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Benefits of Water Exercise for Cardiac Patients: Considerations and Recommendations

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BENEFITS OF WATER EXERCISE FOR CARDIAC PATIENTS:
CONSIDERATIONS AND RECOMMENDATIONS

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Purpose of Graduate Project

The purpose of this research project was to explain how cardiac patients respond to water exercise and the physiological events and benefits that occur throughout water exercise training. When finding a topic to write about, I knew that I wanted to work with the cardiac population and investigate how a different form of exercise can benefit these patients after going through cardiac rehabilitation. Water exercise has increased in popularity and is becoming more well-known as well as beneficial for clinical patients. While researching water exercise and the cardiovascular benefits, I noticed that there were many different topics covered, but no researchers had explained all the factors for cardiac patients together.

I had contemplated a few research topics, and had intended to collect data on cardiac patients in water exercise. But the more I reviewed the literature, the more I realized that there were multiple gaps throughout the years on water exercise that did not focus on cardiac patients specifically. My goal then turned into writing a review article to understand previous studies that have focused on cardiac patients and water exercise and where future research should be focused.

Therefore, the purpose of this review of literature was to show how cardiac patients could obtain the main physiological benefits while performing water exercise. This review paper has four main sections, which include a review of cardiac rehabilitation, land versus water intensities, water exercise and training, and considerations and recommendations. Each section has a summary of physiological changes that occur when immerged in water for exercise with cardiac patients who may have cardiovascular limitations during exercise. I have worked closely with my committee on editing and reviewing my paper. With my work and the feedback provided by my committee, it is intended that the final manuscript will be ready for publication in a journal.

Abstract

Water exercise is becoming a recommended alternative exercise for cardiac patients outside of traditional cardiac rehabilitation. There are many exercise responses that need to be considered when exercising in the water that include, heart rate, blood pressure, volume of oxygen consumed, muscle capacity and strength, ventricular function and quality of life. These factors change within every individual in water due to the effects of water immersion, temperature, and type of movement while in the water. The aim of this review was to understand how water exercise affects cardiac patients and to identify considerations and recommendations when prescribing exercise in water as compared to on land. The first review section starts by explaining the common cardiac diseases studied previously and benefits shown in patients after cardiac rehabilitation programs including improvements in muscular strength and capacity, blood lipid profiles, blood pressures, and assessments of quality of life. The second section in the review then compares exercise intensities on land to exercise intensities when in the water. The most common measures used to monitor exercise intensity are heart rate and rating of perceived exertion. These are greatly affected by the level of immersion and temperature of the water. Immersion in the water has a large influence over the body including a change in blood flow from the periphery to the central vascular system, which then changes and influences heart rate and blood pressure. The third section of the review explains the effect of water exercise on specific cardiac patients. Most researchers have measured blood pressure, muscular strength and capacity, volume of oxygen consumed and ventricular function in response to water exercise. And finally, the fourth section of the paper summarizes some considerations and recommendations to consider and use while working with any cardiac population when exercising and training in the water.

Introduction

Exercise is one of the key components to help reduce the risk of cardiac patients having another cardiac event and to regain strength and function to their lives after being diagnosed or treated for ant type of heart disease. “Physical activity both prevents and helps treat many established atherosclerotic risk factors, including elevated blood pressure, insulin resistance and glucose intolerance, elevated triglyceride concentrations, low high-density lipoprotein cholesterol (HDL-C) concentrations and obesity” (Thompson et al., 2003). Many forms of exercise, like walking and biking, have been studied to determine the effects on the cardiovascular system specifically for cardiac patients.

Most researchers have focused on cardiovascular exercise and the intensity of that exercise in patients. Shephard and Balady (1999) “examined the physiological effects of regular exercise, suggesting how exercise-induced changes might improve cardiac performance.” They also described “the influence of type, intensity, frequency, duration, and volume of exercise and their respective contributions to the development of a rational exercise prescription.” All of these factors must be taken into account when working with cardiac patients since they are high-risk patients. According to the *American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription* (2014), a patient is considered as high-risk if he or she has a known cardiovascular, pulmonary and/or metabolic disease. Also, if patients have major signs or symptoms suggestive of cardiovascular, pulmonary and/or metabolic disease then they are classified as high-risk. Helping them to exercise is essential because they are in a constant battle to prevent another cardiac event from occurring. Thompson (2005) reported that “exercise training in patients with cardiovascular disease increases exercise capacity, reduces cardiac ischemia, delays the onset of or eliminates angina pectoris, and improves endothelial function.”

These benefits have been shown for patients participating in cardiac rehabilitation programs that include land exercise like cycling or walking.

