maximum heart rate can be calculated as $206.9 - (0.67 \times \text{age})$ and from this prediction a suitable intensity can be calculated as a percentage of this predicted maximum (Gellish, et al., 2007). For example, if a 20-year-old wanted to exercise at 80% of their age-predicted maximum heart rate they would need to exercise at an intensity level that elicited a heart rate of approximately 154 beats per minute {[206.9 – (0.67 × 20)] × 0.8}. Also, target exercise heart rates can be calculated from an individual's heart rate reserve. Heart rate reserve is the difference between an individual's maximum achievable heart rate and their heart rate while resting quietly. After heart rate reserve is determined an exercise that elicits an appropriate percentage of that reserve can then be calculated. For example, if an individual's maximum achievable heart rate was 200 beats per minute and their resting heart rate was 70 beats per minute then they would need to get their heart rate to 148 beats per minute to be exercising at 60% of their heart rate reserve {[(200 – 70) × 0.6] + 70}. Oxygen consumption (VO_2) can be used in a similar manner to prescribe exercise. A target exercise VO_2 can be calculated from an individual's maximum VO_2 and also a percentage of VO_2 reserve can be determined if resting VO_2 data is also available.

All of the aforementioned ways to prescribe aerobic exercise intensity, however, can be difficult, especially for the average layperson. Precise measurements using specialized equipment are needed to prescribe exercise using either of the heart rate or oxygen consumption techniques. Furthermore, knowledge of complex calculations with specific constants is also needed when using these methods to prescribe exercise.

A relatively simple way for estimating exercise intensity, especially with today's modern aerobic exercise equipment in many fitness facilities, is the metabolic equivalent of task, or MET. The MET is the ratio of a given metabolic work rate to a standard resting metabolic rate of $1.0 \cdot kg^{-1} \cdot h^{-1}$ (Ainsworth, et al., 2000). Essentially, a task with a MET level of 5.0 is five times more difficult for a given person than resting quietly would be for that same person. Because modern aerobic exercise equipment often gives its users a MET value for their work rate and the existence of Ainsworth, et al.'s (Ainsworth, et al. 2000) extensive list of activities and their corresponding MET levels, the metabolic equivalent could be the preferred method for ascertaining appropriate levels of aerobic exercise for many individuals.

When using METs to combine physical activities of differing intensities, Haskell et al. (Haskell, et al. 2007) suggests using $MET \cdot min \cdot wk^{-1}$. This method allows an individual the opportunity to combine varying intensities of physical activity that might independently fall below current recommendations because of other variables. In summary, an activity's related MET level is multiplied by the amount of time spent engaged in the activity to yield MET·min. For example, walking at 4 miles per hour, which has a MET level of 5.0, for 30 minutes would equal 150 MET·min (5.0 METs × 30 min = 150 MET·min) (Ainsworth, et al., 2000). An individual can them sum their accumulated MET·min for an entire week to equal their $MET \cdot min \cdot wk^{-1}$. Haskell, et al. (Haskell, et al. 2007) recommends accumulating 450-750 $MET \cdot min \cdot wk^{-1}$ when using this formula for calculating aerobic exercise. This range is based on healthy individuals accumulating approximately 150 minutes per week of moderate-intensity physical activity.

Statement of the Problem

Prescribing appropriate exercise intensity levels can often be complicated, difficult, and confusing. The problem of this study was to determine the physiological and physical benefits of two different aerobic exercise prescriptions. One of the exercise prescriptions met the traditional minimum recommendations for exercise volume while the other did not. The data obtained will allow for the MET·min·wk^{-1} method for ascertaining appropriate exercise volumes to be tested.

Purpose of the Study

The purpose of this study was to analyze the changes in health-related data (body weight, body mass index, systolic blood pressure, diastolic blood pressure, resting heart rate, percent body fat, and maximal aerobic capacity) following two different exercise prescriptions that varied in intensity and frequency, yet, remained similar in total MET·min·wk^{-1} volume.

Hypotheses

The following null hypotheses were tested at the 0.05 significance level. Each hypothesis was made on the comparison of moderate-intensity training and moderate/vigorous-intensity training at the pre-training and post-training time periods.

H_{O1}: There will be no significant difference in the two groups' body weight at post-training testing after either of the eight week aerobic training programs.

H_{O2}: There will be no significant difference in the two groups' body mass index at post-training testing after either of the eight week aerobic training programs.

H_{O3}: There will be no significant difference in the two groups' systolic blood pressure at post-training testing after either of the eight week aerobic training programs.

H_{O4}: There will be no significant difference in the two groups' diastolic blood pressure at post-training testing after either of the eight week aerobic training programs.

H_{O5}: There will be no significant difference in the two groups' resting heart rate at post-training testing after either of the eight week aerobic training programs.

H_{O6}: There will be no significant difference in the two groups' percent body fat at post-training testing after either of the eight week aerobic training programs.

H_{O7}: There will be no significant difference in the two groups' maximal aerobic capacity after either of the eight week aerobic training programs.

Variables

Dependent variables: Subject weight, body mass index, systolic blood pressure, diastolic blood pressure, resting heart rate, percent body fat, maximal aerobic capacity

Independent variables: Length of the study, training group assignment

Delimitations

The following delimitations applied to this study:

1. The subjects were limited to females between the ages of 18-30.
2. The subjects had access to an on-campus fitness center facility.
3. The subjects were free of illness and injury.
4. The study ran for a total of 10 weeks including one week for pre-testing, an eight-week progressive exercise intervention, and one week for post-testing.
5. Data collection was the result of instrumentation and the researcher's skill (balance scale, sphygmomanometer/stethoscope, skinfold calipers, metabolic cart)
6. Each subject exercised aerobically at predetermined treadmill intensities based on $MET \cdot min \cdot wk^{-1}$ guidelines.

Limitations

The following limitations applied to this study:

1. All subjects were volunteers.
2. There was no control group.

3. Subjects were not randomly selected.
4. Pre-existing fitness levels may have an effect on aerobic exercise training adaptations.
5. Daily activities outside of study parameters were not monitored.
6. Subject's dietary habits were not monitored throughout the course of the study. Dietary intake can significantly affect health variables over time.
7. Subjects were not strictly monitored during their training sessions. They were sporadically checked in on while exercising in a public fitness facility.
8. Subjects were not previously active

Assumptions

The following assumptions were intrinsic during this study:

1. All subjects answered survey questions accurately and completely regarding the use of medications, illnesses, injuries, and current and past levels of physical activity.
2. All subjects abstained from physical activity for the 24 hours prior to their pre- and post-testing.
3. All subjects adhered to the exercise prescription that was assigned to them.
4. All subjects retained their normal daily activities outside of the study.

Definitions

The following terms are used within this study:

- **Aerobic**: the use of oxygen (Nieman, 2007).

- **Aerobic training**: training that can improve the efficiency of the aerobic energy-producing systems and cardiorespiratory endurance (Wilmore, Costill, & Kenney, 2008).
- **Arterial-venous oxygen difference (a-vO_2 diff)**: the difference in oxygen content between arterial and venous blood; expresses the amount of oxygen removed by tissues of the body (Wilmore, et al., 2008).
- **Blood pressure (BP)**: the pressure exerted by blood on the walls of arteries (Nieman, 2007).
- **Body composition**: the proportions of fat, muscle, and bone that make up the human body (Nieman, 2007).
- **Body mass index (BMI)**: calculation of height and weight indices for determining normal weight, overweight, and obesity (Nieman, 2007).
- **Cardiac output (Q)**: the volume of blood pumped to the body from the heart per minute (Wilmore, et al., 2008).
- **Cardiorespiratory system**: collective term used for both the cardiovascular system (heart and blood vessels) and the respiratory system (nose, pharynx, trachea, bronchi, and lungs) (Tortora & Nielsen, 2009).
- **Detraining**: the loss of favorable physiological adaptations as the result of a reduction or cessation of regular physical activity (Wilmore, et al., 2008).
- **Exercise**: type of physical activity consisting of planned, structured, and repetitive bodily movements done to achieve or maintain fitness or other health objectives (Thompson, Gordon, & Pescatello, 2010).

- **Interval training**: repeated, short, intense exercise bouts with short rest periods in between (Wilmore, et al., 2008).
- **Light-intensity physical activity**: an activity with a corresponding MET value of less than 3.0 (Haskell, et al., 2007).
- **Maximum heart rate**: highest heart rate of which a person is capable of (Nieman, 2007).
- **Maximal oxygen consumption (VO_{2MAX})**: the highest rate of oxygen consumption that a person can achieve during intense, whole-body exercise; maximal oxygen consumption equals cardiac output times arterial-venous oxygen difference (Nieman, 2007).
- **MET (metabolic equivalent of task)**: the ratio of work metabolic rate to a standard resting metabolic rate of $1.0 \cdot kg^{-1} \cdot h^{-1}$ (Ainsworth, et al, 2000)
- **Moderate-intensity physical activity**: an activity with a corresponding MET value of 3.0 – 6.0 (Haskell, et al., 2007).
- **Obesity**: excessive body fat; possessing a body mass index (BMI) ≥ 30.0 $kg \cdot m^{-2}$ (Ehrman, et al., 2010; Wilmore, et al., 2008).
- **Percent body fat**: percentage of an individual's body mass that is made up of fat (Ehrman, et al, 2010)
- **Physical activity**: bodily movement produce by the contraction of skeletal muscles that results in a substantial increase over resting energy expenditure (Thompson, et al., 2010).
- **Resting heart rate (RHR)**: an individual's heart rate while resting quietly; usually between 60 and 80 beats per minute (Wilmore, et al., 2008).

