Chances in Hip Range of Motion After a Phase II Cardiac Rehabilitation in Older Adults

Submitted by

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Changes in Hip Range of Motion after Phase II Cardiac Rehabilitation in Older Adults

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Abstract

There is literature supporting multiple benefits of cardiac rehabilitation; however, one area lacking support is if there is any increase in range of motion of the lower extremities after cardiac rehabilitation. There are multiple benefits of increased flexibility and range of motion of the hip, such as increased balance. The purpose of this study was to quantify changes in elderly hip range of motion (i.e. hip flexion) after six weeks of undergoing therapy in a phase II cardiac rehabilitation program. These results were then compared to those who did not participate in the rehabilitation process. Ten subjects (ages 55-79, mean = 65.40 ± 8.044) with a cardiac diagnosis above the age of 55 were tested. Two of the 10 subjects were not able to complete the study due to unforeseen circumstances. There were 7 subjects in the experimental group who underwent therapy in phase II of a cardiac rehabilitation program at MCO, and 1 subject who did not participate in the program. The results showed a statistically significant increase (p < .05) in hip range of motion, with the knee in flexion and extension, after cardiac rehabilitation. The results provided evidence to support that cardiac rehabilitation has an additional benefit of increasing flexibility and therefore range of motion. These increases may lead to additional benefits such as increased balance and decreased risk of falls.
Introduction

Cardiovascular disease (CVD) is the disease of the heart and blood vessels that is often caused by a narrowing of the blood vessels. This narrowing of blood vessels is often due to accumulation of plaque in the lining of the blood vessels. CVD is the leading cause of disability and death in the United States, resulting in more premature deaths than any other illness. Two principal components of cardiovascular disease are heart disease and stroke, which are the first and third leading causes of death in the United States, accounting for more than 40% of all deaths. About 950,000 Americans die of CVD each year, which amounts to one death every 33 seconds (1). Rehabilitation programs that target CVD have resulted in physical health benefits across a wide range of outcomes, depending on that patient’s adherence to the program (Rejeski et al., 2002). Cardiac rehabilitation is designed to reduce the disability rate and prevent repeated problems for people with CVD. As the number of CVD patients rise, the importance of enrolling patients in a rehabilitation program simply increases as well (Aggarwal A, Ades PA., 2001).

People with certain diagnoses are more appropriate for cardiac rehabilitation. These are patients who have experienced a myocardial infarction, coronary bypass surgery, percutaneous coronary revascularization, stable angina pectoris, valve replacement, and chronic heart failure (Aggarwal A, Ades PA., 2001).

About one fourth of people over 65 years have some symptoms related to coronary artery disease, a factor of CVD. This age group also accounts for two thirds of all myocardial infarctions. People over 65 years of age, account for more than 50% of the patients that undergo revascularization procedures (Aggarwal A, Ades PA., 2001). Since cardiovascular disease is the leading cause of morbidity and mortality among the older United States population it is vital that
these patients go through a cardiac rehabilitation program to help them lead a higher quality of life after their procedure.

Cardiac rehabilitation is a comprehensive, long term program that includes medical evaluation, risk profiling, educating and counseling, coronary risk factor modification by both nonpharmacological and pharmacological intervention, and supervised aerobic exercise training. It may consist of physical therapy, occupational therapy, and nursing. The goal of a rehabilitation program is to help patients with CVD resume their functional abilities and lead productive lives, within the limits they have gained by their disease (Leon AS, 2000; Joshi A, Kevorkian CG, 1997). Although cardiac rehabilitation programs traditionally focus on increasing a patient’s endurance, many cardiac rehabilitation programs also incorporate therapies to improve a patient’s overall strength and flexibility.

Independence in activities of daily living (ADLs) is a major concern of the elderly population. As a person ages their ability to stay independent, and perform all the necessary ADLs, decreases. Locomotor capability is an essential part of a person’s ability to function independently. Any type of restriction in the lower extremities may cause difficulty in locomotor activities such as walking, climbing stairs, and getting in and out of cars. With age it is evident that ROM does decrease (Mazzeo et al. 1998). Research by James and Parker 1989, indicate that as people age, and decrease their level of physical activity, the amount of mobility within their joints decreases (James B, Parker AW, 1989). As the amount of joint mobility decreases, so does the ability of a person to perform functional tasks, most importantly a safe and efficient gait.