There are many ways for cardiac patients to safely exercise on land including walking, cycling, recumbent elliptical, and *NuStep®*, which consists of combining arm and leg cycling. Water exercise is another example of exercise that is becoming more popular for cardiac patients and it "has been reported that water aerobics could be performed at an intensity to improve cardiovascular fitness" (Darby & Yaekle, 2000). Cider, Schaufelberger, Sunnerhagen, and Andersson (2003) indicated that, "due to the buoyancy of water, hydrotherapy exercises can improve mobility, strength, as well as cardiovascular fitness in patients with congestive heart failure (CHF)." Most cardiac patients who are studied in water exercise are patients with coronary artery disease (CAD), congestive heart failure (CHF), and heart failure (HF). These cardiovascular diseases are defined as follows:

- Coronary Artery Disease (CAD) – disease of the arteries of the heart (usually atherosclerotic);
- Heart Failure (HF) – disease where the heart muscle is too weak or stiff to pump blood effectively;
- Congestive Heart Failure (CHF) – inability of the heart to deliver oxygenated blood to metabolizing tissues, secondary to impairment in cardiac output, depressed left ventricular systolic function, abnormalities in skeletal muscle metabolism or pulmonary function, or combination. (ACSM, 2014)

However, there are some concerns when it comes to cardiac patients exercising in a water environment. "Whole-body head-up immersion leads to a significant shift of blood into the intrathoracic circulation, followed by an increase in central venous pressure, heart volume and cardiac output" (Schmid et al. 2007). Meyer and Bucking (2004) explained that the pressure of water as "during head-out water immersion, a 100-cm column of water exerts a pressure of 76 mm Hg on the body surface." In other words, when a person is neck deep in water, the part of the body that is underwater is experiencing an increase in hydrostatic pressure. Although, with the right precautions and special considerations, cardiac patients have been shown to have significant benefits from water exercise.

The benefits of water exercise have been shown to be an alternative type of exercise for cardiac patients. Some significant results from exercise training in water include decreases in blood pressure (both systolic and diastolic), decreases in resting and exercise heart rate, increases in muscular strength and endurance (exercise capacity), increase in oxygen consumption, heart and ventricular function, and increase in overall cardiovascular fitness (Cider, Schaufelberger, Sunnerhagen & Andersson, 2003; Tokmakidis, Spassis & Volaklis, 2008; Tanaka et al., 1997; Farahani et al., 2010; Magdar, Linnarsson & Gullstrand, 1981; Svealv et al., 2009). Different forms of water exercise that have been studied in the water include walking, water aerobics, cycling, and swimming. Few studies similar to Graef and Kruel (2006) have investigated how water effects the heart rate in swimming, running in shallow or deep water, water gymnastics, and water cycling. Many studies also reported that the level of immersion had a significant impact on resting and exercise cardiovascular measures compared to measures when on land, which are explained later in this review. This is due to the hydrostatic pressure when in the water which was described previously. The water temperature was also a key factor when understanding the physiological differences between land and water exercise. Heithold and Glass (2002) described the significance of the temperature as it pertains to thermoregulation and how the body reduces heat during exercise. If the water is cooler, then the body does not have to work as hard to regulate the body temperature. Therefore, these exercise factors during water exercise (type of movements in water, depth of immersion, water temperature) for cardiac patients need to be considered carefully when prescribing exercise.

The purpose of this review was to understand the benefits of water exercise for cardiac patients and what to expect when exercising on land compared to in the water. The review is also an informational tool for instructors and practitioners to use when working with cardiac patients during water exercise.

Benefits of Cardiac Rehabilitation

Cardiac rehabilitation is one of the first recovery options patients should take after being diagnosed with some type of heart disease or having a cardiac procedure. It allows patients to exercise safely under the supervision of clinical personnel and to be educated on how exercise can better their quality of life and reduce future incidents of heart disease. Shephard and Balady (1999) confirmed this by saying "Regular endurance or resistance training results in specific changes in the muscular, cardiovascular, and neurohumoral systems that lead to improvement in functional capacity and/or strength." In other words, patients go through a type of transformation by using exercise to improve physiologically and mentally.

Cardiac patients must go through multiple levels or phases, which help them through the recovery process. The patients start in the hospital, which is considered in-patient Phase I, with treatment for their specific heart disease. Types of treatments include catheterization, open-heart surgery, and cardiac testing like stress testing or echocardiography. Once treated, cardiac patients are recommended to attend cardiac rehabilitation (cardiac rehab) to start exercising and to receive education on different ways to manage their disease both physically and mentally.

Cardiac rehab, also known as Phase II, is an outpatient program for patients who are out of the hospital and attend exercise sessions about 2-3 times a week. The guidelines of the *American Association of Cardiovascular and Pulmonary Rehabilitation* (AACVPR, 2013) recommend "early initiation of outpatient CR/SP (cardiac rehab/secondary prevention) within 1 to 3 weeks post event." Phase III of cardiac rehab occurs after patients have completed Phase II training, which generally takes about 8 to 12 weeks or three months to complete. In Phase III, the patients must apply what they have learned into their own lives. This is also known as the maintenance phase where patients may not have the assistance of staff to help them with exercise.

