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The Effects of Aerobic and Muscular Endurance Based Resistance Exercises on the Cardiorespiratory System in College Age Females

Victoria Streif
Eastern Illinois University

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Victoria Streif

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Victoria Streif

Eastern Illinois University 2014

The Effects of Aerobic and Muscular Endurance Based Resistance Exercises on the Cardiorespiratory System in College Age Females

Abstract

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. Specifically, which mode of exercise has the most significant effect on cardiorespiratory fitness? **Methods:** Twelve sedentary college age females between the ages of 19 to 24 years, with a mean age of 20.9 years, participated in the study. Eligible participants were randomly assigned to one of three groups: an aerobic exercise only group (n=5), a combination of aerobic exercise and muscular endurance based resistance training group (n=3), and a control group (n=4). Subjects in the aerobic exercise only group participated in a six week program of moderate-vigorous aerobic exercise at 60-75% of their measured target heart rate reserve for a total of 50 minutes, three days per week. Subjects in the combination exercise group participated in a six week program of aerobic exercise at 60-75% of their measured target heart rate reserve for 30 minutes, in addition to a muscular endurance based resistance training program, three days per week. Subjects in the control group were asked to refrain from exercise during the six week period. Anthropometric measurements and cardiorespiratory fitness were assessed pre- and post-training period. Cardiorespiratory fitness was assessed through graded exercise testing (Bruce protocol) and continuous pulmonary gas exchange and indirect calorimetry. **Results:** A mixed ANOVA analysis ($p<0.05$) showed no significant difference between maximal VO_2 measurements in regard to time and group ($p = 0.50$). A paired samples t-test further showed no significant difference between the pre- and post-training measurements in maximal VO_2 ($p=0.162$). A second mixed ANOVA analysis ($p<0.05$) showed no significant difference between measured HR_{max} in regard to time and the experimental group ($p = 0.113$). A paired samples t-test further showed no significant difference between the pre- and post-training measurements in maximal heart rate ($p=0.892$). **Conclusion:** In sedentary females, between the ages of 19 and 24, six weeks of moderate-vigorous aerobic exercise plus muscular endurance resistance training elicited no significant difference from six weeks of moderate-vigorous aerobic exercise alone, in regard to the effects on cardiorespiratory fitness. The findings of this study were not in agreement with the suggestion that combination training has a greater impact on the components of cardiorespiratory endurance than aerobic exercise alone. However, the suggestion that no significant change would occur over an extended period of time within sedentary females who had no alteration in physical activity level was supported. Furthermore, in order to elicit a change in cardiorespiratory fitness, physical activity level must be positively altered.

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CHAPTER I

INTRODUCTION

Statement of the Problem

Physical activity is crucial to wellness as we age. Regular structured physical activity, such as exercise, delivers the greatest benefits for physical health and lowers the risk of several chronic diseases (Blair et al., 1989, Blair et a., 1995, Blair et al., 1996). These diseases include cardiovascular disease, metabolic disease, and various forms of cancer (Courneya et al., 2011). Albert and Ridker (2006) emphasized the prevalence and effect of cardiovascular disease in western civilization, which accounts for approximately 40% of annual deaths. The American College of Sports Medicine (2013) recommends ≥ 500-1,000 MET-min • wk^{-1} for most adults, which is associated with a lower risk of cardiovascular disease and morbidity. A dilemma many people face when starting an exercise routine is determining which mode of exercise is most beneficial, aerobic exercise or resistance training. Both modes result in various benefits. Such benefits include increased muscular strength and endurance from resistance training, improved aerobic functional capacity from aerobic exercise, and an improved quality of life from the combination of both modes of exercise. D'hooge et al. (2012) investigated the benefits of a combination of aerobic exercise and resistance training in regard to metabolic control, cardiovascular fitness, and quality of life in adolescents with Type I diabetes. Results demonstrated a significant improvement in physical fitness, general health, and the participants' overall well-being. The results of this current study will potentially add to the body of knowledge concerning which mode, or combination of modes, may have the more significant impact on cardiorespiratory fitness in adult females.

Purpose and Hypothesis

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared with a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. Specifically, this study addressed the question of which mode of exercise has the most significant effect on cardiorespiratory fitness?

It was hypothesized that while both training groups would show significant improvement in cardiorespiratory fitness from baseline to post-training, the individuals in the combination group would show significantly more improvement in cardiorespiratory fitness than the aerobic only training group. Further, it was hypothesized that there would be no significant change from the baseline measurements to the post-training measurements in a non-exercising control group.

Definition of Terms

Cardiorespiratory Fitness: the ability to perform large muscle, dynamic, moderate-vigorous intensity exercise for prolonged periods of time (Pescatello, Arena, Riebe, & Thompson, 2013)

Muscular Endurance: the ability of a muscle group to perform repeated muscle contractions over a period of time sufficient enough to cause muscular fatigue, or to maintain a specific percentage of the one repetition maximum for a prolonged period of time (Pescatello et al., 2013)

Maximal Oxygen Consumption (VO_{2max}): the product of the maximal cardiac output and arterial-venous oxygen difference, i.e., the maximal ability of the body to deliver, take-up, and utilize oxygen to produce energy (Pescatello et al., 2013)

Metabolic Equivalents (METS): a standardized measurement used to describe the absolute intensity of a physical activity (Pescatello et al., 2013)

Respiratory Exchange Ratio (RER): the ratio between the amount of carbon dioxide produced and oxygen consumed (VCO_2/VO_2) in one breath (Pescatello et al., 2013)

Limitations and Assumptions

A limitation to the study was the localized small sample size (n=12) from a mid-western university. However, a delimitation of the research was that it only applies to one gender, female, which reduced some possible variance within the data. A second limitation to the current study was the duration of the experimental period with only a six week intervention period for all groups.

The first assumption was that each participant was truthful in completing the Health History Questionnaire (Appendix C). A second assumption was that all participants fully completed and followed their exercise prescriptions throughout the six week period, and were capable of assessing their own heart rate during the warm-up, cool-down, and body of the workout by using the techniques shown to them. Lastly, the final assumption was that individuals in the control group sustained a sedentary physical activity level throughout the entire six week intervention period.

Significance of the Study

Few studies have examined the relationship between cardiorespiratory fitness and prescribed mode of exercise, aerobic exercise compared to resistance training, in sedentary college age females, with no known cardiovascular, pulmonary, or metabolic disease. Furthermore, few studies have examined the relationship between cardiorespiratory fitness and a combination of aerobic exercise and muscular endurance based resistance training. The present study was conducted to better understand possible significant differences within maximal oxygen uptake and maximal heart rate, as a result of two different training modalities, aerobic exercise and a combination of aerobic exercise plus muscular endurance based resistance training.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. Specifically, which mode of exercise has the most significant effect on improving cardiorespiratory fitness?

This review of related literature was organized as follows: the relationship of cardiorespiratory fitness to cardiovascular disease mortality, assessment of cardiorespiratory fitness, and combination training and the effect on cardiorespiratory endurance.

The Relationship of Cardiorespiratory Fitness to Cardiovascular Disease Mortality

It has been shown that a relationship exists between low cardiorespiratory fitness and an increased risk of cardiovascular disease mortality. It has also been shown that the opposite is true, where high cardiorespiratory fitness has been associated with a decreased risk of cardiovascular disease mortality. Studies have shown that the beneficial properties associated with high levels of cardiorespiratory fitness, such as weight loss and blood pressure reduction, reduce the risk of developing cardiovascular disease and/or death due to cardiovascular disease in healthy individuals of both genders (Kodama et al., 2009; Dencker et al., 2012; Stevens, Cai, Evenson, & Thomas 2002; Lee, Blair, & Jackson, 1999).

A meta-analysis performed in 2009, by Kodama et al., investigated cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events, specifically coronary heart disease, in healthy men and women. Researchers only included studies where cardiorespiratory fitness was assessed by an exercise stress test, an evaluation of the association between cardiorespiratory fitness and cardiovascular disease was conducted, and fitness levels were expressed as maximal aerobic capacity (MAC) or metabolic equivalents (METS). Studies targeted toward individuals with specific cardiovascular and metabolic diseases were excluded. A total of 33 studies were selected for the meta-analysis, which was comprised of 102,980 participants with a mean age range of 37 to 57 years. Kodama et al. (2009) defined three categories for cardiorespiratory fitness: low (<7.9 METS), intermediate (7.9 to 10.8 METS), and high (10.9 or greater METS). A categorical analysis was performed between all three groups in regard to all-cause and cardiovascular disease mortality risk.

