

A STUDY OF THE MOTIVATIONAL MECHANISMS OF  
CARDIAC REHABILITATION PATIENTS

by

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A THESIS

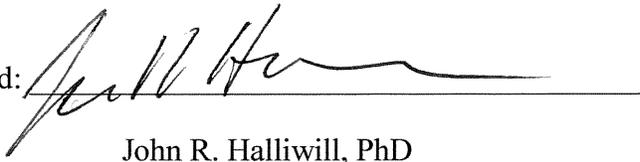
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## **An Abstract of the Thesis of**

Samuel McNeilly for the degree of Bachelor of Science  
in the Department of Human Physiology to be taken November 2015

Title: A Study of the Motivational Mechanisms of Cardiac Rehabilitation Patients

Approved:   
John R. Halliwill, PhD

**Background:** Cardiac rehabilitation is an ever growing field that provides patients the opportunity to regain function following a cardiac event or diagnosis. These programs vary in patient care and practices, and the effectiveness of these programs is clearly documented. However, there is little documented research involving the motivations of patient behaviors that influence the effectiveness of these services.

**Method:** 14 (10 male and 4 female ages  $60.5 \pm 11.6$  years) current cardiac rehabilitation patients who had a formal diagnosis of coronary artery disease were interviewed using a set of open-ended interview questions in a behavioral-based interview.

**Results:** Participants associated their personal success under three mechanisms: a sense of improved personal wellbeing, positive social environment, and perceived safety. Having observable indications of improvement gave patients an objective visualization of their progress. This allowed patients to gauge their own self improvement, thus leading to motivation. In order to create a positive social atmosphere, interactions between patient-patient and patient-therapist must be created. By observing other patient's success, and with constant support through staff

interactions, patients are able to find confidence within themselves and with the recovery process. Lastly, patients needed to believe that they were in the safest possible environment in order to have the self-assurance to push themselves beyond what they believed their own personal limits were. By monitoring patients, either with an electrocardiogram monitor or by staff presence, patients felt a sense of increase physical safety which allowed them to focus on healing.

**Conclusion:** There is always room for improvement, however patients that were interviewed found this program to be fully adequate for their personal healing processes. The research concluded that current thought processes behind current treatments are more than sufficient in being able to rehabilitate patients after a cardiac event. Further research regarding improved in-patient and maintenance phases may be considered to further understand motivations for beginning and continuing after a monitored phase respectively.

## **Acknowledgements**

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## **Introduction**

### **Cardiac Rehabilitation**

Cardiac rehabilitation was first introduced in 1772 when physicians prescribed routine physical work, such as wood chopping, to patients with complaints of chest pain (Mampuya). Modern cardiac rehabilitation owes its thanks to President Dwight Eisenhower's physician, Dr. Howard Snyder, who prescribed routine exercise for the president after he suffered a myocardial infarction in 1955 (Williams and Health). Over time cardiac rehabilitation has progressed and integrated itself into modern medical care all over the world.

#### *What is Cardiac Rehabilitation?*

Cardiac rehabilitation is defined as a program designated to give patients the opportunity to recover from any acute cardiac event or to manage any chronic cardiac condition. Cardiac rehabilitation is a combination of two things, the first being prescribed exercise and the second being educational resources. Cardiac rehabilitation programs work to improve the functional capacity of each patient by serving to regain the patient's strength, both mentally and physically, and provide resources to identify personal risk factors in order for patients to make lifestyle changes to prevent future cardiac incidents. "The ultimate goal of cardiac rehabilitation is to restore and maintain an individual's optimal physiological, psychological, social, and vocational status" (Balady et al.).

### *Program Structure*

At the core of every cardiac rehabilitation program are three central components: 1) exercise training and activity prescription, 2) risk factor modifications, and 3) psychosocial and vocational evaluation and training (Balady et al.).

There are three phases to every program, although they may be named differently, they all have the same fundamental definition. Phase I, which is sometimes omitted from programs, is the inpatient portion. Clinicians work with patients during their admittance to the hospital by ambulating around the hospital hallways and discussing proper at home care once at discharge. This is the time when the majority of patients will have their first encounter with cardiac rehabilitation, which makes it crucial for developing an early relationship with patients. Unfortunately, this may be the only time patients will have any formal cardiac rehabilitation, as only twenty percent of eligible patients will attend a formal Phase II program (Esposito).

Phase II, or monitored care, typically begins two to four weeks after discharge. Patients wear a wireless electrocardiogram device that a rehabilitation therapist will use to monitor their activity during their appointment. During phase II, there is an assessment of risk and prescription of exercise for in-clinic and at home. The assessment of risk includes an education series that reviews the risk factors of coronary artery disease, education on their condition, and examples of how they can make lifestyle changes. Each program differs in what education they offer, but many include heart anatomy, medications, risk factors, and nutrition education courses (Williams and Health). Programs may also staff a certified dietitian that patients can consult with their questions regarding nutrition and be given a personalized meal plan.

Some program regimens include rotational exercises in which a patient spends fifteen minutes on one exercise, before proceeding to the next, and so on until they have completed a forty-five-minute program. Such centers may have patients come in for appointments more often, focusing on in-clinic exercise as opposed to building a home based plan. The program at the Oregon Heart and Vascular Institute focused on a once a week, aerobic intensive regimen. Each patient maintained one activity for approximately thirty minutes with an incorporated warm-up and cool down; reaching aerobic peak half-way through their exercise. During an appointment, the patient was prescribed an at home program based on their in-clinic performance and the equipment they have access to outside of the clinic. For many patients this was simply walking, however for others, weight lifting, water aerobics, and/or cycling were prescribed. At home exercises were prescribed in order to teach patients how to manage their lifestyle outside of the clinical environment, so that they have the tools necessary to continue their recovery process once they graduate from the program.

Phase III, or the maintenance phase, begins right after phase II is complete. This phase is voluntary, and is paid for by the patient; insurance providers have yet to subsidize Phase III costs. It begins with prescribed home based exercise that the patient can gradually build on as they regain strength and begin to feel comfortable with their condition. Many programs offer an in-clinic phase III, such as a gym, that is monitored by a staffed clinician who is available to answer questions and respond to any emergencies that arise. Some programs also offer classes for patients who are in phase III that may include tobacco cessation, tai chi, yoga, and cycling.