Shephard and Balady (1999) gave a brief explanation of the important benefits of exercise for cardiac patients, which included cardiovascular influences, metabolic effects, and lifestyle outcomes. These categories were described as important indirect benefits that patients can achieve through cardiac rehab and exercise (Shephard & Balady 1999). In the first category of cardiovascular influences, the most important changes occur by reducing resting and exercise heart rate, reducing resting and exercise blood pressure, reducing myocardial oxygen demand at submaximal levels of physical activity and expanding of plasma volume. Within the second category of metabolic effects, patients can experience a reduction of obesity, enhanced glucose tolerance and improved lipid profile. The final category of lifestyle outcomes has been shown to have a reduction of psychosocial stress and an increased quality of life that can be achieved through exercise. Thompson et al. (2003) also supported the importance of exercise and the benefits it provides cardiac patients. They listed numerous ways in which exercise can help prevent coronary artery disease and manage or improve risk factors like blood lipid levels, blood pressure and obesity. They also mentioned that it is important for health care providers to be knowledgeable of the benefits of exercise and physical activity so that they can educate their patients.

Physiological changes, such as improvement of muscular strength, are some of the first benefits patients can understand when it comes to exercise training in cardiac rehabilitation. Many cardiac patients have the need to either lose weight (fat weight) or gain weight (muscular strength) to help them with everyday functions and tasks. “Many Phase II outpatient cardiac rehabilitation patients suffer from general musculoskeletal weakness and atrophy caused by inactivity associated with recovery, sedentary lifestyle, or old age” (Spencer, 2007). Cardiovascular exercise training along with some resistance training will help patients gain strength and get back to a healthy lifestyle. Strengthening the muscles allows the body to improve stamina to perform daily activities and be able to do more throughout the day. Many patients who go through cardiac rehab set goals such as playing golf again, playing with kids or grandkids, going on long walks through the neighborhood, or going back to work. Exercise training can help the patients meet those goals using a healthy and safe timeline while minimizing the chance of another cardiovascular event.

Spencer (2007) completed a study on resistance training (RT) that focused on cardiac patients in rehabilitation. The patients were given warm-up exercises, resistance band training, and free weight training over a span of three months. He found that, “While the quantitative improvements and benefits of RT are apparent, with improvements in absolute strength, increased cardiovascular endurance, improved balance, coordination, ROM (range of motion), flexibility, hypertension, hyperlipidemia, glucose tolerance, insulin sensitivity, body composition, the pain associated with peripheral artery disease, as well as physical capacity over a wide range of household physical activities, it is more difficult but just as vital, to gauge RT’s impact on the psyche" (Spencer, 2007). Pollock et al. (2000) also supported how resistance exercise can be beneficial to cardiac patients. "Resistance training has favorable effects on muscular strength and endurance, cardiovascular function, metabolism, coronary risk factors, and psychosocial well-being" (Pollock et al., 2000). They completed a study to understand the effects of resistance training for patients with and without cardiovascular disease. They reported improvements in body fat percentage, muscular strength, glucose metabolism, serum lipids, heart rate, stroke volume and blood pressure in both types of patients. By performing resistance training, cardiac patients can combine this with aerobic training and receive the most physiological benefits from exercise training to reduce the risk of another cardiac event.

Another common benefit of cardiac rehab is improving a patient's blood lipid profile. Many studies (Thompson et al., 2003; Shephard & Balady, 1999; Brubaker et al., 1996) have documented that, with an exercise regimen, patients have decreases in low-density lipoproteins (LDL), triglycerides, and total cholesterol, and increases of high-density lipoproteins (HDL). Though, many of these researchers reported that the improvements were not statistically significant in any of the studies because of different complications during the pre-testing and testing. "There is much variability in the results of exercise/lipid-lowering studies, at least in part because of the heterogeneity of the study methods, populations, exercise interventions, and the use of adjuvant interventions such as diet or pharmacological lipid-lowering agents" (Shepherd & Balady, 1999). Working with cardiac patients to facilitate recovery back to good health is a gradual process. Significant changes in blood lipids require time and effort from the patient to improve on when only focusing on exercise training. A study done by Brubaker, Warner, Rejeski, Edwards, Matrazzo, Ribisl, Miller and Herrington (1996) showed a significant improvement in HDL, Cholesterol/HDL ratio, and triglycerides after an exercise program. They compared patients in a cardiac rehab for three months and also investigated patients who stayed in the program for at least a year or longer. In their findings they stated, “We found that patients that remained in our CRP (cardiac rehab program) on an average of 2.5 years were able to increase their functional capacity 6%, decrease their triglycerides 12%, and decrease their percent fat 8.1% beyond changes observed during the initial 3-month CRP” (Brubaker et al., 1996). Even though blood lipids are difficult to measure due to the effects of medications taken by cardiac patients, exercise has been shown to have a positive effect on blood lipid levels during cardiac rehabilitation.

