PRE-EXERCISE STRETCHING ADAPTATIONS ON A CARDIAC REHAB POPULATION

A Thesis

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PRE-EXERCISE STRETCHING ADAPTATIONS ON A CARDIAC REHAB POPULATION

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I certify that this student has met the requirements for format contained in the University format manual, and that this thesis is suitable for shelving in the Library and credit is to be awarded for the thesis.

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Department of Kinesiology
Abstract of PRE-EXERCISE STRETCHING ADAPTATIONS ON A CARDIAC REHAB POPULATION by Emily Anne O’Shaughnessy

Introduction

Cardiac rehabilitation programs have been implemented as a result of patients benefiting from exercise post-surgery of a cardiac event. An important goal for cardiac rehab programs to strive to achieve is increasing the flexibility of the patients. Static stretching prior to exercise has been utilized in warm-ups throughout cardiac rehabilitation ‘rehab’ clinics. However, no research has observed the influence of static stretching on a cardiac rehab population. Recently, research has concluded that pre-exercise stretching is equivocal based upon differentiating results on range of motion and endurance within healthy sedentary or untrained populations (Kokkonen, 2007; Fowles, 2000). It is unknown if pre-exercise stretching influences the patients’ endurance and flexibility.
Purpose

The purpose of this study was to analyze the influence of pre-exercise static stretching upon the functionality and cardiovascular endurance of the cardiac rehab population.

Methods

Twelve subjects (females = 3) were classified as cardiac rehabilitation patients who participated in low-intensity exercise 3-d-wk in the maintenance phase at the cardiac rehabilitation program. The cross-over, within-subjects design had the subjects complete a four-week study, weeks one and three are 3-d-wk of no stretching, and weeks two and four are 3-d-wk of placebo or experimental stretching while attending the cardiac rehab program. Week one, no pre-exercise stretching was performed; only the collection of baseline measurements (baseline) of RPE, peak heart rate (HR) on each exercise modality, and HR one-minute post-exercise during full exercise sessions. The six-minute walking test (meters) was completed by all subjects following week one, week two, and week four. To collect HR measurements, the subjects wore Polar® HR monitors throughout the study. Week two, the subjects were divided into two groups, experimental performed ten 30-second stretch-holds, repeated once and a placebo performing ‘ineffective’ stretching. Week three, was a wash-out week, no stretching performed. At the end of week three, the subjects had cross-over from experimental to placebo and vice-versa. Week four, final dependent variables that were collected were peak HRs, RPE, and
HR one-minute post-exercise. Statistical analyses of one-way ANOVAs, followed by tukey post-hoc test were used to determine the influence of pre-exercise stretching on the subjects’ peak HR, RPE, HR one-minute post-exercise and six-minute walking tests.

Results

Experimental versus the baseline had a significant increase within the six-minute walking tests ($405.66 \pm 19.22$ m vs $461.54 \pm 26.87$ m $p = 0.005$). There was no difference between placebo and baseline and between experimental and placebo treatments within the (3) six-minute walking tests. There was no significant difference between all three treatments ($p = 0.3$) over the three days a week of treatments ($p = 0.2$), and no significant difference in peak heart rates between the days and treatments ($p = 0.7$) for peak HRs. There was no significant difference between experimental, placebo, or baseline ($p = 0.3$), no significant difference between the three days a week of treatments ($p = 0.5$), and no significant difference between the days and treatments ($p = 0.9$) for RPE. The experimental treatment had significantly higher HR one-minute post-exercise versus the baseline on Monday ($88.3 \pm 4.1$ bpm vs $80.0 \pm 2.8$ bpm $p = 0.0001$) and Wednesday ($86.6 \pm 4.2$ bpm vs $79.2 \pm 2.9$ bpm $p = 0.0001$) and no significant difference on Friday ($p = 0.48$). The experimental treatment had a significantly higher HR one-minute post-exercise versus the placebo treatment on Monday ($88.3 \pm 4.1$ bpm vs $83.4 \pm 2.2$ bpm $p = 0.004$) and no significant difference on Wednesday ($p = 0.07$) or Friday ($p = 0.88$). There was no significant difference between the experimental, placebo, or baseline in HR one-minute post-exercise on Friday.
Conclusion

Pre-exercise static stretching improved the distance (meters) in six-minute walking tests over duration of one week by improving functionality. Pre-exercise static stretching also improved HR one-minute post-exercise over duration of one week. Pre-exercise static stretching had no influence upon peak HRs and rate of RPE.

_____________________________, Committee Chair
Daryl Parker, PhD

___________________________
Date
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My passion for cardiac rehabilitation is what inspired me to conduct this study. I have never had the opportunity prior to grad school to pursue a question that has yet to be answered within the community of scholars. I am excited that I have helped contribute my study to a niche of research that had yet to be filled. I would not have been able to complete this study without the contribution of important colleagues, friends and family.

I would like to first say thank you to Dr. C. Tissa Kappagoda and Linda Paumer, M.A. These two individuals helped spark and direct my interest in conducting the stretching study at UC Davis. Linda had initial helpful insight on how to compile my study and helped give me confidence that the study can be conducted. Dr. Kappagoda has not only helped guide me from the beginning of the study, through data collection, and with the completion of the study, he has also been a mentor and an inspirational role model. Dr. Kappagoda has a passion for research that I will always truly admire.

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgements</td>
<td>ix</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xiii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xiv</td>
</tr>
<tr>
<td>Chapter</td>
<td></td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>Statement of Purpose</td>
<td>3</td>
</tr>
<tr>
<td>Significance of Thesis</td>
<td>4</td>
</tr>
<tr>
<td>Definition of Terms</td>
<td>4</td>
</tr>
<tr>
<td>Delimitations</td>
<td>7</td>
</tr>
<tr>
<td>Limitations</td>
<td>8</td>
</tr>
<tr>
<td>Assumptions</td>
<td>8</td>
</tr>
<tr>
<td>Hypotheses</td>
<td>9</td>
</tr>
<tr>
<td>2. REVIEW OF LITERATURE</td>
<td></td>
</tr>
<tr>
<td>Flexibility and Range of Motion (ROM) in Cardiac Rehab Population</td>
<td>13</td>
</tr>
<tr>
<td>Secondary Outcomes from Stretching on a Cardiac Rehab Population</td>
<td>14</td>
</tr>
<tr>
<td>The Effects of Pre-Exercise Stretching on Exercise</td>
<td>17</td>
</tr>
<tr>
<td>Neural Component</td>
<td>17</td>
</tr>
<tr>
<td>Mechanical (Compliance) Component</td>
<td>18</td>
</tr>
<tr>
<td>The Effects of Training on Flexibility Outcomes</td>
<td>21</td>
</tr>
<tr>
<td>Summary</td>
<td>23</td>
</tr>
</tbody>
</table>
3. METHODS .............................................................................................................................25
   Subjects .................................................................................................................................26
   Experimental Design ...............................................................................................................27
   Collection of Dependent Variables .........................................................................................28
   Pre-Exercise Stretching Protocol ............................................................................................29
   Statistical Design & Analysis .................................................................................................30

4. RESULTS ..................................................................................................................................32
   Six-Minute Walking Tests .......................................................................................................35
   Variables Collected During Exercise Sessions .......................................................................36
   Heart Rate One-Minute Post-Exercise ..................................................................................37
   Heart Rate Recovery ................................................................................................................39

5. DISCUSSION ..........................................................................................................................41
   Appendix A. Cover Letter .......................................................................................................49
   Appendix B. Informed Consent ...............................................................................................52
   Appendix C. Survey ..................................................................................................................58
   Appendix D. Exercise Variables Log .......................................................................................63
   Appendix E. Stretching Log ......................................................................................................68
   Appendix F. Stretching Hand-Out ...........................................................................................70
   References ..................................................................................................................................72
### LIST OF TABLES

<table>
<thead>
<tr>
<th>Tables</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Table 1 Subject Characteristics</td>
<td>33</td>
</tr>
<tr>
<td>2. Table 2 Subject Survey Responses to Cardiac Rehabilitation</td>
<td>34</td>
</tr>
<tr>
<td>3. Table 3 Subject Survey Responses to Stretching</td>
<td>35</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Figure 3.1 Diagram of Study Protocol</td>
<td>30</td>
</tr>
<tr>
<td>2. Figure 4.1 Six-Minute Walking Tests</td>
<td>36</td>
</tr>
<tr>
<td>3. Figure 4.2 Heart Rate One-Minute Post-Exercise</td>
<td>38</td>
</tr>
<tr>
<td>4. Figure 4.3 Heart Rate Recovery</td>
<td>40</td>
</tr>
</tbody>
</table>
Chapter 1

INTRODUCTION

In 2010, coronary heart disease was projected to cost a total of 108.9 billion dollars; including health care services, medications, and loss of productivity (CDC.gov). To reduce cost of coronary heart disease, cardiac rehabilitation programs have been implemented as a result of patients benefiting from exercise post-surgery of a cardiac event. The population that suffers from heart disease typically consists of sedentary, untrained, deconditioned, or orthopedic-limited patients. The primary goal of an outpatient cardiac rehab program is to educate the patients on a safe and effective exercise program. The components of the exercise program include flexibility and cardiovascular endurance. The outcome of the exercise program is to return the patient to vocational and recreational activities (ACSM, 2010). Static stretching has been introduced prior to exercise within some cardiac rehab programs. However, it is unknown if pre-exercise static stretching influences the cardiac rehab patient population on range of motion and functionality.