# Anatomy and Function of the Heart

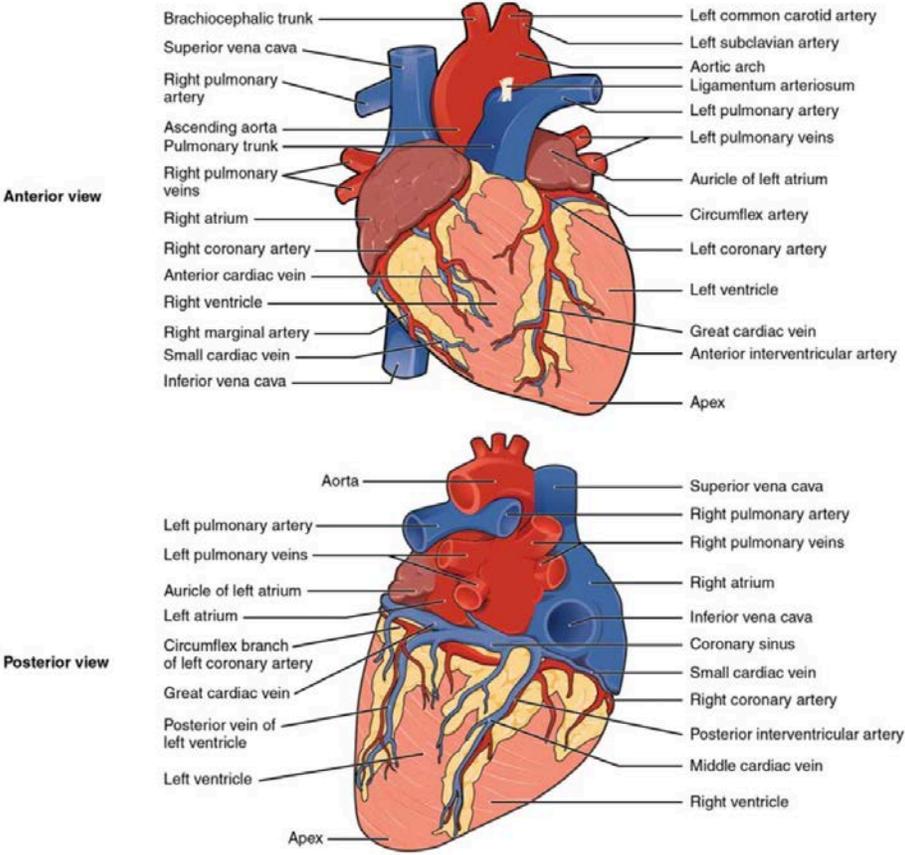


Figure 1: Exterior heart anatomy

The heart is a pump that contracts and relaxes in a rhythm that is set by the amount of work the body is doing at any given time. The heart is made up of muscular tissue with a custom electrical system that allows for the superior chambers of the heart to contract and relax before contraction of the inferior chambers. The right side of the heart pumps blood to and from the lungs to remove waste from the body. The blood is oxygenated within the lungs and then rejoins the heart on the left side where it is pumped outward to the body tissues through an intricate network of vessels. The heart works in a rhythmic succession referred to as *cardiac rhythmicity*. Cardiac rhythmicity is a unique system that keeps the heart contracting and relaxing in a synced rhythm. If

the heart loses its sync, it is called an *arrhythmia*, and although they tend to be benign, severe cases can be lethal.

The *cardiac cycle* refers to the cardiac events that occur from the beginning to end of one heartbeat. There are two stages within the cardiac cycle, *systole* and *diastole*. The stage of contraction is referred to as systole and the stage of relaxation, diastole. The relationship between the cardiac cycle and heart rate is inverse; as heart rate increases, the cardiac cycle duration decreases or as heart rate decreases, the cardiac cycle duration increases.

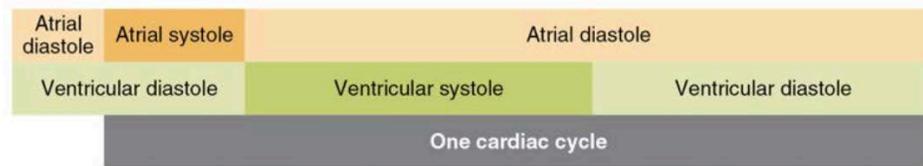


Figure 2: Cardiac Cycle

One complete cardiac cycle includes both atrial and ventricular systole and diastole. Figure 2 shows the different stages of one cardiac cycle. The duration of diastole can be significantly modified by neurological impulses as the body recognizes a need for an increase in blood supply to one area of the body.

At rest, the heart is in diastole for longer durations due to a lower tissue demand for oxygen. The reverse is true when our bodies are excited, such as with exercise or an emotional response. During periods of excitation, diastole duration decreases allowing for more frequent systole so that tissues can receive the required amounts of blood for function. Normal *resting heart rate* for any given individual is between 60 and 100 beats per minute, or bpm. If an individual's resting heart rate is less than 60 bpm, they are in *bradycardia*. This may not be of concern as many athletes are in chronic bradycardia because of their intensive physical training. If an individual's resting heart

rate is higher than 100 bpm, they are in *tachycardia*. When an individual is in chronic tachycardia, the pressure put on their heart is much greater and may result in the need for intervention. However, if an individual has gone through a heart transplant, their resting heart rate will remain at or above 100 bpm as they have no innervations to their heart (DiNardo).

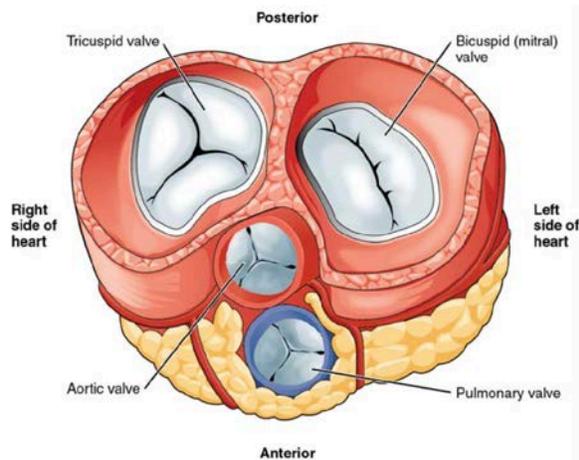


Figure 3: Transverse dissection

Transverse dissection of the heart to illustrate the anatomical placement of the heart valves

Figure 2 shows one cardiac cycle beginning with ventricular diastole. During ventricular diastole, the atria are being filled with blood via the superior and inferior vena cava on the right and the pulmonary veins on the left. Once the pressure within the atria is great enough, the *atrioventricular valves* open allowing for passive and active blood flow between the atria and ventricles. Blood flow between the chambers occurs in three stages. During the first two-thirds, eighty percent of the atrial volume passively flows into its respective ventricle. The final third is pumped into the ventricles during atrial systole. Atrial systole acts as a primer pump when it ejects an additional twenty

percent of its contents into the ventricles. Due to this characteristic of the atria an individual may function normally without knowing they have atrial complications because the atria have the ability to pump 300 to 400 percent more blood than is required by a resting body.

The atrioventricular valves, or AV valves, consists of the mitral and tricuspid valve and work to keep blood from flowing back into the atria after it is pumped into the ventricles. The AV valves open depending on the amount of pressure produced by the atria. In order to help keep the AV valves from regurgitating any blood during ventricular systole, the *papillary muscles* and *chordae tendineae* work to keep the valves closed (Guyton and Hall). If the papillary muscles or chordae tendineae become deconditioned or damaged, valve regurgitation will occur under the powerful forces of ventricle systole. Minor cases of valve regurgitation may require no medical intervention, however serious cases may cause the heart to work harder putting unintended stress on the heart muscles leading to a weakened heart.

Before the ventricles can contract, they experience isometric contraction. This is when the ventricles build up pressure within milliseconds prior to systole. Once the pressure within the ventricle is great enough, the *semilunar valves* are forced open. Once the semilunar valves open, the period of rapid ejection begins in which eighty percent of the blood volume is pumped out towards the body. During the final two thirds of the ejection, referred to as slow ejection, the final twenty percent is ejected. Once the pressure in the aorta and pulmonary artery is greater than that of the ventricles, the semilunar valves snap shut and the ventricles begin diastole (Guyton and Hall).

The semilunar valves consist of the aortic and pulmonary artery valves. They work to prevent backflow from the aorta and pulmonary artery. The tissue of these valves is malleable, yet very robust in order to withstand the forces produced by ventricular systole. Instead of the passive open and closing that the AV valves endure, the semilunar valves snap open and close based on the pressure relationship between the ventricles and their respective vessels. The semilunar valves are also less wide at their opening than those of the AV valves, which puts even greater pressure and mechanical force on their structure causing them to wear down with time. The semilunar valves are therefore more likely to be replaced with age (Guyton and Hall).