Results of the meta-analysis revealed that "individuals with low CRF (<7.9 METS in MAC) had substantially higher risk of all-cause mortality and CHD/CVD compared with those with intermediate and high CRF (7.9 -10.8 and ≥10.9 METS in MAC, respectively)" (Kodama et al., 2009, p.2031). These results suggest that the physical properties of low cardiorespiratory fitness levels do not lower the risk of all-cause and cardiovascular disease related death, and that an intermediate or high cardiorespiratory fitness level is needed to develop a significant reduction in this risk. It was also suggested that physical fitness is a better determinate of cardiovascular disease risks than physical activity alone.

The terms cardiorespiratory fitness and aerobic fitness are used interchangeably in studies assessing the physical fitness level of the cardiopulmonary system. A study conducted by Dencker et al. (2012) researched similar relationships as Kodama et al. (2009) with aerobic fitness and cardiovascular risk factors, except with a subject pool of young children. A low aerobic fitness level has been shown to have a strong correlation with the risk of developing cardiovascular disease and all-cause mortality in adults and adolescents. The lack of aerobic fitness has been shown to transition from adolescence to adulthood. Dencker et al. (2012) investigated whether the same transition of low physical activity may begin prior to adolescence and if this lack of activity could be related to the same cardiovascular risk factors as adults.

The participants of the study consisted of 243 young boys and girls, 8 to 11 years of age. Dencker et al. (2012) utilized a composite risk factor score for cardiovascular disease risk factors, which included a combination of anthropometric measurements, blood pressure, cardiac characteristics, and peak aerobic fitness. Each participant's body mass index (BMI), resting and maximal heart rate, resting and maximal respiratory exchange rate (RER), maximal aerobic capacity (VO_{2PEAK}), total body fat mass, abdominal fat mass, pulse pressure, systolic and diastolic blood pressures, and mean arterial pressure were assessed. Echocardiography was also used to obtain imagery for end-diastolic left ventricular diameter, left arterial end-systolic diameter, end-diastolic posterior wall thickness, end-diastolic inter-ventricular septum thickness, and left ventricular mass. Aerobic fitness was assessed by a maximal exercise test on an electrically braked cycle ergometer with an expired gas mixing chamber for oxygen and carbon dioxide concentrations. All assessments were conducted on the participants once, with no experimental period.

No significant difference was found between boys and girls in regard to most anthropometric measures, except boys had a significantly lower fat mass and resting heart rate (Dencker et al., 2012). Boys also had a significantly higher VO_{2PEAK} and left ventricular mass than girls, which could be associated with their leaner body composition. Once more, a significant correlation ($p<0.05$) was found between aerobic fitness, VO_{2PEAK}, and cardiovascular risk factors in both sexes (Denkcker et al., 2012). Further research in young children is recommended; however, the research conducted by Dencker et al., (2012) strongly showed that aerobic fitness can be closely correlated to cardiovascular disease composite risk factors in young boys and girls. Additionally, Dencker et al., (2012) speculated that if started in youth and sustained throughout life, aerobic fitness may have a larger impact on composite risk factors for cardiovascular disease and mortality than if it was not addressed until adulthood.

A cohort study, conducted in North Carolina by Stevens et al. (2002), utilized patient data from the Lipid Research Clinics to examine the relationship between "fitness" and "fatness" in adult men and women, and its effect on all-cause mortality and cardiovascular disease. Similar to the study conducted by Dencker et al. (2012), body composition was represented by the participant's body mass index (BMI), which was calculated as a ratio between height in meters squared and weight in kilograms. However, cardiorespiratory fitness was assessed using the Bruce protocol on a maximal exertion treadmill test. Maximal oxygen uptake was not assessed during the study, only metabolic equivalents were used to represent maximal exertion and cardiorespiratory fitness.

The participants of this study were taken from eight geographically diverse Lipid Research Clinics in the United States. There were 5,366 total participants selected for the study, none of which had preexisting illnesses or diagnosed cardiovascular disease. Subjects were also excluded if their body mass index was classified as underweight, less than 18.5 kg/m^2, and if they had any contraindications for graded exercise testing. Data was collected from two detailed examinations. The first examination was brief, which mostly consisted of collecting general information, such as highest level of education obtained, current level of physical activity, and smoking history. The second examination was more extensive. Stevens et al. (2002) conducted a physical examination and graded exercise test, interviewed each participant, and obtained plasma samples during the second visit.

The results from this study showed that men and women with a high body mass index and men and women with low cardiorespiratory fitness levels have similar death rates for all-cause mortality and cardiovascular disease mortality (Stevens et al., 2002). However, fitness appeared to have a greater influence on all-cause and cardiovascular disease mortality in women than men. Stevens et al. (2002) associated this difference to the fact that there was a higher percentage of sedentary women than men within the study. The overall message from this study was that fitness and fatness must be addressed together. In order to obtain the benefits of both physical fitness and reduced body fat, it is recommended to maintain a healthy body weight and/or body composition and maintain at least a moderate level of cardiorespiratory fitness (Stevens et al., 2002).

Multiple studies have investigated body composition and cardiorespiratory fitness as factors that influence cardiovascular disease risk factors. Body mass index is one of the most widely used tools when assessing a population, as seen in the previous studies by Dencker et al. (2012) and Stevens et al. (2002); however, BMI does not differentiate between fat mass and fat-free mass. BMI is strictly a height to weight ratio. Furthermore, a cohort study conducted in Texas by Lee, Blair, and Jackson (1999) observed the same fatness vs. fitness concept as the studies previously addressed in this article, but did not use body mass index to represent body composition. Instead, hydrostatic weighing and skinfold-thickness measurements were utilized to assess body fat percentages. Cardiorespiratory fitness was assessed by a maximal treadmill exercise test.

A total of 21,925 men without known disease, between the ages of 30 to 83 years, were selected for the study. Each participant's body composition and cardiorespiratory fitness were assessed once, along with other factors, such as family history, current level of physical activity, and smoking history. After the maximal treadmill exercise test, all men within the 20^{th} percentile for their aerobic fitness were categorized as being physically unfit. All other participants that scored higher than the 20^{th} percentile were categorized as being physically fit. After hydrostatic weighing or skinfold-thickness measurements were obtained, participants were divided into three categories: lean, normal, and obese. Lee et al. (1999) had an eight year follow up of the participants' health records to establish number of deaths, if any, and the cause.

Following the eight year follow-up, Lee et al. (1999) discovered that 428 men had died and approximately one third of the deaths recorded were due to cardiovascular disease. "Mortality risk was elevated in unfit, lean men, with the highest all-cause and CVD mortality in unfit, obese men." (Lee et al., 1999, p. 377). This finding furthermore emphasizes the importance of maintaining both a healthy body composition and an aerobically fit lifestyle, reiterating the findings from Stevens et al. (2002). Lee et al. (1999) concluded that aerobic fitness was more important for all-cause and cardiovascular disease risk reduction than body composition alone, and that engaging in regular moderate intensity physical activity could potentially outweigh the harmful effects of excessive weight gain.

The subjects utilized in each of the previous studies (Kodama et al., 2009; Dencker et al., 2012; Stevens et al., 2002; Lee et al., 1999) were all relatively healthy individuals, with no known cardiovascular or metabolic diseases. The large subject pool of males and females represent the general healthy population well, during youth and adulthood. However, further research targeted towards females is recommended, due to the small number of studies that utilize only female subjects. Overall, the research previously discussed suggests that cardiorespiratory fitness levels are good determinates for cardiovascular disease mortality risk factors and for the prevention of cardiovascular disease.

Assessment of Cardiorespiratory Fitness

Cardiorespiratory fitness is related to the ability of the heart and lungs to uptake, utilize, and transport gases, such as oxygen and carbon dioxide, throughout the body during physical activity. This category of fitness is most closely associated with the pulmonary and circulatory systems within the body. Cardiorespiratory fitness levels may be assessed for health-related and/or fitness-related purposes, such as diagnostic testing or baseline measurements for exercise prescription. According to Pescatello et al. (2013), maximal oxygen uptake (VO_{2max}) is the principle measurement used to evaluate cardiorespiratory fitness levels.

Maximal oxygen uptake is a relative measurement of functional capacity of the heart when weight is addressed in the units of $mL \cdot kg^{-1} \cdot min^{-1}$ (Pescatello et al. 2013). The expression of VO_2 relative to weight is most widely used, as it allows comparison of individuals regardless of size or changes due to patient or client weight fluctuation. Direct measurement of VO_{2max} through open circuit spirometry is the most accurate, non-invasive, technique to measure maximal oxygen uptake during graded exercise testing. Unfortunately, due to costs, open circuit spirometry is typically only used in clinical or research facilities. However, other measurements, such as heart rate, blood pressure, and rating of perceived exertion (RPE) have also been proven to be effective measurements of an individual's functional response to exercise (Pescatello et al. 2013).