Research on pre-exercise stretching has observed equivocal results from pre-exercise stretching on force production and range of motion within healthy active populations (Gurajao, et al., 2009; Cristopoliski, et al., 2009; Baubalt et al., 2010). Additional equivocal studies observed the influence of pre-exercise stretching upon force production and range of motion in healthy untrained subjects (Gajdosik, et al., 2005;
Kokkonen, et al., 2007; Fowles et al. 2000). Currently, no studies have observed the influence of pre-exercise stretching upon a cardiac rehab population.

Baubalt et al. (2010) observed subjects’ maximal voluntary torque of the plantar-flexor muscles. Strength in the plantar-flexor muscles is important during the toe-off phase within a walking gait. Baubalt et al. (2010) resulted in significant decreases in torque immediately following fifteen minutes of static stretching. Conversely, Cristopoliski et al. (2009) observed significant gains in range of motion of the subjects’ step length, higher velocity, and reduced double support during gait performance. Cristopoliski et al. (2009) subjects performed a total of twelve sessions of static stretching. Baubalt et al. (2010) subject population were average age of twenty-three years compared to Cristopoliski et al. (2009) subject population’s average age of sixty-five years. The difference in results of range of motion between the two studies may be related to the specific population studied.

Gajdosik, et al. (2005) and Kokkonen et al. (2007) utilized untrained and sedentary populations had reported positive adaptations to range of motion and force production with pre-exercise static stretching. Gajdosik et al. (2005) specifically observed the subjects’ perform a fast 10m walk following a static stretching routine. Static stretching had significantly improved the subjects’ time in the 10m walk. Kokkonen et al. (2007) had the subjects perform static stretching for a period of forty minutes, three days per week, for ten weeks. Subjects resulted in significant gains in maximal voluntary
contraction and flexibility in twenty minute sprints, vertical jump height, and standing long jump. Conversely, Fowles et al. (2000) observed significant reduction in acute strength following a chronic static stretching routine of thirty-three minutes. Both Fowles et al. (2000) and Kokkonen et al. (2007) subjects were recreationally active and college-aged.

Previous research supports improvements to healthy untrained subjects’ cardiovascular endurance, e.g. improved peak heart rate, heart rate recovery, and RPE (Williams, et al., 2007; Panton, et al., 1996). If prior research supports pre-exercise stretching within healthy untrained and sedentary populations, then the cardiac rehab population may benefit from pre-exercise stretching as well. Therefore, implementing a static stretching program prior to exercise may positively assist the patients with efficiently achieving their cardiovascular endurance goals, e.g. improved peak heart rate, heart rate recovery, and RPE during exercise sessions. If pre-exercise stretching is determined to be significantly influential upon the cardiac rehab patients’ endurance goals, then all cardiac rehab programs should consider implementing the pre-exercise stretching routine within their programs.

Statement of Purpose

The purpose of this study is to analyze the influence of pre-exercise static stretching upon the cardiac rehab population’s peak HRs during exercise, rate of
perceived exertion (RPE), HR one-minute post-exercise and six-minute walking test (yardage) during full exercise sessions within the cardiac rehab program.

Significance of Thesis

The research that is currently available regarding adaptations to static pre-exercise stretching consists of equivocal results. The majority of the research specifically relates to healthy populations and only a few studies are related to untrained, sedentary, or elderly populations. No studies have been performed on untrained or deconditioned populations that have heart disease. Beneficial adaptations including improvements in range of motion and heart rate recovery from pre-exercise stretching have occurred in untrained elderly populations (Gajdosik, et al., 2005; Gurajao, et al., 2009; Kokkonen, et al., 2007; Williams et al., 2007). Therefore, patients of a cardiac rehab program may benefit from pre-exercise stretching. This study is significant to the field of exercise physiology because the population afflicted with heart disease or associated risk factors could increase their cardiovascular adaptations to exercise, e.g. improved functionality, peak heart rate and rate of perceived exertion during exercise, and collection of heart rate one-minute post-exercise, by incorporating pre-exercise static stretches.

Definition of Terms

Cardiac Rehabilitation Program: A program consisting of early assessment and mobilization, identification of and education regarding CVD risk factors, assessment of
the patient’s level of readiness for physical activity, and comprehensive discharge planning (ACSM, 2010)

Deconditioned: An individual, suffers from their peripheral skeletal muscle entering into an ultra-deconditioned state beyond which would exist in a normal sedentary individual (Duscha, et al., 2002)

Exercise Tolerance Test (ETT): Stress tests, usually called graded exercise tests, commonly call for treadmill speed and incline to increase progressively throughout the stages of the test. The test terminates at a specific heart rate designated by the physician or at the time of fatigue; often 70% age-predicted maximum heart rate. Typically, a Balke/Ware or Bruce Treadmill Test and used for diagnostic purposes and baseline values (Simms, et al., 2007)

HR one-minute post-exercise: The decrease in the heart rate from peak exercise to one minute after the cessation of exercise. An abnormal value for the recovery heart rate was defined as a reduction of 12 beats per minute or less from the heart rate at peak exercise (Cole, et al. 1999)

Hip Flexion Contracture: induced by immobility or low levels of physical activity, causes a decrease in peak hip extension, increased pelvic tilt, decreased contralateral step length and speed, and therefore lower gait efficiency (Cristopoliski, 2009).
Hypertension: A resting blood pressure higher than 140/90 and a risk factor for heart disease (ACSM 2010)

Peak Heart Rate (HR): The highest heart rate obtained during exercise.

Phase I of a Cardiac Rehabilitation Program: Inpatient program following immediately a heart surgery. The program consists of patient and family education on future physical activity and lifestyle modifications (Mercy Health Partners, 2011)

Phase II of a Cardiac Rehabilitation Program: A medically monitored exercise program designed for those who had a recent heart illness or surgery/procedure. The program mixes regular physical exercise with risk factor modification (Mercy Health Partners, 2011)

Phase III of a Cardiac Rehabilitation Program: Maintenance phase for cardiac rehab patients. The cardiac rehab patients in phase III are asymptomatic and continue their unmonitored exercise routines at the cardiac rehab program (Mercy Health Partners, 2011)

Range of Motion (ROM): The range of movement or motion of a single or multiple joints (Zakas, 2005)

Rate of Perceived Exertion (RPE): The OMNI scale (0 to 10) is used to determine the subject’s perceived work intensity during exercise (Robertson, et al., 2004)
Sedentary: Subjects who refrained from physical activity, including walking or gardening for an extended period of time, e.g. 10 years (Zakas, 2005)

Six-Minute Walking Test: The measurement of the distance walked (yardage) in six-minutes to determine exercise capacity (Lipkin, et al., 1986)

Static Stretching: Static stretching requires the participants to hold stretches stationary at the end range of motion, for approximately fifteen to sixty seconds prior to cardiovascular exercise (ACSM, 2010)

Untrained: Healthy individuals who have not participated in regular physical activity within the last 12 months (Cristopoliski, 2009)

Delimitations

1. The sample population was limited to subjects who stretched only prior to exercise and not following exercise.
2. The sample population was limited to subjects who have completed a minimum of 36 exercise sessions in phase II of cardiac rehab.
3. The sample population was limited to subjects over the age of 55 years.
4. Blood pressure (BP) was not examined in the investigation. BP has variability in exercise due to medications that may interact with BP responses.
Limitations

1. All subjects were stretching for three days while participating in the study which could cause a learning effect in the study.

2. The sample population was limited to cardiac rehab patients who participated in the maintenance program within the last twelve months.

3. The subjects did not report a dietary log which may have affected responses to exercise while in the study.

4. The subjects did not report an activity log outside of the study which may have affected their exercise during the study.

5. The subjects’ response to stretching may have been affected by variations in physical and mental behavior.

6. The subjects’ genetics may have played a role in the static stretching.

7. The subjects’ are required to take medications for their heart conditions or related risk factors to heart disease. The medications may influence their peak heart rates during exercise.

Assumptions

1. All subjects participated in physical activity only at the cardiac rehab location while participating in the study.

2. All subjects followed their dietary plans according to the dietician’s recommendations.
3. The subjects had adhered and provided their best physical capacity when performing the stretches.

Hypotheses

1. There was no significant change between experimental and placebo stretching on peak heart rates during exercise sessions.
2. There was no significant change between experimental and placebo on heart rate one-minute post-exercise sessions and heart rate recovery.
3. There was no significant change between experimental and placebo on RPE during exercise sessions.
4. There was no significant change between experimental and placebo on (3) six-minute walking tests.
5. There was no significant change between experimental and baseline on peak heart rates during exercise sessions.
6. There was no significant change between experimental and baseline on heart rate one-minute post-exercise sessions.
7. There was no significant change between experimental and baseline on RPE during exercise sessions.
8. There was no significant change between experimental and baseline on (3) six-minute walking tests.
9. There was no significant change between placebo and baseline on peak heart rates during exercise sessions.

10. There was no significant change between placebo and baseline on heart rate one-minute post-exercise and heart rate recovery.

11. There was no significant change between placebo and baseline on RPE during exercise sessions.

12. There was no significant change between placebo and baseline on (3) six-minute walking tests.

13. There was no significant change between the three days of baseline on six-minute walking tests.

14. There was no significant change between the three days of baseline on peak heart rate.

15. There was no significant change between the three days of baseline on RPE.

16. There was no significant change between the three days of baseline on heart rate one-minute post-exercise and heart rate recovery.

17. There was no significant change between the three days of placebo on six-minute walking tests.

18. There was no significant change between the three days of placebo on peak heart rate.

19. There was no significant change between the three days of placebo on RPE.
20. There was no significant change between the three days of placebo on heart rate one-minute post-exercise.