Changes in blood pressure (BP) are another significant benefit of cardiac rehabilitation and how it can improve the health of patients. Many cardiac patients struggle with high BP (hypertension) and are put on medication(s) to help control it. Exercise training helps to strengthen the cardiac muscle and make the heart work more efficiently at pumping blood out of the heart and throughout the body where it is needed. “Afterloading of the left ventricle is reduced, allowing an increase of ejection fraction and stroke volume. The peak cardiac output is thus augmented, with an associated gain in functional capacity. Further, at any given rate of submaximal exercise, the lower systolic pressure yields a corresponding reduction in double-product and this reduces the risk of myocardial infarction” (Shephard & Balady, 1999). Taylor et al. (2003) completed a meta-analysis, in which one of the measures that was reviewed was blood pressure. They assessed in the review patients with CAD who experienced some form of exercise within cardiac rehabilitation. For blood pressure, they found a “significant decrease in systolic blood pressure with a mean difference of -3.2 mm Hg, but there was no difference in diastolic blood pressure” (Taylor et al., 2003). Blood pressure issues are common among cardiac patients and with the help of exercise training through cardiac rehab, patients can reduce their blood pressure, which also reduces this cardiovascular risk factor.

The psychological factors, such as quality of life, for cardiac patients are important when considering participating in cardiac rehabilitation. Many patients become scared or worried about having another cardiac event or have come to the realization that they are not as healthy as they once were. Dugmore, Tipson, Phillips, Flint, Stentiford, Bone and Littler (1999) completed a study and recruited cardiac patients who had experienced a myocardial infarction (MI) and performed regular aerobic exercise for 12 months compared to a control group. They used multiple different scales to measure quality of life and psychological well-being including The Toronto Attitude Scale (TAS), The Profile of Mood Stats (POMS), Quality of Life, and Vocational Status/Lifestyle Change. Dugmore et al. (1999) provided a brief description of each scale and what the main variables assessed:

- TAS – questionnaire to record depression;
- POMS – adjective checklist used to record and detect Tension/Anxiety, Dejection/Depression, Anger/Hostility, Vigour/Activity, Fatigue/Inertia, and Confusion/Bewilderment;
- Quality of Life – analogue scale to assess elements of feeling of wellbeing, mood, level of activity, pain, nausea, appetite, ability to perform housework/job, social activities, level of anxiety, and treatment effectiveness;
- Vocational Status/Lifestyle Change – self-administered questionnaire focusing on employment status, return to work, changes in occupation, hours worked, time lost from work owing to cardiovascular illness, hospital and family practice visits related to cardiovascular illness, patients still under cardiologists, drugs used to treat

> cardiovascular conditions, the presence and severity of angina and rates of reinfarction.

Throughout the study, they reported significant improvements after exercise and during the follow-up, which took place five years later. Patients went through aerobic training three times a week for about 12 months. Cardiorespiratory measures and the psychological wellbeing/quality of life scales were taken and recorded every four months. While patients progressed through the exercise program, their scores from each of the psychological wellbeing and quality of life scales were recorded. For the TAS scores of depression, patients' scores significantly decreased at each stage of exercise. The most significant change occurred from four months into the study to eight months, where the scores decreased about 1.6 for the exercise group. The patients recorded a total decrease of about 4.3 after 12 months of exercise for TAS scores. Within the POMS, the most significant findings from Dugmore et al. (1999) were of Tension/Anxiety and Vigour/Activity. Tension/Anxiety decreased about 8.2 throughout the 12 months of exercise with the largest decrease of about 5.7, which occurred from three weeks to four months within the exercise group. Vigour/Activity showed significant increases throughout the study. They reported that patients improved around 9.6 after finishing the 12-month exercise program. Their Quality of Life scores also significantly improved, with scores starting at 45.1 and ending with 85.9 in the exercise group.

Cardiac rehabilitation has multiple benefits when it comes to patients recovering from heart disease. "Exercise training reduces risk factors, improves functional capacity and prognosis, and enhances psychosocial well-being and quality of life in patients suffering from coronary artery disease (CAD)" (Volaklis, Spassis, & Tokmakidis, 2007). Cardiologists and physicians are increasing their recommendations for cardiac rehab to their patients because it is a safe and effective environment for regaining physiological and psychological benefits after heart disease diagnosis.

Land Versus Water Exercise Intensity

There are many different forms of exercise that people can perform to stay active once completing Phase II of cardiac rehab, and water exercise is becoming a more popular choice among cardiac patients. However, knowing how to track exercise intensity throughout water exercise can be difficult compared to land activities. One reason for this is that “the density of water is approximately 800 times that of air and generates an increase in ambient hydrostatic pressure” (Ayme, Rossi, Gavarry, Chaumet, & Boussuges, 2015). For further understanding, this means that the water creates a significant amount of pressure on the body when submerged and can change how the body responds to exercise. This pressure forces the body to adapt to the environment to keep homeostasis within the body while exercising. Darby and Yaekle (2000) made a statement saying, “comparing and contrasting of land and water exercise research results is sometimes difficult because a number of factors can affect HR and VO_2 responses on land and in the water: cadence of movements, water depth, body position (prone, standing or floating upright with a wet vest), type of movement (arm and legs *vs* legs only exercises), percentage of body fat, or other extraneous variables.” Similar to Darby and Yaekle (2000), other studies such as Ayme, Rossi, Gavarry, Chaumet and Boussuges (2015) as well as Schaal, Collins and Ashley (2012) have completed studies comparing land to water intensities for exercise, in which most of the researchers focused on heart rate (HR) and VO_2 responses in the participants during different modes and/or styles of exercise.