In regard to heart rate, different methods have been used to establish an accurate maximal heart rate. Of course, the most accurate way to assess a maximal heart rate is through a maximal graded exercise test, where an individual exercises until volitional exhaustion. However, graded exercise testing is not always feasible. When a maximal heart rate cannot be obtained through testing, an age-predicted maximal heart rate is estimated using a predetermine equation. The age-based equation of 220 – age is the simplest and most commonly used equation for predicting maximal heart rate; however, it has been shown to overestimate and underestimate these figures within different age ranges (Pescatello et al. 2013).

Tanaka, Monahan, and Seals (2001) conducted a study to assess the validity of the age-predicted maximal heart rate. The study consisted of a meta-analysis and laboratory based research targeted towards testing the validity of the 220 – age equation. The meta-analysis consisted of 351 studies where healthy men and women were assessed through maximal and sub-maximal graded exercise testing. The laboratory based research included 514 subjects, both healthy men and women, with an age range of 18 to 81 years. Subjects were excluded from the study if they currently smoked, were taking medications, other than for the use of hormone replacement, and/or were classified as severely obese with a body mass index equal to or greater than 35 kg/m^2. The participants utilized in the lab were assessed by a continuous, incremental treadmill protocol, where heart rate was monitored with electrocardiography, and minute oxygen consumption was measured with open-circuit spirometry. Tanaka et al. (2001) divided the participants from the meta-analysis into an endurance-trained group, a physically active group, or a sedentary group, and the participants of the laboratory study into either an endurance-trained group or a sedentary group, to determine if physical fitness affected the validity of the equation.

The results from each portion of the research conducted by Tanaka et al. (2001), showed an inverse relationship between maximal heart rate and age in both men and women. This finding shows a validation to the equation of 220 – age; however, an underestimation of approximately twenty beats per minute, or greater, was recorded in some older adults. In general, an age-predicted maximal heart rate is a good estimate for a general target area to look for a maximal heart rate when doing graded exercise testing, but other values, such as rate of perceived exertion, a plateau in maximal oxygen uptake, or respiratory exchange rate, should be considered when assessing a true maximal heart rate or functional capacity.

The relationship between peak heart rate, peak respiratory exchange ratio, and peak VO_2 during treadmill testing was observed by Peyer, Pivarnik, and Coe (2011). A combination of criteria must be utilized when assessing an individual's peak functional capacity, due to the fact that not all subjects will be able to physically meet all given criteria. As shown in the study by Tanaka et al. (2001), an estimated maximal heart rate may not be attainable for every patient or client. Peyer et al. (2011) specifically measured these values in adolescent and teenage females during continuous treadmill testing. Each participant was assessed for peak heart rate, peak respiratory exchange ratio, and peak VO2; however, not all participants were administered the same treadmill protocol. Four different protocols, either incremental or ramp based, were administered between the 453 subjects. Peyer et al. (2011) observed no significant difference between the data from the varied protocols, since each subject ended the test in a running state.

The results of this study illustrated that the type of treadmill protocol had no significant affect on the subject's ability to obtain credible maximal values; even though, the protocols varied in speed, grade, and duration. Peyer et al. (2011) also observed a difference in respiratory exchange rate values between young girls and adults. A difference was also seen in the estimated maximal heart rate values of the subjects and their obtained peak heart rate values, which reiterates the need to not use heart rate as a sole criterion for determining maximal levels of exertion. Furthermore, it is necessary to use different criterion when assessing individuals under the age of 18, than when assessing adults.

Combination Training and the Effect on Cardiorespiratory Endurance

Sarsan, Ardiç , Özgen, Topuz, and Sermez (2006) compared the effects of aerobic and resistance exercise on weight, muscle strength, cardiovascular fitness, blood pressure, and mood in 60 obese women at a university hospital in Turkey. The women were assigned to one of three groups: aerobic exercise, resistance exercise, and control group. The intervention period had duration of 12 weeks. Sarsan et al. (2006) assessed all measurements before and after the 12 week period. The women in the aerobic group performed both walking and cycling exercises for 15 minutes each at a moderate intensity of 50-70% of the subject's heart rate reserve. The women in the resistance training group performed 1-2 sets of 10-15 repetitions of both upper and lower body resistance exercises at 50-70% of the subject's one repetition maximum (Sarsan et al., 2006). Both experiment groups were required to exercise three times per week.

Sarsan et al. (2006) found a significant increase in both the aerobic group ($p=.026$) and combination of aerobic and resistance training group ($p=.058$) in regard to total exercise capacity. The results of this study suggests that "both aerobic and combined aerobic and resistance training are similarly effective and may be used interchangeably for improving exercise tolerance and quality of life in heart failure patients… However, combined aerobic and resistance training may be a preferable intervention to aerobic training only in frail and cachexic heart failure patients" (Sarsan et al., 2006, p. 214-215).

A similar level of improved performance was shown in the study conducted by McRae et al. in 2012. The researchers evaluated the changes in aerobic fitness and muscular endurance following an exercise program of extremely low volume, whole-body, high-intensity aerobic-resistance training. The subjects were 22 recreationally active females in their low to mid-20's. The intervention period lasted for four weeks, four days per week, and consisted of either 30 minute sessions of vigorous endurance training on a treadmill at approximately 85% of the subject's maximal heart rate or whole-body, aerobic-resistance training that involved eight sets of 20 repetitions of a single exercise separated by 10 seconds of rest. After the completion of the training period, McRae et al. (2012) found a significant improvement ($p<.05$) in regard to cardiovascular fitness in both exercise groups. However, only the aerobic-resistance training group showed a significant increase ($p<.05$) in skeletal muscle endurance. Furthermore, the results from this study suggest that both modes, aerobic endurance training and low volume, whole-body, high-intensity interval training, produce similar improvements in aerobic fitness, but additional improvements in muscular endurance were only a result of the interval training (McRae et al., 2012).

In conclusion, research has shown the relationship between cardiorespiratory fitness, cardiovascular disease risk, and all-cause mortality (Kodama et al., 2009; Dencker et al., 2012; Stevens et al., 2002; Lee, Blair, & Jackson, 1999). This relationship emphasizes the importance of measuring cardiorespiratory fitness levels for health assessment, and determining which mode of exercise is most beneficial for improving cardiorespiratory fitness. Aerobic exercise alone directly utilizes the cardiorespiratory system, which is a reason why it is commonly prescribed to improve this aspect of physical fitness. However, Sarsan et al. (2006) and McRae et al. (2012) showed improvements in total aerobic capacity with the combination of aerobic exercise and resistance training. Furthermore, the purpose of this study was to address the question of which mode of exercise elicits the most significant effect on cardiorespiratory fitness?

Practical Applications

The results of this recent study have implications for exercise specialists and exercise physiologists who design exercise prescriptions to enhance cardiorespiratory fitness in college age females. These implications are targeted mostly towards individuals within the field of non-clinical exercise science; however, it may also be beneficial to individuals within a clinical setting for exercise prescription, depending on the severity and type of disease with which the patient was diagnosed. Furthermore, the results of this study may be used as educational material for individuals who want to become more knowledgeable on how to enhance cardiorespiratory fitness, and possibly induce a reduction of the risk factors associated with cardiovascular disease.

CHAPTER III

METHODS

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. Specifically, which mode of exercise has the most significant effect on cardiorespiratory fitness?

Subjects

Sedentary college age females were recruited for this study. The age of the women recruited ranged from 18 to 24 years. All participants were currently enrolled as full-time students at a state university in the mid-west. Participants were recruited, in-person, by the lead investigator during regular school hours, and no incentives were given for participation. Inclusion criteria were females currently enrolled as a student at the state university, with a physical activity level categorized as sedentary by Pescatello et al. (2013) standards. Pescatello et al. (2013) considers an individual to be sedentary if they have not participated in at least 30 minutes of moderate intensity aerobic physical activity on at least three days per week for a minimum of three consecutive months. Exclusions for participation involved all individuals categorized as high risk for cardiovascular disease by Pescatello et al. (2013) standards, and those with two or more risk factors for cardiovascular disease. Additional exclusions consisted of individuals unable to perform maximal exercise testing on a treadmill due to pregnancy, known pulmonary, cardiovascular, or metabolic disease, and/or significant musculoskeletal impairments that hindered the individual's ability to walk for extended periods of time. Additional physical activity exclusions involved females who were currently partaking in a regular muscular strength or hypertrophy based resistance training program at the time of the study. There were no exclusions regarding participant's race, economic status, place of origin, sexual orientation, level of education, or nutritional status.