- **Stroke volume**: volume of blood pumped out of the left ventricle during one contraction (Wilmore, et al., 2008).
- **Vigorous-intensity physical activity**: an activity with a corresponding MET value of greater than 6.0 (Haskell, et al., 2007).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The following sections will summarize current literature that relates to the volume of aerobic exercise. The review will focus on the health benefits of aerobic exercise; the importance and significance of exercise volume; previous studies that involve the use of METs; the phenomenon of detraining. A summary will also be included that will to justify the need for the current study.

Health Benefits of Aerobic Exercise

Regular aerobic exercise results in numerous health benefits. Many of these benefits occur in the cardiorespiratory system of the human body. Improved oxygen consumption, both during submaximal and maximal exertion, is the major benefit to the cardiorespiratory system. Improved cardiac output (Q) and arterial venous oxygen difference (a-vO_2 diff) as well as decreased resting heart rate (RHR) and blood pressure (BP) also accompany chronic aerobic exercise (Ehrman, et al., 2010). In addition to favorable physiological changes, positive anthropometric changes can result from aerobic exercise. Reduced body weight and reduced body fat mass are examples of such measures.

It is a well-known fact the maximum oxygen consumption (VO_{2MAX}), used synonymously with maximal aerobic capacity, improves following chronic aerobic exercise training (Glowacki, et al., 2004; Malek, et al., 2006; O'Donovan, et al., 2005; Slordahl, et al., 2004; Wisloff, et al., 2007). This should come as no surprise. As the physiological processes within the human body are stressed they have no choice but to adapt and become more efficient. The primary mechanisms that underlie the increase in VO_{2MAX} are increased maximal stroke volume and increased maximal cardiac output (Ehrman, et al., 2010). With training these physiological gains leading to increased oxygen consumption can become markedly improved over time. While studying the effects of aerobic exercise on oxidative stress, Rahnama, Graeini, and Hamedinia (Rahnama, Graeini, & Hamedinia, 2007) demonstrated an increase in VO_{2MAX} ($p < 0.05$) in 10 male physical education students (23.8 ± 1.81 years). This increase was approximately 10%, from 48.3 to 53.2 $ml \cdot kg^{-1} \cdot min^{-1}$ after an eight week exercise training period. Training consisted of running at 75-80% of each subject's maximum heart rate for 20-45 minutes on three days per week. Moreover, no change ($p > 0.05$) was found to exist after an eight week period of no training for a control group (49.5 to 46.9 $ml \cdot kg^{-1} \cdot min^{-1}$). Similarly, Malek, et al. (Malek, et al., 2006) found a significant improvement ($p < 0.05$) in VO_{2MAX} while studying the effects of caffeine supplementation on males and females. The group that received the caffeine supplement (22.0 ± 2.7 years, n = 18) increased their VO_{2MAX} from 41.2 to 45.0 $ml \cdot kg^{-1} \cdot min^{-1}$ while the placebo group (22.7 ± 3.1 years, n = 18) also increased their VO_{2MAX} from 39.6 to 42.9 $ml \cdot kg^{-1} \cdot min^{-1}$. Aerobic training consisted of treadmill running at 75% of the subject's maximum heart rate on three occasions per week. Furthermore, Melanson, Freedson, and Jungbluth (Melanson, Freedson, & Jungbluth, 1996) showed an increase in VO_{2MAX} ($p < 0.05$) for subjects who participated in either a running (46.3 to 50.8 $ml \cdot kg^{-1} \cdot min^{-1}$) or an in-line skating (46.1 to 48.9 $ml \cdot kg^{-1} \cdot min^{-1}$) program after a period of nine weeks. No change (46.7 to 47.7 $ml \cdot kg^{-1} \cdot min^{-1}$) was demonstrated in a group of control subjects who participated in no aerobic exercise program. Oxygen consumption is a strong indicator of an individual's overall health. Kokkinos, et al. (Kokkinos, et al., 2008) determined that maximal aerobic exertion was the strongest marker of all-cause mortality risk in a cohort of 15,660 male veterans. Effectively, the higher a person's VO_{2MAX}, the lower their chance of mortality from all causes. Increased oxygen consumption is only one of the important physiological adaptations that accompany chronic aerobic training; however, it is most likely the greatest indicator of overall health.

Maximal oxygen consumption is collectively a product of two other important physiological variables, cardiac output (Q) and arterial-venous oxygen difference ($a\text{-}vO_2$ diff) (Thompson & Baldwin, 2006). An increase in the end result, VO_{2MAX} can only be explained by an increase in either or both of its components. Recently, in a randomized cross-over study, Daussin, et al. (Daussin, et al., 2008) set out to examine the difference in the effects of continuous and interval training on 11 middle-aged (45 ± 3 years) sedentary subjects. Subjects were randomly assigned to either participate in a continuous or interval training exercise prescription first, go through a 12 week detraining period, followed by participation in the other training program. The two training programs were designed so that the subjects performed approximately the same amount of total mechanical work, 4,320 ± 115 versus 4,277 ± 112 kJ for continuous and interval groups respectively. A significant difference was found to exist for both groups after each of the training programs. Continuous training elicited approximately a 9% ($p < 0.05$) increase in VO_{2MAX} while interval training brought about an increase in VO_{2MAX} of approximately 15% ($p < 0.01$). The variables responsible for the increase in oxygen consumption for the two groups, however, differed. The continuous training group's improvements were the result of increased a-vO_2 diff (10.9 ± 0.8 to 12.6 ± 1.1 ml/100 ml; $p < 0.01$), whereas the interval training group experienced greater improvements in maximum Q (18.1 ± 1.1 to 20.1 ± 1.2 l/min; $p < 0.01$). These results suggest that continuous aerobic training results in greater increases in working muscle capillary density and that interval aerobic training results in a stronger heart muscle. Whichever adaptation may be the case for those involved, it is important to note that both training programs led to improved cardiorespiratory function and therefore overall health and well-being.

Resting heart rate and blood pressure can also be used as health indices and are known to be directly affected by chronic aerobic exercise (Housh, Housh, & Devries, 2006). Each can be used independently or in association with other variables to gauge cardiovascular system efficiency. If the heart is highly efficient then it will not need to beat as often to provide oxygen and other nutrients to the tissues of the body. Less stress over a period of time equates to less damage to the organ itself. Likewise, various blood vessels throughout the body will retain their original properties for a longer period of time if less pressure is applied to them. In a recent meta-analysis of 72 randomized controlled trials, Cornelissen and Faggard (Cornelissen & Faggard, 2005) found a decrease in resting heart rate of 7.1 beats per minute ($p < 0.001$) in individuals with normal resting blood pressure following chronic aerobic exercise training. This same study reported a reduction in systolic blood pressure of 2.4 mmHg ($p < 0.01$) as well as a

1.6 mmHg ($p < 0.001$) reduction in diastolic blood pressure in the same group of individuals. The age, body mass index, resting heart rate, systolic and diastolic blood pressures, and maximal oxygen consumption of the included subjects at baseline were 38.3 ± 15.1 years, 25.4 ± 1.9 kg/m^2, 71.9 ± 8.1 bpm, 113.4 ± 5.1 mmHg, 71.8 ± 3.9 mmHg, and 31.5 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively. Characteristics of the trials included a range of 4-52 weeks of training 1-7 days per week for 25-60 minutes at 30-87.5% of the subject's resting heart rate. This report shows that relatively average sedentary individuals can experience a marked reduction in resting heart rate and blood pressure over a period of time.

More specific research studies also demonstrate improved cardiovascular efficiency following a period of aerobic training. Slordahl, et al. (Slordahl, et al., 2004) reported a post-training reduction of 12 beats per minute (71.3 ± 9.0 to 59.3 ± 6.7 bpm; $p < 0.05$) in resting heart rate for a group of 12 sedentary females (21.9 ± 1.3 years). The subjects in this study exercised eight weeks for approximately 40 minutes on three days per week. Intensities for these females ranged from 50-95% of maximal heart rate. The wide intensity range is due to the fact that interval training was the preferred technique utilized for this study. In addition, Moreira, Fuchs, Ribeiro, and Appel (Mareira, Fuchs, Ribeiro, & Appel, 1999) found a trend for lower systolic and diastolic blood pressures following 10 weeks of high- and low-intensity aerobic training in 28 sedentary moderately hypertensive individuals (high-intensity, 47.2 ± 9.2 years; low intensity, 52.2 years ± 9.2 years). Both groups participated in cycle ergometer exercise for 30 minutes per day on three days per week. The high-intensity group trained at 60% of their maximum estimated workload while the low-intensity group trained at only 20%. An average of 56 blood pressures taken over a 24 hour period was calculated and compared from pre- to post-training. Mean 24-hour systolic blood pressure fell from 144.4 ± 13.3 to 138.6 ± 12.9 mmHg for the high-intensity training group and from 137.2 ± 14.9 to 135.2 ± 12.7 mmHg for the low-intensity training group. Also, diastolic blood pressure fell from 93.3 ± 5.8 to 90.6 ± 6.8 mmHg for the high-intensity training group and from 92.1 ± 10.0 to 89.3 ± 7.7 mmHg for the low-intensity training group. Although these results were not deemed to be statistically significant (systolic, $p = 0.479$; diastolic, $p = 0.765$) due to a lack of voluntary study participants, they do demonstrate that blood pressure tends to decrease over time similarly between high and low intensity aerobic exercise training.