Heart rate is one of the most common measures used to gauge intensity during all forms of exercise. Though in water, some studies (Graef & Kruel, 2006; Heithold & Glass, 2002; Lees, 2007) reported that the resting and exercise HR decreases in immersion. “In rest or water exercise situations, the alterations found in the HR are influenced by factors such as the body position, the immersion depth, the water temperature, the HR in rest and the decrease of the hydrostatic weight” (Graef & Kruel, 2006). Heithold and Glass (2002) completed a study that used HR variations as one of their measures to investigate the differences between land and water intensities during multiple activities. There were many exercises used within the study and were categorized into four types, which were above shoulders, legs, below shoulders, and total body. In their results, they reported that HR was higher during land exercise compared to water exercise. There was a lower variation in HR of about 20 beats per minute (bpm), 30 bpm, 20 bpm and 30 bpm for above shoulders, legs, below shoulders and total body, respectively. Heithold and Glass (2002) further explored the reason as to why HR in water was so much lower than on land and reported that changes in HR can occur depending on the temperature of the water.

Many studies (Heithold & Glass, 2002; Lees, 2007; Graef & Kruel, 2006) have reported that the temperature of the water can influence HR responses at rest and during exercise as well. Lees (2007) reported “lower heart-rate responses have been reported at rest and during cycle ergometry at temperatures ranging from 18 to 25 degrees Celsius (64 to 77 degrees Fahrenheit).” Though, Lees (2007) also studied exercise training in warmer water temperatures up to 31 to 35 degrees Celsius (87 to 95 degrees Fahrenheit) and reported that this had similar effects on HR as compared to land exercises. The reason for temperature being a large impact on HR in water compared to on land has to do with thermoregulation within the body. During exercise on land, the HR rate increases due to the work of the muscles and the heat being created by the body. "During exercise, the core temperature rises due to metabolic heat, which is a by-product of the added metabolism used to fuel skeletal muscle contraction. As the body's core temperature rises, so does the heart rate. However, in cool water, the body can more readily lose this added heat via conduction and convection, thereby decreasing this heat induced rise in heart rate" (Heithold and Glass 2002). Graef and Kruel (2006) studied many articles to understand how HR responds to different water temperatures during rest and multiple exercises. At rest, they reported that water temperatures that ranged from 27 degrees Celsius to 33 degrees Celsius caused the HR to decrease about seven to 16 bpm. During cycle ergometer in the water, they found a wide range of changes in HR in different temperatures. From 18 degrees Celsius to 20 degrees Celsius, there was a decrease of about five to 19 bpm in HR. From 21 degrees Celsius to 25 degrees Celsius, the HR decreased about 10 bpm to 11 bpm. And finally, from 26 degrees Celsius to 30 degrees Celsius, the HR decreased around 6 bpm. During swimming exercise, the temperature of the water ranged from 18 degrees Celsius to 26 degrees Celsius, which decreased the HR between seven to 15 bpm. With these results, it can be determined that with cooler the water temperatures, the greater the decrease in HR as compared to warmer water temperatures.

Table 1

Average Decreases (Mean ± SD) in Heart Rate (beats per minute or bpm) Caused by Water Temperature

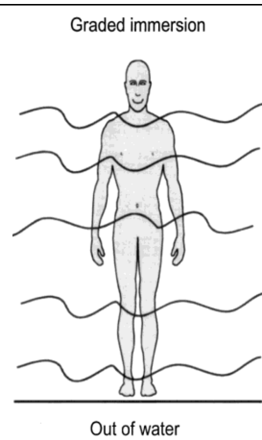
Temperature (°C)	**Temperature (°F)**	**Heart Rate (bpm)**
18-20	64-68	12 ± 8
20-25	68-77	12.5 ± 8
25-30	77-86	10.5 ± 4
30-34	86-93	8 ± 2

Adapted from Graef and Kruel (2006)

Another factor that can affect HR is the level of immersion at which a patient exercises in the water. Graef and Kruel (2006) completed a review on how HR responds to different modes of water exercise and the depth level in water. The exercise topics included swimming, running in shallow and deep water, water gymnastics, water cycling, immersion depth, and water temperature. Graef and Kruel (2006) concluded that HR is shown to be lower in water than when compared to on land. Though, the depth of immersion seemed to have a large effect on HR responses. The hydrostatic pressure from the water causes the blood to be redistributed towards the center of the body rather than the peripheries. "In resting healthy subjects, submitted to thermoneutral head-out water immersion, hemodynamic alterations include increases in both cardiac preload and cardiac output and decreases peripheral vascular resistance" (Ayme, Rossi, Gavarry, Chaumet & Boussuges 2014). In other words, when a person is in water that is neck deep, the pressure of the water causes the body to reevaluate where the blood is most needed. This results in the increase in ventricular filling and function of the heart. Graef and Kruel (2006) compared the studies in their review to understand how much the level of immersion changed the

