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The Effects Of Upper Body vs Lower Body Training On Rate-Pressure Product

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THE EFFECTS OF UPPER BODY VS LOWER BODY TRAINING

ON RATE-PRESSURE PRODUCT

being

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by

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ABSTRACT

Lower body activities such as walking, running, and cycling have traditionally been used as the activity mode during physiological exercise testing. Interest in specific responses to upper extremity exercise has increased since upper body cycle ergometry became an important alternative exercise mode in the 1970's. Previous research on upper extremity exercise utilized upper body cycle ergometry or a standard push-pull rowing movement. Few upper extremity studies measured rate-pressure product.

The purpose of this study was to compare rate-pressure product between lower extremity exercise utilizing upright cycling and primarily upper extremity exercise on a double arm swing Ski Erg ergometer. Hemodynamic response was measured using an automated motion tolerant exercise test monitor. The study utilized one dependent variable (rate-pressure product) and four independent variables (exercise mode, exercise intensity, age group, and gender).

A repeated measures ANOVA was conducted to determine the effects of exercise mode, gender, and age group on rate-pressure product at identical exercise workloads. Significant differences in rate-pressure product were found for exercise mode, but not for gender or age group. Mean rate-pressure product increase for each workload was then compared using the Tukey LSD post hoc test. Rate-pressure product increase during each workload of upper extremity was significantly greater than during the corresponding lower extremity workload.

This finding provides further evidence that greater hemodynamic demand during upper extremity exercise is a generalized response which occurs in response to isolated

upper extremity exercise independent of the exact arm movement or specific muscle involvement. The findings also indicate greater hemodynamic response to upper extremity exercise is independent of gender or age group.

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DEDICATION

To my parents, Jerry and Emily Baird for your support and encouragement throughout this journey. To all my friends who were patient with me and kept me motivated throughout this process.

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Chapter I

Introduction

From the early days of formal exercise science research at the Harvard Fatigue Laboratory in the 1920s, the primary mode of exercise intervention for research has been lower- extremity activity such as walking, running, and cycling. In the 1970s, the evolution of upper extremity cycle ergometry led to a surge of interest in measuring physiological responses to these upper body exercises (Clausen, 1976). Upper body cycle ergometry does not seem to be a particularly realistic approximation of real life upper body work or competitive arm movement. Upper body cycle ergometry utilizes arm rotation at chest level with limited shoulder and elbow extension. Upper body work such as shoveling and competitive movements such as swimming and cross country skiing utilize a more complete range of shoulder rotation and elbow extension.

There are a number of applications for which upper extremity continuous exercise could be a preferred modality. Examples include:

1. Rehabilitation of individuals with lower limb impairment or amputation.
2. Exercise to increase duration of cardiorespiratory target zone conditioning for individuals with peripheral artery disease (Zwierska, et al., 2005).
3. Specific sports conditioning exercise for athletes such as Nordic skiers whose competitive performance is heavily influenced by upper extremity power capacity.

Studies utilizing upper body cycle ergometry have found a disproportionate hemodynamic demand for this modality (Civino et al., (2009); Eston & Brodie, (1986); and Roberts, (2002)). Heart rate and blood pressure are higher at any absolute exercise intensity. It is assumed this difference is caused primarily by the lower muscle mass available during arm exercise compared to leg exercise. If increased hemodynamic demand transfers to other modes of upper body exercise, upper extremity exercise may pose even greater risk in individuals who already have cardiovascular pathologies or elevated blood pressure (Thompson, 2010). New options for exercise programming are continuously identified and implemented. As health fitness professionals working to increase public participation in physical activity, it is our duty to understand physiological demands and health risks associated with novel activities. As new exercise devices such as the SkiErg are developed it is important to fully understand their unique characteristics and demands.

Statement of the Problem

The purpose of this study will be to compare rate-pressure product between primarily lower extremity exercise utilizing upright cycling and primarily upper extremity exercise on a SkiErg arm swing ergometer.

Sub-problems

In this investigation, the following sub-problems will be investigated:

1. Is there a difference in the rate-pressure product response to incremental cycling versus SkiErg exercise?
2. Is the rate-pressure product response to incremental cycling versus SkiErg exercise different between subjects from Group A (20 to 30

years of age) compared to those between Group B (50 to 60 years of age)?

3. Is the rate-pressure product response to incremental cycling versus SkiErg exercise different between males and females?

Definition of Terms

The following are terms used in the study:

Apparently healthy individuals. Men under the age of 45 and women under the age of 55 who have no symptoms of or known presence of heart disease or major coronary risk factor, men 45 or older and women 55 or older who have no symptoms or known presence of heart disease and less than two major cardiovascular risk factors (Thompson, 2010).

Blood pressure. In 2003,the Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7), defined blood pressure as the force applied by circulating blood on the walls of the blood vessels and on the chambers of the heart.

Hemodynamic. The movement of the blood through blood vessels. Hemodynamic responses indicate the amount of work the veins, arteries, and chambers of the heart are experiencing. Many factors including age, gender, exercise, blood pressure, and medications influence these responses (McGraw-Hill Concise Dictionary of Modern Medicine (2002).

Rate-pressure product. An indicator of oxygen requirements of the heart muscle. Rate-pressure product is calculated as the product of the heart rate and systolic blood pressure, which is the maximum pressure exerted by the blood on the vessel walls.

Rate-pressure product is a scaled value determined by multiplying heart rate and systolic arterial blood pressure (Kent, 1997). It is considered an extremely valid indirect index of myocardial oxygen consumption.

Resting heart rate. The heart rate at rest. The average resting heart rate is between 60-80 beats per minute. Regular endurance training can reduce the resting heart rate to less than 40 beats per minute (Oxford Dictionary of Sports Science & Medicine, 2007).

SkiErg. SkiErg is a product name applied to the upper-extremity double pole ski-ergometer developed by Concept 2. It is important to clarify that the movement on this ergometer is not designed to mimic the total body activity of Nordic skiing because the feet are stationary with minimal lower body involvement. Instead, it utilizes nearly the same upper body movements as double pull cross country technique. The SkiErg is thought to produce many of the same cardiovascular benefits as the cycle; however, it is a newer device with little documentation of specific outcomes. (SkiErg Concept 2, 2010).

Limitations

The study was limited to:

1. The accuracy of blood pressure measures during exercise.
2. The inability to precisely control intensity throughout exercise testing.
3. The sample size that is used for the study.
4. The sample population subjects were drawn from.

Delimitations

The study was delimitated to:

1. Healthy individuals ranging from 20 to 30 years of age.
2. Healthy individuals between 50 & 60 years of age.
3. Upper body movement specific to that of the SkiErg.
4. Lower body movement specific to that of upright cycling.

Assumptions

The following assumptions were made during the study:

1. The workload readings on the cycle and the SkiErg digital displays remain valid and reliable.
2. The readings for heart rate and rate-pressure product at rest and during activity were accurate.
3. The participants made every effort to follow correct testing procedures.

Null Hypotheses

The following null hypotheses were tested at the 0.05 level of significance.

1. There will be no significant difference in rate-pressure product response to incremental exercise between primarily lower extremity cycling and primarily upper extremity SkiErg exercise at the same absolute workload.
2. There will be no significant difference in rate-pressure product response to incremental cycling versus SkiErg exercise between Group A and Group B.