In addition to enhanced physiologic function, chronic aerobic exercise can lead to important anthropometric improvements. Obesity is known to be highly correlated with many life-threatening disease processes. Coronary heart disease, hypertension, stoke, type 2 diabetes, dyslipidemia, gallbladder disease, and even some cancers have been related to excessive levels of body weight and/or body fat (Ehrman, et al, 2010). Weight management and appropriate body composition is therefore an integral part of a person's overall health and well-being. Many research studies have shown that consistent aerobic exercise training can aid in managing both of these factors (Ghahramanloo, Midgley, & Bentley, 2009; Glowacki, et al., 2004; Grediagin, Cody, Rupp, Benardot, & Shern, 1995; Lemura, et al., 2000; Slentz, et al., 2004). While evaluating the time-course changes of women in response to several different exercise prescriptions, Lemura, et al (Lemura, et al., 2000) showed that aerobic training lead to decreased body fat (26.4 ± 2.9 to 22.9 ± 2.7%, $p < 0.05$) after a 16-week period for 10 sedentary women (21.0 ± 2.0 years). The effects were not significant after only eight weeks of training (26.4 ± 2.9 to 24.1 ± 3.1%), however, the decreased trend had obviously already begun. Additionally, increased levels of body fat had returned six weeks after aerobic training cessation (22.9 ± 2.7 to 24.8 ± 2.9, $p < 0.05$). These subjects underwent training on three non-consecutive days of the week for 30 continual minutes at an intensity that elicited a heart rate of 70-75% of their maximum. No significant changes ($p < 0.05$) were found to exist for a control group of 12 similar female subjects (20.0 ± 1.0 years). Throughout the course of the study subjects maintained nutrition logs to confirm that they did not change their dietary habits. These data suggest that aerobic exercise can independently have a significant impact on body composition.

Importance of Exercise Volume

Exercise volume is the collective result of its three major variables, frequency, intensity, and duration. Frequency is the number of days per week that an individual engages in physical activity; whereas duration is the amount of time (usually in minutes) spent doing physical activity per day. Intensity can be thought of as describing how challenging a certain activity is for an individual (Housh, Housh, & Devries, 2006). How these three factors interact determines the chronic adaptations that can occur. Many empirical investigations have been done in an attempt to determine the optimal amount of each of these variables.

It is currently recommended that beginning exercisers accumulate physical activity that expends approximately 1,000 $kcal \cdot wk^{-1}$ (Thompson, et al., 2010). How an individual achieves this level of energy expenditure can vary greatly depending on the previously mentioned influencing factors. Previous studies (Swain & Franklin, 2002) concluded that exercise intensities as low as 30% initial VO_2 reserve could be sufficient enough to improve VO_{2MAX} as long as duration and frequency remained relatively high throughout training. These results were mainly related to individuals who had a preliminary VO_{2MAX} that was relatively low (< 40 $ml \cdot kg^{-1} \cdot min^{-1}$). In a later review (Swain & Franklin, 2006), however, the same authors observed that greater health and physiological benefits were observed when subjects performed higher intensity aerobic exercise (> 6.0 METs *or* 80-85% heart rate/VO_2 reserve). The benefits observed included incidence of heart disease and its risk factors, favorable changes in blood pressure, positive alterations in blood lipids, and reductions in body fat percentage.

In contrast to high frequency training, significant benefits can be achieved with as few as three training sessions per weeks provided a necessary, quite substantial intensity. While controlling for total oxygen consumption, Helgerud, et al. (Helgrerud, et al., 2007) showed that their moderate-intensity trained subjects showed no improvement in VO_{2MAX} while subjects participating in aerobic exercise at a higher relative intensities showed greater gains. Moderately trained male subjects were ascribed to one of four groups and exercised on three days per week for eight weeks. The first group exercised at an intensity that corresponded to 70% of their maximum heart rate (HR_{MAX}) for 45 minutes per training day. Group number two ran continuously at their pre-training lactate threshold (approximately 85% HR_{MAX}) for 24 minutes and 15 seconds per training day. The remaining two groups participated in either short- or long-duration interval training. Group three complete 15 seconds of exercise at 90-95% HR_{MAX} followed by 15 seconds at approximately 70% HR_{MAX} for 47 consecutive repetitions. The fourth group ran for 4 minutes at 90-95% HR_{MAX} followed by 3 minutes at 70% HR_{MAX} for 4 consecutive repetitions. Groups one and two showed no increase in VO_{2MAX} (55.8 ± 6.6 vs. 56.8 ± 6.3 and 59.6 ± 7.6 vs. 60.8 ± 7.1 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively). Both interval training groups, however, did show significant improvements in aerobic capacity (group 3 = 60.5 ± 5.4 vs. 64.4 ± 4.4 $ml \cdot kg^{-1} \cdot min^{-1}$, $p < 0.01$; group 4 = 55.5 ± 7.4 vs. 60.4 ± 7.3 $ml \cdot kg^{-1} \cdot min^{-1}$, $p < 0.001$). These data demonstrate that male subjects who are already somewhat trained need more intense physical activity to improve cardiorespiratory fitness when total exercise volume is controlled for.

Previous Studies Involving the use of METs

Haskell, et al. (Haskell, et al., 2007) recommends a $MET \cdot min \cdot wk^{-1}$ range when accumulating physical activities of different intensities, however, METs are rarely ever used to directly prescribe exercise. Several observational studies have used METs to calculate energy expenditure (Hu, et al., 1999; Lakka, et al., 2003, Lee, Hsieh, & Paffenbarger Jr., 1995; Lee & Paffenbarger Jr., 2000). These studies utilized self-report physical activity questionnaires to assess the exercise intensity, in METs, of their subjects. While examining the relationship between exercise intensity and incidence of type 2 diabetes, Hu, et al. (Hu, et al., 1999) used survey data to develop a MET score (value) for each subjects weekly amount of physical activity. This method for estimating energy expenditure was preferred due to the large number of subjects (N = 70,102). They determined that the amount of total exercise was more important than exercise intensity in determining the risk for developing type 2 diabetes. Furthermore, Lakka, et al. (Lakka, et al, 2003) used METs to determine the association between cardiorespiratory fitness and metabolic syndrome. Once again, the sample size was relatively large (N 1,069) and an estimate of leisure-time physical activity energy expenditure was deemed to be sufficient for analysis.

This method of estimating energy expenditure is appropriate for studies that involve large cohorts. It is relatively rare to directly prescribe exercise based on METs. More preferred exercise prescription methods are usually based on subject's heart rate or aerobic capacity.

Detraining

It is important to make note of the concept of detraining, understood to be the loss of favorable training-induced physiological adaptations as a result of the cessation of regular physical activity (Mujika & Padilla, 2000; Wilmore, et al., 2008). The phenomenon is significant to this particular investigation because during the course of the study subjects went through a period of no aerobic training. This lapse in training was caused by a regularly scheduled vacation from school activities for the subjects. Furthermore, this principle can also be readily applied to the general public. It is not uncommon for members of the free-living population to go through periods of regular activity that is abruptly interrupted for some reason.

While investigating the factors that determine aerobic capacity, Coyle, et al. (Coyle, et al., 1984) demonstrated a significant ($p < 0.05$) 7% loss in VO_{2MAX} from 62.1 ± 3.3 to 57.7 ± 2.6 $ml \cdot kg^{-1} \cdot min^{-1}$ only 12 days of insufficient training stimulus. These results, however, were demonstrated in a relatively small sample (N = 7) and all of the subjects were classified as being highly trained, having been continuously training in their chosen sport, running or cycling, for 14.9 ± 4.4 months. On the contrary, Cullinane, Sady, Vadebonceur, Burke, and Thompson (Cullinane, Sady Vadebonceur, Burke, &

Thompson, 1986) found no difference in VO_{2MAX} following 10 days of exercise cessation in male (28.2 ± 5.6 years) long distance runners. These subjects were likely to have been more highly trained than those examined by Coyle, et al (Coyle, et al., 1984). The subjects under investigation by Cullinane, et al. (Cullinane, et al., 1986) had been running at least 80 kilometers per week regularly for the previous year. The intensity variation between the two groups of subjects may also partially account for conflicting results between the two studies.

The occurrence of the detraining principle has also been examined in sedentary subjects. Wibom, et al., (Wibom, et al., 1992) described a 6.0 ± 6.7% ($p < 0.05$) decrease in VO_{2MAX} following a period of detraining in nine previously inactive men. In this particular study, however, the detraining period was substantially longer, three weeks, which equaled half of the original six week training period. Subjects experienced a 9.6 ± 2.3% increase ($p < 0.05$) in VO_{2MAX} following the training period before their significant loss in training adaptations (from 44 ± 4 to 48.22 ± 1.11 to 45.33 ± 3.04 $ml \cdot kg^{-1} \cdot min^{-1}$).