HR. When the water level is at the knee, there is not a significant change in HR, but a decrease of about 0 to two bpm was recorded. At the level of the hip and the umbilical scar, there was a significant decrease of eight bpm to 13 bpm in HR. When the water level is at the xiphoid appendix, the HR significantly decreased about 13 bpm to 16 bpm. Next is immersion at the shoulders, but Graef and Kruel (2006) noted that when immersion level was at the shoulder, there was a difference between people holding their arms out of the water compared to in the water. When the water level was at the shoulders with arms out of the water, the HR significantly decreased about 12 bpm to 13 bpm. With arms still in the water, there was a significant decrease of 13 bpm to 25 bpm in HR. The last level of immersion was at the neck, which showed a significant decrease of 13 bpm to 17 bpm in HR (see Figure 1).

Figure 1. Effects of Water Immersion Level on Resting Heart Rate



Heart Rate	**Level of Immersion**
↓ 15 ± 3 bpm	Neck
↓ 14 ± 3 bpm	Xiphoid Process
↓ 11 ± 3 bpm	Umbilical
↓ 1 ± 1 bpm	Knee
No change	Ankle

Adapted from Meyer and Bucking (2004).

Another measure of intensity during exercise is rating of perceived exertion (RPE) using the Borg's scale. The RPE scale is a very common way to measure intensity that is used in almost all forms of exercise. Few studies focus on RPE and compare those results with other cardiorespiratory measures. Alberton, Antunes, Tartaruga, Silva, Cadore, Fernando and Kruel

(2011) studied the correlation between RPE and physiological variables during stationary running in water at different cadences. Even though they used healthy and younger women, they still found a significant finding that "all the cardiorespiratory variables presented a high and significant relationship with the RPE, demonstrating that the intensity of the water aerobics exercises can be prescribed using the RPE" (Alberton et al. 2011). Heithold and Glass (2002) reported the reason for most studies showing higher RPE with increased exercise intensity in water as compared to on land is "RPE integrates information received from peripheral working muscles and joints, from the central cardiovascular and respiratory function, and from the central nervous system." Another system of perceived exertion that has been studied is subjective effort perception (SPE). Graef and Kruel (2006) compared multiple studies that looked at the SPE scale and other studies that continued with the RPE scale. In conclusion, they found that there does need to be more research about the SPE scale but it can be used as an effective tool for intensity during water exercise. Although RPE is still the primary measure for exercise intensity on both land and in water, patients and practitioners need to become more familiarized with the scale so that it can be interpreted properly for accurate measures throughout exercises performed at different intensities.

Water Exercise for Cardiac Patients

Water exercise is becoming increasingly popular among adults with heart disease and research that focuses on water exercise and cardiac patients has also increased. "Hydrotherapy is an alternative method of exercising since the buoyancy effect reduces loading. Exercises to improve mobility, strength, as well as cardiovascular fitness can easily be provided in water" (Schmid et al., 2007). Water exercise has also been shown to influence blood pressure and ventricular function as well. There is a wide range of patients used for water aerobics studies, but when working with cardiac disease, the main patients who have been studied are those who have congestive heart failure (CHF) and coronary artery disease (CAD). The patients recruited for these studies are typically stable cardiac patients for safety reasons of each study. However, there are a couple studies (Meyer & Bucking 2004; Magder, Linnarsson & Gullstrand 1981) that used patients who were in a more severe and unstable cardiac state who could be observed for physiological changes as compared to physiological changes within stable patients. The following paragraphs include studies that used only cardiac patients as their participants and how these patients responded to water exercise.

Many cardiac patients struggle with high blood pressure (BP) or hypertension. “It [hypertension] is responsible for 40% of the mortality rate for stroke and 25% of that for coronary artery disease” (Cunha, Macedo, Araujo, Santos, Borges, Soares, Ayres & Pfrimer 2012). Exercise training is one way to help treat or reduce hypertension in patients and recent research has shown that water exercise can improve BP values after water exercise training. Tanaka, Bassett, Howley, Thompson, Ashraf and Rawson (1997) were some of the first researchers to report the effects of swimming on multiple physiological variables, mainly for hypertensive exercisers. They recruited 26 male and female hypertensive patients and separated them into a training and control groups. The training group completed a 10-week swimming program that occurred three days per week and lasted 60 minutes each day. Measures that were observed in this study included resting heart rate and blood pressure along with blood samples, plasma and blood volumes, forearm vascular resistance, and body composition. The summary of their results is shown below in Table 2. After the swimming exercise program, the patients showed a significant decrease in BP from both pre- to post-exercise while seated on land and in the supine position. Though, the systolic BP was significant while the diastolic BP was not significant. The average change in systolic and diastolic BP while seated was around 6 mm Hg and 2 mm Hg, respectively. When in the supine position, the change in mean systolic and diastolic blood pressure was around 6 mm Hg and 5 mm Hg, respectively.