21. There was no significant change between the three days of experimental on six-minute walking tests.

22. There was no significant change between the three days of experimental on peak heart rate.

23. There was no significant change between the three days of experimental on RPE.

24. There was no significant change between the three days of experimental on heart rate one-minute post-exercise.
Chapter 2

REVIEW OF LITERATURE

Heart failure (HF) afflicts over three million individuals each year in the United States (Kitzman, et al., 2010) and as a result, cardiac rehabilitation (“rehab”) programs were implemented in hospitals. The objectives of the cardiac rehab program are to restore and maintain the patients’ optimal physiological, social, vocational, and emotional status in order to reduce their risk for future cardiovascular events (AACPR, 1991). Cardiac rehab programs educate the patients that suffer from heart disease with associated comorbidity risk factors on how to improve their current lifestyles. The additional comorbidity risk factors related to heart disease include smoking, obesity, hypertension, dyslipidemia, and type II diabetes (ACSM, 2010) are typically associated with sedentary, untrained, or deconditioned lifestyles. An example of a deconditioned individual is prolonged bed rest following heart surgery (Duscha, et al., 2002). The majority of the population within the cardiac rehab program consist of patients forty-five years or older and more males compared to females.

When an individual is diagnosed with heart disease, they have the option to participate in a cardiac rehabilitation program, typically within two to six weeks following acute coronary artery disease (CAD) symptoms (Lavie & Milani 1995). The outpatient phase, phase II, is when the patient is introduced to heart rate monitored
exercise and maintaining a healthy lifestyle through education. The monitored phase is approximately three to four months or a total of 36 sessions (Lavie & Milani 1995).

Besides, introducing patients to endurance and strength exercises, flexibility is also introduced. Flexibility training is encouraged in cardiac rehab programs because the cardiac rehab population has flexibility loss as a result of aging (Fatouros, et al. 2006). The loss of flexibility is associated with muscle disuse and as a result decreased flexibility, the patients prior to entering a cardiac rehab program lack functional abilities (Fatouros, et al. 2006). Currently, cardiac rehab programs implement flexibility either at the beginning of exercise or following exercise. Recent research on the benefits of stretching prior to exercise has been equivocal based on the specific population studied. Therefore, the need for further understanding the influence that pre-exercise stretching has within a cardiac rehab program will need to be addressed.

*Flexibility and Range of Motion (ROM) in the Cardiac Rehab Population*

Current cardiac rehab programs improve patients’ lifestyles by increasing flexibility, strength, and cardiovascular exercise. The importance of pre-exercise stretching included in some programs has not been established through research. However, a common belief exists that stretching prior to exercise will help ROM (ACSM, 2010). Zakas, et al. (2005) observed the acute effects of stretching duration in the ROM of sedentary elderly women. The authors’ findings suggested that there was no difference in the stretch duration of 60 seconds versus a stretch duration of two 30 second
stretches or four 15 second stretches on range of motion in the lower extremities. The results from Zakas et al. (2005) suggest that the duration of pre-exercise stretching may not be of significant importance for a cardiac rehab population. However, all stretch durations did produce significant improvements in ROM. Specifically, the acute gains in ROM are important because of the physiological aging process within the cardiac rehab population results in changes in elasticity and compliance of the connective tissue.

Similar to Zakas et al. (2005), Feland et al. (2001) observed the ROM in 62 healthy subjects over the age of sixty-five with hip or knee replacements. The subjects stretched tight hamstrings for 60-seconds, five times per week, for six weeks. Additionally, the authors observed residual effects of static stretching for four weeks post treatment. The results concluded that when the subjects held their stretches for a minimum of 60-seconds, significant gains in ROM occurred. Improvements in ROM and flexibility as a result of static stretching with exercise are necessary to improve the overall quality of life for a cardiac rehab population (Lavie & Milani, 1995; Maines & Lavie, 1997).

Secondary Outcomes from Stretching on a Cardiac Rehab Population

Various cardiac rehab programs recommend patients to follow a static stretching protocol prior to initiating exercise. Static stretching requires the patients to hold stretches stationary at the end range of motion, for approximately fifteen to sixty seconds prior to cardiovascular exercise (ACSM, 2010). Increasing flexibility and endurance,
increasing balance and range of motion, improving heart rate (HR) and blood pressure (BP) are all goals in cardiac rehab programs. The inclusion of flexibility and range of motion in cardiac rehab populations are associated with obtaining a higher quality of life post-cardiac rehab (Maines & Lavie 1997; Lavie & Milani 1995).

Although flexibility may play a role on improvement within quality of life, the influence of pre-exercise stretching upon achieving a significant improvement in overall endurance through rate of perceived exertion (RPE), improvement in HR recovery, and intensity of exercise, has yet to be thoroughly established through research. Williams et al. (2007) observed the influence of a 16-week flexibility training protocol upon the vascular function in an elderly population. The flexibility training protocol resulted in significant improvements in reductions in resting rest heart rate and ejection fraction, and an increase in stroke volume. The results suggest that with inclusion of flexibility training with exercise, the flexibility training may delay the effects of aging on vascular function in a cardiac rehab population (Williams et al., 2007).

A study related to heart rate recovery and heart rate variability (Farinatti, et al., 2011) observed significant improvements in heart rate recovery within male subjects of limited flexibility. The subjects were average age of twenty-three years with low-flexibility levels. Farinatti et al. (2011) observed a 16% significant decrease in heart rate recovery following a single ten-minute static stretching session of thirty-second stretch-holds. Farinetti et al. (2011) correlated the significant decrease in heart rate recovery with
a possible increase in parasympathetic activity following exercise. The results from Farinatti et al. (2011) could translate to a cardiac rehab population because the cardiac rehab population consists of patients with low-flexibility.

According to Panton et al. (1996), intensity of exercise is a primary component of exercise prescription and suggested that exercise intensity is the important factor for the development and maintenance of exercise. The HR is a standard measurement that follows linearly to volume of oxygen consumption (VO2) and is measured easily (Panton et al., 1996). The training intensity is usually elicited between 60-80% HRmax (Panton et al., 1996). As the patient proceeds with their exercise routine, their rate of perceived exertion (RPE) is measured. In addition to measuring HR, the RPE is a good indicator of the intensity of the exercise being performed. If pre-exercise stretching can benefit by improving peak HR, recovery HR, RPE, and therefore improve the intensity of exercise within a workout, then cardiac rehab programs should encourage the stretching protocol.

The exercise tolerance test (ETT) is a valuable prognostic test of a cardiac rehab patient’s endurance (Adams, et al., 2008). The ETT is performed prior and upon completing the cardiac rehab program. The ETT produces measurements of exercise capacity (METs), markers of chronotropic dynamics, heart rate reserve (HRR), and the VO2 (Adams, et al., 2008). The cardiac rehab patient performs the ETT until fatigued and measurements are recorded. The goal for the cardiac rehab program is to improve the patient’s measurements when tested upon completion of the program. Flexibility may
play a key role in the performance of endurance during the ETT. If flexibility can influence the patient’s outcome measurements of the final ETT, then pre-exercise stretching should continue to be encouraged within the program.

Current research, including studies on athletes, army recruits, and healthy untrained subjects, have observed both positive and negative effects of stretching prior to exercise within healthy populations, (Chen et al., 2011; Gurjao, et al., 2009; LaRouche, & Connolly 2006; Pope, et al., 2000). Although studies within the healthy population on pre-exercise stretching had conflicting results, a specific review of studies focused on the untrained and sedentary elderly populations (65 years and older), suggested that the elderly population resulted beneficially from stretching prior to exercise (Gajdosik, et al., 2007; Gajdosik, et al., 2005; Gurjao, et al., 2009; Kokkonen, et al., 2007). The untrained elderly populations that have been previously studied had no risk factors for heart disease and were recognized as a healthy population. In consideration that there are conflicted results between studies on pre-exercise stretching adaptations in mixed populations, the influence that pre-exercise stretching has upon a cardiac rehab population has yet to be studied. Currently, no studies have solely observed the influence that pre-exercise stretching has within an untrained, sedentary, deconditioned, or orthopedic-limited elderly population with risk factors related to heart disease.

The Effects of Pre-Exercise Stretching on Exercise

Neural Component
The neural component is one of two components that may influence the force-length relationship in static stretching (Babault, et al., 2010; Fowles, et al., 2000). When altering the force-length relationship, the proprioceptive feedback and coordination would also alter, which causes differences in the neural activation patterns (Fowles, et al., 2000). According to Fowles et al. (2000), one of the main explanations for a decrease in strength by 28% immediately following thirty minutes of stretching, is caused by the failure of activation by the Golgi tendon reflex, mechanoreceptors, or nocioceptor pain feedback. The authors defined the importance of the Golgi tendon reflex as an autogenic inhibition that occurs when the Golgi tendon organs detect high force combined with muscle lengthening. The goal of the Golgi tendon is to reduce possible strain on the muscle while performing intense stretching (Fowles, et al., 2000). During prolonged static or passive stretching, the Golgi tendon is not necessary to continually discharge and therefore, may not be a key component in affecting static stretching (Fowles, et al., 2000). In congruence with Fowles et al. (2000), Baubalt et al. (2010) suggested that the mechanical component may be more significant than the neural component.