Twenty-two females volunteered to participate in the study. Prior to testing, participants completed a comprehensive set of forms including an informed consent for participation in the study (Appendix A), an informed consent for graded exercise testing (Appendix B), and a health history questionnaire (Appendix C). All eligible participants were randomly assigned to one of three groups: an aerobic exercise only group (n=7), a combination of aerobic exercise and muscular endurance based resistance training group (n=8), and a control group (n=7). Group one, the aerobic exercise only group, participated in a six week program of moderate-vigorous aerobic exercise. These individuals were required to perform aerobic exercise at 60-75% of their measured target heart rate reserve for a total of fifty minutes, three days per week. Group two, the combination exercise group, consisted of a six week program of a combination of muscular endurance based resistance training and moderate-vigorous aerobic exercise. These individuals were required to perform aerobic exercise, similar to group one, at 60-75% of their measured target heart rate reserve for thirty minutes, in addition to a muscular endurance based resistance training program, three days per week. Group three, the control group, was asked to refrain from exercise during the six week period. However, they were instructed to continue to perform any regular physical activity related to their place of employment, home environment, or occasional recreational activities, as long as it did not accumulate into regular aerobic exercise. Regular aerobic exercise was categorized as participating in a planned, structured aerobic physical activity sustained over a period of time (i.e. ≥30 minutes), which was performed consecutively for more than two days per week.

Anthropometric Measurements

Participants were assessed at the beginning of the six week intervention period and directly after the six week period. All anthropometric measurements were utilized as part of the ACSM (Pescatello et al., 2013) cardiovascular risk stratification, as criteria for inclusion and exclusion of research. Initial measurements included height in inches, weight in pounds, chronological age, and a calculated body mass index (weight (kg) ÷ height (m^2)). Height was assessed to the nearest half inch using a wall mounted stadiometer. Subjects were asked to remove their shoes and stand with their back straight against the wall, facing outward, with their chin parallel to the floor. The sliding horizontal headpiece was lowered until it was flush to the participant's scalp. Weight was assessed to the nearest half pound using a mechanical beam weighted scale. The subjects were asked to remove their shoes and were only allowed to wear one layer of clothing, other than their undergarments. Body mass index was calculated to the nearest tenth, after the conversion of weight in pounds to kilograms and height in inches to meters, through the formula weight (kg) ÷ height (m^2).

Cardiorespiratory Fitness

Cardiorespiratory fitness was also assessed prior to the six week intervention period and after the six week period. Cardiorespiratory measurements included resting blood pressure, estimated and measured maximal heart rate (HR_{max}), maximal aerobic capacity (VO_{2max}), peak exercise metabolic equivalents (METS), and peak respiratory exchange rate (RER). Peak RER, METS, VO_{2max} and heart rate were measured through continuous pulmonary gas exchange and indirect calorimetry using a Quark CPET® (COSMED, Rome, Italy) metabolic cart. Blood pressure was assessed after five minutes of rest prior to exercise testing and after five minutes of rest following exercise testing. A manual sphygmomanometer, with units of measure set in mmHg, was utilized to assess the blood pressure measurements.

At least one day preceding testing, the participants were instructed to not eat or consume any caffeine for approximately four hours prior to their test, to wear comfortable clothes and tennis shoes, and were informed of the time range expected for testing. The equipment utilized from the metabolic cart was sanitized and calibrated before each new test. Participants had to have a normal resting blood pressure, or within ten mmHg from set criteria, with a systolic pressure less than 120 mmHg and a diastolic pressure less than 80 mmHg (Pescatello et al., 2013), in order to begin the testing procedure. Participants with a hypertensive blood pressure, systolic pressure greater than or equal to 140 mmHg and/or a diastolic pressure greater than or equal to 90 mmHg, were not allowed to participate in the graded exercise testing.

All subjects who qualified for the maximal treadmill testing, after being risk stratified from the data given on their health history questionnaire (Appendix C), were connected to the metabolic cart and their information was inputted into the software. Each individual was allowed to walk on the treadmill for one to two minutes at 1.0 mph with 0% grade, in order to familiarize herself with the equipment prior to beginning the protocol. This was especially important for the individuals (n=3) that had never used a treadmill prior to the study. The Bruce protocol was utilized as the testing protocol during the graded exercise test, which is an incremental exercise protocol where both speed and grade increase after each three minute stage, until the subject reaches their maximal limits. The Bruce protocol is one of the most widely used treadmill protocol in both the fitness and clinical exercise science field (Pescatello et al., 2013). The subjects showed no contraindications, such as the inability to walk at an incline, for the chosen protocol. Once the test was begun, the participants were not allowed to hold on to the handle bars in front of and to the side of them on the treadmill, unless to briefly balance themselves during the transition between stages. The participants were also instructed to walk towards the front of the treadmill and to look directly in front of them, to reduce the risk of injury during testing. The lead investigator monitored each individual's exertion level through the measurements assessed during the test, visual level of fatigue, and verbal assessment of rating of perceived exertion. In order for the graded exercise test to be considered a maximal exertion test, participants had to meet at least two of three criteria: respiratory exchange ratio (RER) ≥ 1.05, exertional peak heart rate $\geq 85\%$ of estimated peak heart rate, and/or a plateau affect in the measured VO2. Once at least two of the three criteria were met, the subject was told that her test then qualified as a maximal test and it was then at her discretion when she was ready to terminate the test. Participants were instructed at the beginning and throughout the test to inform the administrator at least 30 to 60 seconds before they were ready to stop. As soon as the test was terminated, participants were required to complete a three to five minute cool-down by walking on the treadmill at 1.5 mph with 0% grade. Each participant, after completing the cool-down, rested in the seated position for an additional five minutes, at which point blood pressure was assessed again. Before the subject was allowed to be seated, the facial mask was removed. Once all measurements were taken, the lead investigator explained their results and gave them further instruction on what was required of them next.

Resistance Training

All participants who were assigned to group two, the combination of aerobic and resistance training group, were required to perform additional one repetition maximum testing to use as baseline measurements for their exercise prescription. Muscular strength and endurance were not further assessed after the initial testing. All measurements were assessed on resistance machines in the Student Recreation Center at the mid-western university.

Maximal muscular strength was assessed through one repetition maximum (1RM) testing, which measured the maximum amount of weight the participant could lift for one repetition only. Seven multi-joint exercises that targeted the agonist and antagonist of all major muscle groups were utilized during the study. These exercises included chest press, seated row, shoulder press, lateral pull down, leg press, abdominal crunch, and back extension. The subjects were instructed to rest three to five minutes between each 1RM trial load. After all 1RM's were measured, 50% and 60% of the maximal weight was calculated for the muscular endurance based resistance training exercise prescription.

Procedures

Once all subjects were screened and agreed to the terms and conditions of the study by signing both the informed consent for participation in the research (Appendix A) and the informed consent for the graded exercise test (Appendix B), they were randomly assigned to one of three groups, two experimental groups and a control group. The exercise prescription for both experimental groups was based around a range of 1,000-1,500 MET minutes per week. MET minutes were calculated as the product of the number of METS associated with one or more physical activities and the number of minutes performed during that session of physical activity (METS ×minutes). Also, the exercise prescription in both experimental groups was altered for progression after the initial three weeks of training. All equipment utilized by the participants for their prescribed exercise was located within the Student Recreation Center at the mid-western university. All exercises were performed independently and were not supervised; however, if any questions or concerns arose, participants either scheduled a time to meet with the lead investigator of the study or contacted the lead investigator by phone or email.

Group one of the experimental groups was assigned a six week program of moderate-vigorous aerobic exercise. The aerobic exercise was performed on a treadmill three days per week for a total of 50 minutes per session, excluding the warm-up and cool-down. The first three weeks consisted of moderate-vigorous aerobic exercise at 60-70% of their target heart rate reserve. The final three weeks consisted of moderate-vigorous aerobic exercise at 65-75% of their target heart rate reserve. Target heart rate reserve was calculated as the participant's heart rate reserve (maximal heart rate – resting heart rate) multiplied by the desired exercise intensity percentage, the product of that portion was then added back to the resting heart rate. Participants were instructed to track their heart rate, in order to remain within their target heart rate range, through a 10-second heart rate measurement on the radial artery located on the inside of the subject's wrist. The 10-second heart rate was calculated by the number of palpated beats, within 10 seconds, multiplied by six.