One study in particular by Nolan, Rothman, and Nelson, 1996 looked at ankle dorsiflexion (DF) ROM in relation to falls in the elderly. This study had a sample size of 20 elderly subjects who were divided into a Fall group and a Non-fall group. Measurements of both
groups were taken and it was found that the means for DF, in the Fall group versus the Non-fall group were 36% and 43% less for the Fall group, right and left ankles, respectively. This study suggests that the decrease in DF may be a contributing factor of falls in women over the age of 59 years.

There have been studies that suggest participation in regular aerobic activity and stretching is an effective intervention to help reduce and prevent functional decline that is associated with age. Physical activity and stretching have been shown to increase the amount of joint mobility within the lower extremities (Mills EM, 1994; Mazzeo RS, et al., 1998). One study done by Mills suggested that regular aerobic activity and stretching has the potential to increase lower extremity joint mobility in the elderly (Mills EM, 1994). Although there have been studies that show that regular exercise can help to increase joint mobility within elderly adults, there have not been many studies that distinctly show that a cardiac rehabilitation program increases joint range of motion.

The purpose of this study was to quantify changes in elderly hip range of motion (i.e. hip flexion) after six weeks of participation in a phase II cardiac rehabilitation program. These results were then compared to those who did not participate in the rehabilitation process. It was hypothesized that there would be an increase in hip flexion over the six week period of time compared to the group who did not participate in the program.
Literature Review

Rehabilitation of the elderly with cardiovascular disease is a major public issue. Statistics show that the number of people over the age of 65 will more than double in the next 50 years; therefore, there will be an increase in the number of elderly with heart disease who are candidates for cardiac rehabilitation (Aggarwal A, Ades PA., 2001). Aging is a complex process that involves many changes within a person’s lifestyle and his/her physiological makeup. Those people within the elderly population, who suffer from cardiovascular problems, are characterized by high rates of disability. Disabilities include, but are not limited to, decrease in safety in ambulation, decrease ability to perform ADLs, and decrease ability to participate in social events all brought about due to physical limitations experienced from the disease. One characteristic that is seen to increase in the elderly population is their increased risk of falls. Falls can be physically detrimental, especially to this group who are at a higher risk of osteoporosis, weakened bones, and have less muscular strength. (Aggarwal A, Ades PA, 2001; Leon AS, 2000).

Participation in both aerobic and anaerobic exercise is safe, and both contribute to healthy aging. Cardiac rehabilitation includes both of these types of exercise. The program is focused on improving physical function and extending disease-free survival. It is effective for increasing the functional capacity, decreasing disease symptoms, and improving the quality of life for affected patients (Aggarwal A, Ades PA., 2001; Stewart K et al. 2003). In addition, exercise rehabilitation has a positive effect on many coronary risk factors, including hypertension and obesity (Aggarwal A, Ades PA., 2001; Stewart K et al. 2003).
Cardiac rehabilitation programs are usually divided into four phases. Phase I is during hospitalization, currently less than 1 week for an uncomplicated MI. Phase II is generally the first three months after hospitalization, and is usually conducted in a supervised outpatient facility. Phase III is late outpatient, still supervised, and either community or home-based. Phase IV is community-based, usually unsupervised, and is the lifetime maintenance phase (Leon AS, 2000).

The specific benefits that are attributed to exercise training, included in the rehabilitation process, are: improve functional capacity and exercise tolerance, improve cardiovascular efficiency, reduce thrombotic risk factors, improve coronary blood flow, reduce risk of cardiovascular disease, and improve psychosocial well-being (Leon AS, 2000, Mazzeo RS, et al., 1998). It is important for a patient to establish a baseline functional capacity prior to involvement in the program, because it will give valuable information about the progress throughout the duration of the program. It also gives information about what type of home activities will be safe to perform, exercise prescription, disability assessment, and prognosis (Leon AS, 2000).

A study by Rejeski et al. found that exercise is a valuable intervention for improving physical function of older adults with CVD, and those with an increased risk for CVD. This study involved over 140 males and females between the ages of 50 and 80 years. Each person had a cardiac problem. The results of this study suggested the older cardiac rehabilitation clients, having a lower physical function and greatest risk of falling, achieved the greatest short-term benefit from organized physical activity compared to those coming into the program with a higher physical function, and a lower risk of falling. The study showed that the greatest benefit
of the cardiac rehabilitation was in the first three months of treatment, compared to the benefits
acquired in later months (Rejeski et al., 2002).