**Mechanical (Compliance) Component**

Based on the reviewed research, the mechanical component of static stretching may influence the impact that static stretching has upon strength and cardiovascular endurance. The mechanical component of the muscle-tendon units of the sedentary and deconditioned individuals, who perform low-impact exercises, tend to be less compliant,
making these individuals less flexible (Witvrouw, et al., 2004). These individuals are predisposed to exercise-related injuries because the tendon absorbs less energy than their higher energy counterparts and may cause more trauma to the muscle fibers (Witvrouw, et al., 2004). The trauma to the muscle fibers as a result of the low energy absorption may lead to tendon and/or muscle damage (Witvrouw, et al., 2004). However, low-impact exercises do not require large amounts of energy to generate large power outputs, unlike individuals who need the flexibility around their joints to generate large power during higher-impact exercises, e.g., soccer, football, or gymnastics. Therefore, stretching may not be necessary for sedentary and deconditioned individuals based on the low requirement of power output.

Alternatively, static stretching may be necessary for cardiac rehab patients based upon a few studies performed on untrained and elderly populations. According to Wilson & Flanagan (2008) the need for a study on cardiac rehab patients performing pre-exercise stretches is necessary. The researchers performed a study on cerebral palsy patients whom are severely deconditioned due to the increased spasticity in their limbs (Wilson, & Flanagan 2008). The cerebral palsy patients had a high level of stiffness surrounding their joints as a result of their spasticity. Increased stiffness reportedly improves running velocities (Kuitunen, et al., 2002), however too high a level of stiffness could cause detrimental effects on performance and well-being (Wilson, & Flanagan 2008). The elevated stiffness has been associated with increasing the stress induced by impact forces and can lead to musculoskeletal injuries (Wilson, & Flanagan 2008). Similar to cerebral
palsy patients, individuals entering the cardiac rehab programs tend to have a similar level of stiffness surrounding their joints resulted from being deconditioned and leading sedentary lifestyles.

When static stretching was introduced to the individuals with cerebral palsy, the level of stiffness decreased resulting in increased injury prevention (Wilson, & Flanagan 2008). If the stiffness in the joints resulted in too low of stiffness, less efficiency in movement could result (Wilson, & Flanagan 2008). As an individual becomes fatigued, stiffness could decrease and result in decreased injury prevention (Wilson, & Flanagan 2008). Therefore, a balance in stiffness is necessary in order to operate in the ideal range that allows for efficient performance while keeping injury-risk minimal (Wilson, & Flanagan 2008).

The mechanical component of musculotendon stiffness may be associated with an increase in workloads, duration of exercise, and strength gains as a result of increased generated force and torque. LaRouche and Connolly (2006) observed twenty-nine nonathletic healthy male subjects perform a pre-exercise static stretching protocol for a total of three days per week for four weeks. As a result of increased passive torque, the subjects were able to handle higher muscle tensions. The authors concluded that significant improvements to range of motion were a result of increased stretch tolerance.
The Effects of Training on Flexibility Outcomes

Limited studies have discussed the impact that pre-exercise stretching has upon a sedentary, untrained, or deconditioned population’s cardiovascular endurance. However, studies the have been conducted upon the influence of static stretching on the untrained and elderly populations concluded that static stretching is proven beneficial (Cristopoliski, et al., 2009; Feland, et al., 2001; Gajdosik, et al., 2007; Gurjao, et al., 2009; Kokkonen, et al., 2007; Kokkonen, et al., 2010).

Kokkonen et al. (2007) observed thirty-eight untrained subjects who participated in a stretching group for ten weeks, forty minutes a day, three days a week. The authors concluded that chronic stretching averaged an increase in muscular endurance by 29.5% and by 23.9% in muscular strength. Although the duration of the stretching protocol is not practical for a clinical population, these improvements suggested the need to further study the possible benefits of pre-exercise stretching upon the sedentary, untrained, and deconditioned populations’ overall endurance. This study suggests that pre-exercise stretching included within a cardiac rehab program could improve the patients’ level of exercise intensity within a full workout.

Additional studies have observed improvements in balance and gait, as a result of pre-exercise stretching (Cristopoliski, et al., 2009; Feland, et al., 2001; Gajdosik, et al. 2005; Rodacki, 2009). All of these specific benefits can assist the cardiac rehab program, specifically individuals over the age of fifty-five. Gajdosik et al. (2005) observed
nineteen elderly women (aged 55-89 years old)’s range of motion and passive resistive forces. The results concluded that pre-exercise stretching assisted with significantly improving their ROM and passive resistive forces, following a static stretching protocol prior to start of exercise.

Proposed additional benefits from static stretching for untrained elderly populations include reducing hip flexion contracture and increasing hip and pelvis range of motion (Cristopoliski, et al., 2009). Both essential benefits are recognized to assist the untrained elderly population with ongoing exercise. Cristopoliski et al. (2009) observed twenty healthy elderly females (65 ± 9 years) perform a gait analysis with inclusion of four static stretching exercises held for 60-seconds for four weeks. The inclusion of the stretching program resulted in significant improvements of hip extension by a gain of 25% in range of motion and a significant improvement of plantar-flexion by a gain of 17.5%. The significant improvements in ROM improved the gait by increasing step length and velocity. Rodacki et al. (2009) also showed significant improvements in step length, velocity, and reduced double stance time in fifteen healthy elderly women (65 ± 3.2 years). Improvements in step length and velocity are important for sedentary, untrained, and deconditioned individuals because they need increase in movement to build their cardiovascular endurance. Static stretching has shown to improve efficiency in achieving their attainment of their cardiovascular goals.
Summary

Previous studies have recognized equivocal results from pre-exercise stretching within healthy untrained elderly populations on endurance and ROM (Cristopoliski, et al., 2009; Feland, et al., 2001; Kokkonen, et al., 2007; Zakas, et al., 2005). However, the influence that pre-exercise stretching has upon the sedentary, untrained, deconditioned, and orthopedic-limited elderly population associated with heart disease, has not yet been studied. Kokkonen et al. (2007) concluded that stretching over the duration of eight weeks had benefited an untrained population with increasing flexibility and ROM. However, additional authors had concluded that the duration of stretching may not be significant yet any addition of flexibility training may significantly improve acute durations of range of motion (Cristopoliski, et al., 2009; Feland, et al., 2001; Kokkonen, et al., 2007; Zakas, et al., 2005). If pre-exercise stretching benefited the untrained population in endurance and ROM, then a cardiac rehab population may benefit as well.

The equivocal research of pre-exercise stretching on trained and untrained populations leads to more misunderstanding on how a deconditioned and sedentary population will be influenced by pre-exercise stretching. The current research thus far has provided a need for further research on the influence of pre-exercise stretching on an untrained, sedentary, and deconditioned population with heart-related disease or risk-factors. No studies have observed the influence that pre-exercise stretching has upon a cardiac rehab population. Based on previous studies observing the influence of stretching
upon significantly improving ROM, HR recovery, and endurance within untrained elderly populations, the necessity for stretching will be determined for the cardiac rehab population.
Chapter 3

METHODS

The purpose of this study was to analyze the influence of pre-exercise static stretching upon cardiovascular endurance of maintenance-phase cardiac rehabilitation “rehab” patients. A cross-over, within-subject design was used for the study. The twelve randomized subjects within the study were currently in the maintenance-phase of a cardiac rehab program. The maintenance-phase of the cardiac rehab program is an optional phase for the patients to continue their exercise routines; however, the patients would continue their exercise unmonitored by the cardiac rehab staff. The subjects were randomized into either an experimental treatment consisting of ten static stretches held for 30-seconds, repeated once or a placebo treatment consisting of ineffective stretching holds of less than 3 seconds. The study included a stretching routine prior to exercise, which is currently recommended by the cardiac rehab staff at UC Davis Medical Center. The design of the study (Figure 1) statistically analyzes three days-a-week of no stretching versus two weeks of three days-per-week of baseline and experimental pre-exercise stretching on peak heart rates (HR) and rate of perceived exertion (RPE) during exercise, heart rate (HR) one-minute post-exercise, and three six-minute walking tests (meters).
Subjects

Twelve subjects (Females = 3, Age = 65 ± 10, BMI (Female) = 25.8 ± 2, BMI (Male) = 31.7 ± 8) were recruited in-person from the maintenance-phase of the cardiac rehab program. Recruitment for the study was based on the subjects graduating from phase II in the cardiac rehab program and had completed an initial exercise tolerance test (ETT). The subjects were provided with a cover letter (Appendix A) and informed consent form (Appendix B) that provided information about the study and stated that the patients’ privacy and confidentiality were maintained. The subjects were patients of the maintenance-phase of the outpatient cardiac rehab program as a result of prior incidence with heart disease or associated risk factors for heart disease, e.g. type II diabetes, smoking, obesity, sedentary lifestyles, high cholesterol, and hypertension. All subjects had completed thirty-six exercise sessions (three days-per-week for three months) prior to entering the maintenance cardiac rehab program. The researcher had no personal connection with the subjects prior or during the study. The subjects that participated in the study were provided compensation for participating in the study.

The inclusion criteria for the subjects to participate in the study included: patients of the UC Davis Medical Center’s maintenance-phase cardiac rehab program within the last twelve months, between the ages of 55 and 75 years old and have had history with heart disease or associated risk factors for heart disease. Additionally, the subjects had to be asymptomatic. The subjects were excluded if the subjects were in phase II of the
cardiac rehab program and symptomatic or had contraindications to exercise. Also, the subjects are excluded, if they did not comply with stretching prior to exercise, and had prior diagnosis with arrhythmias or recent heart attacks.

Prior to the start of the study, permission was obtained from UC Davis’ Internal Review Board (IRB) for the usage of the cardiac rehab patients’ health information provided in surveys and for monitoring the patients pre-exercise stretching for three days-a-week for two weeks. The study was categorized as low risk by the UC Davis IRB. All the patients that volunteered to be part of the program were provided a cover letter (Appendix A) signed an informed consent form (Appendix B) and filled-out a health background survey (Appendix C).