Group two of the experimental groups was assigned a six week program of moderate-vigorous aerobic exercise and muscular endurance based resistance training. The aerobic exercise was also performed on a treadmill three days per week for a total of 30 minutes per session. Similar to group one, the initial three weeks consisted of moderate-vigorous aerobic exercise at 60-70% of their target heart rate reserve, and the final three weeks consisted of moderate-vigorous aerobic exercise performed at 65-75% of their target heart rate reserve. Each participant, excluding the control group, was instructed to walk on the treadmill with an 8-10% grade at the individually prescribed speed. The percent grade was chosen for the participants to be able to execute the aerobic exercise at the prescribed intensity level, while maintaining a walking pace. All participants were prescribed aerobic exercise at a walking pace, below five miles per hour.

The resistance training portion for group two consisted of seven multi-joint exercises, which included chest press, seated row, shoulder press, lateral pull down, leg press, abdominal crunch, and back extension, which targeted the agonist and antagonist of all major muscle groups. All resistance training exercises were performed on machines in order to decrease the possibility of improper form while the lifts were executed. The initial three weeks consisted of one set of 20 repetitions at 50% of the participant's one repetition maximum (1RM). The final three weeks consisted of one set of fifteen repetitions at 60% of the participant's one repetition maximum (1RM). Since no muscle group was targeted back-to-back, a rest period between lifts was not necessary.

Both experimental groups performed a five to ten minute warm-up of brisk walking on the treadmill prior to starting the body of the exercise. The participants' heart rates were suggested to remain less than 40% of their target heart rate reserve during the warm-up period, which was measured manually through a 10-second heart rate identical to the procedure used during the body of the workout, i.e., the number of palpated beats on the radial artery, within 10 seconds, multiplied by six. Both experimental groups also performed a cool-down to gradually reduce their heart rates until it was within 20 beats per minute of their resting heart rate. Once the heart rate was within this range, participants were instructed to finish their sessions with static stretches, lasting 30 to 60 seconds each, targeting the major muscle groups that were used during exercise.

The final group was the control group. Subjects in this group were asked to refrain from exercise during the six week period. However, they were instructed to continue to perform any regular physical activity related to their place of employment, home environment, or occasional recreational activities, as long as it did not accumulate into regular aerobic exercise. Regular aerobic exercise was categorized as participating in a planned, structured aerobic physical activity sustained over a period of time (i.e. $\geq$30 minutes), which was performed consecutively for more than two days per week.

Once every other week, participants were questioned, through email or verbally, on how they were doing with the program and to make sure that they were following through with the protocol. An exercise log (Appendix D) was also given to both of the experimental groups to keep track of their exercise sessions and to help them remember their prescribed exercise and duration. A copy of the exercise log was submitted to the lead investigator directly following the end of the third week and the end of the sixth week. After completing six weeks of the designated exercise regimen, participants performed a final graded exercise test using the Bruce protocol to determine and document any changes from the initial screening.

Data Analysis

Descriptive statistics (mean ± SD) for all variables, change in peak VO_2 and peak METS, with groups were calculated. Comparisons among the mean differences between groups for differences in change in the dependant variable, time, over the six week experimental period, were analyzed using a mixed ANOVA with significant omnibus results followed up with post-hoc testing. Paired samples t-tests utilizing a Bonferroni adjustment were conducted to further determine whether a significant difference existed between the two independent variables, groups. SPSS 20.0 statistical analytic software (SPSS, Chicago, IL, USA) was used for the statistical analysis.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. Specifically, which mode of exercise has the most significant effect on cardiorespiratory fitness?

It was hypothesized that while both training groups would show significant improvement from baseline to post-training, individuals in the combination group would show significantly more improvement in cardiorespiratory fitness than the aerobic only training group. Further, it was hypothesized that there would be no significant change from the baseline measurements to the post-training measurements in the control group.

RESULTS

Descriptive Characteristics of Subjects

Twenty-two sedentary college age females volunteered to participate in the study. The age of the women recruited ranged from nineteen to twenty-four years, with a mean age of 20.9 years. Participants reported that they were sedentary, by ACSM (Pescatello et al., 2013) standards, at the time of the study. A sedentary physical activity level was defined by Pescatello et al. (2013) as an individual who had not participated in at least thirty minutes of moderate intensity physical activity on at least three days per week for a minimum of three consecutive months. All additional exclusion and inclusion criteria, as previously stated, were met prior to the start of the research. Eligible participants were randomly assigned to one of three groups: an aerobic exercise only group (n=7), a combination of aerobic exercise and muscular endurance based resistance training group (n=8), and a control group (n=7).

Dropouts (n=10) occurred throughout the duration of the study. The high rate of lost participation resulted in a total of twelve sedentary college age females who completed the study. Two participants were removed from the research within the first and second weeks of the study, due to newly developed health contraindications. Four participants dropped out of the study within the second and third weeks of research, due to time conflicts with either school or work. Four participants dropped out of the study within the final week of research, due to early departure from the area. Each subject group was reduced in size by a minimum of two participants: the aerobic exercise only group (n=5), the combination of aerobic and resistance training group (n=3), and the control group (n=4).

Anthropometric Measurements

Initial anthropometric measurements included height in inches, weight in pounds, and a calculated body mass index (weight (kg) ÷ height (m^2)). Chronological age was also assessed during this period, even though it was not an anthropometric measurement. Height was assessed to the nearest half inch using a wall mounted stadiometer. Weight was assessed to the nearest half pound using a mechanical beam weighted scale. Body mass index was calculated, after the conversion of weight in pounds to kilograms and height in inches to meters, through the formula weight (kg) ÷ height (m^2). All anthropometric measurements were utilized as part of the ACSM (Pescatello et al., 2013) cardiovascular risk stratification, as criteria for inclusion and exclusion of research.

Table 1. *Means and Standard Deviations for Anthropometric Measurements*

	Aerobic Only (n=5)	Aerobic + Resistance (n=3)	Control (n=4)
Age (yrs.)	20.8 ± 1.3	20.3 ± 1.5	21.5 ± 2.1
Weight (lbs.)			
Baseline	130.1 ± 8.6	168.2 ± 35.3	130.3 ± 16.0
Post-Training	128.6 ± 10.8	168.5 ± 39.2	132.3 ± 17.9
BMI (kg/m^2)			
Baseline	22.5 ± 0.9	29.4 ± 6.0	22.8 ± 3.1
Post-Training	22.2 ± 0.9	29.7 ± 7.0	23.1 ± 3.4

Cardiorespiratory Fitness

Cardiorespiratory fitness was assessed prior to the six week intervention period and after the six week period. Cardiorespiratory measurements included resting blood pressure, estimated and measured maximal heart rate (HR_{max}), maximal aerobic capacity (VO_{2max}), peak exercise metabolic equivalents (METS), and peak respiratory exchange ratio (RER). Peak RER, METS, VO_{2max}, and HR_{max} were measured through continuous pulmonary gas exchange and indirect calorimetry using a Quark CPET® (COSMED, Rome, Italy) metabolic cart. A manual sphygmomanometer, with units of measure set in mmHg, was utilized to assess the blood pressure measurements.

Pre- and post-six week period blood pressure measurements were utilized as part of the ACSM (Pescatello et al., 2013) cardiovascular risk stratification, as criteria for inclusion and exclusion of research. Participants had to have a normal resting blood pressure, or within ten mmHg from set criteria, with a systolic pressure less than 120 mmHg and a diastolic pressure less than 80 mmHg (Pescatello et al., 2013), in order to begin the testing procedure, and were excluded if systolic pressure was greater than or equal to 140 mmHg or diastolic pressure was greater than or equal to 90 mmHg. Exertional maximal heart rate and peak respiratory exchange ratio were utilized as part of the criteria to determine maximal effort during graded exercise testing; however, maximal heart rate was additionally utilized to determine cardiorespiratory fitness within this study, but peak respiratory exchange ratio was not. Therefore, changes in blood pressure and respiratory exchange ratio were not analyzed for significance in regard to cardiorespiratory fitness between groups. Metabolic equivalents were also not analyzed for significance in regard to cardiorespiratory fitness between groups, because the MET levels were factored into the equation (METS $\times$ 3.5) for calculating maximal oxygen consumption (VO_{2max}).