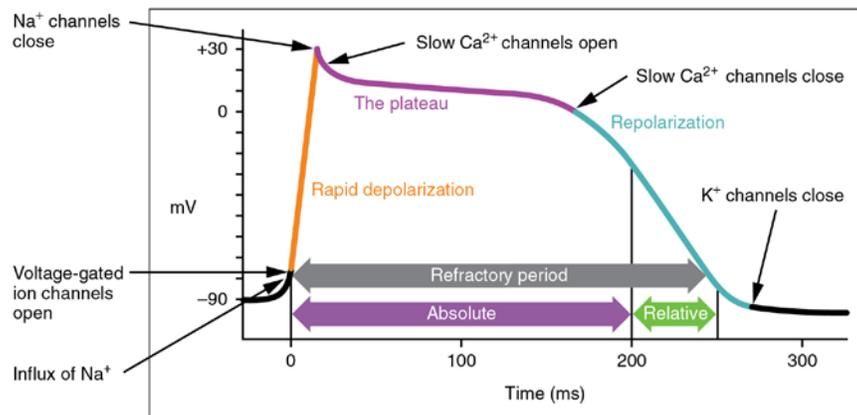


Figure 4: Cardiomyocyte Action Potential

To note, there is a plateau phase that is unique to cardiomyocytes. This insures a complete cardiac cycle without a premature start to a new cycle.

**Cardiomyocytes**, or muscle cells, are either resting or active depending on their membrane potential. When a cardiomyocyte is at rest, it is polarized and has a negative membrane potential. When the electrical signals reach the cardiomyocyte, voltage-gated ion channels open causing rapid depolarization of the cell brought on by a rapid influx of positively charged ions.

In order to properly pump blood, cardiomyocytes have an extended refractory period not seen in other types of muscle cells. This keeps the heart from prematurely contracting out of its cardiac rhythmicity. This insures that the heart has completely pumped the necessary amount of blood between chambers and the body before continuing to the next cardiac cycle.

An adult heart has the ability to generate its own electrical impulses via the heart's electrical conduction system. There are five main components of the cardiac conduction system which are the sinoatrial node, the atrioventricular node, the atrioventricular bundle, the atrioventricular bundle branches, and the Purkinje fibers.

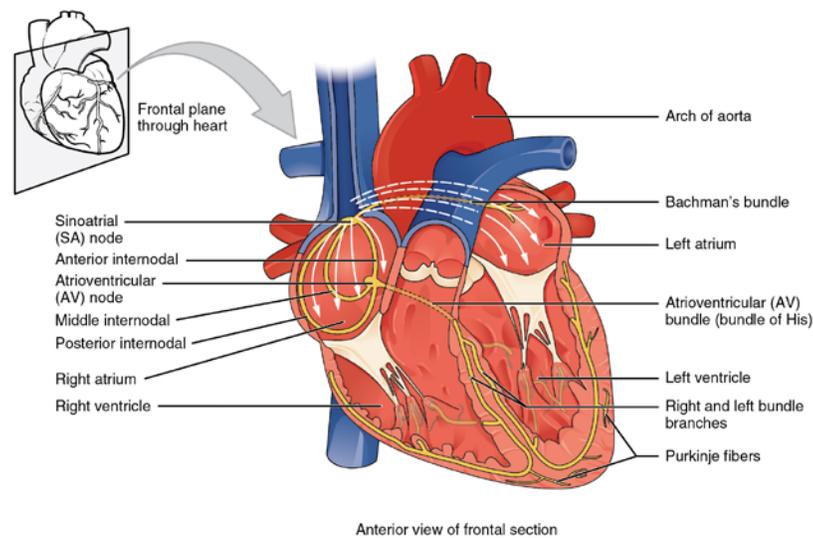


Figure 5: Conduction system anatomy

Located in the superior posterolateral wall of the right atrium, the *sinoatrial node* establishes the electrical signal that is responsible for the contraction force and rate of the heart. The sinoatrial node is commonly referred to as the pacemaker of the heart because it has the highest rate of depolarization and therefore initiates the sinus rhythm of the heart. The electrical impulses spread from the sinoatrial node through the

atria and towards the atrioventricular node via the internodal pathways. There are three internodal pathways: anterior, middle, and posterior that all transport the electrical impulse through the atria and towards the atrioventricular node.

Located in the posterior wall of the right atrium immediately behind the tricuspid valve is the *atrioventricular node*, which is responsible for ventricular contractions. The atrioventricular node is positioned within the *atrioventricular septum* which prevents the electrical impulses from spreading directly to the ventricles. This allows for a 0.1 second pause between atrial and ventricular contractions, which allows the atrial cardiomyocytes to fully contract and discharge all of their contents into the ventricles.

Once the electrical impulse has passed through the AV node, it travels across the interventricular septum via the *atrioventricular bundle* before dividing between the left and right atrioventricular bundle branches.

The *Purkinje fibers* extend from the apex to the base of the heart. The contraction allows a the squeezing movement that moves blood away from the apex towards the aorta and pulmonary arteries and out to the body

“This rhythmical and conductive system of the heart is susceptible to damage by heart disease, especially by ischemia of the heart tissues resulting from poor coronary blood flow. The effect is often a bizarre heart rhythm or abnormal sequence of contraction of the heart chambers, and the pumping effectiveness of the heart often is affected severely, even to the extent of causing death.” (Guyton and Hall)

### **Cardiac Diagnostics and Procedures**

There are several types of cardiac complications that can be diagnosed. Some are preventative diagnoses that can be treated with medications and therapy, while

others may require invasive treatments. Whether simply treated with medicines, or a complex open heart surgery, cardiac rehabilitation can help acclimate a patient on how to live with their new condition and prevent further injury to their heart.

### *Electrocardiogram Basics*

During a monitored clinical visit, a patient is wirelessly connected to a computer system that monitors their live, *electrocardiogram*, or ECG. An ECG is a vital piece of information for the rehabilitation therapist to monitor the health of a patient's heart after they have been diagnosed with coronary artery disease. An ECG can show if the heart is beating at an appropriate rate, rhythm, and form. Each patient is different, and this is why it is important for the rehabilitation therapist to make the effort to know each of their patient's condition while interpreting their ECG.

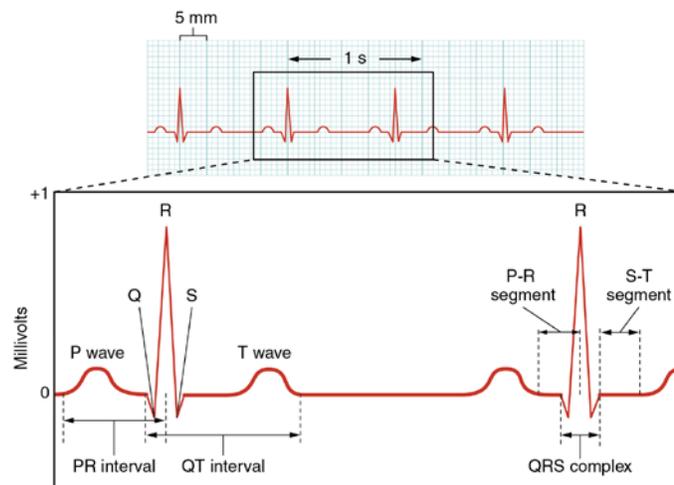


Figure 6: Electrocardiogram

Each patient has a distinct ECG that is produced by their heart's electrical system, Figure 6 depicts an ECG pattern without abnormalities.

An ECG is a pattern built from wave forms that express the electrical current running through the heart as millivolts over a period of time. There are five waves that

are expressed on an ECG; the P, Q, R, S, and T waves. Each wave has a distinct physiological process that it represents during the contraction of the heart muscle.