Summary

Aerobic exercise has been well-established as improving several vital processes that occur in the human body. These improvements are known to enhance the quality of life of the individuals participating in these activities. The extent of exercise adaptations are directly correlated to the variables that surround aerobic exercise, intensity, duration, and frequency. Exercise intensity can be measured in several different ways. Calculations from an individual's heart rate and aerobic capacity can be made to determine appropriate exercise intensity; however, these methods often require an indepth knowledge of exercise physiology and/or sophisticated equipment. Metabolic equivalents (METs) could be a simple way to estimate energy expenditure during activities especially when comparing tasks that differ greatly in nature. Experimental study designs (Glowacki, et al., 2004; Malek, et al., 2006; O'Donovan, et al., 2005; Slordahl, et al., 2004; Wisloff, et al., 2007), however, have failed to determine if METs, more specifically $MET \cdot min^{-1}$, can be used to directly prescribe aerobic exercise.

Detraining is a phenomenon involving the loss of favorable exercise-induced changes that occurs when people who regularly participate in exercise abruptly quit for any number of reasons. It is likely to take longer than 10 days for this physiological regression to occur.

The present study seeks to validate the use of MET·min as an appropriate means to determine total aerobic exercise volume. This research will give further insight into the interaction between physical activities that differ in intensity.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this study was to investigate the effects of two different exercise prescriptions on several health indicators in healthy young females. In the following sections the methods and procedures used throughout the study will be explained in detail. These sections will include a description of the subjects, an explanation of the study design, the testing procedures used to collect data, the similarities and differences between the two aerobic training programs, and the analysis that was used to report data.

Subjects

Twenty-three female subjects from the Oklahoma State University community volunteered to participate in an aerobic exercise study. To be eligible to participate subjects had to be asymptomatic of chronic disease, free of orthopedic injury, and otherwise be apparently health. Furthermore, qualified subjects could not have participated in structured aerobic exercise for four or more consecutive weeks over the six months prior to beginning the study. Subjects were informed of the potential risks associated with aerobic exercise testing and training and gave their written approval to participate. The Oklahoma State University Institutional Review Board gave its written authorization for this study. All subjects were randomly assigned to one of two exercise training groups. Throughout the course of the training program 11 subjects dropped out of the study; 5 dropped out because they could not devote an adequate amount of time to training 2 because of injuries that were not related to the study, and 4 for unknown reasons. Furthermore, 2 subjects were excluded from data analysis because of training noncompliance. The age, height, and weight of the 10 participating subjects were 20.4 ± 1.34 years, 159.3 ± 6.12 cm, and 66.01 ± 13.83 kg, respectively. One of the subjects described herself as being American Indian while the other nine indicated they were Caucasian.

Study Design

The study used individual and group quantitative measures to present descriptive research. Subjects were randomly assigned to take part in one of two different eight-week aerobic training programs. One group, the **moderate-intensity (MI) group**, participated only in aerobic exercise that could be classified as being moderately intense (3.0 – 6.0 METs) while meeting American College of Sports Medicine guidelines for duration, 30 minutes per day, and frequency, 5 days per week, regarding moderately intense aerobic exercise (Haskell, et al., 2007). The other group, the **moderate/vigorous-intensity (MVI) group**, participated in both exercise that could be classified as being moderately intense (3.0 – 6.0 METs) and exercise that could be classified as being vigorously intense (> 6.0 METs). This group, however, did not meet American College of Sports Medicine recommendations for duration and/or frequency for either moderate- or vigorous-intensity aerobic exercise (Haskell, et al., 2007). In other words, the MVI group participated in moderate-intensity aerobic exercise on only four days per week instead of the recommended five. Furthermore, this group participated in vigorous-intensity exercise for only 10 minutes per day instead of the recommended 20; however, they achieved this amount of exercise on four days per week instead of the recommended three.

Group assignment was determined by third-party coin flip. In summary, the head’s and tail’s sides of a coin were each assigned one of the two exercise groups. Subject identification numbers were then given an arbitrary order of coin side assignment. A third party, not personally connected to the study, then flipped a coin while the principal investigator wrote down the result of each coin flip in the previously determined arbitrary order for each subject identification number. For example, subject number 9 might have been given the result of the fourth coin flip. Only after all subject identification numbers had been given a head's or tail's designation were the exercise groups revealed for each coin side and subjects matched to identification number.

Testing Procedures

On one occasion in the week prior to the beginning of the training program and the week immediately following the conclusion of their assigned training program subjects visited the Applied Musculoskeletal and Human Physiology Research Laboratory to undergo anthropometric and exercise testing procedures. Testing procedures on each day followed the exact same protocol. Subjects were first weighed and measured using an ordinary mechanical balance scale fitted with a telescoping measuring rod. Next, after the subjects had been resting quietly in the seated position for approximately 1-2 minutes, blood pressure was assessed via manual sphygmomanometer and stethoscope. Skinfold caliper measurements were then taken at seven different sites of the right side of the body so that body composition could later be calculated according to American College of Sports Medicine standards (Thompson, Gordon, & Pescatello, 2010). Briefly, duplicate measures were taken at the following sites: subscapular, triceps, chest, midaxillary, suprailiac, abdomen, and thigh. Body density was then calculated as: $1.097 - (0.00046971 \times \text{sum of seven skinfolds}) + (0.00000056 \times \text{sum of seven skinfolds}^2) - (0.00012828 \times \text{subject's age})$. Body density could then be converted to percent body fat with one of the following three formulas based on age and ethnicity: (4.81 ÷ body density) – 4.34 for American Indians, (5.05 ÷ body density) – 4.62 for Caucasians aged 18-19, *or* (5.01 ÷ body density) – 4.57 for Caucasians age 20 and older.

Both testing sessions for all subjects ended with a test of maximal oxygen uptake (VO_{2MAX}) determined by graded motorized treadmill (Trackmaster TMX 425C, Medgraphics, St.Paul, MN). A standard Bruce protocol was used for VO_{2MAX} testing (Nieman, 2007). In summary, subjects began walking on a treadmill at 1.7 miles per hour with a 10% grade. Every three minutes the treadmill increased in both speed and grade (stage 2 = 2.5 mph, 12% grade; stage 3 = 3.4 mph, 14% grade; stage 4 = 4.2 mph, 16% grade) until each subject indicated that she was so exhausted that she would no longer like to continue. Throughout the treadmill test, subjects wore a continuous heart rate monitor (Timex, T5G941F5, Middlebury, CT). A resting heart rate value was recorded while the subjects were standing on the treadmill approximately 2-3 minutes before beginning their graded test. Oxygen uptake was considered maximal if the subjects respiratory exchange ratio exceeded 1.10 and her heart rate came within 10 beats per minute of her age-predicted maximum heart rate [206.9 – (0.67 × age)].

Training Programs

All training sessions for both exercise groups took place on motor driven treadmills (Life Fitnes 97Ti, Schiller Park, IL; Nautilus, T914, Vancouver, WA; *or* Quinton, ClubTrack Plus, Bothell, WA) located in a fitness center that was open to the public. Treadmills were chosen for exercise training for two reasons: 1) walking is a familiar activity for individuals who have been are previously inactive, and 2) the machines can be set to precisely elicit an exact amount of work regardless of the subject's individual characteristics. Subjects participated in their assigned eight weeks of training over a nine calendar-week period of time. The time discrepancy exists as the result of a regularly scheduled academic break that occurred after training weeks five or six, depending on when each subject began her training program. Furthermore, prior to beginning the training, subjects were instructed to continue their regular lifestyle habits outside of study parameters. They were instructed that this included their physical activity, dietary, and their sleep habits, as well as the continued use of any medication that they may be taking.

When each subject arrived at the facility they were required to check-in with the principal investigator prior to beginning their training session for that day. Subjects in the MI group were assigned to exercise on five days per week while subjects in the MVI group were assigned to exercise on four days per week. At the time of check-in each subject was given a workout card that corresponded to their randomly assigned group and their specific progression week within the program. Subjects began their training at the lower end of the recommended 450-750 $MET \cdot min \cdot wk^{-1}$ range to properly acclimate them to a more active lifestyle. The MI group began their training by accumulating 495 $MET \cdot min \cdot wk^{-1}$ while the MVI group accumulated 500 $MET \cdot min \cdot wk^{-1}$ during the first training week. Both training programs were progressed every two weeks by approximately 75 $MET \cdot min \cdot wk^{-1}$. The inconsistency between the two training programs exists to allow continuity between other training variables. Both groups participated in the same amount of total training time per exercise day, 40 minutes. Each session began with a five minute warm-up at a light intensity (< 3.0 METs) and was followed by 30 continuous minutes of exercise stimulus. The MI group achieved their 30 minutes of aerobic exercise at a constant moderate intensity (3.0 – 6.0 METs). The MVI group achieved their 30 minutes of aerobic exercise at varied intensities. Their first 10 exercising minutes was at a vigorous intensity (> 6.0 METs) while their final 20 minutes was spent at a moderate intensity (3.0 – 6.0 METs). After accomplishing their 30 minutes of exercise stimulus, each group then went through a cool-down period at their assigned warm-up intensity. Throughout their training programs subjects were not strictly monitored during each exercise training session. They were, however, sporadically supervised, with or without their knowledge, to ensure training adherence.