All assumptions were tested for a mixed ANOVA statistical analysis. With all of the assumptions met, two mixed ANOVA ($p<0.05$) analyses were completed, which compared the mean differences between groups for differences in change in the dependant variable, time, over the six week experimental period. The independent variable, groups, which represented the three experimental groups, was used as the between-subjects factor during both mixed ANOVA analyses. A paired samples t-test was conducted following both mixed ANOVA analyses to test for significant differences in regard to time, without looking at groups as the between-subjects factor. A Bonferroni adjustment ($p=0.05/2=0.025$) was utilized to test for significance, attuned for the two variables within the dependent variable, groups.

The first mixed ANOVA ($p<0.05$) compared change in the dependent variable, time, in regard to pre- and post-training maximal aerobic capacity (VO_2, ml/kg/min) measurements assessed at two time points with groups as the between-subjects factor. There was no significant difference between maximal VO_2 measurements in regard to time and the experimental group ($p = 0.50$). A paired samples t-test was conducted to determine if there would be a significant difference in maximal VO_2 between times tested, not factoring in the different groups. The paired samples t-test, without looking at groups as the between-subjects factor, further showed no significant difference between the pre- and post-training measurements ($p = 0.162$). Descriptive statistics for maximal oxygen consumption (VO_{2max}) by group and time are shown in Table 2. Figure 1 shows mean changes in VO_{2max} over time by group.

Table 2. *Means and Standard Deviations for VO_{2max} over Time*

	Aerobic Only (n=5)	Aerobic + Resistance (n=3)	Control (n=4)
VO_{2max} (ml/kg/min)			
Baseline	35.56 ± 5.73	30.81 ± 5.94	36.45 ± 6.94
Post-Training	38.02 ± 6.82	31.75 ± 7.55	36.10 ± 6.90

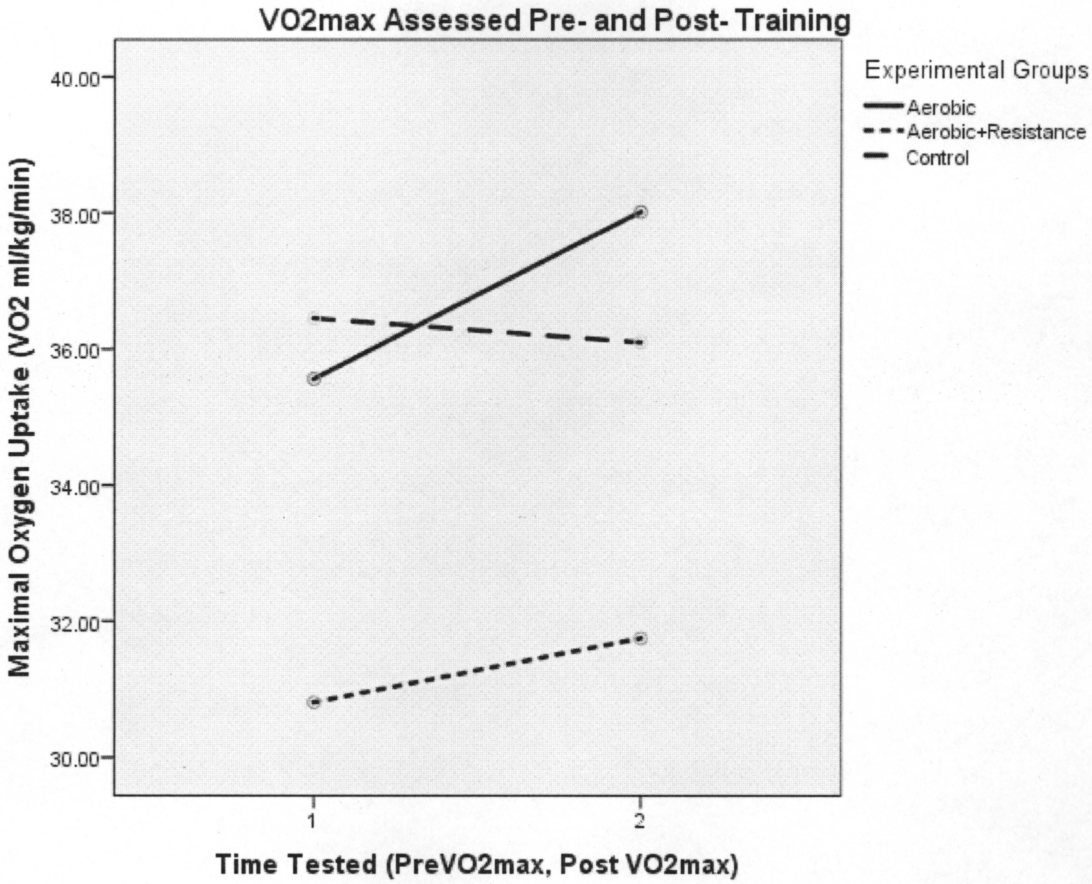

Figure 1. *Mean Change in VO_{2max} over Time in All Groups*

The second mixed ANOVA ($p<0.05$) compared change in the dependent variable, time, in regard to pre- and post-training maximal heart rate (HR_{max}) measurements assessed at two time points with groups as the between-subjects factor. There was no significant difference between measured HR_{max} in regard to time and the experimental group ($p = 0.113$) and there was no significant interaction between the three groups across the two assessment times. A paired samples t-test was conducted to determine if there would be a significant difference in HR_{max} between times tested, not factoring in the different groups. The paired samples t-test, without looking at groups as the between-subjects factor, further showed no significant difference between the pre- and post-training measurements ($p = 0.892$). Descriptive statistics for maximal heart rate by group and time are shown in Table 2. Figure 1 shows mean changes in HR_{max} over time by group.

Table 3. *Means and Standard Deviations for Maximal Heart Rate over Time*

	Aerobic Only (n=5)	Aerobic + Resistance (n=3)	Control (n=4)
HR_{max}			
Baseline	182.40 ± 11.76	183.33 ± 10.01	203.50 ± 8.66
Post-Training	175.60 ± 32.39	198.67 ± 3.22	202.75 ± 11.62

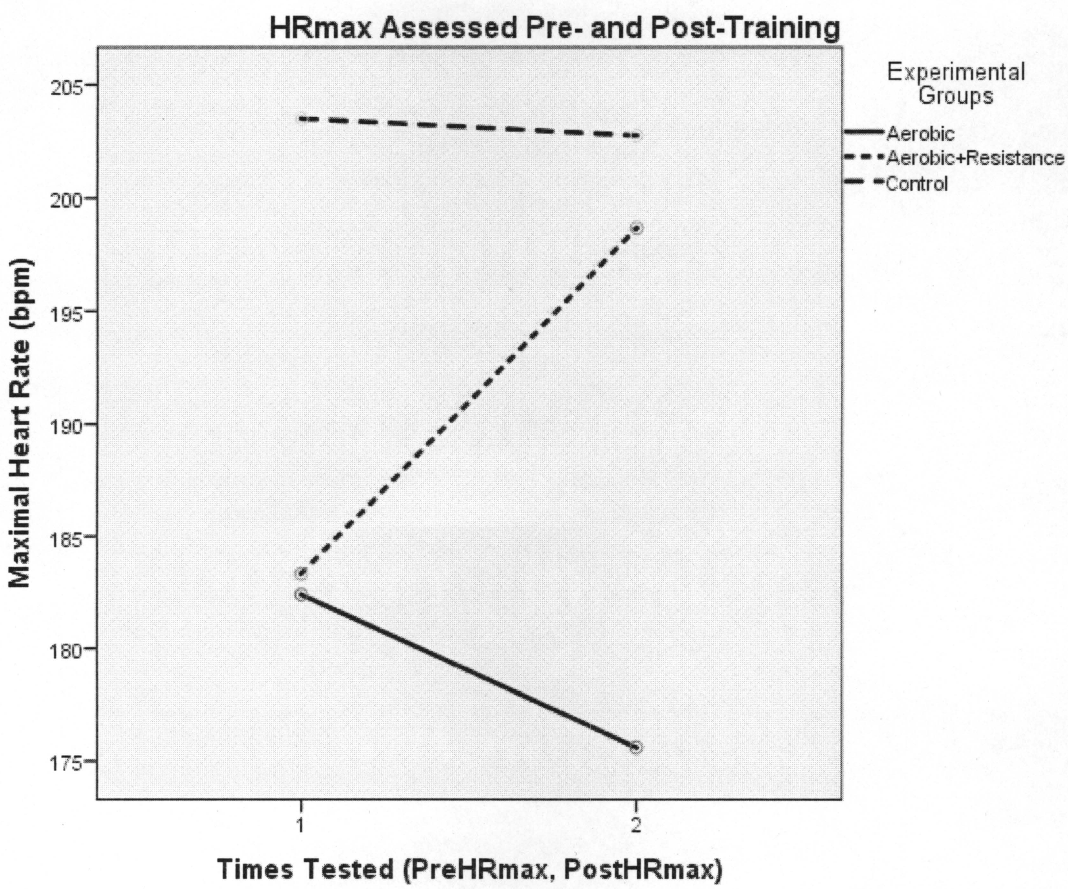

Figure 2. *Mean Change in Maximal Heart Rate over Time in All Groups*

Discussion

It was hypothesized that while both training groups would show significant improvement from baseline to post-training, the individuals in the combination group would show significantly more improvement in cardiorespiratory fitness than the aerobic only training group. Further, it was hypothesized that there would be no significant change from the baseline measurements to the post-training measurements in the non-exercising control group.