3. There will be no significant difference in rate-pressure product response to incremental cycling versus SkiErg exercise between males and females.

Significance of the Study

This study will help clarify differences in hemodynamic response to lower extremity versus upper extremity exercise. The response to upper extremity exercise is a particular focus because there is growing interest in upper extremity exercise for those with chronic health issues or lower body injuries. Upper extremity exercise can also help build a functional or sports conditioning cross-training programs. Upper body conditioning exercises can be combined with lower body conditioning exercises to provide a more effective total body conditioning program. Because upper extremity exercise has historically been neglected in exercise science research, there is a clear need for improved understanding of this exercise modality.

Chapter 2

Review of Literature

Physiological responses to upper body specific exercise have received relatively little research attention compared to lower extremity exercise. Continuous or aerobic exercise seems to be perceived primarily as activity involving lower body movements. It has been much rarer to consider upper body specific activity. Professional research has begun to focus more on effects of upper body training and benefits it may provide.

Hypertension continues to be a major worldwide public health concern. Studies focusing on chronic effects of exercise on blood pressure have predominated the exercise science literature, but in the past 20 years acute effects of exercise on blood pressure have received increased research emphasis (Pescatello, Fargo, Leach, & Scherze, 1991). The following review will emphasize measuring blood pressure, acute blood pressure and rate-pressure product measures during exercise, upper body exercise, and the effects of upper body exercise on rate-pressure product.

Blood Pressure Criteria

A large body of research has demonstrated that chronic exercise reduces baseline blood pressure and the risk of hypertension. In 2003, JNC 7 released new standards on blood pressure ranges and associated risks. The article from JNC 7 provided guidelines as to what is considered normal, prehypertension, hypertension, stage 1 hypertension and stage 2 hypertension for systolic and diastolic values.

	Systolic		**Diastolic**
Normal	<120	and	<80
Prehypertension	120-139	or	80-89
Stage 1 Hypertension	140-159	or	90-99
Stage 2 Hypertension	≥160	or	≥100

In March of 2011, an article was released highlighting disconcerting statistics regarding Americans with hypertension Taylor, Wilt, & Welch (2011). The following key statistics were reported:

1. In 2008, more than 59 million Americans 18 years of age or older had been diagnosed with high blood pressure. This number disregards a large number of Americans who had not even been evaluated;
2. Three out of four people reported to have high blood pressure were morbidly obese, obese, or at least overweight. However, 15 % of individuals within a healthy weight zone were still considered to have high blood pressure;
3. Adult Americans who reported exercising at an elevated level for 30 minutes three days a week or more were at least one –third less likely to have high blood pressure;
4. Consistent distributions of diagnosed hypertension are associated with race. For example: the prevalence of hypertension in Hispanic adults is 18%, 27% for Caucasians, and 32% in blacks;

5. Individuals who utilize public health care tend to exhibit a higher rate of hypertension. Those who did not have insurance had 14% with high blood pressure, private insurance holders had a 19% rate, and those with public health insurance showed a race of 29%;
6. The statistics showed a direct relationship with the age of the population and the number suffering from hypertension with statistics of
    - Age 65 and over - 29%
    - 45-64 years of age - 34%
    - 25-44 - 3 %.

History of Blood Pressure Measurement

Stork and Jilek (2011), states that manual blood pressure measurement using cuff shymomanometry is still the most commonly utilized blood pressure measurement method. Etienne Jules Marey performed the first accurately recorded blood pressure reading in the nineteenth century. The device she developed to use for blood pressure reading was called the sphygmogram. This methodology is popular because the equipment is relatively inexpensive and readily available. The technique also has well established validity and satisfactory reliability. This text does indicate that before using blood pressure devices in a study it is important to test the equipment in the lab and make sure it is valid. Although, there have been many mechanical and technological advances since Marey, the devices and techniques for measuring blood pressure have changed very little.

Blood Pressure and Upper Extremity Exercise

In 2008, Westhoff et al. assigned twenty four subjects with hypertension and a sedentary lifestyle to a 12-week arm-cycling exercise intervention. Arm cycling workloads were performed to achieve a standardized blood lactate criteria of 2.0 ± .05 mmol/l. Previous to this study, it had been assumed that chronic cardiovascular exercise would reduce systolic and diastolic blood pressure a maximum of 3-4 mmHg. After the 12-week upper-body training period, the average blood pressure reduction was 7mmHg in systolic blood pressure and 6mmHg in diastolic. The results of this study show how valuable upper extremity exercise can be in the reduction of both systolic and diastolic blood pressure.

Pescatello et al. (1991) conducted a study investigating the acute effect of exercise on heart rate and blood pressure immediately after exercise. The study was designed after the Subcommittee on Nonpharmacological Therapy of the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure released a summary stating that medications being prescribed to control blood pressure may be more dangerous than the risk factors related to hypertension. This article went on to say the only effective and safe way to control blood pressure was through weight management and sodium and alcohol restriction. The study protocol utilized participants whose blood pressure was monitored constantly throughout a 24 hour time period during their daily activities. During the subject’s normal daily routine, heart rate and blood pressure were recorded every minute for 10 minutes following an exercise routine that was considered normal for the participants regular exercise routine. Both the hypertensive and normotensive exercise groups demonstrated blood pressure reductions following exercise, with the hypertensive group having the greatest decrease. On average the hypertensive individuals had a lower blood pressure for slightly over 12 hours following their exercise session. The study concluded that exercise will provide short and long-term effects on blood pressure.

Upper vs. Lower Extremity Exercise

Upper body continuous exercise was first promoted as an important exercise alternative in the early 1970s. It was initially considered as an exercise mode for astronauts by the National Aeronautics and Space Administration (NASA). Traditional lower extremity exercise apparatus could not be utilized effectively on space missions because of reduced gravity. The 1970's also coincided with a greater societal appreciation of aerobic exercise and a greater reliance on exercise testing for medical applications. Stress tests were becoming a preferred tool for initial assessment of health risk such as coronary artery disease. It quickly became clear however that treadmill and bike testing were not appropriate for all individuals. Upper body exercise tests were eventually developed to take the place of regular stress tests in some situations (Clausen, 1976).

Civino et al. (2009) performed a study using isolated upper body exercise on an arm crank ergometer comparing it to total body exercise on a cross trainer. This study had participants maintain a heart rate within a predetermined range on both exercise modes which was monitored using a Polar WearLink wireless heart rate monitor, while blood pressure was manually recorded. Results showed the blood pressure increased significantly more during isolated upper extremity exercise, compared to combined.

Participants also stated they felt like their body became fatigued very quickly during the arm cycle ergometer exercise.

Eston and Brodie (1986), compared oxygen uptake, minute ventilation, rating of perceived exertion, and heart rate during lower body exercise, upper body exercise, and total body exercise. This study used a Schwinn Air-Dyne ergometer for upper-body, lower-body, and combined exercise. The Schiwnn Air-Dyne ergometer is a stationary cycle with pedals and arm pump handles. This device uses air to provide resistance for both lower and upper extremity movements. The nineteen subjects at the University of Liverpool that participated in the study performed three tests at 49, 75.3, and 98 Watts in random order for each exercise mode.