Statistical Analysis

A 2 × 2 repeated measures analysis of variance (ANOVA) was used to identify if and where significant differences existed between or within groups. Statistical significance of effects was based on an alpha level of $p < 0.05$. All data comparisons were made with the computer software SPSS version 17.0 (SPSS Inc., Chicago, IL).

CHAPTER IV

FINDINGS

Introduction

This chapter will focus on the numerical results and analysis of the data of the study that were collected at pre- and post-training time points. The purpose of this study was to compare the effects of two different aerobic training programs on various indicators of health in healthy young females. The two groups were the moderate-intensity (MI) training group and the moderate/vigorous-intensity (MVI) training group. Each group consisted of females who were identified as not being regularly active. Each group participated in a similar amount of total aerobic exercise on a weekly basis when using the $MET \cdot min \cdot wk^{-1}$ formula as described earlier.

Pre- and post-training resting and exercising data were collected on both groups during the eight week study. Data were either collected or calculated on each of the 10 female subjects for 6 resting variables (weight, BMI, systolic blood pressure, diastolic blood pressure, resting heart rate, and percent body fat) and one exercising variable (maximal aerobic capacity *or* VO_{2MAX}). There were five subjects in each group with a total (N) mean and standard deviation of age being 20.2 (±1.229) years (Table 1).

Table 1
Pre-training and descriptive characteristics of subjects (N=10).

	Moderate (n = 5)	**Moderate/Vigorous** (n = 5)	**F**	**P**
Age (yr)	20.2 ± 1.304	20.6 ± 1.517	.000	1.000
Height (in)	63.8 ±1.924	63.6 ± 3.05	1.052	.335
Weight (lb)	151.8 ± 27.124	139.6 ± 35.522	.234	.642
BMI (kg/m^2)	26.184 ± 3.328	24.064 ± 4.035	.207	.661
Systolic BP (mmHg)	130.4 ± 14.588	120 ± 15.748	.312	.592
Diastolic BP (mmHg)	72.4 ± 5.55	70.80 ± 7.014	.204	.664
Resting HR (bpm)	101.6 ± 20.12	89 ± 11	1.387	.273
Body fat (%)	27.49 ± 5.623	26.76 ± 5.91	.001	.974
VO_{2MAX} ($ml \cdot kg^{-1} \cdot min^{-1}$)	34.0 ± 2.677	38.44 ± 4.561	.464	.515

Table 2
Summary of aerobic training programs for each group including treadmill setting, intensities, and total work.

Group	**Weeks**	**Speed (mph)**	**Incline (%)**	**METs**[c]	**Duration (min)**	**Total Work** (**$MET \cdot min \cdot wk^{-1}$**)
Moderate[a]	1-2	3.0	0.0	3.3	30	495
	3-4	3.1	1.0	3.8	30	570
	5-6	3.4	1.5	4.3	30	645
	7-8	3.7	2.0	4.8	30	720
Moderate/ Vigorous[b]	1-2	3.5	5.0	6.1	10	500
		2.9	0.0	3.2	20	
	3-4	3.7	5.0	6.4	10	576
		3.1	1.5	4.0	20	
	5-6	3.8	5.5	6.8	10	648
		3.3	2.5	4.7	20	
	7-8	3.8	6.0	7.1	10	724
		3.6	3.5	5.5	20	

[a]Trained 5 days per week
[b]Trained 4 days per week
[c]3.5 + (0.1 × speed) + (1.8 × speed × grade) ÷ 3.5; speed in $m \cdot min^{-1}$; grade in decimal form

Table 3
Subject attendance by group.

	Attended Sessions	Assigned Sessions	Average Attendance
Moderate	37 ± 2.9	40	93%
Moderate/Vigorous	30.8 ± 1.8	32	96%

Table 2 gives a summary of the eight week aerobic training programs that each of the two groups followed during the study. As shown, the training programs were designed so that each group accomplished approximately the same amount of total work in a given calendar week when calculated using the MET·min·wk^{-1} formula. Furthermore, for continuity purposes, each subject no matter the group participated in the same duration of exercise stimulus per session, 30 minutes. The two main differences between exercise protocols were sessions per week (4 or 5) and the intensity per session. Finally, each of the training programs was progressed every two weeks.

Throughout the course of the study subjects exercise session attendance (table 3) was strictly monitored. Also, at the conclusion of the study subjects were asked to subjectively report their adherence to their assigned exercise prescription. At the conclusion of the study neither attendance (moderate = 93%, moderate/vigorous = 96%) nor adherence (moderate = 99%, moderate/vigorous = 100%) acted as covariates.

Hypothesis

A total of seven hypotheses were tested to determine if there were significant differences that existed between and/or within groups over time. Repeated measures analysis of variance (ANOVA) was used to analyze the treatment effects.

The following null hypotheses were tested at the .05 significance level. Investigation of each hypothesis was made on comparison of moderate-intensity only aerobic training and moderate/vigorous-intensity aerobic training and the duration of the study.

Results of Hypothesis 1

H_{O1}: There will be no significant difference in subject body weight among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 3.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.564$), time ($p = 0.683$), or group×time ($p = 0.891$) main effects, thus the null hypothesis was accepted.

Table 4.
2×2 repeated measures ANOVA for subject body weight.

Source	SS	df	MS	F	P
Group	732.050	1	732.050	.361	.564
Error	16204.400	8	2025.550		
Time	.450	1	.450	.180	.683
Group×Time	.050	1	.050	.020	.891
Error	20.000	8	2.500		
Total	16956.950	19			

Results of Hypothesis 2

H_{O2}: There will be no significant difference in subject body mass index among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 4.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.401$), time ($p = 0.543$), or group×time ($p = 0.820$) main effects, thus the null hypothesis was accepted.

Table 5.
2×2 repeated measures ANOVA for subject body mass index.

Source	**SS**	**df**	**MS**	**F**	**P**
Group	21.903	1	21.903	.788	.401
Error	222.442	8	27.805		
Time	.027	1	.027	.403	.543
Group×Time	.004	1	.004	.055	.820
Error	.529	8	.066		
Total	244.905	19			

Results of Hypothesis 3

H_{O3}: There will be no significant difference in subject systolic blood pressure among the groups at pre- and post-training testing before and after eight week aerobic training program. The results are shown in Table 5.

ANOVA results revealed that significance was found for the main effect of time ($F = 7.682$, $df = 1$, $p = .024$). There was no significant difference at the $p < .05$ level for group ($p = .378$) or group×time ($p = .318$) main effects. There was a significant difference for pre-training and post-training systolic blood pressure for both groups before and after the training intervention, thus the overall null hypothesis was rejected.

Table 6.
2×2 repeated measures ANOVA for subject systolic blood pressure.

Source	**SS**	**df**	**MS**	**F**	**P**
Group	352.800	1	352.800	.871	.378
Error	3240.000	8	405.000		
Time	135.200	1	135.200	7.682	.024*
Group×Time	20.000	1	20.000	1.136	.318
Error	140.800	8	17.600		
Total	3888.800	19			

*significant at $p < .05$

Results of Hypothesis 4

H_{O4}: There will be no significant difference in subject diastolic blood pressure among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 6.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.457$), time ($p = 0.141$), or group×time ($p = 0.341$) main effects, thus the null hypothesis was accepted.

Table 7.
2×2 repeated measures ANOVA for subject diastolic blood pressure.

Source	**SS**	**df**	**MS**	**F**	**P**
Group	88.200	1	88.200	.610	.457
Error	1156.800	8	144.600		
Time	88.200	1	88.200	2.673	.141
Group×Time	33.800	1	33.800	1.204	.341
Error	264.000	8	33.000		
Total	1631.000	19			

Results of Hypothesis 5

H_{O5}: There will be no significant difference in subject resting heart rate among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 7.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.250$), time ($p = 0.891$), or group×time ($p = 0.654$) main effects, thus the null hypothesis was accepted.

Table 8.
2×2 repeated measures ANOVA for subject resting heart rate.

Source	SS	df	MS	F	P
Group	530.450	1	530.450	1.540	.250
Error	2755.600	8	344.450		
Time	2.450	1	2.450	.020	.891
Group×Time	26.450	1	26.450	.216	.654
Error	977.600	8	122.200		
Total	4292.550	19			

Results of Hypothesis 6

H_{O6}: There will be no significant difference in subject percent body fat among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 8.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.250$), time ($p = 0.891$), or group×time ($p = 0.654$) main effects, thus the null hypothesis was accepted.

Table 9.
2×2 repeated measures ANOVA for subject percent body fat.

Source	SS	df	MS	F	P
Group	11.130	1	11.130	.180	.682
Error	494.268	8	61.784		
Time	.359	1	.359	.247	.633
Group×Time	2.888	1	2.888	1.985	.197
Error	11.640	8	1.455		
Total	520.285	19			

Results of Hypothesis 7

H_{O7}: There will be no significant difference in subject maximal aerobic capacity among the groups at pre- and post-training testing before and after an eight week aerobic training program. The results are shown in Table 9.