Within the comparison of change over time, no significant difference was found from baseline measurements to post-training measurements for any of the groups. This statement was true in regard to change in both maximal VO_2 and maximal heart rate. The results from the study did not support the hypothesis that both training groups would show significant improvement over the six-week period, nor did it support the hypothesis that the individuals in the aerobic exercise plus resistance training group would show significantly more improvement in cardiorespiratory fitness than the aerobic exercise only training group. However, the findings from this study did support the hypothesis that there would be no significant change from baseline measurements to post-training measurements in the control group. These results indicate that aerobic exercise alone and the addition of muscular endurance based resistance training to an aerobic exercise program provide no additional enhancement of cardiorespiratory fitness within a six week training period.

No previous research was found comparing the cardiorespiratory effects of a six week training program of aerobic exercise to a six week training program of aerobic exercise and muscular endurance based resistance training in apparently healthy college age females. However, various studies have researched the cardiorespiratory effects of aerobic exercise only (Kodama et al., 2009; Dencker et al., 2012; Stevens et al., 2002; Lee, Blair, & Jackson, 1999). Other studies have also researched the effect of resistance training alone and the combination of aerobic exercise and muscular strength based resistance training (Sarsan et al., 2006 and McRea et al., 2012).

The results of this study contradicted the findings of Sarsan et al. (2006) and McRea et al. (2012), and showed no significant improvement in cardiorespiratory fitness. The studies conducted by these researchers found significant improvements in total aerobic capacity after aerobic training and in a combination of aerobic and resistance training. Sarsan et al. (2006) found a significant increase in both the aerobic group ($p=0.026$) and combination of aerobic and resistance training group ($p=0.058$) in regard to total exercise capacity after a 12 week intervention period. Additionally, McRae et al. (2012) found a significant improvement ($p<0.05$) in cardiovascular fitness in the observed endurance training group and the interval training group after a four week training period.

The contradiction of findings may be the result of a time limitation. No significant improvements occurred in any of the groups over the duration of the six week period. Most of the research that has shown significant improvements in cardiorespiratory fitness as a result of exercise has had an intervention period greater than six weeks (D'hooge et al., 2012 and Sarsan et al., 2006). D'hooge et al. (2012) investigated the benefits of a combination of aerobic exercise and resistance training in regard to metabolic control, cardiovascular fitness, and quality of life in adolescents with Type I diabetes over a period of 20 weeks. Results of this study demonstrated a significant improvement in physical fitness, general health, and the participants' overall well-being. As previously stated, Sarsan et al. (2006) found a significant increase in both the aerobic group ($p=0.026$) and combination of aerobic and resistance training group ($p=0.058$) in regard to total exercise capacity after a 12 week intervention period. However, McRae et al. (2012) showed that it was possible to find a significant improvement ($p<0.05$) in fitness levels after only participating in a four week training period.

The contradiction of findings may have also been the result of the prescribed training intensity, since no significant improvements occurred in either of the exercise groups with the exercise prescription set at a moderate to vigorous intensity of 60-75% of the subject's calculated VO_2 and heart rate reserve. McRae et al. (2012) found significant improvements in cardiovascular fitness levels after a four week period of high intensity exercises set at approximately 85% of heart rate reserve. However, both Sarsan et al. (2006) and D'hooge et al. (2012) had their exercise intensities set within the range of 50-85% of each subject's heart rate reserve, where significant improvements were seen.

Furthermore, the results of the study may have been the result of both the six week training period and the prescribed moderate to vigorous exercise intensity of 60-75% of VO_2 and heart rate reserve. In order for a significant improvement in cardiorespiratory fitness to occur, both the duration of the training period and exercise intensity must be altered, i.e., shorter durations of time must be coupled with higher intensities of exercise, as seen in the research by McRae et al. (2012). The limitations of sample size and duration of research may have elicited the confliction between the findings in this study and previous studies. Supplementary investigation within this area of research is highly suggested

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Findings

The purpose of this study was to evaluate the cardiorespiratory response in college age females, between the ages of 19 and 24, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. After the six week intervention period, no significant improvements in regard to cardiorespiratory fitness occurred within any of the groups, which would suggest that the difference in the chosen modes of exercise had no effect on improving cardiorespiratory fitness within the study.

Conclusion

In this investigation of sedentary females, between the ages of 19 and 24, the following conclusion was drawn: neither six weeks of moderate-vigorous aerobic exercise nor aerobic exercise plus muscular endurance resistance training elicited a significant improvement in cardiorespiratory fitness as assessed by changes in VO_2 and heart rate. The findings of this study were not in agreement with the suggestion that combination training has a greater impact on the components of cardiorespiratory endurance than aerobic exercise alone. However, the suggestion that no significant change would occur over an extended period of time within sedentary females that had no alteration in physical activity level was supported. Furthermore, in order to elicit a change in cardiorespiratory fitness, physical activity level must be positively altered.

Recommendations for Future Research

More investigation is needed to understand the effects of aerobic exercise and muscular endurance based resistance training on the cardiorespiratory system in sedentary college age females, specifically, viewing the relationship between which mode of exercise has the most significant effect on cardiorespiratory fitness. Future research in this area should attempt to use subjects that vary in age, gender, physical activity level, and/or ethnicity. Moreover, a larger subject pool may show more significant relationships between variables. Different methodology, such as varied exercise intensity levels, duration, and mode of exercise, may also pose different or similar results than the results found in the current study. Instead of assessing cardiorespiratory fitness through maximal graded exercise testing on a treadmill, future studies may utilize sub-maximal exercise tests or cycle ergometers to assess subjects' fitness levels. Multiple variations of the methodology are suggested for future research, as long as the alterations pose little to no known adverse effects to the subjects selected.

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APPENDIX A

Informed Consent for Participation in Research

Informed Consent for Participation in Research

Purpose:

The purpose of this study is to evaluate the cardiorespiratory response in adult females, between the ages of eighteen and twenty-five, before and after participating in a six week moderate-vigorous aerobic exercise program compared to a six week moderate-vigorous aerobic exercise program combined with a muscular endurance based resistance training program. This study will specifically be focused towards female students enrolled at Eastern Illinois University.

Participation:

Participation in this study is completely voluntary. You may decline to contribute information or cease participation at any point, without penalty.

Description of Study Procedures:

A researcher or assistant will give you this informed consent form to read and sign. Following compliance, the researcher or assistant will present you a Health History Questionnaire and an additional informed consent specified for a graded exercise test to read and complete. Once both forms are complete, you will be risk stratified to determine whether you are low, moderate, or high risk by ACSM risk stratification standards. If you are classified as low or moderate risk you will be able to continue with the study, if not, your participation will be ceased. General baseline measurements will be assessed for all participants, which include height, weight, blood pressure, and cardiorespiratory function through a graded exercise test. After baseline measurements, the participants will be randomly divided into three groups: an aerobic exercise only group, a combination of aerobic exercise and muscular endurance resistance training group, and a non-exercise control group. Specific muscular strength measurements will be administered to the combination group to calculate their one repetition maximums. The study will consist of a six week training period. Both exercise groups will be required to follow a specific exercise prescription throughout this period and will be required to exercise three days per week for approximately sixty minutes per session. They will also be required to keep a log of their weekly activity. After initial consultation on how to properly perform each exercise, the participants will exercise independently without the researcher's supervision. Once every other week, all participants, including the control group, will be verbally questioned about their progress with the program and to make sure that they are following through with the protocol. Weekly logs will also be viewed and collected at this time. After the completion of the six week training period, all participants will undergo post-training measurements, which will once more include height, weight, blood pressure, and cardiorespiratory function through a graded exercise test. Thus forth, the participation of the participants will no longer be necessary once all data has been collected.