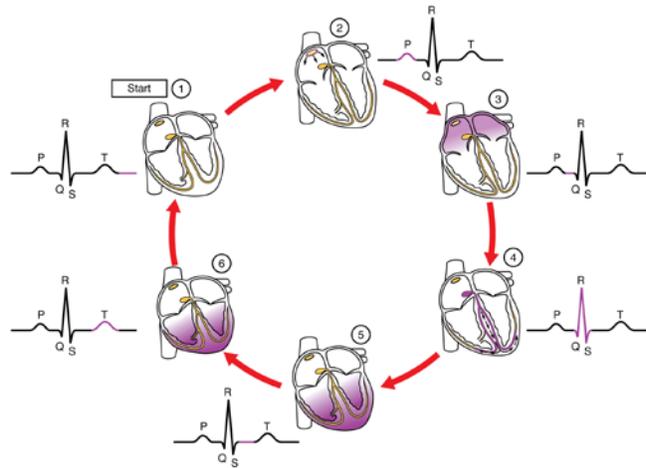


Figure 7: Electrocardiogram as related to the cardiac cycle

An ECG creates a storyline of a patient's heart beginning with the electrical impulse that originates from the sinoatrial node (Figure 7: segment 1). The **P wave** (Figure 7: segment 2) represents atrial depolarization as the electrical signal moves from the SA node towards the AV node. The period of time between the P and R waves is referred to as the PR interval (Figure 7: segment 3), and is the measure of time that it takes for the electrical signal to travel from the sinoatrial node to the atrioventricular node. The Q, R, and S waves are commonly referred to as the **QRS complex** (Figure 7: segment 4) and represents ventricular depolarization. The period of time that the ventricles are depolarized and repolarized are represented by the ST segment (Figure 7: segment 5) and the **T wave** (Figure 7: segment 6) respectively.

### *Stable Angina Pectoris*

**Stable Angina** is a chest pain caused by a lack of blood supply to the **myocardium**. It occurs when blood flow diminishes to the muscle tissue of the

myocardium, which is caused by a narrowing or blocking of a coronary artery. Angina should not be confused with heartburn, lung infection, or lung inflammation as these are separate diagnoses. Angina is specific to pressure, fullness, and/or squeezing caused by the heart muscles attempting to acquire adequate blood supply (Chen, “Stable Angina”).

Patients are likely to feel angina when the heart is under greater stress than normal such as during exercise. The pain is relatively short, lasting approximately five minutes, and may feel as if it is spreading from the chest to the arms and back. Angina can be treated with rest and/or the use of nitroglycerin, however serious cases may result in hospital admittance. Angina is a symptom of heart disease, and as such, is taken seriously at cardiac rehabilitation centers (Chen, “Stable Angina”).

#### *Chronic Heart Failure*

**Chronic heart failure**, or CHF, is a result of a heart that is unable to pump blood to body tissues as well as it should. This may be caused by narrowing of the coronary arteries, such as with a coronary artery disease, or high blood pressure that leave the heart weak and unable to perform at adequate levels. Heart failure is usually treated with lifestyle changes, such as increased exercise and diet change. Many of the conditions that lead to CHF are irreversible but symptoms can be improved with time and therapy (Chen, “Heart Failure - Overview”).

#### *Chronic Atrial Fibrillation*

**Atrial fibrillation** is an irregularly irregular heart rhythm that causes poor blood flow through the heart. Atrial fibrillation is a chaotic rhythm of the atria that brings them out of sync with the ventricles and leads to poor release of blood through the AV

valves. Symptoms of atrial fibrillation include heart palpitations, shortness of breath, and weakness. Many elderly individuals live with chronic atrial fibrillation without consequence as it is typically not a life-threatening diagnosis. However, younger individuals may seek treatment through medication or other invasive procedures that shock the heart back into rhythm (Mankad).

### *Valve Repair*

**Valvular heart disease** is any disease in which one of the valves of the heart becomes deconditioned and is no longer capable of its intended function.

Deconditioning typically occurs with aging, and as such one in ten people over the age of seventy-five have valvular heart disease. With most cases of valvular heart disease, the affected valve is replaced with either a mechanical or tissue valve (Carabello and Crawford Jr.).

### *Percutaneous Coronary Intervention*

**Percutaneous coronary intervention**, or PCI, is the common practice of non-surgically reopening a coronary artery that is blocked by cholesterol-laden plaques. This procedure is attempted before surgical options, as this allows for the patient to return to their regular lifestyle more quickly than if they had gone through open heart surgery. The procedure is performed by inserting a deflated balloon through a catheter that runs from a femoral artery to the blocked coronary artery. Once the balloon reaches the blockage, it is inflated, reopening the artery (Chen, “Angioplasty and Stent Placement - Heart”).

### *Coronary Surgical Revascularization*

A common revascularization procedure is a **coronary artery bypass graft**, or CABG, in which stenotic arteries are bypassed by grafting other healthy blood vessels near the heart to the coronary arteries. A CABG is a secondary option for individuals who are not eligible for a PCI. CABG has been shown to be better at reducing the chances of myocardial infarction and death than PCI, but with a trade off of an increased risk of stroke (Kato).

### *Heart Transplantation*

**Heart transplants** only occur when a patient is at an end-stage heart failure or they have severe coronary artery disease. Most commonly this procedure involves a cadaveric allograft that replaces the patients existing heart. Heart transplants are a last resort treatment that are intended to improve quality of life, but not considered a cure for heart disease (Cooper).

### **Exercise**

At the Oregon Heart and Vascular Institute, there were several types of exercise equipment for the patients to use. The majority of patients would begin their regular routine walking, either on the treadmill or ambulating around the track. Patients who opt for the treadmill were given an exercise outline that began with a warm-up, then increased intensity every three minutes until a peak aerobic performance was reached, followed by a decrease of intensity, and eventually a cool down. Each exercise program was roughly thirty minutes with the patient reaching peak intensity between fifteen and twenty-one minutes. Programs used the **metabolic equivalent of task** (MET) system as

a way for patients and clinicians to manage progress. The chart below lists standard exercises and their respective MET.

<b>Physical Activity</b>	<b>MET</b>
Sleeping	0.9
Watching Television	1.0
Writing or Typing at Desk	1.5
Very Slow Walk (approx. 1.7 mph)	2.3
Slow Walk (approx. 2.5 mph)	2.9
Stationary Bicycling Very Light Effort	3.0
Medium to Fast Walk (approx. 3.0 mph)	3.3
Light or Moderate Effort Exercise	3.5
Fast Walk (approx. 3.4 mph)	3.6
Medium Bicycling (less than 10 mph)	4.0
Stationary Bicycling Light Effort	5.5
Sexual Activity	5.8
Jogging	7.0
Vigorous Effort Exercise	8.0
Running	8.0
Rope Jumping	10.0

Table 1: MET table with example exercise

The majority of cardiac patients stay within two to four METs during their time at cardiac rehabilitation, however some ambitious patients may reach a jogging MET level when they were physically ready to do so.

After the patients complete their lower body work, as able, the patient would begin an upper body work out. Upper body work outs typically were done using an upper body ergometer, however an elliptical, rowing machine, and free weights were also used if patients were physically able. During upper body work, blood pressure is typically higher, which results in many patients only having the ability to complete five or fewer minutes of upper body work before their exertion is too much and it becomes

dangerous (Mezzani et al.). For a select few patients, upper body work is never an option because they are at risk for hypertensive complication.