ANOVA results revealed that no significant differences existed at the $p < .05$ level for group ($p = 0.118$), time ($p = 0.120$), or group×time ($p = 0.810$) main effects, thus the null hypothesis was accepted.

Table 10.
2×2 repeated measures ANOVA for subject maximal aerobic capacity.

Source	SS	df	MS	F	P
Group	92.881	1	92.881	3.062	.118
Error	242.702	8	30.338		
Time	4.140	1	4.140	3.031	.120
Group×Time	.084	1	.084	.062	.810
Error	10.93	8	1.366		
Total	350.737	19			

Summary

This chapter compared the results of the pre- and post-training testing data of seven different dependent variables from the subjects from both groups. Comparisons were made both between and within groups over time. The only significant difference that was determined to exist across time for both groups was the measure of systolic blood pressure. Stated another way, no matter the group assignment, systolic blood pressure was found to be different after eight weeks of aerobic training when compared to before training. All of the other variables (weight, BMI, diastolic BP, resting HR, percent body fat, and maximal aerobic capacity) were demonstrated to remain unchanged as a result of the eight weeks of training no matter the group assignment.

CHAPTER V

DISCUSSION

Introduction

The overarching hypothesis of this study was that two different aerobic exercise prescriptions that varied in intensity and frequency would elicit the same physiological response when they were controlled for total volume using the $MET \cdot min \cdot wk^{-1}$. This section will further develop on the numerical data presented in the previous section and compare these findings to similar previous research. The purpose of this section will be to contribute to what currently exists in the area of aerobic exercise volume and training programs and to help formulate future areas of investigation.

Repeated measures ANOVAs were used on all seven hypotheses. No significant differences were found to exist within or between the two groups for any of the variables under investigation. This study was conducted to determine if aerobic exercise training programs with similar amounts of total exercise volume, determined using the $MET \cdot min \cdot wk^{-1}$ method, and differing amounts of individual aerobic exercise variables could elicit similar physiological and anthropometric changes over a given time period. The results roughly indicate that there were similar trend changes in the dependent variables over time for both groups; however, ultimately the group sizes were too small and group improvements were too minute to detect any significant changes that may have occurred.

Both training groups, moderate intensity and moderate/vigorous-intensity, began their training programs by accumulating approximately 500 $MET \cdot min \cdot wk^{-1}$ and further increased their training by roughly 75 $MET \cdot min \cdot wk^{-1}$ after every two weeks for a total of eight training weeks. The moderate-only training group exercised on five days per calendar week while the moderate/vigorous-training groups exercised on only four days per calendar week. Both groups accumulated 30 minutes of training stimulus per day. The moderate-intensity group exercised at a constant moderate intensity (3.0-6.0 METs) for the entire 30 minutes whereas the moderate/vigorous-intensity training group achieved 10 minutes of exercise at a vigorous intensity (> 6.0 METs) followed immediately by 20 minutes of exercise at a moderate intensity (3.0-6.0 METs). Both groups completed identical five minute warm-up and cool-down periods at a light intensity (< 3.0 METs) before and after their exercise training stimulus. Each of the two training programs was designed in to reflect current American College of Sports Medicine physical activity guidelines for healthy adults.

Training Program and Maximal Aerobic Capacity

The results from the present study indicate no significant difference from pre- to post-training for maximal aerobic capacity measurements for either group. While mean measures for each group improved over time (from 34 to 35.04 for moderate; from 38.44 to 39.22 for moderate/vigorous) the within group improvements can only be described as approaching statistical significance ($p = 0.12$). Group assignment, however, had absolutely no effect on this variable ($p = 0.81$). These results differ slightly from previous studies using aerobic training programs of similar length.

Rahnama, et al. (Rahnama, et al., 2007) demonstrated an increase maximal oxygen consumption of approximately 10% ($p < 0.05$) after eight weeks of training. The combined average increase in VO_{2MAX} for subjects in the present study was only approximately 2.5%. Differences between the parameters of the two studies do, however, exist. Most notably, the subjects in the present study are female whereas all of the 20 subjects studied by Rahnama, et al. were male. Although men and women adapt in a relatively similar manner to similar training programs (Ehrman, et al., 2010), Rahnama, et al.'s training protocol differed from the present study in frequency, intensity, and duration. They trained on three days per week at much higher intensities, 75-80% HR_{MAX}, for up to 45 minutes. Similarly, subjects studied by Malek, et al. (Malek, et al., 2006) experienced an increase in VO_{2PEAK} of approximately 9%. Once again, however, these subjects consisted of both males and females and the training programs used in the two studies varied greatly. Malek, et al.'s subjects performed 45 minutes of treadmill running at 75% of their VO_{2PEAK} on three days per week. It can be stated then that repeated exposure to more intense training for longer periods of time elicits a more marked improvement in aerobic capacity over eight weeks of training.

Interestingly, the present study's trend results differ from those reported by Daussin, et al. (Daussin, et al., 2008). They showed that interval training, repeated, short, intense exercise bouts with short rest periods in between produced a greater improvement (approximately 15%, $p < 0.01$) in VO_{2MAX} than did continuous training (approximately 9%, $p < 0.05$) when controlling for total volume. In the present study subjects who trained continuously at a moderate intensity showed a greater relative increase (approximately 3.1%) in VO_{2MAX} than those who participated in both moderate and vigorous intensity exercise (approximately 2%). Although the current moderate/vigorous-intensity training program should not be thought of as traditional interval training the dissimilarities between the two studies are noteworthy. These results suggest that increases in cardiac output illustrated by Daussin, et al. result from cycling back and forth between exercise and rest as opposed to extended periods of more intense exercise followed by prolonged less intense exercise.

Maximal aerobic capacity is thought of as the foremost measure of an individual's cardiorespiratory fitness level and overall health. Persistent aerobic training will always result in increased cardiorespiratory fitness provided a sufficient training volume is achieved. The lack of a statistically significant increase in VO_{2MAX} in the present study can be explained by an exercise training stimulus that was inadequate for the subjects involved. It is important to note, however, that the trend in VO_{2MAX} for both exercise training groups was towards improvement.

Training Program and Resting Heart Rate

The results from the present study indicate no significant difference from pre- to post-training for subjects' resting heart rates. Both groups actually experienced a slight increase in resting heart rate following eight weeks of aerobic training (from 101.6 to 102.5 bpm for moderate; from 89 to 92 bpm for moderate/vigorous). These results are not in accordance with the well-established fact that chronic aerobic exercise training leads to a decrease in an individual's resting heart rate.

In a study using similar subjects (sedentary females, 21.9 ± 1.3 years) Slordahl, et al. (Slordahl, et al., 2004) found an average reduction of approximately 12 bpm ($p < 0.05$) following eight weeks of training. The training program for those subjects was substantially different from the current investigation. Slordahl, et al.'s subjects participated in aerobic interval training at intensities ranging from 50-95% of their HR_{MAX}. Furthermore, these subjects also differed in that they exercised for 40 minutes per day on three days per week. Despite training variations, these results agree with the findings of Cornelissen and Faggard (Cornelissen & Faggard, 2005). When analyzing 72 randomized controlled trials they noted an average reduction in resting heart rate by 7.1 bpm ($p < 0.001$) following chronic aerobic training.

The discrepancies between the present and previous studies regarding resting heart rate are not immediately clear. It can be speculated that the current investigation did not produce an adequate training stimulus to produce a significant decrease in resting heart rate. The present training program was comparatively mild to other studies using relatively healthy young females. Also, many environmental and behavioral variables can independently and collectively affect an individual's resting heart rate (Wilmore, et al., 2008). Ambient temperature, humidity, and noise level can cause distinct variations in resting heart rates for the same individual. Furthermore, caloric intake prior to exercise participation and amount sleep can cause inconsistencies in heart rate readings. The time of day can also impact an individual's heart rate. It is important to note, however, that subjects in both training groups experienced a similar pre- and post-training result in resting heart rate. Although neither improved as would be expected they both progressed in a parallel manner.

The result of chronic aerobic exercise should be improved cardiovascular efficiency. An indicator of improved cardiovascular efficiency is a reduction in and individual's resting heart rate. Although that reduction in resting heart rate was not realized in the present investigation several confounding variables could explain this result.

Training Program and Blood Pressure

The results from the present study indicate a significant difference from pre- to post-training for within group subject systolic blood pressure (from 125.2 ± 15.32 to 120 ± 13.5 mmHg; $p < 0.05$). Due to insufficient subject representation further analyses could not be conducted on these data to determine true statistical significance. There is no indication for a significant difference for between-group subject systolic blood pressure over time. The results further indicate no significant difference from pre- to post-training for within group subject diastolic blood pressure (from 71.6 ± 6.02 to 67.4 ± 11.63 mmHg), however, a trend exists towards a reduction ($p = 0.14$). There is no indication for a significant difference for between-group subject diastolic blood pressure over time. These results agree with similar findings regarding blood pressure and chronic aerobic exercise.