Participant Risks and Discomforts

This study poses short-term physical risks, which include minor aches and pains associated with physical activity and exercise. If proper form and attention are not utilized during activity there is a risk of falling off the treadmill during operation and/or straining a muscle, tendon, or ligament during exercise. There are additional risks associated with performing a maximal exertion graded exercise test such as falling off the machine, psychological stress from maximal physical exertion, and/or a cardiovascular or pulmonary event. However, if the subject shows significant signs or symptoms of a cardiovascular or pulmonary event, the test will be terminated immediately. Furthermore, there are no known social or legal risks associated with this study. Special safety precautions will be utilized throughout the study. Subjects will be trained in proper technique for all exercises that are prescribed to their selected group and informed on how to operate the exercise equipment utilized during training. In case of an emergency, a phone will be available to call 911 or the local emergency services. The individual assessing baseline and post-training measurements will also be CPR and AED certified in case of such emergency.

Confidentiality

Information is given anonymously and will remain private throughout the study. The information gained from your Health History Questionnaire and pre- and post-training assessments will be kept confidential and will not be released or revealed to any persons without your written consent. However, the information obtained may be used for scientific purposes with your right to confidentiality retained.

Inquiries:

Any questions regarding the procedures used or questions regarding your results are encouraged.

If you have any concerns or questions, please ask for further explanation. You may contact the principal investigator by phone day or night at (618) 843-4064 or by email at vnstreif@eiu.edu.

Rights of Research Subjects

If you have any questions or concerns about the treatment of human participants in this study, you may call or write:

Institutional Review Board
Eastern Illinois University
600 Lincoln Ave.
Charleston, IL 61920
Telephone: (217) 581-8576
E-mail: eiuirb@www.eiu.edu

You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with EIU. The IRB has reviewed and approved this study.

I have read this form and I understand the test procedures that I will be asked to perform. I understand the potential risks and discomforts of this study and having had the opportunity to ask questions, which have been answered to my satisfaction, I consent to participate in this study.

Printed Name of Participant ____

Signature of Participant ____________________________________ Date__________

I, the undersigned, have defined and fully explained the investigation to the above subject.

Signature of Investigator ___________________________________ Date__________

APPENDIX B

Informed Consent for Graded Exercise Testing

Informed Consent for Graded Exercise Testing

Patient Name (Print): ____

I hereby consent to voluntarily engage in a symptom-limited graded exercise test to determine maximal oxygen uptake and cardiopulmonary function. This test will facilitate evaluation of cardiopulmonary function and/or assist in prescribing or evaluating an exercise program.

- ❖ It is my understanding that I will be questioned prior to taking the test about my current and past medical history, family medical history, and exercise history by completing a Health History Questionnaire to the best of my knowledge. I will be risk stratified and given two pre-test blood pressure measurements to exclude contraindications to such testing. Additionally, my heart rate, rate of perceived exertion, and appearance will be monitored continuously throughout the test.

- ❖ I understand that I have the responsibility to be honest and forthcoming in providing information about my medical history and any unusual or discomforting symptoms that I experience before, during, and/or after the test.

- ❖ It is my understanding that there exists the possibility that certain abnormal changes may occur during the progress of the test. These changes could include, but are not limited to: abnormal heart beats/rhythms, abnormal blood pressure responses, abnormal or excessive shortness of breath, and in very rare instances a cardiovascular event. Furthermore, I understand that every effort will be made to minimize these risks by taking care in selection of and supervision of individuals during testing.

- ❖ I understand that all exercise testing will be performed on a treadmill that allows the workload to gradually increase until fatigue, shortness of breath, chest discomfort, or other signs or symptoms appear that would dictate cessation of the test. The test may also be stopped if abnormalities are observed in my heart rate, appearance, and/or blood pressure, or if I choose to terminate the assessment.

- ❖ It is my understanding that specific safety precautions will be utilized throughout the study. In case of an emergency, a phone will be available for the individual administering the test to call 911 or the local emergency services. The individual administering the test will also be CPR and AED certified in case of such emergency. Moreover, the American College of Sports Medicine states that all individuals risk stratified as low or moderate risk are applicable to participate in a maximal exertion test, such as the treadmill graded exercise test, without a physician present.

The benefits of exercise testing include the assessment of functional working capacity, maximal cardiac function, maximal pulmonary function, the detection of possible heart and/or lung disease, the clinical appraisal of health risks, and the facilitation of an exercise prescription.

I have read the preceding information and understand it. Questions concerning this procedure have been answered to my satisfaction. I have also been informed that the information derived from this test is confidential and will not be disclosed to anyone, other than those that are involved in my care or exercise prescription, without my expressed written consent.

Patient Signature: ____________________________________ Date: _____________

Witness Signature: ____________________________________ Date: _____________

APPENDIX C

Health History Questionnaire

HEALTH HISTORY QUESTIONNAIRE

General Information

Name: (LAST)________________ (FIRST)__________________ (MI)________

Birth Date: ______________________ Age: __________ Gender: ___________

Address: (STREET)________________________________ (Apt/Unit #)__________

(CITY)____________________ (STATE)__________ (ZIPCODE)____________

Phone Number: ______________________ Email: __________________________

Emergency Contact: _________________________ Relationship: ______________

Emergency Contact Number(s): ____

Physician Name: ____________________ Physician Number: _________________

Personal Medical History

Do you have a recent or past history, or has a physician ever diagnosed you with any of the following?

_____ Cardiovascular Disease
_____ Cardiac Surgery
_____ Irregular Heart Beats
_____ Defective Heart Valve(s)
_____ Heart Murmurs
_____ Heart Attack (MI)
_____ Angina (chest pain)
_____ Stroke
_____ Peripheral Artery Disease
_____ Thyroid Disease
_____ Liver Disease
_____ Renal (Kidney) Disease
_____ Pulmonary Disease
(Chronic bronchitis, emphysema, etc.)
_____ Asthma
Exercise induced? _____

_____ Pre-diabetes
_____ Diabetes (Type I or Type II)
_____ Dyslipidemia (high cholesterol)
_____ Hypertension (high blood pressure)
_____ Hypotension (low blood pressure)
_____ Obesity (BMI $\geq 30kg/m^2$)
_____ Cancer (specify type):__________
_____ Lightheadedness/Fainting/Blackouts
_____ Chronic Fatigue
_____ Epilepsy
_____ Migraine Headaches
_____ Arthritis
_____ Edema (swelling in ankles or feet)
_____ Back Pain/Discomfort
_____ Joint Pain
Where? ___________________

Do you have musculoskeletal problems that limit your physical activity?

(check) Yes____ No_____

If so, please specify:

____

Do you currently smoke cigarettes? (check) Yes_____ No_____

If you previously smoked, when did you quit? ______________________________

Do you drink caffeinated beverages? (check) Yes_____ No_____

If so, how much/often: ____

Are you currently following a special diet? (check) Yes_____ No_____

If so, please specify the diet:

____

When was the last time you ate a snack or meal?

____

Is there a possibility you could be pregnant? (check) Yes_____ No_____

Are you allergic to any medications? (check) Yes_____ No_____

If so, please specify the medication:

____

Please list any surgeries or hospitalizations you have had and the date/year each took place:

____

____

____

Please list any medications you are currently taking, the reason you are taking them, and the dosage:
(Including birth control, over-the-counter medications, and supplements)

____

____

____

Family Medical History

Check if any of the following family members have a history of cardiovascular disease, such as heart attacks, coronary artery disease, or sudden death: Female relatives prior to the age of 65, and male relatives prior to the age of 55.

Mother: ______ (explain): ____________ Father: ______ (explain): ____________

Sister: ______ (explain): ______________ Brother: ______ (explain): ___________

Daughter: _____ (explain): ____________ Son: ______ (explain): ______________

Exercise History

Do you currently exercise on a regular basis? (circle) Yes No

If yes, please explain what you do on a weekly basis and the duration of the program.

Mode/Type: ____

Total Sessions/Week: ____

Minutes/Session: (check) < 90 minutes ____ 90-150 minutes ____ >150 minutes ____

Duration of Program: (check) < 3 months ______ ≥ 3 months ______

I have read, understood, and completed this questionnaire. Any questions that I had were answered to my full satisfaction. I am aware that I have the right to ask to stop any assessment at any time.

Patient Signature: ______________________________ Date: ____________

Witness Signature: ______________________________ Date: ____________

APPENDIX D

Exercise Log

Name:				
Week:	Date:	Time:	Activity Performed:	Treadmill Speed Range & % Grade:
1				
2				
3				
4				
5				
6				