Experimental Design

Upon initiating phase II in the cardiac rehab program, the subjects were provided a stretching hand-out that recommended static stretches to be performed prior to exercise. A similar stretching hand-out (Appendix F) was used for the experimental treatment of stretch-holds of 30-seconds, repeated once per stretch during the second and fourth week of the study. Also, the stretching hand-out (Appendix F) was used for the placebo treatment of stretch holds of less than three seconds during the second and fourth week of the study.

At the beginning of the study, the subjects were randomized into treatments, an experimental treatment and a placebo treatment. None of the subjects were informed if
either treatment of stretching may be effective on their exercise sessions. Following the second week, the subjects crossed-over from experimental to placebo, or vice-versa (Figure 3.1). All procedures of the study were explained to the subjects prior to the start of the study and the subjects were informed that they had the right to leave the study at any time.

Collection of Dependent Variables

Prior to the start of the study, a baseline measurement for each subject was obtained using a six-minute walking test. The six-minute walking test was also performed following the second week of the study and upon completion of the study. The six-minute walking test required the subjects to walk down a hallway for six minutes and the meters were recorded (Appendix D). Each week, the subjects were asked to start walking at a new starting point to prevent prior learning effect. Prior to the start of each exercise session, the subjects were asked to wear a Polar® heart rate monitor throughout their entire exercise session. The Polar® heart rate monitor recorded their peak HRs and HR one-minute post-exercise.

During the subjects’ exercise sessions their RPE and peak HRs were recorded for each exercise modality (Appendix D). The RPE was recorded half-way through their exercise session using the OMNI Scale (0-10). The HR was recorded within one minute following completion of the same exercise session (Appendix D). Both weeks of pre-
exercise stretching were analyzed with the dependent variables of peak HRs and HR recovery in beats per minute (BPM), and RPE.

*Pre-exercise Stretching Protocol*

The principle investigator led the subjects through their stretching routines prior to the start of their exercise. The subjects in the experimental treatment were required to hold multiple static stretches for 30-seconds per stretch applying moderate intensity and to possible discomfort but not to the point of pain. The total time-frame for the experimental stretching was eight minutes and thirty seconds. The total number of stretches performed was ten stretches with some stretches including both sides of the body. The specific types of stretches were designated by the principle investigator prior to the start of the study. A stretching log (Appendix E) was kept of all forms of stretching throughout the study. The experimental treatment occurred for a total of three days-a-week during weeks two and four of the study. The placebo treatment followed a substandard “inefficient” stretching routine of holding the static stretches for less than three seconds at low force and ROM. The total time for the placebo stretching was sixty-one seconds. The placebo treatment followed the same stretch routine as the experimental treatment. The placebo treatment occurred for a total of three days-a-week during weeks two and four of the study. Upon the completion of the second week of the study, subjects in the experimental treatment were required to cross-over to the placebo treatment and vice versa, with a week of no stretching in-between the stretching protocols (Figure 3.1).
Figure 3.1 Diagram of Study Protocol. Diagram of the four-week study of pre-exercise stretching and the collection of dependent variables of peak heart rate (bpm), rate of perceived exertion (OMNI scale), heart rate one-minute post-exercise (bpm), and (3) six-minute walking tests (meters).

Statistical Design & Analysis

The software to compute the statistical analyses was Statistica® (StatSoft, INC®, Tulsa, OK) to compare the subjects' experimental versus placebo versus baseline with the dependent variables of peak HRs, RPE, HR one-minute post-exercise, and (3) six-minute walking tests. A one-way ANOVA was conducted between experimental versus placebo
versus baseline (no-stretching) with three six-minute walking tests. The data collected from the experimental, placebo, and baseline was represented by means and standard deviations for the three six-minute walking tests.

Additional one-way ANOVAs were performed for experimental versus placebo versus baseline (no-stretching) with peak heart rate, rate of perceived exertion, and heart rate one-minute post-exercise. The data collected from experimental, placebo, and baseline was represented by means and standard deviations for peak heart rate, rate of perceived exertion and heart rate one-minute post-exercise. A Tukey Post-Hoc test was performed following significant ANOVAs to determine where specific differences occurred between the experimental, placebo, and baseline with days.
Chapter 4

RESULTS

The current study examined the influence of pre-exercise stretching on the cardiovascular endurance of a cardiac rehab population over duration of four weeks on peak heart rates (bpm) and rate of perceived exertion during exercise (RPE), heart rate one-minute post-exercise (bpm) following exercise, and three six-minute walking tests (meters). Three female subjects (Age = 65 ± 10 years Wt = 65.5 ± 4 kg Ht = 159 ± 2 cm BMI = 25.8 ± 2 kg/m²) and nine male subjects (Age = 65 ± 10 years Wt = 104.5 ± 21 kg Ht = 177.5 ± 8 cm BMI = 32 ± 7 kg/m²) who had prior diagnosis of heart disease or associated risk factors for heart disease and who had participated in the maintenance-phase cardiac rehab program three days per week within the last twelve months, volunteered to participate in the study. All twelve subjects were asymptomatic and had no contraindications to stretching or exercise. All pre-exercise stretching and exercise data collection was performed on-site at the UC Davis Medical Center Cardiac Rehabilitation Program.
### Table 1: Subject Characteristics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td>65 ± 10</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>Female = 65.5 ± 4</td>
</tr>
<tr>
<td></td>
<td>Male = 104.5 ± 21</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>Female = 159 ± 2</td>
</tr>
<tr>
<td></td>
<td>Male = 177.5 ± 8</td>
</tr>
<tr>
<td>BMI</td>
<td>Female = 25.8 ± 2</td>
</tr>
<tr>
<td></td>
<td>Male = 32 ± 7</td>
</tr>
<tr>
<td>Heart Disease</td>
<td>Coronary Artery Disease, By-Pass, Heart Block, Congestive Heart Failure, Stent</td>
</tr>
<tr>
<td>Associated Risk Factors With Heart Disease</td>
<td>COPD, Irregular Heart Beat, Atrial Flutter, Hypertension, Family History, Obesity, Type II Diabetes, High Cholesterol</td>
</tr>
<tr>
<td>Smoking (Packs/Day)</td>
<td>0 Subjects</td>
</tr>
<tr>
<td>Drinking (Alcoholic Glass/Day)</td>
<td>2 Subjects = 1-2</td>
</tr>
</tbody>
</table>
Table 2: Subject Survey Responses to Cardiac Rehabilitation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Time in Maintenance Program</td>
<td>2 months – 8 yrs</td>
</tr>
<tr>
<td>Graduation From Phase II Cardiac Rehabilitation Program</td>
<td>2004-2012</td>
</tr>
</tbody>
</table>
| Cardiac Rehab and Treadmill Activity (Mins/Hours per Week) | 5 Subjects = 30-60 mins  
5 Subjects = 1-3 hours |
| Cardiac Rehab and Bike Activity (Hours per Week) | 1 Subject = < 30 mins  
5 Subjects = 30-60 mins  
3 Subjects = 1-3 hours |
| Cardiac Rehab and Nu-Step Activity (Hours per Week) | 1 Subject = < 30 mins  
2 Subjects = 30-60 mins  
2 Subjects = 1-2 hours |
| Cardiac Rehab and Elliptical Activity (Hours per Week) | 2 Subjects = 30-60 mins  
2 Subjects = 1-3 hours |
| Cardiac Rehab and Weights (Hours per Week) | 2 Subjects = < 30 mins  
2 Subjects = 30-60 mins  
2 Subjects = 1-3 hours |
Table 3: Subject Survey Responses to Stretching

| Stretching Prior to Cardiac Rehab Program | 4 Subjects = No  
                                    | 8 Subjects = Yes |
|------------------------------------------|------------------|
| How Often Did Stretching Occur Prior to Exercise (Days) | 1 Subject = 7  
                                    | 1 Subject = 4  
                                    | 4 Subjects = 3  
                                    | 2 Subjects = 2  
                                    | 1 Subject = 1  
                                    | 2 Subjects = 0  |
| Type of Stretches Performed | 2 Subjects = Upper Only  
                                    | 2 Subjects = Lower Only  
                                    | 8 Subjects = Full Body |
| Length of Stretch Holds (Seconds) | 10-30 |
| Length of Stretching Routine (Minutes) | 5-15 |

Six-Minute Walking Tests

The outcome of the six-minute walking tests (meters) was significantly higher in the experimental compared to the baseline (no-stretch). Both the experimental and placebo was completed during one-week trials of 30-second static stretch holds (experimental), 3-second static stretch holds (placebo) or no-stretching (baseline). A six-minute walking test was performed prior to the start of the study, at the end of week two of the study and upon completion of the study. There was a significant increase between experimental and baseline (405.66 ± 19.22 m vs 461.54 ± 26.87 m p = 0.005) (figure 4.1.). There was no difference between placebo and baseline or experimental and placebo.
Figure 4.1. Treatments of thirty-second static stretch holds (experimental) or three-second stretch holds (placebo), or baseline (no-stretching) for three days per week. Each subject performed a six-minute walking test (meters) prior to the start of the study, upon completion of week two, and upon completion of the study (week four).

* Significance between experimental and baseline in six-minute walking tests.