### *Exercise Background*

The importance of exercise on the cardiopulmonary system stems from its primary purpose, which is to supply the body with the appropriate amount of oxygen and remove any waste products from body tissues. The coronary arteries are the sole supplier of blood supply to the myocardium. When there is a disruption in the blood supply to the myocardium, caused by a blockage of a coronary artery, permanent damage may occur. When there is damage to the cardiomyocytes, an individual will experience a ***myocardial infarction***. The size of the myocardial infarction is related to the number of cardiomyocytes that die as a result of poor blood supply. Exercise is considered to be cardioprotective, meaning that regular exercise can reduce the risk of a heart attack and can also increase the rate of survival for an individual who has an myocardial infarction (Halliwill).

There is plenty of evidence suggesting the positive effects of exercise on health. For patients with cardiac disease, exercise becomes an absolute necessity that, when added to their daily routine, will decrease the risk of coronary artery disease. According to a study published in the Journal of Physiology, there is a direct relationship between the amount of exercise a person does and how well they will survive a myocardial infarction (Halliwill). The evidence showed that a trained individual, someone who burns 1500 kcal per week with exercise, was less likely to yield myocardial damage during a heart attack as compared to an untrained individual, someone who burns under 1500 kcal per week with exercise.

Cardiac rehabilitation centers focus on aerobic exercise, or what is commonly referred to as cardio. Aerobic exercise is long duration, low to high intensity activity that results in a sustained increase in heart rate. Aerobic type exercises have been shown to be more effective in cardiac patients than short duration, high intensity anaerobic exercises (Mezzani et al.).

*Rated Perceived Exertion*

During exercise, the patients are instructed to announce their perceived level of rated exertion at certain times during their exercise in order to keep them at an appropriate work load. This allows for the clinician to modify exercise programs based on how the patient is feeling at any given point. As patients recover, they will begin to self rate similar work loads as less exertion. This may result in an increased work load the following week, which is why is it important for patients to become in tune with how their bodies are adjusting after their diagnosis. Once a patient begins to understand their personal perceived exertion, they can fully become aware of their progress both in and out of the clinical environment. It is at this point that patients can measure their own personal increased wellbeing.

<b>Rating of Perceived Exertion</b>		
<b>RPE</b>	<b>Description</b>	<b>Example</b>
6	Very, very light	Little to no effort, as one would feel while lying in bed or sitting in a chair relaxed.
7		
8		
9	Very light	
10		
11	Fairly light	

12	Somewhat hard	Effort, as one would feel with moderate to intense aerobic exercise.
13		
14		
15	Hard	
16		
17	Very hard	
18		
19	Very, very hard	
20	Maximum exertion	

Table 2: Borg Rating of Perceived Exertion Scale

Cardiac rehabilitation patients are asked periodically through their exercise programs how they rate their perceived exertion. It is preferred that patients stay within the somewhat hard perceived exertion limits to prevent complications.

A majority of patients that have been through a cardiac event are prescribed ***beta-adrenergic blocking medications***, or beta-blockers. These medications compete at the beta-adrenergic receptors of the myocardium, blocking sympathetic nerve signals that would increase heart rate. For many patients this is to help decrease the stress on their heart from the sympathetic nervous system stimulation by preventing an increase in heart rate up to a certain point as designed by the specific beta-blocker. If patients do not understand this effect, it can become dangerous for patients to use their heart rate to measure work load because their heart become incapable of reaching what would be considered a normal heart rate during aerobic type exercise. For this reason, it is important for clinicians to discuss the RPE scale so that patients rely less on their heart rate and more on how their body feels to determine their personal workload abilities.

A study conducted by Meghan Day at the University of Wisconsin investigated the reliability of the RPE scale to quantify exercise intensity. Nine men and ten women

performed a protocol consisting of five exercises at varying intensities. The results were conclusive in that the “RPE method can be considered a reliable technique to monitor training intensities and provide for progressive increase in resistance” (Day et al.).

The American Association of Cardiovascular and Pulmonary Rehabilitation put out a statement on the appropriate levels of aerobic exercise intensity based on an individual’s diagnosis or treatment. In this article, they discussed the various research that has been conducted to show how different levels of exercise intensity were beneficial to patients with a certain cardiac diagnosis or treatment. Table 3 is an illustration of the level of exercise intensity that have been shown, through various research efforts, to be effective for rehabilitating patients. The empty cells represent an area of exercise intensity in which there is no formal scientific evidence for its effectiveness for the corresponding treatment (Mezzani et al.).

	<b>Exercise Intensity Domains</b>		
	Light to moderate	Moderate to High	High to severe
Stable Angina	x	x	x
CHF	x	x	x
Atrial Fibrillation	x	x	
Valve Repair	x	x	
PCI	x	x	x
CABG	x	x	x
Heart Transplant	x	x	x

Table 3: Exercise intensity limits for cardiac diagnoses

## **Methodology**

### **Aim**

The aim of this study was to explore patient's motivations underpinning participation in a cardiac rehabilitation program, whether that be to complete a Phase II program or continuing their cardiac rehabilitation experience on through to a Phase III in-clinic gym membership.

### **Design**

The design of this experiment is loosely based off a study conducted by Alexander Clark and colleagues published in 2005 in which they interviewed groups of patients in focus groups. For this research, I chose a qualitative design in order to analyze the underlying motivations of patients. The research was conducted using an interview style with the patient in a private setting that allowed for open dialogue. Interview questions for Phase II and III can be found in Appendix B and C respectively.

### **Study Settings**

The study was conducted at the Oregon Heart and Vascular Institute in Springfield, Oregon. The services provided to patients included a comprehensive twelve-week Phase II program with educational classes, an optional out-of-pocket membership to a Phase III gym, and exercise classes available to gym members.

### **Participants**

A total of 14 patients were interviewed from Phase II and Phase III combined. There were 10 males and 4 females aged  $60.5 \pm 11.6$  years. All patients had a formal

diagnosis of coronary artery disease and were currently taking part in cardiac rehabilitation.

### **Data Collection**

Each participant was given the list of questions before the interview began for their agreement to continue and to help guide the dialogue. Participants were allowed to skip any questions they did not feel comfortable answering. A different set of questions was designed for Phase II and Phase III patients. Each questionnaire was designed to focus on the patient's current experiences within the program, thus Phase III patients were not asked specific questions regarding educational classes. The questions were related to the process of attending cardiac rehabilitation and their own personal perceptions of the different aspects including, but not limited to, how they were introduced to the program, their experience with the educational classes, and how the resources available to them helped with their success.

### **Ethical Considerations**

Each patient gave written consent for the use of their interview data for this research project (Appendix A). The participants were informed as to the purpose of the research and that their personal information would remain confidential. They had the option to opt out of the interview at any time up until the publication of this thesis. No staff from the hospital was present during the interviews to allow for an open dialogue with each participant without reservation. The Oregon Health and Vascular Institute and its affiliates had no access to the information that was presented by each participant.

## **Data Analysis**

During each interview, the commentary was transcribed into a word document that was later compiled and analyzed for common themes. Common experience, mechanisms, and contexts were identified and organized under the three common themes established by analysis. Notes from interactions outside of the formal interviews with other patients and staff were considered when conducting my analysis.

## **Findings**

There was a very positive attitude towards cardiac rehabilitation among the majority of patients that I had the pleasure of interviewing. I observed patients through the entire process of the program beginning with their initial assessment on through to their graduation. There were three common motivational mechanisms within cardiac rehabilitation that were indicated by the interviewee's responses: increased personal well-being, positive social atmosphere, and a perceived safe environment.