Results of the study indicated heart rate and rating of perceived exertion were significantly higher, while work efficiency was lower for arm exercise, compared to the lower or the combined modes. Eston and Brodie (1986), concluded the body is working much harder during isolated upper body exercise at any given workload, making it more strenuous on the body. They also emphasized the importance of monitoring participants during this type of activity.

In 2003, Simonson and Wyatt evaluated the effects of body position during exercise on heart rate, blood pressure, rate pressure product, mean arterial pressure and work of the heart during workloads at similar oxygen uptakes and peak work for individuals exercising on the supine cycle ergometer and the upright treadmill.

The study sample consisted of nine males, ages 21-35 years. The research found the supine cycle ergometer elicited significantly greater rate-pressure product than the upright treadmill. The study of supine versus treadmill oxygen uptake produced statistics during equal oxygen consumption that showed:

VOL (L/min)	HR (bpm)	BP (mmHg)	MAP (mmHg)	RPP
Supine				
66.64	151	178/85	132	271.9
±2.15	± 6	±4/3	±2	±15.2
Treadmill				
59.91	151	149/73	111	226.0
±2.41	±3	±2/2	±1	±6.4

From this data it was concluded that supine exercise produced a higher increase in blood pressure compared to treadmill. They suggested that the supine body position caused an increased venous return which in turn led to a higher diastolic volume. Greater ejection volumes tend to increase systolic blood pressure. The higher blood pressure in the supine cycle exercise results from reduced gravitational influence on venous return and the resulting blood volume changes.

Exercise Rate-Pressure Product

Exercise rate-pressure product is an indicator of how much oxygen the heart muscle requires. Since rate-pressure product is made of up the heart rate and systolic blood pressure, if either factor increases the heart is forced to work harder. As the heart works harder, it requires more oxygen. Thus the rate-pressure product is the most important variable for understanding cardiovascular demand during activity (American College of Sports [ACSM], 2010a).

Gender is another factor affecting heart rate; females have a more elevated heart rate at the same relative workload of exercise than males do. The elevation for females is used to provide compensation for their smaller stroke volume (Roberts, 2002).

Ski Erg and Cycling

Both the Ski Erg and stationary cycling have become increasingly popular in recent years. Cycling has been around for many years, even long before the increased public health emphasis on the need for physical activity. Initially, cycling was used as a method of transportation, but it has progressed into a popular exercise modality. Cycling provides various health benefits such as controlling blood pressure and decreasing resting heart rate. Along with these benefits, it is known to provide an aerobic workout and a great lower body strengthening workout (Cummins & Gladden, 1986). According to the Ski Erg manufacturer, Concept 2, it provides numerous similar benefits. The Ski Erg is thought to provide a high-intensity low-impact aerobic workout. It provides a high caloric expenditure while increasing strength and cardiovascular capacity. (Ski Erg Concept 2, 2010).

Hemodynamic

Hemodynamic response to exercise varies widely based on individual differences in genetics, lifestyle and training. The rate of oxygen consumption is a key measurable value for understanding changes in circulatory efficiency during exercise. An increase in exercise intensity causes an increase in respiratory rate, causing blood to be pumped more quickly through the body. The increased blood flow is due to an increase in the cardiac output (ACSM, 2010b).

Miles (1984) conducted an experiment comparing upper body and lower body exercise using an arm-crank as the upper body exercise versus cycling for the lower body exercise. They reported a direct linear relationship between metabolic rate, muscle cell metabolites produced, and resulting blood flow. The authors speculated the relationship occurred because increased cardiac output is directed specifically to the active skeletal musculature. Vasodilatation occurs in the active muscles not only because of local hypoxia, but because of accumulating metabolites produced by the contracting muscles.

In this experiment, Miles et al found that upper and lower body exercise produce significantly different blood pressure and heart rate values at similar cardiac outputs. Arm-crank-exercise resulted in higher peripheral resistance, which led to an increase in blood pressure. The greater peripheral resistance could possibly be due to the greater hemoconcentration elicited by arm-crank exercise than that elicited by cycling. He calculated the difference to be four to six percent.

The research also concluded that upper body exercise requires a greater isometric component than lower body exercise. Greater torso stabilization is required for arm crank exercise than for cycling. This increased isometric component may also influence blood pressure. He concluded isometric exercise leads to a much higher blood pressure than that observed during dynamic exercise alone. The combination of an isometric exercise component in a primarily dynamic exercise is more common during upper body exercise because the arms must be held in position and because a higher relative workload is more likely to require a greater isometric contribution. (Farrell, Joyner & Caiozzo, 2012)

Summary

A large body of evidence demonstrates that chronic exercise lowers both blood pressure and heart rate at any submaximal workload. These changes result in a reduced rate-pressure product reflecting less myocardial oxygen demand. Significant research also exists demonstrating the basic linear increase in cardiovascular measures during acute exercise of increasing intensity. Most of this research has utilized primarily lower body exercise. The studies utilizing upper extremity exercise found greater heart rate and blood pressure compared to lower extremity exercise at similar workloads (Civino et. al., (2009). All the upper extremity studies identified for this review, except one, utilized upper body cycle ergometry. The remaining study used a standard push-pull movement. Few of the upper extremity studies measured rate-pressure product. Since rate-pressure product provides the best indication of cardiac work, and because it incorporates heart rate and blood pressure, it is the most important hemodynamic outcome variable (Kent, 1997). It is also important to consider arm movements other than upper body cycling because hemodynamic demand could vary dependent on muscle mass involved or on the position of the arms relative to the heart (ACSM's Advanced Exercise Physiology, 2012).

Chapter 3

Methodology

Introduction

The purpose of this study was to compare rate-pressure product between primarily lower extremity exercise utilizing upright cycling and primarily upper extremity exercise on a SkiErg arm swing ergometer. This study utilized both preliminary and operational procedures. The preliminary procedures consist of selecting the subjects, research design, and instruments used. The operational design consists of the instrument administration, data collection, and data analysis.

Preliminary Procedures

Subjects. The subjects in this study included 11 apparently healthy volunteers ranging from 20 to 30 years of age, and nine apparently healthy individuals between 50 and 60 years of age. The 20 to 30 year old sample was referred to as Group A. Group A consisted of 11 volunteer students from the Health and Human Performance department at Fort Hays State University in Hays, Kansas. The 50 to 60 year old population was referred to as Group B. Group B consisted of 9 current faculty or staff at Fort Hays State University in Hays, Kansas who regularly participate in moderate intensity formal exercise through the FHSU Wellness Center.

Research Design. This study evaluated whether rate-pressure product response to identical increments in absolute work load differed between upper and lower extremity exercise. The study utilized one dependent variable (rate-pressure product and four independent variables (exercise mode, exercise intensity, age and gender). It was conducted at the quasi- experimental level using a two test repeated measures design. The first test measured rate-pressure product during upper extremity SkiErg exercise at 25, 35, 45, 55, and 65 watts. The second test measured rate-pressure product response to identical workloads during lower extremity cycle ergometry.