Moreira, et al. (Moreira, et al., 1999) showed a trend toward both decreased systolic and diastolic blood pressures following 10 weeks of cycle ergometer exercise. A group of moderately hypertensive males and females saw an average decline in mean 24-hour systolic blood pressure of approximately 5.8 mmHg. Also, this same group of subjects had around a 3% reduction in mean 24-hour diastolic blood pressure (from 93.3 ± 5.8 to 90.6 ± 6.8). These results were not deemed statistically significant, however, the trend towards reduction is apparent. It is also of great meaning to note that these individuals were older (47.2 ± 9.2 years) and that they participated in somewhat mild aerobic exercise, approximately 60% of the maximum estimated cycle workload. It is understood that relatively older individuals have less dramatic exercise-induced physiological adaptations (Ehrman, et al., 2010). These findings further support the meta-analysis of Cornelissen and Faggard (Cornelissen & Faggard, 2005). In 72 trials with training programs varying from 4-52 weeks in length a significant reduction in systolic (approximately 2.4 mmHg, $p < 0.01$) and diastolic blood pressures (approximately 1.6 mmHg, $p < 0.001$) were found to exist.

Blood pressure, much like resting heart rate, can be thought of as an index of overall health and well-being. High blood pressures put individuals at risk for developing life-threatening cardiovascular events (Thompson, et al., 2010). Lower blood pressures are indicators of more efficient cardiovascular systems and can be achieved through regular physical activity.

Training Program and Weight/Body Mass Index

The results from the present study indicate no significant difference from pre- to post-training for subject body weight (from 145.7 ± 30.48 to 145.4 ± 30.9 lbs) or body mass index (from 25.12 ± 3.66 to 25.05 ± 3.72 kg/m^2). Furthermore, no obvious trends appear to exist for either of these variables. Due to complex weight management variables the cause-effect evidence for aerobic exercises and weight management is not always readily apparent in empirical studies. Physical activity level is only one of several factors that determine caloric regulation and ultimately body weight.

Ghahramanloo, et al. (Ghahramanloo, et al., 2009) reported a significant decrease ($p < 0.05$) in BMI following eight weeks of endurance training. This decreased was approximately 1.5%. The subjects consisted of nine previously untrained male volunteers. They participated in a progressive treadmill running program on three days per week that resulted in 30 minutes of continuous exercise at 80% of their HR_{MAX} by the end of the study. Caloric intake for these subjects was not nearly as rigorously controlled for. The authors infer that since all of their subjects were students of similar age (24.8 ± 1.5 years) that lived on-campus then they all ate the same thing because meals were provided by the university. This line of reasoning can be described as questionable at best. Grediagin, et al. (Grdiagin, et al., 1995) showed that a significant amount of weight can be lost be females (31 ± 6 years; 3.3 ± 2.6 lbs, $p < 0.05$) after twelve weeks of low-intensity exercise on four days per week. *Low-intensity* was characterized as 50% of VO_{2MAX} and the duration of each training session was adjusted so that each subject expended approximately 300 kcal. Interestingly, however, a group of similar female subjects (30 ± 5 years) experienced no decrease in weight after twelve weeks of high-intensity aerobic exercise on four days per week. *High-intensity* was defined as 80% VO_{2MAX} and the duration of each training session was adjusted so that each subject expended approximately 300 kcal. The authors speculate that the non-significant difference for the high-intensity group was due to their increased levels of fat-free mass as a result of higher training intensities. It is worth mentioning that both groups under investigation were relatively small ($n = 6$).

Body weight and body mass index (BMI) are two important indicators of health that can readily be applied to the general public. A sustained, long-term negative caloric balance is ultimately the only way to achieve significant weight loss. Aerobic exercise is a means of increasing a person's expended calories; however, it is not the only way to achieve a negative caloric balance. Other variables including caloric intake and body composition should be accounted for while attempting to properly manage and individual's weight.

Training Program and Percent Body Fat

The results from the present study indicate no significant difference from pre- to post-training for subject percent body fat (from 27.13 ± 5.45 to 27.39 ± 5.3%). Furthermore, no obvious trend appears to exist for this variable. As with body weight, body composition in the result of combinations of complex variables of which aerobic exercise is only one exist in finding concrete experimental data that suggest a direct cause and effect link between the two.

Lemura, et al. (Lemura, et al., 2000) illustrated a decreased trend in body fat (from 26.4 ± 2.9 to 24.1 ± 3.1%) in sedentary women (21 ± 2 years) following eight weeks of aerobic training. After 16 weeks of training this trend was found to be statistically significant (from 26.4 ± 2.9 to 22.9 ± 2.7%, $p < 0.05$). Similar control subjects (sedentary females, 20 ± 1 year) participating in no aerobic exercise experienced no change in percent body fat after eight or 16 weeks (from 27.9 ± 2.8 to 27.0 ± 2.9 to 28.1 ± 2.7%). The aerobic training subjects participated in their choice of treadmill walking/jogging, cycling ergometry, or rowing ergometry on three non-consecutive days per week for 30 minutes at an intensity that elicited 70-75% of their HR_{MAX}. Grediagin, et al. (1995), however, noted no significant changes in their subjects' percent body following 12 weeks of either high- or low-intensity training of equal energy expenditure on four days per week (-3.4 ± 4.1% for high-intensity training; -2.9 ± 3.9% for low-intensity training).

Body composition can be used with other health variables to gauge an individual's health status. Aerobic exercise can be used as a means of altering body composition by using excess calories and keeping fat mass at a low level. The present study did not significantly impact body composition most likely because it was deficient in either length, intensity, or both.

Future Research

Future research is necessary to determine if total aerobic exercise volume can be appropriately measured using the $MET \cdot min \cdot wk^{-1}$ formula. This study exposed its subjects to varying aerobic exercise intensities as high as 7.1 METs on motor driven treadmills. There are, however, many different aerobic training methodologies (continuous, intermittent, interval, circuit) that utilize any of several different modalities (cycle ergometers, rowing machines, selectorized weight equipment, body weight).

Future research may use $MET \cdot min \cdot wk^{-1}$ to determine the appropriate physical activity volumes for structured exercise as well as activities of daily living. No matter the type of aerobic exercise research into $MET \cdot min \cdot wk^{-1}$ should expand to other various populations. The elderly, persons with disabilities, and those afflicted with chronic disease would stand to benefit the most from $MET \cdot min \cdot wk^{-1}$ research as these population subsets often cannot or will not participate in traditional forms of exercise. This potential research could allow for the determination of future physical activity guidelines.

Summary

The purpose of this study was to analyze the changes in health-related data following two different exercise prescriptions that varied in intensity and frequency, however, remained similar in total MET·min·wk^{-1} volume. Ten healthy college-aged female volunteers were used as subjects. The subjects were divided into two groups, moderate-intensity training group and moderate/vigorous-intensity training group. Both training groups began their programs by accumulating approximately 500 MET·min·wk^{-1} and further increased their training by roughly 75 MET·min·wk^{-1} after every two weeks for a total of eight training weeks. The moderate-only training group exercised on five days per calendar week while the moderate/vigorous-training groups exercised on only four days per calendar week. Both groups accumulated 30 minutes of training stimulus per day. The moderate-intensity group exercised at a constant moderate intensity (3.0-6.0 METs) for the entire 30 minutes whereas the moderate/vigorous-intensity training group achieved 10 minutes of exercise at a vigorous intensity (> 6.0 METs) followed immediately by 20 minutes of exercise at a moderate intensity (3.0-6.0 METs). Both groups completed identical five minute warm-up and cool-down periods at a light intensity (< 3.0 METs) before and after their exercise training stimulus. Each of the two training programs was designed in to reflect current American College of Sports Medicine physical activity guidelines for healthy adults. Pre-training and post-training data were collected for seven different health-related variables. The variables were maximal oxygen consumption, resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, body weight, body mass index, and percent body fat. The results showed that within-group resting systolic blood pressure was the only significantly different variable of the seven. Trend data, however, did also exist for improved maximal aerobic capacity and decreased resting diastolic blood pressure. In general, both groups progressed in the same manner over the course of the eight week training period. This study evaluated the outcomes of traditional measures following a training programs that were desgined using non-traditional methods. Future research is needed to determine if using $MET \cdot min \cdot wk^{-1}$ is an appropriate means of measuring total aerobic exercise volume.

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APPPENDICES

APPENDIX A

RESEARCH PARTICIPANT CONSENT FORM

"The Effect of Exercise Intensity on Health Indicators in Healthy Young Adults"

Principal Investigators

David Thomas, BS and Douglas Smith, PhD

Oklahoma State University
Department of Health, Leisure, and Human Performance

The present study will compare the effects of constant and varied aerobic exercise intensities on various indicators of overall health.

Purpose of Research
You understand that the purpose of this study is to determine and compare the effectiveness of two different aerobic exercise training programs that vary in intensity, frequency, and duration. Aerobic exercise is known to be inversely related with various adverse health conditions, such as cardiovascular disease, hypertension, stroke, type 2 diabetes, obesity, colon cancer, breast cancer, anxiety, and depression. By determining exercise program effectiveness optimal health goals can be achieved in a more efficient and effective manner for individuals who participate in structured physical activity. You are being selected as a participant for this study because you are a healthy, college-aged male or female who does not currently participate in a regular, structured exercise program.