Variables Collected During Exercise Sessions

Experimental, placebo, or baseline occurred prior to exercise three-days per week. Peak heart rates were collected during each exercise session. There was no significant difference between the experimental, placebo, and baseline (120.94 ± 10.9 vs 122.5 ±
no significant difference between the three days-a-week of experimental, placebo, or baseline (122.1 ± 5.5 vs 121.1 ± 6.8 vs 119.7 ± 7.1 p = 0.2), and no significant interaction effect (122.1 ± 5.5 vs 121.8 ± 6.3 vs 121.2 ± 5.4 p = 0.7).

Rate of perceived exertion (RPE) was collected during each exercise session, three days per week. There was no significant difference between the experimental, placebo, and baseline (5 ± .5 vs 5 ± 0.6 vs 5.5 ± 0.5 p = 0.3), no significant difference between the three days-a-week of treatments (5 ± .5 vs 5.2 ± 0.6 vs 5 ± 0.6 p = 0.5), and no significant difference between the days and experimental, placebo, or baseline (5.1 ± 0.6 vs 5.2 ± 0.6 vs 5.4 ± 0.6 p = 0.9).

Heart Rate One-Minute Post-Exercise

Heart rate was collected for experimental, placebo, and baseline following one-minute of post-exercise of each exercise session three-days per week. A significant interaction effect was observed for one-minute post heart rate. The experimental treatment had significantly higher heart rate compared to baseline on Monday (88.3 ± 4.1 bpm vs 80.0 ± 2.8 bpm p = 0.0001) and Wednesday (86.6 ± 4.2 bpm vs 79.2 ± 2.9 bpm p = 0.0001) and no significant difference on Friday (p = 0.48). Experimental had a significantly higher heart rate compared to placebo on Monday (88.3 ± 4.1 bpm vs 83.4 ± 2.2 bpm p = 0.004) and a trend for a difference on Wednesday (p = 0.07) or Friday (p = 0.88). There was no significant difference between experimental, placebo, and baseline on Friday.
Baseline had no significant difference between heart rates for Monday, Wednesday, or Friday. The placebo had no significant difference between heart rates for Monday, Wednesday, or Friday. Experimental had significantly lower heart rates from Monday to Friday (88.3 ± 3.4 bpm vs 83.3 ± 4.1 bpm p = 0.003) (figure 4.2.).

*Statistical difference (p = 0.05) between Monday (Day 1) and Friday (Day 3) occurred within the experimental treatment.

*Figure 4.2. Heart rate was collected one-minute post-exercise for experimental, placebo, and baseline on Monday, Wednesday, and Friday per week.*
Heart Rate Recovery

Heart rate was collected for experimental, placebo, and baseline following one-minute of post-exercise of each exercise session three-days per week. Experimental had significantly higher heart rate recovery compared to baseline on Monday (p = 0.0001) and Wednesday (p = 0.0001) and a trend for a difference on Friday (p = 0.48). A significant interaction effect was observed for heart rate recovery. Experimental had a significantly higher heart rate compared to placebo on Monday (p = 0.004) and no significant difference on Wednesday (p = 0.07) or Friday (p = 0.88). There was no significant difference between experimental, placebo, and baseline on Friday.

Baseline had no significant difference between heart rate recovery for Monday, Wednesday, or Friday. The placebo had no significant difference between heart rate recovery for Monday, Wednesday, or Friday. Experimental had a significantly lower heart rate recovery from Monday to Friday (p = 0.003) (figure 4.2.).
Heart Rate Recovery

*Figure 4.3.* Heart rate recovery was calculated by the difference of heart rate one-minute post-exercise from peak heart rate for experimental, placebo, and baseline on Monday, Wednesday, and Friday per week.

* Statistical difference (p = 0.05) between Monday (Day 1) and Friday (Day 3) occurred within the experimental treatment.
Chapter 5

DISCUSSION

The results of the study observing pre-exercise stretching for experimental will be different than the baseline with the three six-minute walking tests supported the original hypothesis. The hypotheses that experimental will be different than the placebo and baseline with peak heart rate, rate of perceived exertion, heart rate one-minute post-exercise, and heart rate recovery were not supported. The hypothesis that the experimental, placebo, and baseline will be different between the three days-per-week for peak heart rate and rate of perceived exertion were not supported. However, the hypothesis that experimental on heart rate one-minute post-exercise and heart rate recovery will be significantly different between the three days was supported.

Three six-minute walking test (meters) were observed within twelve subjects. The current study resulted in a significant difference between the experimental versus placebo and baseline. Experimental resulted in significant improvement of 13.8% over the period of one week. The significant gain in functionality within the experimental treatment is supported by Zakas et al. (2005) and Feland et al. (2001). Zakas et al. (2005) observed significant acute improvements in range of motion in the lower extremities and trunk of sedentary elderly women following 60-seconds, two 30-second, or four 15-second stretch routines. Feland et al. (2001) also observed significant acute gains in range of motion of their elderly subjects’ hamstrings of 2.4 degrees in flexion following a pre-exercise static stretching routine.
Therefore, the supported hypothesis of pre-exercise static stretching of thirty-second stretch-holds can significantly improve functionality provides important significance within cardiac rehabilitation programs. Improved functionality correlates with improved range of motion (Zakas, et al. 2005). One of the main goals of the cardiac rehab programs is to improve range of motion and functionality of patients and as a result, to improve the patients’ activities of daily living, e.g. shopping independently at the grocery store.

The true explanation of the significant improvement in the subjects’ functionality is unknown. One theory that may attribute to the subjects’ significant improvement in functionality could be an increase in the subjects’ strength as a result of pre-exercise static stretching. Kokkonen et al. (2007) had observed changes in the subjects’ strength as a result of chronic static stretching. Kokkonen et al. (2007) observed significant improvements of 30.4% in knee flexion endurance and 28.5% knee extension endurance within unconditioned subjects following a chronic static stretching program. Kokkonen et al. (2007)’s protocol consisted of 40-minute static stretching, three days-per-week, for ten weeks. The authors contributed the significance in strength gains to increases in muscle length as a result of recruitment of muscle motor units. The increases in muscle length contribute to the increase in contractile velocity and forces generated at shortening velocities (Kokkonen et al., 2007). It can be speculated that muscle lengthening may have occurred within the subjects of the current study, however maximal voluntary contraction was not measured.
Age-related health conditions (e.g. alterations in balance and osteoarthritis) could have played a role within the significant improvement of functionality. An explanation for improvement in gait speed could be the influence of changes in gait pattern. Rodacki et al. (2009) observed significant improvements of 25% in hip extension within the elderly subjects’ gait pattern. Hip extension plays an important role in pelvic tilt which influences and determines the step length and velocity (Rodacki et al., 2009). Improvements in gait speed could be contributed to increased pelvic rotation and tilting range of motion (Rodacki et al., 2009). The benefit of improvement in gait speed within this study is that increased gait speed correlates with decreased fall-risk (Rodacki et al., 2009). Therefore, pre-exercise static stretching may be correlated with improvement in fall-risk within the elderly population.

Psychological influence may have played a role in the outcome of the six-minute walking tests. As the subjects progressed in gait speed during the six-minute walking tests, the subjects may have developed a learning effect. Once the subjects had completed their first six-minute walking test, the subjects may have attempted to compete with their prior gait speed. Since subjects were aware that they needed to complete three six-minute walking tests, the subjects may have mentally prepared prior to the tests, to out–pace their previous test. It is unknown how big of a role the subjects’ mentality may have played upon the outcome of the six-minute walking tests.
An observed benefit of pre-exercise static stretching on the cardiac rehab population was a significant improvement in heart rate one-minute post-exercise over a period of one week (88.3 ± 3.4 bpm vs 83.3 ± 4.1 bpm p = 0.003). The improvement in heart rate post-exercise is supported by a recent study conducted by Farinatti et al. (2011). Farinatti et al. (2011)’s subjects had low-flexibility similarly to the population within the current study. The subjects had a significant improvement in post-exercise heart rate following ten-minute exercise sessions of thirty-second holds (Farinatti et al., 2011). Farinatti et al. (2011) suggests that increased parasympathetic activity may play a role post-exercise in heart rate recovery, as a result of pre-exercise static stretching. Therefore, the parasympathetic activity within the twelve subjects of the current study may have also played a role in improvement in heart rate one-minute post-exercise.

Goldberger, et al. (2005) assessed the reactivation of parasympathetic activity post exercise. Increased onset of parasympathetic activity translates into improved heart health and a decreased risk for arrhythmias post-exercise (Goldberger, et al. 2005). Post-exercise heart rate recovery has been recognized as a strong predictor of mortality in patients undergoing ETTs (Goldberger, et al. 2005) and therefore, if cardiac rehab programs included static stretching, the mortality in patients may improve.

No significant differences between treatments or days were observed within the subjects’ peak heart rates or RPE. Therefore, pre-exercise static stretching had no effect upon the subjects’ perceived effort of exercise or the peak heart rates achieved throughout the subjects’ exercise sessions. If pre-exercise static stretching had a
significant improvement on peak heart rate, the subjects’ RPE may have correlated as well. RPE may have not been affected because of the differences within the subjects’ interpretation of the effort of intensity of exercise. Some subjects reported RPE correlating their effort of intensity in exercise with their physical well-being. For example, a subject reported an intensity level of six on the OMNI scale, associating their perceived effort with increased stiffness as a result of osteoarthritis. Therefore, additional physical barriers may have affected the subjects’ response to RPE.