Instrumentation. The setting for data collection was the Exercise Physiology Laboratory, Cunningham Hall 102 on the campus of Fort Hays State University. The instruments used in this study were a WattBike Pro Stationary Cycle Ergometer, a Concept2 Ski Erg, an Accusplit 601X, and a Sun Medical Systems Tango+ motion tolerant blood pressure measuring system. The WattBike ergometer was used as the lower body exercise device because it isolates primarily lower body movement. The WattBike ergometer was designed to have <2% error for workload, and <1% variance on a retest. This bike was previously calibrated by engineers, and includes in the warranty that trying to recalibrate the equipment without proper training invalidates the bike, as warned on the company's website, http://www.wattbike.com/uk/wattbike. The SkiErg was used as the upper body exercise device because it can be implemented to utilize upper body movements, with minimal involvement of the lower body. The stop watch was used to measure time increments at which the workload of the machine must be increased.

The Sun Medical Systems Tango+ is called a motion tolerant blood pressure measurement device. It was designed so to accurately and objectively measure heart rate, blood pressure, and rate-pressure product during exercise testing. The Sun Medical blood pressure measuring device was designed by engineers to meet American Heart

Association (AHA) and the Association for the Advancement of Medical Instrumentation (AAMI-SP10) guidelines to provide accuracy during exercise testing.

Operational Procedures

Testing procedures. Each of the participants signed an informed consent form (Appendix A) prior to participation. The researcher met with each subject individually before the test to answer any questions and reviewed the full procedure to ensure that subject safety was a priority.

All testing was administered during a single 90 minute session. Tests were conducted by the primary author of this paper under the supervision of a university faculty member with a doctorate in exercise science and certification as an American College of Sports Medicine Registered Clinical Exercise Physiologist (RCEP). A primary competency RCEP certification is administration and interpretation of diagnostic incremental exercise tests ACSM (2010b). This qualification was beneficial because exercise mode and intensity were independent variables in this study. Insuring consistent implementation of exercise test protocols and measurement procedures should increase validity and reliability of the data.

After subjects affirmed understanding the procedures and having no reservations about participation, the automated measurement sensors were positioned. The Tango+ blood pressure apparatus requires attachment of 3 standard ECG electrodes. Electrodes V2 and RL were applied in standard lead positions. The V6 electrode was placed in a modified position 2 ½ centimeters inferior to standard V6 positioning. This placement was used to avoid interference with jog bra type apparel typically worn by female subjects. This was acceptable placing in this study because the only purpose for the ECG signal was an accurate heart rate reading.

Each subject first performed the lower extremity WattBike protocol, recovered for 15 minutes then performed the upper extremity SkiErg protocol. Exercise order was not counterbalanced. Some individuals had used the SkiErg in the Fort Hays State Exercise Physiology Laboratory for supervised fitness training prior to implementation of this project. It was clear from oral feedback of these individuals that the lower extremity testing would create considerably less physiological stress than upper extremity testing. The procedures, absolute workloads, and time intervals were identical for each Graded Exercise Test (GXT) whether performed on the Bike or SkiErg. The subject exercised for 2 minutes at a 25 watt workload. This was followed by four additional exercise stages at 35, 45, 55, and 65 watts. Each stage was interspersed with 1 minute of unloaded pedaling (bike) or arm-swing (skier). The 1 minute unloaded segment between stages was necessary to complete the heart rate and rate-pressure product measurements. Even though the Tango+ is designed to be motion tolerant, it is not capable of accurate measurement during high intensity arm swing exercise. Accurate measurements would have been possible during actual work segments on the bike, but the 1 minute measurement segment for both tests was utilized to keep the protocols equivalent.

Data Collection. Heart rate and rate-pressure product were recorded from the Tango+ digital monitor after each measurement period. All data collected was recorded on a hard copy data sheet (Appendix B). Only the researcher and faculty supervisor had access to the data.

Data Analysis. Mean and standard deviation of rate-pressure product for each workload was calculated (Appendix C). A Repeated Measures Analysis of Variance (ANOVA) was performed using the Statistical Package for the Social Sciences 20.0 (SPSS). The data was analyzed at a 0.05 level of significance. When a significant finding was identified by ANOVA, the Tukey Least Significant Difference (LSD) Post Hoc analysis was conducted. The Tukey LSD Post Hoc test was used in this study because it is appropriate for ANOVA with different sample sizes. It is also accurate for problems where the quantities being compared are correlated (Math Works, 2012).

Chapter 4

Results

The purpose of this study was to compare rate-pressure product (RPP) between primarily lower extremity exercise utilizing upright cycling and primarily upper extremity exercise on a SkiErg arm swing ergometer. The procedures, absolute workloads, and time intervals were identical for each Graded Exercise Test (GXT) whether performed on the Bike or SkiErg. The subject exercised for 2 minutes at a 25 watt workload. This was followed by four additional exercise stages at 35, 45, 55, and 65 watts. Each stage was interspersed with 1 minute of unloaded pedaling (bike) or arm-swing (skier). The 1 minute unloaded segment between stages was necessary to complete the heart rate and rate-pressure product measurements.

Data collection took place from March of 2012 to May 2012 at the Fort Hays State University in the Exercise Physiology Lab. Participants were grouped into the following categories; five 20-30 year old females (mean weight = 59 ± 5.98 kg.), six 20-30 year old males (mean weight = 87.2 ± 12.23 kg.), four 50- 60 year old females (mean weight = 63.2 ± 1.87 kg.), and five 50-60- year old males (mean weight = 91.2 ± 15.3 kg.). The 20-30 year old sample was referred to in the study as group A, while the 50-60 year old sample was group B.

During the study some subjects did not complete the entire upper extremity protocol because of shoulder and arm muscle fatigue. As long as participants completed one full minute at their last workload their data was included in the analysis for that workload. One female subject from group A could not complete even one minute at the 45 watt workload so her data was not included in the 45 or 55 watt means. The highest value achieved by each subject was included in the final workload to represent the peak achieved in this exercise protocol. All other participants were included in each workload although many were struggling, reducing pace intermittently, and/or incorporating more lower body movements than specified by the protocol.

The data was analyzed using an Analysis of Variance with Repeated Measures (ANOVA) on the SPSS statistical packages. When a significant finding was identified by ANOVA, the Tukey Least Significant Difference (LSD) Post Hoc Analysis was conducted.

Tables and Figures supporting data analyzed for each hypothesis are presented throughout Chapter 4. Tables with descriptive statistics and critical values are in the appendices.

Analysis of Variance Results

Rate-pressure product. A repeated measures ANOVA was conducted to determine the effects of exercise mode, gender and group on rate-pressure product at identical exercise workloads. Results associated with each independent variable are presented in Table 1. Significant differences in rate-pressure product were found for exercise mode, but not for gender or group. The Tukey LSD analysis of exercise intensity is presented in Table 2.