Although the increase in aerobic activity, and the benefits of it, greatly contribute to the
increase function of the patient, additional factors may affect whether the patient is able to fully
regain an active lifestyle. Joint range of motion is one such factor. The literature suggests that, as
a person ages, there is a significant decline in the range of motion within the joints (James B,
Parker AW, 1989; Mazzeo et al. 1998). The range of motion of a joint depends on the bone(s)
that make up the joint, muscles around the joint, and connective tissue structure and function.
Other factors, such as pain and the ability to generate muscle force, also contribute to the amount
of range of motion within a joint. Aging does show a decrease in the range of motion within
joints. Joint range of motion has been shown to decrease with aging. ROM tends to decline
throughout the life span due to age-related changes in the mechanical properties and morphology
of joint structures (Mecagni, 2000). Aging results in an increase in the crystallinity of collagen
fibers, as well as increases the fibers’ diameter, which reduces the extendibility. The maximum
range of motion occurs in the mid- to late twenties for men and women, respectively (Mazzeo

According to James and Parker, active and passive ranges of motion within the hip, knee,
and ankle all showed a consistent reduction as a person aged. The decline in ROM became more
evident during the ninth decade of life, and on average women were more mobile than men in
most of the ranges of motion that were measured (James B, Parker AW, 1989). James and Parker
also indicated that the decrease in joint mobility that occurred with age might occur as a function
of the reduced physical mobility of the elderly.
A decrease in range of motion of joints, especially of the lower extremities, within the elderly population is one of the causes of the decrease in their health status, functional ability, and quality of life. Research by Mecagni et al. that suggests that ankle range of motion is associated with the maintenance of balance during ambulation. With a decrease in range of motion of the ankle compensations may have to be made that cause a person to have an inefficient and unsafe gait (Mecagni C et al., 2000). Another study done by Gehlsen and Whaley 1990 stated that decreased hip and ankle range of motion is related to the number of falls that occurred within the elderly population. Those people who participated in the study that had a significant history of falls showed lower values of ranges of motions at the hip and knee than those participants with no history of falls (Gehlsen GM, Whaley MH, 1990). Both of these studies demonstrate that range of motion within the joints, especially of the lower extremity, are important in the prevention of falls. Not only will the increase in range of motion prevent falls, but it will also help to prevent musculoskeletal injuries, such as strained muscles.

Exercise intervention, which has a purpose to improve flexibility, does so by improving the muscle and/or connective tissue properties, reducing joint pain, and/or changing the muscle recruitment patterns (Mazzeo RS, et al., 1998). There is evidence that shows that exercise can help to reduce the incidence of falls and maintain physical function in the elderly. In a study done by Lord et al. two hundred eighty subjects were randomized to a group exercise (GE) group and went through a series of exercises, mostly weight-bearing exercises. There were other groups, combined controls groups (CC), in which the subjects did not participate in the exercise program. Overall there were 22% fewer falls within the GE group than the CC group (Lord S, et al., 2003). This study supports the study done my Mecagni et al., which indicated decreased range of motion in the ankle is a risk factor for decreased balance, resulting in falls (Mecagni C
et al., 2000). However, interventions that include flexibility training show a reduction in the number of falls.

Accidents are the sixth leading cause of death in people over the age of 65 years, and falls account for two thirds of these deaths. Falls also account for the majority, about 40% of traumatic injuries that occur in the elderly (Steinweg KK, 1997). Since age does cause a decrease in the range of motion within joints, and a decrease in range of motion causes a decrease in one’s ability to balance it is important to maintain the range of motion within joints as a person ages to reduce the risk of falls. Elderly who have gone through surgery, or have cardiac problems, are more likely to become more sedentary if they are not involved in an exercise program. This sedentary lifestyle will cause an even greater decrease in the ranges of motion within the joints, than those decreases that are just associated with the aging process. Although falls are common within the elderly there is much that can be done to prevent future falls, and reduce further injury (Steinweg KK, 1997).

It is estimated that by the year 2030 the number of individuals 65 years and older will reach 70 million in the United States. At this time the people 85 years and older will be the fastest growing portion of the population (Mazzeo et al., 1998). As the number of people within the elderly population grows, it is important to determine the extent and means by which physical activity can improve independence and quality of life. Phase II of the cardiac rehabilitation program involves different types of physical activities. Therefore, it is important to determine all the benefits of this program, and how they will help the patient become more functional.