An influence that may have played a role on peak heart rate outputs collected during exercise sessions, were medications that cardiac rehab patients are required to take on a daily basis. Throughout the study, the subjects had reported no changes in medications. Examples of medications that could influence heart rate during exercise include beta-blockers that decrease the heart rate and cardiac output (AHA, 2012). Additional medications that may influence the subjects’ heart rates during exercise include calcium channel blockers which may decrease the heart’s pumping strength; ACE inhibitors which allow the blood to flow more easily and makes the heart work more efficiently (AHA, 2012). Therefore, the true effect of pre-exercise stretching upon peak heart rate remains unknown. The role of medications upon heart rate recovery within the current study is unknown. Heart rate collected one-minute post-exercise had improved following the experimental treatment within one week. The influence of medication upon improved vagal reactivation post-exercise compared to the influence of pre-exercise static stretching cannot be determined.
Conclusion

Based on the results of the current study, further investigation will need to be conducted on deconditioned, sedentary, or untrained populations. The subject population studied was of the maintenance-phase of the cardiac rehab program and the population had been exposed to exercise for a greater period of time than the phase II cardiac rehab population. The study had resulted in significant improvements within the subjects’ six-minute walking tests and heart rate one-minute post-exercise. Therefore, more research needs to be warranted upon specifically observing the six-minute walking tests. Stride length using a pedometer was not measured during the current study. Stride length may have influenced the outcomes of the current study. Cristopoliski et al. (2009) and Rodacki et al. (2008) observed significant improvements in gait parameters as a result of pre-exercise static stretching. Cristopoliski et al. (2009) observed significant improvement in step length, velocity, and double support stance time within healthy elderly women following static stretching. Additionally, Rodacki et al. (2008) observed significant improvements in gait velocity, step length, and double support stance time within healthy elderly subjects following static stretching. Both studies support the need for an additional biomechanical study on stride length and observance of gait characteristics of the lower extremities.

Additionally, a study needs to be conducted observing the subjects maximal voluntary contraction and force production during the six-minute walking tests.
Improvements in strength may have played a role in the outcome of the six-minute walking tests within the current study. Kokkonen et al (2007) supported the significant improvement in strength within the subjects as a result of chronic stretching for duration of 40-minutes for three days-a-week for ten weeks. Kokkonen et al (2007)’s study warrants more research into acute strength gains following a shorter duration of static stretching.

Further research may be considered within the subject population with heart failure. Based on the significant outcome of the six-minute walking tests within the current study, heart failure subjects may significantly improve. Heart failure is a chronic condition that no longer allows the heart to pump blood efficiently throughout the body (Bonow, et al. 2011). A study is warranted observing the heart rate, stroke volume, and ejection fraction of heart failure patients following the six-minute walking tests. Improvement in ejection fraction within heart failure subjects can assist with the management of the chronic condition in addition to medications. Upon conclusion, the results from the current study have warranted the continuation of research on pre-exercise static stretching within cardiac rehab programs. Cardiac rehab programs should consider group stretching led by a trained clinical staff member, in order to ensure full benefits of pre-exercise static stretching.
APPENDICES
APPENDIX A

Cover Letter
Dear __________________________

Your assistance in a study regarding pre-exercise stretching while participating within a cardiac rehab program is needed. As a Master’s student in Exercise Physiology at CSU Sacramento, I am conducting this study to analyze the influence that pre-exercise stretching has on an exercise session during the maintenance phase of a cardiac rehab program. The cardiac rehab program that you had participated in had been selected because pre-exercise stretching is a recommendation by the clinical staff, not a requirement. Therefore, the option of pre-exercise stretching is available to all patients. I am now asking patients that have participated in the cardiac rehab program within the last twelve months and are currently in the maintenance phase of the program, to participate in a stretching study. Your name was one of the many patients who have participated in the cardiac rehab program within the last twelve months.

Your participation in the study will require you to attend three exercise sessions per week for four weeks. Prior to starting the study, you will be asked to perform a six-minute walking test. You will also be asked to perform a six-minute walking test
following the first week of the study and upon completion of the study. Prior to starting your exercise session, you will be asked to wear a heart rate monitor to accurately record your peak heart rate during your exercise session and to record your recovery heart rate at the end of your exercise session. At the beginning of each day of the study, you will be asked to perform a stretching routine prior to each exercise session during two-weeks of the study. The stretching routine will not differ from the routine that has been described to you by the cardiac rehab staff at the start of your cardiac rehab program. During your exercise session, you will be asked to report your rate of perceived exertion (RPE). You will also be asked to provide your background health information specifically related to your diagnosis with heart disease. As the principle researcher and any other researchers involved in the study, we will abide by the Health Insurance Portability and Accountability Act (HIPAA) act and no institution or individual will be identified by this study.

Please consider participating in the study by contacting Emily O’Shaughnessy by email at eo265@saclink.csus.edu or contact her at (916) 220-6954. Thank you for your time and commitment and I look forward to hearing from you soon.

Sincerely,

Emily O’Shaughnessy
APPENDIX B

Informed Consent
CONSENT TO PARTICIPATE IN A RESEARCH STUDY

STUDY TITLE: Pre-Exercise Stretching Adaptations on a Cardiac Rehab Population

PRINCIPAL INVESTIGATOR: Emily O'Shaughnessy, B.S. Kinesiology

CO-PRINCIPAL INVESTIGATOR: Dr. Ezra Amsterdam, M.D.

INTRODUCTION

This is a research study conducted by Emily O'Shaughnessy, B.S. from the Department of UC Davis Medical Center Cardiac Rehab. The main goal of a research study is to learn things to help patients in the future. No one can guarantee that a research study will help you.

Participating in research is voluntary. You have the right to know about the procedures, risks, and benefits of the research study. If you decide to take part, you can change your mind later and leave the study. To participate in this study, you will need to give your written consent by signing this form. Please take your time to make your decision and discuss it with your family, friends, and caregivers.

About 12 people will take part in this study at UC Davis Medical Center Cardiac Rehab.

WHY IS THIS STUDY BEING DONE?

We hope to learn if pre-exercise stretching for ten minutes will improve rate of perceived exertion (RPE), heart rate (HR) recovery, and the six-minute walking test.

You are being asked to take part in this study because you are in the maintenance phase of UC Davis Medical Center’s Cardiac Rehab program. You are between the ages of 45 and 75 years old in stable condition, asymptomatic, and have had either a by-pass surgery or stent replacement.

BEFORE YOU BEGIN THE STUDY

You will be asked if you had an exercise tolerance test (ETT) within the last 12 months. You will be asked to provide your health background information specifically related to your diagnosis with heart disease.

WHAT WILL HAPPEN IF I TAKE PART IN THIS RESEARCH STUDY?

If you decide to take part in this study, you will be asked to:

- Participate in the UC Davis Cardiac Rehab program located onsite at the Lawerence J. Ellison Ambulatory Care Center for three days per week for two weeks.
- Wear a heart rate monitor throughout a full session of stretching and exercise
- Perform a six-minute walking test, prior to the study, a six-minute walking test following the first week of stretching, and a final six-minute walking test upon completion of the study.
- Perform the stretching routine that is recommended by the staff of the cardiac rehab program.
- Report your RPE during your workout.
- Wait at least a minute during recovery from exercise before removal of the heart rate monitor to obtain accurate HR recovery.

<table>
<thead>
<tr>
<th>The following procedures are part of standard of care and may be done even if you do not join the study:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Recommendation of pre-exercise stretching</td>
</tr>
<tr>
<td>- Reporting of RPE</td>
</tr>
<tr>
<td>The following procedures WILL ONLY BE DONE IF YOU JOIN THE STUDY:</td>
</tr>
<tr>
<td>- Wearing a heart rate monitor for the duration for a full exercise session</td>
</tr>
<tr>
<td>- Six-minute walking test</td>
</tr>
<tr>
<td>- Routine of pre-exercise stretching before each exercise workout, for three days per week for two weeks</td>
</tr>
<tr>
<td>- Recording of HR recovery</td>
</tr>
</tbody>
</table>

**HOW LONG WILL I BE IN THE STUDY?**

You will be asked to participate for a full month, three days per week for the first week and third week, and five days per week for the second week and fourth week.

**WHAT SIDE EFFECTS OR RISKS CAN I EXPECT FROM BEING IN THE STUDY?**

There may be a risk of fatigue during the study as a result of pre-exercise stretching prior to your exercise session. There may also be risks to your privacy. The Researchers will store study records and other information about you in a secure location and will grant access only to those with a need to know. However, just like with other personal information kept by your health care providers, your banks, and others, even these safeguards cannot guarantee absolute protection of the data. If private information gets into the wrong hands, it can cause harm. Although rare, there are reported cases of breaches that have resulted in discrimination in insurance or employment.

For more information about risks and side effects, ask the Researcher.

**ARE THERE BENEFITS TO TAKING PART IN THE STUDY?**
You may not benefit from taking part in this research. If pre-exercise stretching is proven to be significantly beneficial to your exercise routine within the cardiac rehab program, you will be encouraged to continue the recommended stretching prior to your prescribed exercise routines. The information we get from this study may help us to recognize the benefits of pre-exercise stretching upon a patient’s endurance, perception of intensity during their workout, and HR recovery.

WHAT ARE THE COSTS OF TAKING PART IN THIS STUDY?

There is no charge for you to participate in this study. Neither you nor your insurance carrier will be charged for your taking part in the research. All costs associated with the study will be paid by the sponsor/department.

WILL MY INFORMATION BE KEPT CONFIDENTIAL?

We will do our best to make sure that your personal information will be kept confidential. However, we cannot guarantee total privacy. Your personal information may be released if required by law.

PERSONAL INFORMATION, DATA, RELATED RECORDS

Your personal information and recorded data will be securely stored in a storage unit only accessed by the principle investigator to prevent access by unauthorized personnel. Additionally, the measurements of the six-minute walking test, RPE, and HR recovery are stored electronically on Microsoft Excel and can only be accessed by the researchers. If we access your personal health information (e.g. your medical record), you will be asked to sign a separate form to give your permission.