Table 1

Repeated Measures ANOVA Results for Independent Variables

	SS	*df*	*MS*	*F*	*Significance*
Mode	2857547.27	1	2857547.27	2563.13*	.0001*
Gender	4284.15	1	4284.15	3.98	.063
Group	3139.27	1	3139.27	. 2.92	.107

*p<0.05

Table 2

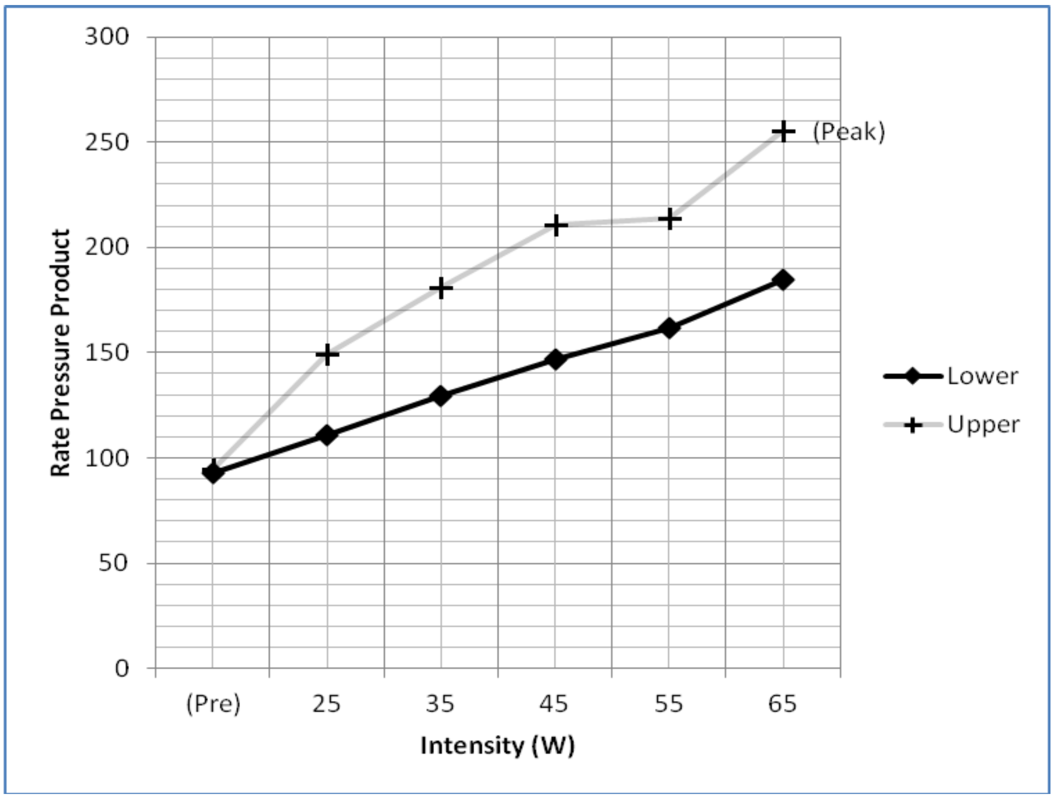
Tukey LSD Post Hoc Analysis of Work Stages

Upper extremity – Lower extremity	MD	SE	Sig
Pre	1.2	0.9	.876
25 watts	38.2	12.3	.001*
35 watts	51.7	12.9	.001*
45 watts	54.3	13.1	.001*
55 watts	44.5	12.6	.012*
65 watts	67.6	15.3	.001*

*p<0.05

Exercise Mode. Null Hypothesis 1 was: There will be no significant difference in rate-pressure product response to incremental exercise between primarily lower extremity cycling and primarily upper extremity SkiErg exercise at the same absolute workload. Since exercise mode was significant, a Tukey LSD test was conducted to identify where the significance was located. Rate-pressure product during each workload of upper extremity was significantly different when compared to the corresponding lower extremity workload. Changes in mean rate-pressure product associated with each workload increase are illustrated in Figure 1.

Figure 1. Mean Rate-Pressure Product for Each Workload during Upper and Lower Extremity Exercise

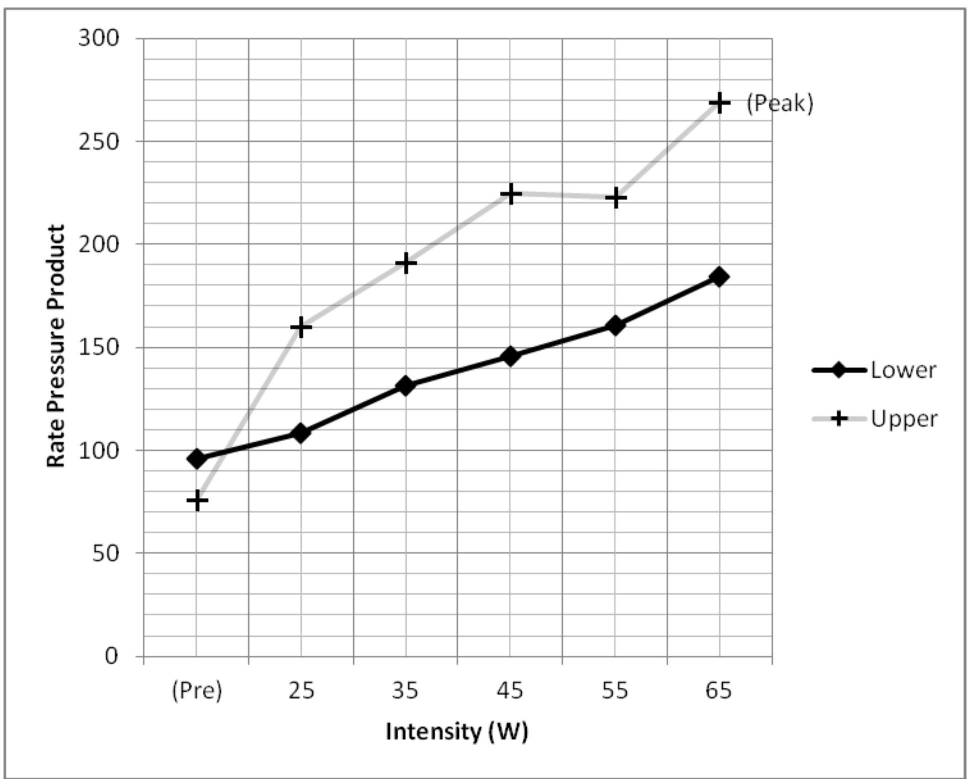


(Peak) = Maximum rate-pressure reached, even if not at 65 Watt intensity

Null Hypothesis 1 was rejected. Rate-pressure product trended up with increasing exercise intensity during both lower and upper extremity exercise. RPP values were significantly greater ($p < 0.05$) for every workload following with the onset of exercise.