Cardiac rehabilitation programs, mostly in phase II of the program, normally include low intensity aerobic exercise in combination with stretching activities. After the involvement of this
portion of the program it was hypothesized that the individuals would have an increase in range of motion of the hip joint in flexion. There have not been any studies that have specifically looked at this aspect of cardiac rehabilitation. As discussed above, lower extremity range of motion is critical for a person’s, especially elderly person’s, balance and reduction of risk of falls. Therefore, research is needed in this area to demonstrate another potential health benefit of a cardiac rehabilitation program, more specifically phase II of the program.

Methods

Study Design

The design of this study included a pre-test and a post-test. It was a quasi-experimental design. There was one experimental group and one control group. The subjects self-selected their groups, either the experimental or control, based upon their decision regarding whether or not to enroll in Phase II of the cardiac rehabilitation program.

Variables and Outcome Measure

The independent variables of this experiment were the participation in the Medical College of Ohio’s phase II cardiac rehabilitation program, with two levels: a control group that did not participate and an exercise group that did participate, and time (i.e. pre and post test). The dependent variables were passive range of motion of each subject of hip flexion. Confounding variables may have included each subject’s level of physical activity prior to the involvement in the program, major differences in age among those subjects involved in experimental group compared to the control group, and each subjects diagnoses and purpose of being involved in the
rehabilitation program. The primary outcome measure in this study was the changes in the hip joint flexion range of motion.

Subjects

Subjects in this study were recruited from the Medical College of Ohio’s cardiac rehabilitation clinic. The investigator verbally requested participation in the study after explaining the procedure of the study. The subjects were both male and female ages 55 years and older. All subjects had a history of a cardiac problem, and had been assessed to ensure their involvement in the program is safe. The experimental group included those subjects participating in a cardiac rehabilitation program at the Medical College of Ohio. The control group included those subjects who chose not to be involved with the cardiac rehab program. Subjects were asked to read and sign a written informed consent form before participation in the study.

Exclusion criteria included any person who was pregnant, persons with a lower limb amputation, non-ambulatory persons, persons who did not understand the risks involved, and persons who were under the age of 55.

There were 8 subjects in the experimental group; however one of those 8 subjects was discharged from the study secondary to moving out of the area. There were 2 subjects in the control group; however 1 of those 2 was removed secondary to she was not present at the final measuring of her hip ROM.
Instruments

One twelve-inch universal goniometer was used to measure the range of motion at the hip joint for flexion (Sammons Preston, Bolingbrook, IL). The standard goniometer is an acceptable tool to measure joint ROM (Norkin & White, 2003).

Studies by Enwemeka and Gogia have determined that goniometric measurements of the lower extremity show criterion-related validity. This was done by comparing goniometric measurements with measurements taken on radiographs (Gogia et al., 1987; Enwemeka, 1986). In addition, goniometric measurement was shown to have high intratester reliability. In a study by Pandya et al., passive range of motion measurements were taken for upper and lower extremities. It was shown to have high intratester reliability with an ICC ranging from 0.81-0.94 (Pandya et al., 1985).

The tester established reliability of measuring hip range of motion with the goniometer with the ICC.

Procedures

The participation of the subjects was verbally requested from patients at the Medical College of Ohio. If patients agreed to participate, the study was then explained to them while they were in the cardiac rehabilitation clinic. The subjects were also asked to read and sign a written informed consent. Based upon the subject’s decision to participate in the phase II of the cardiac rehabilitation program or not, decided whether they were in the control or experimental group.

After the subjects agreed to participate in the study, and reviewed and signed the written informed consent form, the investigators set up a time for the first session. In this session the
initial measurements of the hip were taken, and this measurement was the subject’s baseline measurement. Bilateral passive range of motion was taken for hip flexion, using a standard 12 inch goniometer. The procedures to take the range of motion measurements are described by Norkin and White (Norkin & White, 2003). Subjects were also asked to provide their age, gender, height, weight, and cardiac diagnosis at that time. All sessions of this experiment were located in the MCO’s cardiac rehabilitation clinic.

    Hip flexion occurs in the sagittal plane around a medial-lateral axis. To measure hip flexion, the subject was asked to lie in a supine position (i.e. on his/her back) on a plinth, with his/her knees extended, and both hips in 0 degrees of abduction, adduction, and rotation. The investigator first asked the patient to perform active hip flexion to allow the investigator to observe how much hip flexion occurs, as well as any compensations that may have been apparent. The investigator then passively flexed the subject’s hip. As the hip was flexed the knee was also allowed to flex passively during the motion to lessen the tension in the hamstrings muscles. The flexion of the knee in this measurement was to eliminate tight hamstrings that may have limited the range of motion at the hip. The subject’s pelvis was stabilized to prevent posterior titling or rotation. The contralateral lower extremity was flat on the table in the neutral position to provide additional stabilization.