### *Increased well-being*

When asked to define cardiac rehabilitation, patient's answers conceptualized the mechanism of an increased personal well-being, "[cardiac rehabilitation rehabilitates] our mindset on exercise, nutrition, causes of risk factors, personalized for your lifestyle." My observations suggest that for most patients, the initial emotional response was dim due to their anxiety of an unforeseen medical event. Patients with whom this was their second or third time in the program responded to be more determined to increase their quality of life with each return to the rehabilitation center. Patients at or under the age of thirty were often unmotivated by being around patients that were far older than they, and unfortunately, many did not return and complete a program through graduation. However, once patients recognized that their purpose at the cardiac rehabilitation clinic was to find a balance of healing and lifestyle, their emotional discouragements ceased. Patients were motivated by progress, and a program that centers around personalized rehabilitation gives patients the confidence they need to recognize their personal increased well-being.

In order for patients to recognize their own improvements, they must be adequately informed about their diagnosis. One of the biggest hurdles for patients to overcome is a lack of knowledge regarding their condition. When patients who were diagnosed with coronary artery disease were asked to describe their condition, many were unable to articulate which of their coronary arteries was blocked. The educational component of cardiac rehabilitation gives patients the resources they need for a basic understanding of their condition, medications, and risk factors.

Once patients are educated on risk factors, they are able to make lifestyle adjustments that will reduce their probability of having a recurrent cardiac event. For many patients, simply lifestyle adjustments such as increasing their level of activity and/or forming a healthier diet were all that were necessary to reduce their risk. For others, more challenging adjustments such as tobacco cessation were recommended. As one patient stated, “[cardiac rehabilitation] is an education to build a toolbox in order to take care of myself.”

Increased well-being looks different for each patient. Commonly it was observed to contribute to self-centralized motives relating to the avoidance of fatality, “motivation is life...in that regard I may come off as selfish, but I had a full life prior to the event and I want to get back to the way it was.” Having come close to death, patients in the cardiac rehabilitation center were motivated by the prospects of returning to an accustomed level of activity that existed prior to their event.

Patients will respond positively when programs offer an experience of personalized care that gives them the necessary tools to succeed in adapting their lifestyle to decrease their risk of a recurrent event. The realization that if they do not

make the necessary changes, they are at increased risk for another event, gave sufficient motivation towards healing and prevention as seen by an ever progressing sense of well-being throughout the program.

### *Positive social atmosphere*

The second motivational mechanism is a positive social atmosphere; patients must feel comfortable with those around them in order to be motivated to complete their recovery process. Patients that were interviewed either fell under the umbrella group of self or external-motivators; there were few that fell in-between. Self-motivators described their interactions with their therapist as being most motivational, “nobody has slowed me down, the staff is very positive and has good energy, however I could be doing the same thing in an empty room.” External-motivators found motivation from other patients, “I like talking to the other patients and getting to know them. I used to be a hairstylist so I have a natural attitude to talk to people and get to know them.”

Receiving positive reinforcement from their therapist gave patients a positive attitude that strengthened patient-therapist relationships. At the start of each appointment, the therapists converse with each of their patients regarding their at home activity and corresponding perceived exertion. By listening to each patient’s personal abilities and adapting their patient’s exercise prescriptions to fit those abilities, the therapists were able to build trust with their patients. One patient noted, “the staff has been humbler than expected, which has made it easier to work with them.” Another stated “[the therapist] would push you and make you see the exercises through, and make sure that you felt like you could work harder. It always made me feel like I was never being let off the hook, which was motivating to me.” Patient responses were

indicative that once a trust was built with their therapist, it became easier to find motivation behind instructions; even if the instructions were intended to push the patient beyond the limits they currently thought they were capable of.

Extroverted patients found their motivation by engaging with other patients and lending them guidance, “I could see other patients struggling, so I found it helpful to lend them hope through the process.” Introverted patients found that listening to others was more beneficial, “it was helpful to hear other people ask questions [during the education lectures] and to hear those answers.” For all patients, the observation of other’s success who have recovered from similar events was highly motivational and would have not been experienced had they opted out of a cardiac rehabilitation program.

Specifically, Phase III patients are highly motivated through their interactions with other patients. Once graduated from the Phase II program, they no longer have regularly scheduled visits with a designated therapist. Instead they substitute their patient-therapist relationship with regular visits amongst other patients they have met throughout their recovery process. One long time patron found the socialization aspect of the Phase III program to have been hugely motivational for continuation of their membership. They attribute much of this to the socialization they get from their attending of the exercise classes, in which they are inspired by the other class attendees and the instructor to stay healthy and continually exercise.

One Phase III patient described the social experience as, “a group of people that you engage with. There is something that is really neat about having a class with a group of people all with a commonality. You get to know one another, their physical

boundaries that allow you to empathize with one another. When someone doesn't show up, others care to find out why. There is a spiritual element that goes beyond the physical and emotional that can only be experienced when you engage with other people.”

#### *Perceived safe environment*

The final motivational mechanism is perceived safety; patients must recognize their own capabilities in order to advance their recovery without the fear of injury. In order to have this recognition, a patient must be surrounded by an environment in which every aspect propagates itself as protective. As one patient said, “I wouldn't have been able to succeed without the facility and its [sanctuary like] feel.” Being in a clinical setting with a knowledgeable staff brings ease of mind to patients as they regain self confidence during their personal recovery process.

During Phase II, patients are supervised via a wireless four lead ECG monitor that gives therapists a detailed, and instant view of a patient's heart activity throughout their appointment. Constant monitoring of each patient's heart activity allows therapists an instantaneous observation of warning signs for an impending event, which then can be sent as a report to the patient's physician. A therapist who believes that their patient is unfit for exercise after preliminary examination of the patient's ECG would have cause to suspend exercise, and in rare cases, admit the patient to the hospital. It is the patient's confidence in their therapist that allows for perceived safety in their prescribed exercise, and therefore, their continuation with their program.

“If you have had an episode and have had the realization that things could go wrong, there is something comforting about being in a hospital environment. Having the extra safety net is a huge plus. Once you’ve had an unpredictable episode, you never know what could happen, and it is comforting to know that there is an emergency department right next door with a trained staff here to help in case of emergency.”

## **Conclusion**

No system is perfect, however for the patients that were interviewed, there was little that was discouraging them to continue their cardiac rehabilitation experience. This research does not address the entire cardiac rehabilitation spectrum, and there is more that can be learned about how to improve the cardiac rehabilitation experience. There are two areas of focus that further research on motivational mechanisms may seek to understand; further development of Phase I and patient-therapist interaction in a Phase III setting.

A common theme among interviewees was that they recollected very little from their Phase I education and rehabilitation. I interviewed one patient who I took part in their Phase I interactions, and they were unable to recall my participation. This may be due to the vast stimulation that patients endure during their hospital admittance. Not only are they in shock as to what has happened to them, but they are highly medicated and under constant surveillance by nurses, physicians, and family. Research into the best approaches for patient engagement in Phase I may be helpful for increasing the number of return patients to the clinic for a Phase II program.

When Phase III patients were interviewed, they would frequently cite a diminishing level of interaction from the staff while they were at the gym as compared to when they began their Phase III component. When asked, they believed that an increase in interaction may be helpful for morale, especially for those patients who are not as involved with the other patients. Further research on patient-therapist interactions may be helpful in increasing the number of patients who continue their rehabilitation on through Phase III.

Patients inherently want to recover, and with the proper guidance, compassion, and observation, they will find the motivation that they need to succeed. Cardiac rehabilitation has been shown to be the safe, interactive, and proactive solution for patients recovering from a cardiac event or diagnosis.