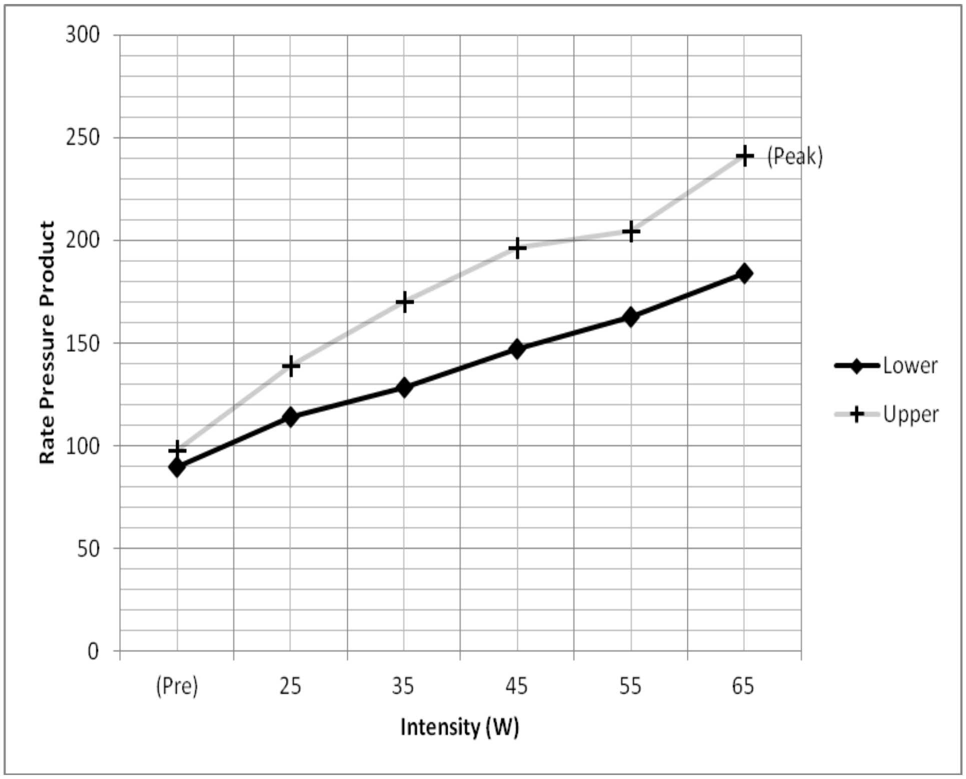
Group. Null hypothesis 2 was: There will be no significant difference in rate-pressure product response to incremental cycling versus SkiErg exercise between Group A and Group B. The Repeated Measure ANOVA did not identify a significant difference between groups, although it approached significance. The pattern of rate-pressure response for Group A is illustrated in Figure 2 and the response for Group 2 in Figure 3.

Figure 2. Mean Rate-Pressure Product Response by Exercise Mode for Group A



(Peak) = Maximum rate-pressure product reached, even if not at 65 Watt intensity

Figure 3. Mean Rate-Pressure Product Response by Exercise Mode for Group B

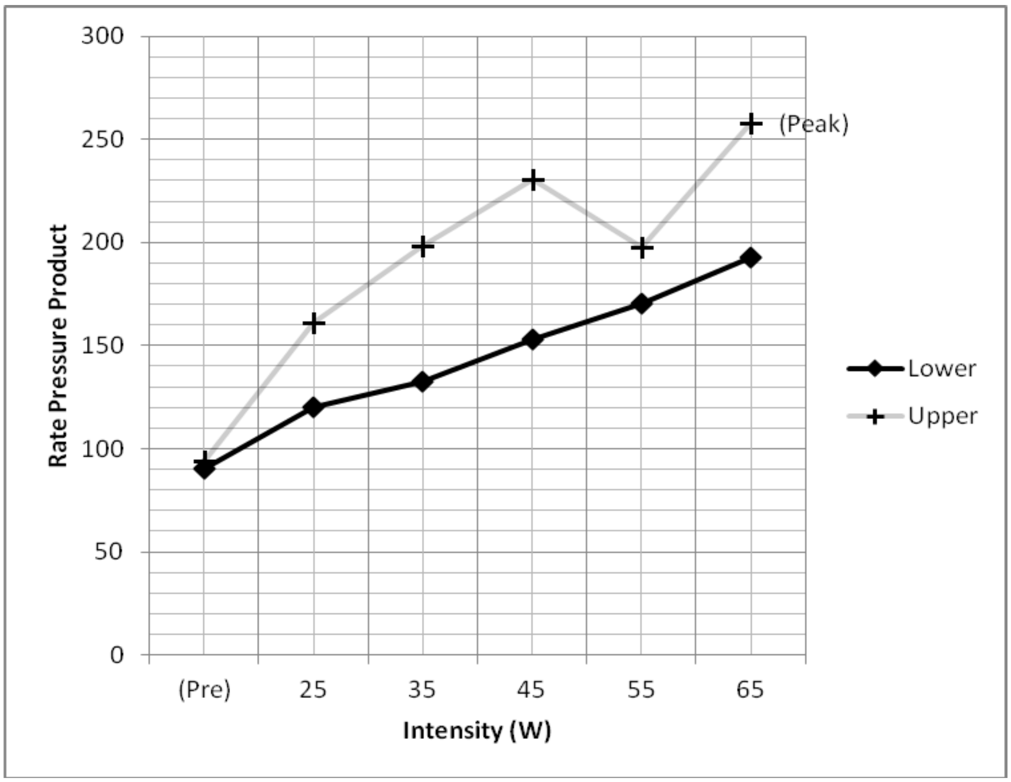


(Peak) = Maximum rate-pressure reached, even if not at 65 Watt intensity

Null Hypothesis 2 was retained. Although the difference between mean values by exercise is generally larger for Group A, this difference did not meet criteria for statistical significance.

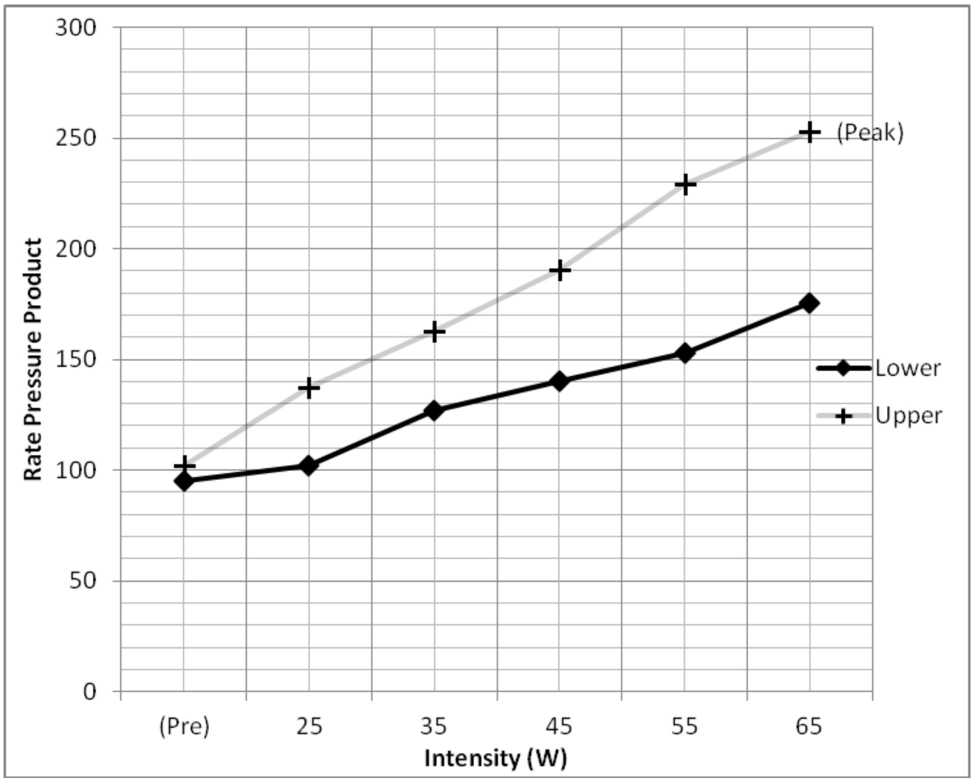
Gender. Null Hypothesis 3 was: There will be no significant difference in rate-pressure product response to incremental exercise between males and females. The Repeated Measure ANOVA did not identify a significant difference between genders. The pattern of rate-pressure response for females is illustrated in Figure 4 and the response for males in Figure 5.