    Passive hip flexion was taken a second time with the patient’s knee extended. This measurement took into account the tension within the hamstring muscles (Norkin & White, 2003). There were a total of three measurements taken for hip flexion with the knees extended, and three measurements taken for hip flexion with the knees flexed. The average of the three measurements for each movement was then recorded.
For hip flexion the fulcrum was placed over the lateral aspect of the hip joint; the greater trochanter of the femur will be used as a reference. The proximal arm of the goniometer was aligned with the lateral midline of the pelvis. The distal arm was aligned with the lateral midline of the femur; the lateral epicondyle was used as a reference here (Norkin & White, 2003).

After the first assessment of the subject, he/she began phase II of the cardiac rehabilitation program. All subjects followed the Medical College of Ohio Next Step Cardiac Rehabilitation program. In this phase of cardiac rehab patients were involved in a variety of physical activities and educations programs.

Patients came to the program 3 times a week for 12 weeks, equaling about 36 sessions. Each session consisted of about 15 minutes of warm up, 30 minutes of cardiovascular conditioning, and another 15 minutes of stretching and cool-down. Patients participating in the rehabilitation program are divided into three groups, which determine their exercise intensity. The three intensity groups are described in Table 1. As patients progress they would work at higher intensities. Most patients, before starting the program, undergo a cardiopulmonary exercise (CPX) test. Based on the results of the CPX tests the patients would work within a percentage of their Heart Rate Range (HRR) or a percentage of their maximum MET levels.
Table 1

<table>
<thead>
<tr>
<th>% of MET level or HRR</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>participants</td>
<td>-Older Adults (70 yrs and older) - patients with CHF - patients with a LVEF &lt;30%</td>
<td>-50-60 years old - MI - PTCA - Stent - CABG - AVR (aortic valve replacement)</td>
<td>- patient did NOT have MI - chest pain that lead to PTCA or stent - usually younger patients</td>
</tr>
</tbody>
</table>

HRR= heart rate range, MI= myocardial infarction, CHF= congestive heart failure, LVEF= left ventricular ejection fracture, PTCA= Percutaneous Transluminal Coronary Angioplasty

Each time a patient went to a rehabilitation session his/her heart rate, blood pressure, heart rhythm, and weight were all taken before any physical activity or education. Patients were encouraged to maintain their independency by taking their own heart rate, weight, and recording when they finished each assigned physical activity. The program consisted of different aerobic activities such as walking around a track or on a treadmill, rowing on an ergometer, riding on a stationary bike, and using a NuStep TRS 4000. Other activities included stretching and breathing exercises. Patients in this program were also involved in education and counseling on different subjects such as exercise, nutrition, stress management, and knowledge/ risk factors of heart disease.

After 6 weeks from the initial assessment the subjects were then reassessed on their hip ROM following the same procedures as discussed above.

Data Analysis

Descriptive statistics were used on the demographic data of age, height and weight. The two dependent variables include the measures of hip flexion with the knee flexed (HIPF) and hip flexion with the knee extended (HIPE). The two independent factors were the factor of time
(i.e., pre and post test) and the factor of group membership (i.e., experimental and control). The data was analyzed with Paired Samples T-Tests. The p value was set at .05.

The research hypothesis for each dependent variable was that the experimental group will have shown a greater rate of change in hip range of motion compared with the control group. In addition, it was expected that both groups would have been equivalent at pre-test.

Results

Table 2 provides demographic information regarding the participants of the study. There were 10 subjects who started in the study, however due to unforeseen circumstances only 8 were able to complete the study. There were 7, 2 female and 5 male, subjects in the experimental group and 1 female subject in the control group. All subjects had a cardiac diagnosis, including one of the following: coronary artery bypass surgery, diastolic dysfunction, atrial fibrillation, stable angina, PTCA, or heart transplant.

<table>
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<tr>
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<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
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<tr>
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<td>6</td>
<td>18</td>
<td>15.29</td>
<td>4.31</td>
</tr>
</tbody>
</table>
A paired T-test was done to compare right and left hip range of motion with both the knee flexed and the knee extended. There was no significant difference between right and left; the results shown of hip flexion with both the knee flexed and extended are of the right hip. One tailed Paired T-tests were performed secondary to the expected increase in range of motion.