# Appendix A

<b>PeaceHealth</b> <i>Authorization to Use and Disclose Health Information</i>																						
Patient	Patient Name: _____ Birth Date: _____ Ph. #: _____ SSN: _____																					
From / To	<div style="border: 1px solid black; padding: 5px;"> <p><b>I authorize the use and/or disclosure of the health information described below for the above-named patient by the following entities:</b></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> <b>Information is to be released FROM:</b>            _____            _____         </td> <td style="width: 50%; border: none; vertical-align: top;"> <b>Information is to be disclosed TO:</b>            _____            _____         </td> </tr> </table> <p><b>Please specify the hospital, clinic, or practice holding the records (see back side for listing):</b>            _____            _____</p> </div>	<b>Information is to be released FROM:</b> _____ _____	<b>Information is to be disclosed TO:</b> _____ _____																			
<b>Information is to be released FROM:</b> _____ _____	<b>Information is to be disclosed TO:</b> _____ _____																					
Purpose	<b>For the purpose(s) of:</b> <input type="checkbox"/> At the request of the patient or legal/personal representative <input checked="" type="checkbox"/> Other purposes (specify each purpose): <u>STUDENT PROJECT</u>																					
Info to be Disclosed	<b>Description or nature of information to be used and/or disclosed:</b> (initial all that apply) <table style="width: 100%; border: none;"> <tr> <td style="width: 33%; border: none;"><input type="checkbox"/> Discharge summaries</td> <td style="width: 33%; border: none;"><input type="checkbox"/> Pathology reports</td> <td style="width: 33%; border: none;"><b>Specially Protected Information:</b></td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> History &amp; physical exams</td> <td style="border: none;"><input type="checkbox"/> Radiology &amp; imaging reports</td> <td style="border: none;"><input type="checkbox"/> Mental health treatment records</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Consultations</td> <td style="border: none;"><input type="checkbox"/> Laboratory reports</td> <td style="border: none;"><input type="checkbox"/> Drug/Alcohol abuse diagnosis, treatment, and referral records</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Operative reports</td> <td style="border: none;"><input type="checkbox"/> EKG reports</td> <td style="border: none;"><input type="checkbox"/> Information re: HIV / AIDS / Sexually transmitted diseases</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Physician progress notes</td> <td style="border: none;"><input type="checkbox"/> Emergency Dept. records</td> <td style="border: none;"><input type="checkbox"/> Information re: Genetic testing (Oregon)</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Nursing notes</td> <td style="border: none;"><input type="checkbox"/> Medication records</td> <td style="border: none;"><input type="checkbox"/> Records for the following dates or treatment:</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Clinician office notes</td> <td style="border: none;"><input type="checkbox"/> Billing statements</td> <td style="border: none;"></td> </tr> </table> <p><input checked="" type="checkbox"/> Other information (specify):  <u>INFORMATION VOLUNTEERED BY PATIENT</u></p> <p><b>All health records from the above named entity</b> (Excludes above Specially Protected Information unless indicated by initials)</p>	<input type="checkbox"/> Discharge summaries	<input type="checkbox"/> Pathology reports	<b>Specially Protected Information:</b>	<input type="checkbox"/> History & physical exams	<input type="checkbox"/> Radiology & imaging reports	<input type="checkbox"/> Mental health treatment records	<input type="checkbox"/> Consultations	<input type="checkbox"/> Laboratory reports	<input type="checkbox"/> Drug/Alcohol abuse diagnosis, treatment, and referral records	<input type="checkbox"/> Operative reports	<input type="checkbox"/> EKG reports	<input type="checkbox"/> Information re: HIV / AIDS / Sexually transmitted diseases	<input type="checkbox"/> Physician progress notes	<input type="checkbox"/> Emergency Dept. records	<input type="checkbox"/> Information re: Genetic testing (Oregon)	<input type="checkbox"/> Nursing notes	<input type="checkbox"/> Medication records	<input type="checkbox"/> Records for the following dates or treatment:	<input type="checkbox"/> Clinician office notes	<input type="checkbox"/> Billing statements	
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Notices	<p>1. I understand that, if the recipient of the information disclosed under this authorization is not a health plan or provider covered by federal or state privacy laws, the information may be re-disclosed by the recipient and no longer protected by those laws. If the information being disclosed under this authorization includes HIV/AIDS, Sexually Transmitted Diseases, mental health, genetic testing, and drug/alcohol abuse diagnosis, treatment, or referral information, Federal law and regulation including 42 CFR Part 2 and 45 CFR Parts 160 and 164 or state law may prevent the recipient from re-disclosing this information.</p> <p>2. I may refuse to sign this authorization. My refusal will not adversely affect my ability to receive treatment, to enroll in a health plan, to be eligible for benefits, or to obtain payment for services unless this authorization is sought for purposes of research-related treatment, to determine my eligibility or enrollment in a plan, for underwriting or risk determinations or if the services related to the information to be disclosed are performed solely for the purpose of providing that information to someone else.</p> <p>3. I may revoke this authorization at any time by notifying the Health Information Management/Medical Records Department of the above named entity on its designated form. However, any such revocation will not apply to any activity undertaken based on this authorization. PeaceHealth's Joint Notice of Privacy Practices also describes how to revoke this authorization.</p> <p>4. I received a copy of this authorization. I may inspect or request copies of information disclosed by this authorization.</p>																					
Dates	<p><b>Unless revoked, this authorization is valid for 90 days from the signature date below, or for the following time period.</b></p> Beginning date: _____ Ending (expiration) date: _____ <small>(in Washington state, expiration date can be no later than 1 year after this authorization is signed if disclosure is to employer or financial institution.)</small>																					
Signature	<p><b>SIGNATURE: I have read this authorization, and I understand it.</b></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 60%; border: none;">Signature of Patient or personal representative _____</td> <td style="width: 20%; border: none;">Relationship to patient: _____</td> <td style="width: 20%; border: none;">Date _____</td> </tr> </table> <p><small>*If the patient's personal representative, you may be required to provide appropriate documentation to demonstrate authority to act on behalf of the patient (Examples of documentation include Power of Attorney, Death Certificate, Court order)</small></p>	Signature of Patient or personal representative _____	Relationship to patient: _____	Date _____																		
Signature of Patient or personal representative _____	Relationship to patient: _____	Date _____																				
For PeaceHealth Use Only	<table style="width: 100%; border: none;"> <tr> <td style="width: 25%; border: none;"><input type="checkbox"/> Date Received _____</td> <td style="width: 25%; border: none;"><input type="checkbox"/> MRN # _____</td> <td style="width: 25%; border: none;"><input type="checkbox"/> Acct # _____</td> <td style="width: 25%; border: none;"><input type="checkbox"/> Identity and authority verified</td> </tr> <tr> <td style="border: none;"><input type="checkbox"/> Fees explained if needed</td> <td style="border: none;"><input type="checkbox"/> Records sent by _____</td> <td colspan="2" style="border: none;">Date/Time _____</td> </tr> </table>	<input type="checkbox"/> Date Received _____	<input type="checkbox"/> MRN # _____	<input type="checkbox"/> Acct # _____	<input type="checkbox"/> Identity and authority verified	<input type="checkbox"/> Fees explained if needed	<input type="checkbox"/> Records sent by _____	Date/Time _____														
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SYS1020 (07/16/14)

## Appendix B

**Name:**

**Age:**

**Date of Interview:**

1. What is your personal definition of cardiac rehabilitation?
2. How were you first introduced to cardiac rehabilitation?
3. What was your initial response to cardiac rehabilitation?
4. What has been the biggest motivating factor or factors that either made you decide to start cardiac rehabilitation or have kept you in the program?
5. How would you describe your initial emotional response to becoming a candidate for cardiac rehabilitation?
6. How were you educated on cardiac rehabilitation?
7. Which educational resources have you viewed or taken part in?
8. Did you find it beneficial to have those resources available?
9. How would you rate your health related habits prior to cardiac rehabilitation?
10. Has this changed since beginning cardiac rehabilitation?
11. Do you feel that the resources that are available to you have given you the opportunity to succeed?
12. Have you been able to take what you have learned at the rehabilitation clinic and apply that to your daily life? If not, what is keeping you from doing so?
13. Have you found that getting to know the staff and other patients motivate you?
14. What are some things the staff has done to encourage you? Discourage you?
15. What would you believe to be the number one cause for patients to choose not to undergo cardiac rehabilitation besides cost?
16. If you were to design your own cardiac rehabilitation program, what you include that isn't already a part of this program?