Figure 4. Mean Rate-Pressure Product Response by Exercise Mode for Females



(Peak) = Maximum rate-pressure reached, even if not at 65 Watt intensity

Figure 5. Mean Rate-Pressure Product Response by Exercise Mode for Males



(Peak) = Maximum rate-pressure reached, even if not at 65 Watt intensity

Null Hypothesis 3 was retained. The difference between mean values by group did not meet criteria for statistical significance.

Chapter 5

Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to compare rate-pressure product between primarily lower extremity exercise utilizing upright cycling and primarily upper extremity exercise on a SkiErg arm swing ergometer. The sample was also divided by gender and by group for further evaluation. Subjects ranging from 20 to 30 years of age were referred to as Group A. while 50 to 60 year old participants were referred to as Group B. The results of a Repeated Measures Analysis of Variance statistical analysis found a statistically significant difference between exercise modes but not between groups or genders.

Discussion

This is the first known study that utilized the overhead double arm swing skiing motion as opposed to upper body cycle ergometry or push-pull arm lever rowing as the primary arm movement. Despite this different arm motion, the basic hemodynamic response to incremental exercise was similar to previous studies. Civino et al., (2009), Eston and Brodie, (1986), and Roberts (2002) all found a greater hemodynamic and metabolic response to upper extremity exercise compared to lower extremity or total body exercise. In this study the only statistically significant finding was a greater rate-pressure product at every workload during upper extremity exercise. This finding provides further evidence that greater hemodynamic demand during upper extremity exercise is a generalized response which occurs in response to isolated upper extremity exercise independent of the exact arm movement or specific muscle involvement.

Within the limits of the sample the findings of this study also indicate greater hemodynamic response to upper extremity exercise is independent of gender or age group. Roberts (2002) stated that females have an increase heart rate response during exercise because of their smaller stroke volume. In this study any possible greater heart rate response did not result in a significantly greater rate-pressure product. This study was not designed to analyze heart rate and blood pressure in isolation, but it could be assumed that if an elevated heart rate response did occur in females it was at least partially counterbalanced by a reduced blood pressure response.

Another gender related observation during this study was that females had greater difficulty achieving and attaining the 2 highest upper extremity workloads. Additionally, Group A females actually had greater difficulty maintaining high upper extremity workloads than Group B females. This counterintuitive finding might indicate a general lack of upper extremity training and activities of daily living in 20-30 year old females. It may also reflect some association of upper extremity capacity with total body mass as the Group A females were lighter than Group B females, as shown in sample descriptions in Chapter 4. The relative leveling in the rate of increase from 45 to 55 watts during upper extremity exercise may be due to some participants stopping or changing technique due to local muscle fatigue. Again, local muscle fatigue was not controlled or measured as an independent variable in this study. Any discussion of contributing factors is purely speculative. It may however, indicate additional interventions for future studies.

Conclusions

Based on the results and within the scope of this study, the following conclusions were drawn.

1. The double arm swing exercise utilized in this study consistently elicits a significantly higher rate-pressure product when compared to lower extremity exercise.
2. Even though fewer females were able to complete the upper extremity exercise protocol, the effect of incremental upper extremity exercise on rate-pressure product was not significantly different than for males.
3. Within the limits of the age groups utilized in this study, age did not affect the rate-pressure product response to upper extremity exercise.

Recommendations for Further Study

1. Future studies should compare rate-pressure product response to the same relative workload. Relative workload could be considered separately from absolute workload, but it may be provide more information to directly compare relative and absolute workload.
2. Future studies should directly compare the SkiErg overhead double arm swing movement to upper extremity cycle ergometry.
3. Future studies should utilize more participants of each gender.
4. Future studies should utilize more participants from a greater range of training backgrounds such as untrained individual or those who regularly participate only in low intensity exercise.

5. Future studies should utilize different body positions such as seated during SkiErg exercise.
6. Future studies should consider using a counter balanced design to control for potential bias due to testing order.

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APPENDIXES

Appendix A

Consent to Participate in Research

CONSENT TO PARTICIPATE IN RESEARCH

Department of Health and Human Performance, Fort Hays State University

Study title: Effects of Upper vs. Lower Extremity Exercise and Age on Heart Rate, Blood Pressure, and Rate Pressure Product.

Name of Researcher Zanae Baird
Contact Information 785-443-5939 of zebaird@scatcat.fhsu.edu
Name of Faculty Supervisor & Contact Information, if student research Dr. Greg Kandt, 785-628-4371 or gkandt@fhsu.edu

You are being asked to participate in a research study. It is your choice whether or not to participate.

Your decision whether or not to participate will have no effect on the benefits or services the quality of your care or academic standing to which you are otherwise entitled. Please ask questions if there is anything you do not understand.

What is the purpose of the study?

The purpose of this study will be to compare blood pressure, heart rate, and rate-pressure product between lower extremity cycling exercise and upper extremity ski ergometer exercise and whether age may have an effect on the magnitude of these physiological responses. Previous studies indicate that blood pressure, heart rate, and rate-pressure product may be significantly during upper extremity exercise compared to primarily lower extremity exercise such as cycling.

What does this study involve?

You will be asked to report individually to Room 102, Cunningham Hall at an agreed upon time on 2 separate days. The time required for each visit will be approximate 40 minutes. The activities for each session will be identical except the exercise modality will be lower extremity (cycling) exercise on one visit and upper-extremity (skier arm swing) exercise on another visit. The order in which you complete these 2 exercise modalities will be random. You subject will be fitted with a blood pressure cuff and device for automated blood pressure measurement. Before the test the test you will warm up with a 25 WATT workload on the machine that you will be using that day. Both the lower extremity and upper extremity exercise will use the same workloads and progression. This test will consist of five stages of 2 minutes each. The first stage will be at a workload of 50 WATTS. Each stage will last two minutes and after this period the workload will increase 15 WATTS. Heart rate and blood pressure will be measured during the last 30 seconds of each stage. If you feel unusual or unaccustomed fatigue at any point during this activity you should inform the researchers and stop exercising.

If you decide to participate in this research study, you will be asked to sign this consent form after you have had all your questions answered and understand what will happen to you. The total length of time of your participation in this study is approximately 90 minutes. Approximately 24 participants will be in this study.

Are there any benefits from participating in this study?
You will be provided with his or her own results from each test including their heart rate, blood pressure, and rate pressure product during each stage of exercise. The investigator will answer any questions you may have pertaining to the study or results. You will also have access to the full study results if you choose.

Will you be paid or receive anything to participate in this study?
You will not receive any compensation for participating in this research.

What about the costs of this study?
There are no costs for the participating in this study other than the time you will spend.

What are the risks involved with being enrolled in this study?

It is unlikely that participation in this project will result in harm to you, although there is a small potential risk associated with any physical activity participation. Risks of participating in this research study include falling, muscle strains, ligament sprains, fractures, cardiopulmonary problems or even death. If you participate in the Wellness Center exercise program the intensity of activity associated with these tests is no greater than the exercise you participate in as part of that program. If you are a student in the Health and Human Performance Department, the activity intensity will be no greater than that routinely experienced in departmental activity classes. Risks will be minimized by constant monitoring of your heart rate and blood pressure during the exercise.

In the event of physical and/or mental injury resulting from participation in this research project, Fort Hays State University does not provide any medical, hospitalization or other insurance for participants in this research study, nor will Fort Hays State University provide any medical treatment or compensation for any injury sustained as a result of participation in this research study, except as required by law.