The principle investigator and co-principle investigator will have access to your recorded measurements and health information. Also, designated University officials, including the Institutional Review Board, have the authority to review research records.

If information from the study is published or presented at scientific meetings, your name and other personal information will not be used.

DO I HAVE TO PARTICIPATE AND CAN I STOP BEING IN THE STUDY?

Taking part in this study is your choice and completely voluntary.

If you decide to take part in this study, you can decide to stop at any time. Leaving the study will not affect your medical care here at UC Davis. Tell the Researcher if you are thinking about stopping or decide to stop so any risks from the pre-exercise stretching can be managed safely.
The Researcher may withdraw you from this research if circumstances arise which warrant doing so even if you would like to continue.

We will tell you about new information or changes in the study that may affect your health or willingness to continue in the study.

**WHAT OTHER CHOICES DO I HAVE IF I DO NOT TAKE PART IN THIS STUDY?**

If you choose not to take part in this study your other choices may include:
- Not participating in the study.

Please talk to your doctor about your choices before deciding if you will take part in this study.

**WILL I BE COMPENSATED FOR BEING IN THIS STUDY?**

You will receive a compensation for one month’s worth of the maintenance phase program, equaling $40. If you do not complete the study, you will be required to pay the remaining balance of the maintenance phase program.

**WHO CAN ANSWER MY QUESTIONS ABOUT THE STUDY?**

If you have questions, please ask us. You can talk to the Researcher about any questions or concerns you have about this study at

Emily O’Shaughnessy at phone number 916-220-6954

Dr. Tissa Kappagoda at phone number 916-734-3761

For questions about your rights while taking part in this study call the Institutional Review Board at (916) 703-9167 or write to IRB Administration, CTSC Building, Suite 1400, Room 1429, 2921 Stockton Blvd., Sacramento, CA 95817. Information to help you understand research is on-line at: [www.research.ucdavis.edu/IRBAadmin](http://www.research.ucdavis.edu/IRBAadmin).

**WHAT HAPPENS IF I AM INJURED BECAUSE I TOOK PART IN THIS STUDY?**

It is important that you promptly tell the Researcher if you believe that you have been injured because of taking part in this study. If you are injured as a result of being in this study, the University of California will provide necessary medical treatment. The costs of the treatment may be covered by University or the study sponsor or may be billed to your insurance company just like other medical costs. The University and the study
sponsor do not normally provide any other form of compensation for injury. You do not lose any legal rights by signing this form.

CALIFORNIA SUBJECT'S BILL OF RIGHTS FOR BIOMEDICAL RESEARCH

As a research subject, you have the following rights:

1. To be told what the study is trying to determine.
2. To be told what will happen to you and whether any of the procedures, drugs, or devices is different from what would be used in standard practice.
3. To be told about the frequent and/or important risks, side effects, or discomforts of the things that will happen to you for research purposes.
4. To be told if you can expect any benefit from participating and, if so, what the benefit might be.
5. To be told the other choices you have and how they may be better or worse than being in the study.
6. To be allowed to ask any questions concerning the study, both before agreeing to be involved and during the course of the study.
7. To be told what sort of medical treatment is available if any complications arise.
8. To refuse to participate or to change your mind about participating after the study is started. This decision will not affect your right to receive the care you would receive if you were not in the study.
9. To receive a copy of the signed and dated consent form.
10. To be free of pressure when considering whether you wish to agree to be in the study.

My signature below indicates that I understand my rights and want to take part in this study as a research subject. I have read and understand the information above. I understand that I will be given a signed and date copy of this consent form.

__________________________________  ____________________
Signature of Subject                  Date
Print Name of Subject

_______________________________________  ____________________
Signature of Person Obtaining Consent  Date
Print Name
APPENDIX C

Survey
Name: _____________________________________  Today's date: ____________________

Address: ______________________________________________________________________

City, state, zip: _________________________________________________________________

Telephone: home (___)_________ - _____________  Date of birth: _____________________

work (___ ) _______ - _____________  Sex (circle): □ Female

Male

BACKGROUND

2) Please indicate below which chronic condition(s) you have:

☐ Diabetes  ☐ Asthma  ☐ Emphysema or COPD

☐ Other lung disease Type of lung disease:

______________________________________________

☐ Heart disease Type of heart disease:

______________________________________________

☐ Arthritis or other rheumatic disease Specify type:_________________________________

☐ Cancer Type of cancer:

______________________________________________

☐ Other chronic condition Specify:

______________________________________________

3) Are you currently taking any medications?  ☐ Yes  ☐ No
*If yes, please list your medications here:
________________________________________
________________________________________

4) Please indicate below any heart disease risk factor(s) you have:

☐ Hypertension  ☐ Obesity  ☐ Type II diabetes
☐ High cholesterol  ☐ Family history of heart disease

5) Do you smoke?  ☐ Yes  ☐ No
   a. If you smoke, how many packs per day do you smoke?

6) Do you drink alcohol?  ☐ Yes  ☐ No
   a. If you drink, how many drinks do you have per day?

7) What is your current activity level? (Please circle)

<table>
<thead>
<tr>
<th>Days per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

8) How long were you in the cardiac rehab program?

9) When was your graduation date from the cardiac rehab program?
10) You were initially informed about how to stretch before your prescribed exercise program. Were you stretching before exercise while participating in the cardiac rehab program?

☐ Yes ☐ No

a. If no, have you ever stretched before exercise?  ☐ Yes  ☐ No
   i. If you have not stretched, why not?

_____________________________________________________________

b. If yes, how often did you stretch before exercise? (Please circle)

[Bar chart showing days per week]

0  1  2  3  4  5  6  7

Days per week

c. Please indicate the type of stretches you have performed:

☐ Lower body (ankles, knees, legs, hips)
☐ Upper body (abs, back, shoulders, arms, neck)
☐ Full body (upper and lower body)

d. How long did you hold each stretch (e.g. 10-30 seconds):

e. How long was your total stretching routine (e.g. 10 minutes)?

11) If you have any other input in regards to stretching, please comment here:
Thank you for your help!

<table>
<thead>
<tr>
<th></th>
<th>none</th>
<th>less than 30 min/wk</th>
<th>30-60 min/wk</th>
<th>1-3 hrs per week</th>
<th>more than 3 hrs/wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Bike</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nu-Step</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Elliptical</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Weights</td>
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<td>2</td>
<td>3</td>
<td>4</td>
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</tbody>
</table>
APPENDIX D

Exercise Variables Log
Exercise Variables Log

Subject’s Code # _______

Week 1 - No stretching

<table>
<thead>
<tr>
<th>Day</th>
<th>Time (Mins/Secs)</th>
<th>Mode of Exercise</th>
<th>Heart Rate (BPM)</th>
<th>RPE (OMNI 0-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heart Rate Recovery (1 min upon completion)

Day 1 ________________ BPM
Day 2 ________________ BPM
Day 3 ________________ BPM

Six-Minute Walking Test ____________ Yardage

Recorded by ___________________________  Date __________
Week 2 – Stretching (PLACEBO or EXP)

<table>
<thead>
<tr>
<th>Day</th>
<th>Time (Mins/Secs)</th>
<th>Mode of Exercise</th>
<th>Heart Rate (BPM)</th>
<th>RPE (OMNI) 0-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heart Rate Recovery (1 min upon completion)

Day 1 ________________ BPM
Day 2 ________________ BPM
Day 3 ________________ BPM

Six-Minute Walking Test ________________ Yardage

Recorded by ____________________________ Date ____________
Week 3 - No stretching

<table>
<thead>
<tr>
<th>Day</th>
<th>Time (Mins/Secs)</th>
<th>Mode of Exercise</th>
<th>Heart Rate (BPM)</th>
<th>RPE (OMNI) 0-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heart Rate Recovery (1 min upon completion)

Day 1 ________________ BPM
Day 2 ________________ BPM
Day 3 ________________ BPM

Recorded by ________________________________ Date____________
Week 4 – Stretching (PLACEBO or EXP)

<table>
<thead>
<tr>
<th>Day</th>
<th>Time (Mins/Secs)</th>
<th>Mode of Exercise</th>
<th>Heart Rate (BPM)</th>
<th>RPE (OMNI) 0-10</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heart Rate Recovery (1 min upon completion)

Day 1 ____________________ BPM
Day 2 ____________________ BPM
Day 3 ____________________ BPM

Six-Minute Walking Test ___________ Yardage

Recorded by ________________________________ Date ___________
APPENDIX E

Stretching Log
# Stretching Log (10 Total)

Subject’s Code # _______

Placebo ____ or Experimental____

## Week 2

<table>
<thead>
<tr>
<th>Type of Stretch</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck Bends</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder Pull</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palms Outstretch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side Bend</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waist Twist (15s each side)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calf-Stretch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadriceps (standing)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamstrings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle Circles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (mins/secs)</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

## Week 4

<table>
<thead>
<tr>
<th>Type of Stretch</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck Bends</td>
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</tr>
<tr>
<td>Overhead</td>
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<tr>
<td>Shoulder Pull</td>
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<tr>
<td>Palms Outstretch</td>
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<tr>
<td>Side Bend</td>
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<td></td>
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</tr>
<tr>
<td>Waist Twist (15s each side)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Calf-Stretch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quadriceps (standing)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hamstrings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankle Circles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time (mins/secs)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Recorded by ________________________________ Date____________
APPENDIX F

Stretching Hand-Out
REFERENCES