Table 2

Changes in Resting Heart Rate and Blood Pressure After a 10-Week Swimming Program in Hypertensive Adults

Variables	**Before Training**	**After Training**
Resting HR (bpm)	80.8 ± 3.8	70.7 ± 3.2*
Seated Blood Pressure (mmHg)	Systolic: 150 ± 5 Diastolic: 96 ± 4	Systolic: 144 ± 4* Diastolic: 94 ± 3
Supine Blood Pressure (mmHg)	Systolic: 141 ± 5 Diastolic: 90 ± 4	Systolic: 135 ± 5* Diastolic: 85 ± 3

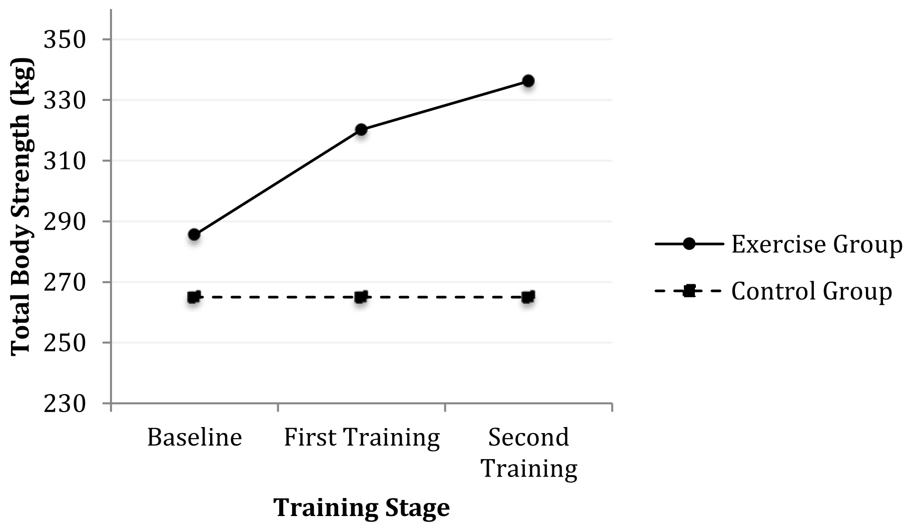
(Adapted from Tanaka, Bassett, Howley, Thompson, Ashraf and Rawson (1997) – Means ± S.D. Star (*) represents $p < 0.05$ after exercise training)

Another study similar to Tanaka et al. (1997) investigated the effect of water aerobics on BP instead of swimming on blood pressure. Farahani, Mansournia, Asheri, Fotouhi, Yunesian, Jamali and Ziaee (2010) had a protocol that resembled the Tanaka et al. (1997) study and investigated similar measures on only men with hypertension and also found significant improvement of blood pressure values. They performed a 10-week water aerobics exercise to observe the changes in resting blood pressure. Their results indicate that there was a decrease in systolic, diastolic, and mean arterial pressure of about 17 mm Hg, 4 mm Hg, and 8 mm Hg, respectively, after completing the water exercise sessions.

Water exercise training has also been shown to have benefits regarding muscular strength and endurance, which most cardiac patients need to improve. Many patients have either been sedentary for a long while or have been immobile due to heart disease treatment causing them to not be active. A study done by Cider, Schaufelberger, Sunnerhagen and Andersson (2003) focused on how congestive heart failure (CHF) patients responded to an exercise program in a swimming pool. The patients completed an eight-week water exercise program that lasted 45 minutes for each training session with the water level just below the neck. The water temperature was warmer at 33-34 degrees Celsius (91-93 degrees Fahrenheit) and the patients exercised at moderate intensity. The main variables tested were exercise capacity and muscle function, which consisted of muscles strength and endurance. In this study, they measured strength and endurance by peak torque while using the assessment tool Kinetic Communicator II (KIN-COM). “This equipment is hydraulically driven and microcomputer-controlled device that operates in an isokinetic mode, i.e. an equal speed and a perfectly adjusted resistance through the whole movement” (Cider, Schaufelberger, Sunnerhagen & Andersson, 2003). They also measured handgrip, heel-lifts, shoulder abduction, and shoulder flexion that were all unilateral isokinetic or isometric. Another measure used in this study was the 6-minute walk test to assess exercise capacity. They found significant improvements in distance walked after the water exercise program. Some of the important results from this study are shown below in Table 3. These results represent muscle endurance, which includes exercise capacity, oxygen uptake, and 6-minute walk test. They found significant improvement in distance walked after the water exercise program. For muscle function, or muscle strength, they found significant improvements for heel-lifts, shoulder flexion, shoulder abduction and isometric endurance in knee extension.