Procedures
You understand that the tasks required of you are as follows:

1. Complete Health History Questionnaire and informed consent forms.
2. Complete a testing protocol at the Applied Musculoskeletal and Human Performance Laboratory at the OSU Colvin Recreation Center. Pre-tests include 1) height and weight measurements, 2) resting blood pressure, 3) resting and exercising heart rate, 4) body fat (skinfold pinch) measurements, and 5) a graded treadmill test done to maximal exertion. Skinfolds will be made twice at seven different sites on the right side of the body using a skinfold caliper. Additional measurements may be made if duplicate measurements are not approximately similar. The graded treadmill test consists of treadmill walking, jogging, and/or running with an expired air collector placed over your mouth and nose. You will begin walking on a treadmill at 1.7 mph with a 10% grade. At three minute intervals both the speed and incline of the treadmill will increase. The test is complete when you become fatigued and feel like you can no longer continue.
3. You will be randomly assigned to either a moderate-intensity aerobic exercise group or a moderate/vigorous-intensity aerobic exercise group. Each group has its own specific eight week exercise prescription to adhere to. During those eight weeks you will be expected to attend as many as either four or five, depending on

group assignment, exercise training sessions per week. Each session will last approximately 40-45 minutes and will take place at a time that is convenient for you and the principal investigator(s). All exercise training sessions will take place in the cardio theater area of the Colvin Recreation Center.

4. Return to the Colvin Recreation Center the week following your completion of your designated exercise training program for post-testing. The testing protocol will be identical to the pre-testing protocol.
5. You understand that you may withdraw from the study at any time, without penalty.

Compensation

No additional incentive is being offered; however results of the study can be assessed by all participants following analysis

Risks of Participation

Risks associated with the study are minimal and every effort has been made to minimize them. These risks include, but are not limited to fainting, dizziness, heart arrhythmias, and rarely heart attack, stroke, or death. Furthermore, muscles, ligaments, tendons, and joints could also be injured. The exercise programs are progressive in nature, meaning they begin at lighter workloads and slowly progress in intensity at regular intervals. Trained personnel will be able to assist you at any and every point throughout the exercise testing and training program to aid in further reducing these risks.

Medical Liability

You understand the risks associated with this study and voluntarily choose to participate. You certify that to the best of your knowledge you are in good physical condition and are able to participate in the study. You understand that in case of injury or illness resulting from this study, emergency medical care is available through community health care providers by dialing 911. You understand that no funds have been set aside by Oklahoma State University to compensate you in the event of illness or injury.

Confidentiality

Aside from the original data all references will only contain group designations or ID numbers which you will be assigned. The list of corresponding names and ID numbers will be stored in a locked file cabinet in the Applied Musculoskeletal and Human Physiology Laboratory that only the principle investigators will have access to. After all data is collected, the form containing names and numbers will be shredded. Consent forms will contain names but no ID numbers. These forms will be kept in a second locked file cabinet in the Applied Musculoskeletal and Human Physiology Laboratory which only the principle investigators will have access to. They will be shredded one year after the research is completed (spring 2011). Data will be reported as groupings (position) and will not be linked to participants.

Human Subject Statement

If you should have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Oklahoma State University, Stillwater, OK 74078, 405-744-3377, or irb@okstate.edu. If you need any additional information concerning the study contact Dave Thomas, 1514 W. Hall of Fame, Stillwater, OK 74078, 405-202-3391, dave.thomas10@okstate.edu, or Doug Smith 197 CRC, Oklahoma State University, Stillwater, OK 74078, 405-744-5500, doug.smith@okstate.edu.

Signatures
I have read and fully understand the consent form. I sign it freely and voluntarily. A copy of this form has been given to me.

Participant's Signature Date

Investigator's Signature Date

APPENDIX B

OKLAHOMA STATE UNIVERSITY
APPLIED MUSCULOSKELETAL HUMAN PERFORMANCE LABORATORY

Personal Medical History Survey

Complete both pages of this form.

Subject ID # ___________ Date ___________

Age ___________ Sex ___________ Height ___________ Weight ___________

1. Have you ever been diagnosed as having: (indicate all that apply)

	Never	In the Past	Presently
A. Heart disease			
B. Rheumatic fever			
C. High blood pressure			
D. Other vascular disorders			
E. Diabetes			
F. Kidney disorder			
G. Liver disorder			
H. Asthma			
I. Allergies			
J. Chronic bronchitis			
K. Other respiratory illness			
L. High serum lipids (cholesterol)			
M. Anemia			
N. Low blood sugar			
O. Neuro-musculo-skeletal disease			
P. Heart murmur			

2. Please indicate any surgery that you have undergone and the approximate date(s):

____

____

3. Please indicate recent illnesses or major injuries that you have had and approximate dates:

____

____

4. Do you currently smoke? __________ Packs per day? __________

5. Please list all medications or supplements (prescription and non-prescription) that you are presently taking.

Medication	Dosage	Duration

6. Have you ever performed aerobic exercise? __________

7. Describe exercise or activity program during the last six (6) months. Include the activity, amount per day, days per week, and length of time you have been exercising at this level.

Exercise Activity	Minutes/Day	Days/Week	Weeks/Month

APPENDIX C

MET Equivalents of Common Physical Activities

(Adapted from: Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M, Strath, S. J., et al. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise*, *32*(9 Suppl), S498-S516)

Activity	**Example**	**METs**
Inactivity	Sleeping	0.9
Inactivity	Sitting quietly, watching television	1.0
Walking	3.0 mph, moderate pace, firm surface	3.3
Walking	4.0 mph, very brisk pace, firm surface	5.0
Home activities	Vacuuming	3.5
Home activities	Child care (dressing, bathing, grooming, etc…)	2.5
Home repair	Washing and waxing car	4.5
Home repair	Roofing	6.0
Occupation	Masonry	7.0
Occupation	Typing	1.5
Running	5.0 mph	8.0
Running	6.0 mph	10.0
Running	8.0 mph	13.5
Sports	Boxing, in ring	12.0
Sports	Golf	4.5
Sports	Competitive racquetball	10.0
Sports	Basketball	6.0
Sexual activity	Vigorous effort	1.5

VITA

David Warren Thomas

Candidate for the Degree of

Master of Science

Thesis: USING MET·MIN·WK^{-1} TO PRESCRIBE AEROBIC EXERCISE TO HEALTHY YOUNG FEMALES

Major Field: Health and Human Performance

Biographical:

Personal Data: Born in Bartlesville, Oklahoma, February 26, 1984, the son of Glenn and Suzanne Thomas

Education: Graduated from Shawnee High School, Shawnee, Oklahoma, May 2002; received Bachelors of Science degree in Health Promotion from Oklahoma State University, Stillwater, Oklahoma, May 2008; completed the requirements for the Master of Science degree in Health and Human Performance at Oklahoma State University, Stillwater, Oklahoma in July 2010.

Experience: Fitness Intern, St. John Siegfried Health Club, Tulsa, Oklahoma (2008); Personal Trainer, Oklahoma State University Seretean Wellness Center, Stillwater, Oklahoma (2008-2010); Graduate Assistant, Oklahoma State University Seretean Wellness Center, Stillwater, Oklahoma (2008-2010).

Professional Memberships: American College of Sports Medicine.

Name: David Warren Thomas

Date of Degree: July, 2010

Institution: Oklahoma State University

Location: Stillwater, Oklahoma

Title of Study: USING MET·MIN·WK^{-1} TO PRESCRIBE AEROBIC EXERCISE TO HEALTHY YOUNG FEMALES

Pages in Study: 66

Candidate for the Degree of Master of Science

Major Field: Health and Human Performance, Applied Exercise Science

Scope and Method of Study: The purpose of this study was to analyze the changes in health-related data following two different exercise prescriptions that varied in intensity and frequency, however, remained similar in total MET·min·wk^{-1} volume. Ten healthy college-aged female volunteers were used as subjects. The subjects were divided into two groups, moderate-intensity training group and moderate/vigorous-intensity training group. Both training groups began their programs by accumulating approximately 500 MET·min·wk^{-1} and further increased their training by roughly 75 MET·min·wk^{-1} after every two weeks for a total of eight training weeks. The moderate-only training group exercised on five days per calendar week while the moderate/vigorous-training groups exercised on only four days per calendar week. Both groups accumulated 30 minutes of training stimulus per day. The moderate-intensity group exercised at a constant moderate intensity (3.0-6.0 METs) for the entire 30 minutes whereas the moderate/vigorous-intensity training group achieved 10 minutes of exercise at a vigorous intensity (> 6.0 METs) followed immediately by 20 minutes of exercise at a moderate intensity (3.0-6.0 METs). Both groups completed identical five minute warm-up and cool-down periods at a light intensity (< 3.0 METs) before and after their exercise training stimulus. Each of the two training programs was designed in to reflect current American College of Sports Medicine physical activity guidelines for healthy adults. Pre-training and post-training data were collected for seven different health-related variables. The variables were maximal oxygen consumption, resting heart rate, resting systolic blood pressure, resting diastolic blood pressure, body weight, body mass index, and percent body fat.

Findings and Conclusions: The results showed that within-group resting systolic blood pressure was the only significantly different variable of the seven ($p = 0.24$). Trend data, however, did also exist for improved maximal aerobic capacity and decreased resting diastolic blood pressure. In general, both groups progressed in a similar manner over the course of the eight week training period.

ADVISER'S APPROVAL: Dr. Douglas Smith