Please rate the following from 1 to 10, in which 1 is “could have been better” and 10 is “I wouldn’t change anything,” if you respond with a 5 or less, please elaborate:

- |   |                      |
|---|----------------------|
| Introduction to cardiac rehabilitation: | 1 2 3 4 5 6 7 8 9 10 |
| Initial Experience at the center:       | 1 2 3 4 5 6 7 8 9 10 |
| Overall Experience thus far:            | 1 2 3 4 5 6 7 8 9 10 |
| Social aspect of the program:           | 1 2 3 4 5 6 7 8 9 10 |
| Encouragement from staff:               | 1 2 3 4 5 6 7 8 9 10 |
| Staff engagement:                       | 1 2 3 4 5 6 7 8 9 10 |
| Independence:                           | 1 2 3 4 5 6 7 8 9 10 |

## Appendix C

**Name:**

**Age:**

**Date of Interview:**

1. What is your personal definition of cardiac rehabilitation?
2. How would you describe your overall experience from your cardiac rehabilitation program?
3. How were you educated on cardiac rehabilitation?
4. Which educational resources have you viewed or taken part in?
5. Did you find it beneficial to have those resources available?
6. What can you take away from this experience?
7. Will you use the skills you have learned at the center outside of your program and in the future? If so, what skills will you take from this experience?
8. Would you recommend phase III to friends and family to take part in at a cardiac rehabilitation program if prescribed by their physician? Why?
9. What was the biggest motivating force for you to continue the program?
10. What was the biggest deterrent during the program?
11. Did you have any personal goals set for yourself? If yes, what were they?
12. Did you feel like you accomplished those goals that you set for yourself?
13. Do you feel that the resources that are available to you have given you the opportunity to succeed?

Please rate the following from 1 to 10, in which 1 is “could have been better” and 10 is “I wouldn’t change anything,” if you respond with a 5 or less, please elaborate:

- |   |                      |
|---|----------------------|
| Overall Experience:                             | 1 2 3 4 5 6 7 8 9 10 |
| Social aspect of the program:                   | 1 2 3 4 5 6 7 8 9 10 |
| Encouragement from staff:                       | 1 2 3 4 5 6 7 8 9 10 |
| Staff engagement:                               | 1 2 3 4 5 6 7 8 9 10 |
| Independence:                                   | 1 2 3 4 5 6 7 8 9 10 |
| Your ability to education others:               | 1 2 3 4 5 6 7 8 9 10 |
| Your ability to continue the skills you gained: | 1 2 3 4 5 6 7 8 9 10 |

## Glossary of Terms

**Arrhythmia:** any disturbance in the rhythm of the heartbeat.

**Atria:** either of the two upper chambers on each side of the heart that receive blood from the veins and in turn force it into the ventricles.

**Atrial fibrillation:** fibrillation in which the normal rhythmical contractions of the cardiac atria are replaced by rapid irregular twitching of the muscular wall that cause the ventricles to respond irregularly.

**Atrioventricular bundle:** a bundle of specialized muscle fibers regulating the heartbeat by conduction impulses from the right atrium to the ventricles.

**Atrioventricular node:** a small mass of muscular fibers at the base of the wall between the atria, conducting impulses received from the sinoatrial node by way of the atrioventricular bundles and, under certain conditions, functioning for the sinoatrial node as pacemaker of the heart.

**Atrioventricular septum:** the small part of the membranous septum of the heart just above the septal cusp of the tricuspid valve, separating the right atrium from the left ventricle.

**Atrioventricular valves:** a membranous fold or other structure that controls the flow of fluid, as one that permits blood to flow in one direction only of or relating to the atria and ventricles of the heart

**Beta-adrenergic blocking medications:** any of various substances that interfere with the action of the beta-receptors; used primarily to reduce the heart rate or force the prevention, management, or treatment of angina, hypertension, or arrhythmias.

**Bradycardia:** a slow heartbeat rate, usually less than 60 beats per minute.

**Cardiac Cycle:** one complete heartbeat, consisting of one contraction and relaxation of the heart.

**Cardiac Rhythmicity:** the state of being rhythmical as related to the heart

**Cardiomyocytes:** a muscle cell of the heart.

**Chordae tendineae:** any of the tendons extending from the papillary muscles to the atrioventricular valves and preventing the valves from moving into the atria during ventricular contraction.

**Chronic heart failure:** a condition in which the heart fails to pump adequate amounts of blood to the tissues, resulting in accumulation of blood returning to the heart

from the veins, and often accompanied by distension of the ventricles, edema, and shortness of breath.

**Coronary artery bypass graft:** a surgical procedure in which a diseased or obstructed hollow organ is temporarily or permanently circumvented.

**Diastole:** the normal rhythmical dilation of the heart during which the chambers are filling with blood.

**Electrocardiogram:** the graphic record produced by a galvanometric device that detects and records the minute differences in electric potential caused by heart action and occurring between different parts of the body: used in the diagnosis of heart disease.

**Heart transplant:** a surgical procedure in which a person's diseased heart is replaced with a healthy heart from a deceased donor.

**Metabolic equivalent of task:** the energy expended while completing a task.

**Myocardial infarction:** damage to an area of heart muscle that is deprived of oxygen, usually due to blockage of a disease coronary artery, typically accompanied by chest pain radiating down one or both arms, the severity of the attack varying with the extent and location of the damage.

**Myocardium:** the muscular substance of the heart

**P wave:** a deflection in an electrocardiogram indicating depolarization of the atria.

**Papillary muscles:** one of the small bundles of muscles attached to the ventricle walls and to the chordae tendineae that tighten these tendons during ventricular contraction.

**Percutaneous coronary intervention:** a small, expandable tube used for inserting in a blocked vessel or other part.

**Purkinje fibers:** any of the specialized cardiac muscle fibers forming a network in the ventricular walls that conduct electric impulses responsible for the contractions of the ventricles.

**QRS complex:** the principal deflection in the electrocardiogram, representing ventricular depolarization.

**Resting heart rate:** the number of heartbeats per minute during a state of rest.

**Semilunar valves:** a membranous fold or other structure that controls the flow of fluid, as one that permits blood to flow in one direction only shaped like a half-moon; crescent.

**Sinoatrial node:** the small mass of tissue in the right atrium functioning as a pacemaker of the heart by giving rise to an electric impulses that initiate heart contractions.

**Stable Angina:** an attack of painful spasms characterized by sensations of choking and suffocating.

**Systole:** the normal rhythmical contraction of the heart, during which the blood in the chambers is force onward.

**T wave:** the first deflection in the electrocardiogram following the QRS complex, representing ventricular repolarization.

**Tachycardia:** excessively rapid heartbeat.

**Valvular heart disease:** a condition in which one or more of the four valves of the heart has become damaged, resulting in poor blood flow through the chambers of the heart and to the body and lungs.

**Ventricles:** either of the two lower chambers on each side of the heart that receive blood from the atria and in turn force in into the arteries.

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