How will your privacy be protected?

The information collected as data for this study includes: height, weight, age, and gender. It also includes heart rate, blood pressure and rate pressure product during each stage of the walking test.

The data will be stored by the principal investigator in a secure lockbox until the study is completed. It will then be given to the faculty advisor by the principal investigator to be stored for 10 years so the data is available should any questions about the research statistics arise. If not accessed in 10 years the data will be destroyed with a cross cutter paper shredder. The data will be stored via paper forms, which will be locked up in the principal investigator or faculty advisor's file cabinet. The only people who will have access to the data will be the investigator and faculty advisor.

Efforts will be made to protect the identities of the participants and the confidentiality of the research data used in this study, such as: Potentially identifiable information about you will consist of height, weight and age. All permanent records are being identified using a randomly assigned participant identification number, not your name. This identifier is assigned by the two investigators. The faculty research advisor will keep the demographic, informed consent forms, and data collection forms locked in a file cabinet inside of his office that only he has the key to. Access to all data will be limited to the research.

The information collected for this study will be used only for the purposes of conducting this study. What we find from this study may be presented at meetings or published in papers but your name will not ever be used in these presentations or papers.

<u>Other important items you should know:</u>

• Withdrawal from the study: You may choose to stop your participation in this study at any time. Your decision to stop your participation will have no effect on the quality of care, academic standing, eligibility to participate in any programs, etc.

• Funding: K-INBRE (Kansas Idea Network of Biomedical Research Excellence) provides funding to Fort Hays State University for equipment used in this research.

<u>Compensation for Injury</u>

"I have been informed and I understand that Fort Hays State University is not required to provide medical treatment or other forms of reimbursement to persons injured as a result of or in connection with participation in research activities conducted by Fort Hays State University or its faculty, but that Fort Hays State University may provide such treatment or reimbursement at its discretion. If I believe that I have been injured as a result of participating in the research covered by this consent form, I should contact the Office of Scholarship and Sponsored Projects, Fort Hays State University at 785-628-4349."

<u>Whom should you call with questions about this study ?</u>

Questions about this study or concerns about a research related injury may be directed to the researcher in charge of this study: Zanae Baird at (785) 443-5939 or the Research Faculty Advisor: Dr. Greg Kandt at (785) 628-4371.

If you have questions, concerns, or suggestions about human research at FHSU, you may call the Office of Scholarship and Sponsored Projects at FHSU (785) 628-4349 during normal business hours.

<u>CONSENT</u>

I have read the above information about Effects of Upper vs. Lower Extremity Exercise and Age on Heart Rate, Blood Pressure, and Rate Pressure Product and have been given an opportunity to ask questions. **I**

am healthy enough to participate in the walking tests described above and I have no health conditions that may be impacted by participating in the study. By signing this I agree to participate in this study and I have been given a copy of this signed consent document for my own records. I understand that I can change my mind and withdraw my consent at any time. By signing this consent form I understand that I am not giving up any legal rights. I am 18 years or older.

____

Participant's Signature and Date

Appendix B

Data Sheet

Data Sheet

Date

Random ID Age Gender Height cm. Weight Kg

Temp Humidity

Stage	Mode	Watts	HR	Sys BP/Dia BP	RPP
Pre-Sit					
Pre-Stand					
1	Lower	25			
1	Upper	25			
2	Lower	35			
2	Upper	35			
3	Lower	45			
3	Upper	45			
4	Lower	55			
4	Upper	55			
5	Lower	65			
5	Upper	65			

Appendix C

Mean and Standard Deviation Values

Mean and Standard Deviation Values

Descriptive Statistics Lower Body Exercise Rate-Pressure Product

	Gender	Agecategory	Mean	Std. Deviation
prerppb	male	A	98.1	8.8
		B	92.3	15.7
		Total	95.2	12.4
	female	A	94.2	8.7
		B	86.6	13.3
		Total	90.4	11.3
	Total	A	96.1	8.5
		B	89.4	14.0
		Total	92.8	11.8
rpp 25b	male	A	97.0	54.5
		B	106.9	18.1
		Total	102.0	38.6
	female	A	119.3	14.7
		B	121.2	22.0
		Total	120.3	17.7
	Total	A	108.2	39.4
		B	114.0	20.4
		Total	111.1	30.7
rpp 35b	male	A	129.4	12.1
		B	124.9	15.4
		Total	127.1	13.3
	female	A	133.0	23.6
		B	131.6	21.0
		Total	132.3	21.1
	Total	A	131.2	17.8
		B	128.3	17.7
		Total	129.7	17.3
rpp 45b	male	A	141.5	13.9
		B	138.8	12.3
		Total	140.2	12.5
	female	A	150.2	24.1
		B	155.8	37.0
		Total	153.0	29.6
	Total	A	145.9	19.1
		B	147.3	27.5

		Total	146.6	23.1
rpp 55b	male	A	154.6	14.9
		B	151.3	8.8
		Total	153.0	11.7
	female	A	166.5	46.9
		B	173.6	52.0
		Total	170.1	36.7
	Total	A	160.6	16.3
		B	162.5	37.1
		Total	161.5	27.9
rpp 65b	male	A	179.8	16.1
		B	171.2	14.9
		Total	175.5	15.3
	female	A	188.4	22.7
		B	197.2	61.0
		Total	192.8	43.6
	Total	A	184.1	19.1
		B	184.2	44.0
		Total	184.2	33.0

Descriptive Statistics Upper Body Exercise Rate Pressure Product

	Gender	Agecategory	Mean	Std. Deviation
prerpps	male	A	99.0	20.9
		B	104.9	26.7
		Total	101.9	22.8
	female	A	53.2	49.9
		B	98.6	32.2
		Total	102.9	46.1
	Total	A	76.1	43.4
		B	106.7	42.9
		Total	111.4	49.0
rpp 25s	male	A	142.3	18.0
		B	132.9	26.0
		Total	137.6	21.7
	female	A	177.5	36.2
		B	144.9	30.3
		Total	161.2	35.9
	Total	A	159.9	32.8
		B	138.9	27.4

		Total	149.4	31.3
rpp 35s	male	A	169.6	31.3
		B	156.0	27.4
		Total	162.8	28.6
	female	A	213.1	41.2
		B	184.0	21.3
		Total	198.5	34.5
	Total	A	191.3	41.4
		B	170.0	27.5
		Total	180.7	35.9
rpp 45s	male	A	202.1	33.2
		B	179.3	31.5
		Total	190.7	32.8
	female	A	247.5	53.4
		B	214.0	20.8
		Total	230.8	42.1
	Total	A	224.8	48.3
		B	196.6	31.1
		Total	210.7	42.1
rpp 55s	male	A	249.3	30.2
		B	209.7	30.1
		Total	229.5	35.2
	female	A	196.5	30.6
		B	199.3	34.8
		Total	197.9	36.3
	Total	A	222.9	81.3
		B	204.5	79.3
		Total	213.7	78.7
rpp 65s	male	A	276.5	25.4
		B	229.8	24.9
		Total	253.1	34.2
	female	A	261.8	38.5
		B	253.7	54.0
		Total	257.8	44.4
	Total	A	269.2	31.7
		B	241.7	41.6
		Total	255.5	38.6