One T-test was done to compare pre and post-test of the hip with the knee flexed and one with the knee extended. There was a significant difference in pre and post test of hip flexion with the knee flexed (p < .05), as well as with the knee extended (p < .05). Figures 2 and 3 show mean measurements of hip flexion with knees flexed and extended over time.

Figure 2

![Changes in Hip Flexion with Knees Flexed in EG](image)
Since there was only one control subject in the study only the raw data of changes in hip range of motion can are given for the right hip. The subject had a pre hip flexion with knees flexed measurement of 92 degrees, and a post measurement of 88 degrees. The subject had a pre hip flexion with knees extended measurement of 52 degrees, and a post measurement of 52 degrees.

Discussion

The expected results of this study were supported by the results of the data collected. There was a significant increase in range of motion of subjects with hip flexion after 6 weeks of cardiac rehabilitation with the knees in both flexion and extension, compared to the subject who did not participate in cardiac rehabilitation. Although there was only one control subject the raw data showed there to be no increase in range of motion over a 6 week period of time.
The average gain in hip flexion with the knees flexed was about eight degrees; and with the knees extended the average gain in motion was about 17 degrees. This increase in range of motion is significant and may be beneficial for the subjects. Most of the gain in range of motion is more than likely due to an increase in hamstring flexibility, achieved through active use of the muscles as well as stretching.

All subjects in this study were ages 55 and older. A decrease in range of motion of joints of the lower extremity within the elderly population is one of the many causes of a decrease in health status and functional ability. Since the population is aging and people are living longer there will be an increase in individuals with CVD, therefore increasing the number of participants in cardiac rehabilitation programs. Research supporting all the benefits of cardiac rehabilitation programs is important. This study did support the fact that through phase II of cardiac rehabilitation, subjects were able to increase their hip range of motion.

A study by Gehlsen and Whaley 1990 stated that decreased hip and ankle range of motion is related to the number of falls that occurred within the elderly population. Because adequate range of motion of the lower extremity joints is important, this increase seen after 6 weeks of participation in cardiac rehabilitation is beneficial to patients. It allows them to have better balance and safer ambulation, decreasing their risk of falls.

Research supporting benefits of cardiac rehabilitation that reduce the risk of cardiovascular disease has been conducted (Aggarwal A, Ades PA., 2001; Stewart K et al. 2003). This study was unique in that it looked at an aspect of cardiac rehabilitation that has not been looked at before, its effect on range of motion at the hip. In addition to the positive effect on coronary risk factors, such as hypertension and obesity, this study supported another benefit a
cardiac rehabilitation program may offer. The increase in hip range of motion has the potential of further benefiting its participants.

Participants of the cardiac rehabilitation program at MCO did not spend a great deal of time stretching their hamstrings at each session. Unless the participants performed the stretched on their own, they engaged in the stretching part of the program for the last 10-15 minutes of their time in the clinic. The cool down at the end of the session included stretching of all muscle groups, and did not target the hamstring muscles. However, an increase in flexibility can, and was, still achieved through the increased active use of the muscles by the cardiovascular exercises performed in the rehabilitation program, in addition to the stretching.

**Limitations of the Study**

There were a small number of subjects in the experimental group, as well as only one subject in the control group. Because of the small sample size it limited the power of this study. In the future it is suggested that there be an increased number of subjects in both the experimental and the control groups. In addition there was only one male in the control group, so the results may not accurately represent female outcomes. The majority of subjects in this study were Caucasian, and the results may not be representative of other races.

Another limiting factor was that the level of activity prior to entry into the study was not assessed. This may have been limiting because those subject who were more active may have already had more range of motion in their hip and had little room to increase. In future studies it is suggested that subjects take a survey on prior level of activity before entering into the study.
This study did not follow up on the patients to see if they did have a decreased risk of falls. It is suggested that future studies determine if the subjects were at risks for falls or had a history of falls prior to admission into the cardiac rehabilitation program, as well as follow-up after the 6 weeks of the program to determine if the patients had less of a risk of falls.

**Conclusion**

It was supported in this study that increases in hip range of motion can be achieved in phase II of cardiac rehabilitation. Most of the gain in range of motion is more than likely the cause of an increase in flexibility of the hamstring muscles. The increase in range of motion is another potential benefit of a cardiac rehabilitation program. With an increase in range of motion within the hip joint a person is more likely to have better balance, and safer ambulation. Safer ambulation will decrease the number of falls within the elderly population, therefore decreasing injuries for the population.
References

(1) http://www.cardiovascular-disease.org/