Another study assessed physiological adaptations in water exercise for cardiac patients. Tokmakidis, Spassis, and Volaklis (2007) used a protocol that trained, detrained and retrained using aqua aerobics exercise for male patients with coronary artery disease (CAD) using water aerobic exercise. The whole study was completed in 12 months but was separated into four-month training sessions. During each water exercise session, there was a 15-minute warm up and a 10-minute cool down, which left 50 minutes of water exercise training. The water exercise training sessions were then further broken down into water aerobics or water strength training and 10-minutes of water recreation, which consisted of ball games (Tokmakidis, Spassis & Volaklis 2007). When measuring for muscle strength, they used one repetition max (1RM) and a 6-minute walk test in waist deep water. In Figure 2, Tokmakidis, Spassis, and Volaklis (2007) combined the measures to determine overall body strength throughout the entire study. The graph indicates how total body strength progressed during the first and second training sessions and how it regressed during detraining. The greatest improvement in total body strength occurred during the first training session, which showed the training group increasing from about 288 kilograms to about 325 kilograms. After the patients detrained and loss about 10-15 kilograms of total body strength, the retraining session resulted in an increase of strength to about 340 kilograms. The results from this study are a prime example as to why cardiac patients should never stop exercising and how exercise can benefit them.

Figure 2. Effects of Water Exercise on Total Body Strength After Two Sessions of Water Training in Patients With CAD



Adapted from Tokmakidis, Spassis, and Volaklis (2007).

Cider, Schaufelberger, Sunnerhagen and Andersson (2003) and Tokmakidis, Spassis and Volaklis (2007) are other examples of different water exercise training programs to determine how water exercise, or hydrotherapy, could help cardiac patients with muscle function and endurance. “Our training programme focused both on peripheral muscle training and on central circulatory exercises in order to improve poor muscle function as well as aerobic capacity” (Cider, Schaufelberger, Sunnerhagen and Andersson 2003).

Table 3

Results from Cider, Schaufelberger, Sunnerhagen and Andersson (2003) - Effects of Water Training on Exercise Capacity and Endurance

Measure	**Participant Group**	**Before**	**After**
Exercise Capacity (W)	Training	84 ± 23	91 ± 24
	Control	74 ± 25	70 ± 22
VO_2 (ml/kg·min)	Training	14.3 ± 2.7	15.3 ± 3.2
	Control	14.3 ± 3.0	12.5 ± 2.7
6-Minute Walk (m)	Training	421 ±115	450 ± 94
	Control	329 ± 98	335 ± 95

Adapted from Cider, Schaufelberger, Sunnerhagen and Anderson (2003).

Exercise capacity, volume of oxygen (VO_2), or overall aerobic exertion throughout exercise, are other measures that are often used to gauge exercise intensity. Exercise capacity is important for patients to improve on to help them with activities of daily living (ADLs) and to have enough stamina throughout the day to accomplish chores or goals. Cider, Schaufelberger, Sunnerhagen and Andersson (2003) also investigated exercise capacity along with muscle function, which was mentioned. Muscle function refers to the body's ability to perform exercise physically in the extremities. The results indicated that the training group of stable CHF patients significantly improved in maximal exercise capacity, maximal oxygen consumption and 6-minute walk test. Cider, Schaufelberger, Sunnerhagen, and Andersson (2003) stated "in our study there was a 6% increase in peak VO_2 in the training group and a 16% decrease in peak VO_2 in the control group." Even though 6% does not seem like a significant improvement, CHF patients have many limitations during exercise such as heart rate response, which can prevent them from improving more than a healthy person after exercise. A patient that has CHF has to be careful of their heart rate because during exercise, the heart may be unable to function at the pumping volume needed, which results in an accelerated heart rate. The largest improvement shown in Table 3 is the 6-minute walk test. After eight weeks of hydrotherapy, patients were able to walk about 29 meters more than when they started the water exercise training study. Tokmakidis, Spassis and Volaklis (2008) also found improvements in aerobic exercise performance by measuring peak VO_2 and the 6-minute walk test. This study was unique in that it was a training, detraining, and then a re-training session of water exercise with patients with coronary artery disease (CAD). From baseline to after the re-training session, the participants improved their peak VO_2 from 26.2 $\pm$ 4.0 to 29.2 $\pm$ 6.1 $ml/^{kg-1}/min^{-1}$ respectively. This indicates that the patients improved their oxygen uptake throughout exercise training and retraining, which leads to an improved fitness level. The patients' 6-minute walk test also increased throughout the training and retraining sessions and improved about 33.7 $\pm$ 25.6 meters from the baseline measurements. A 6-minute walk test combines exercise capacity and muscular strength, so improvements in this category represents increases in the overall fitness of the cardiac patients.

Water exercise has also been shown to greatly impact the function of the heart, whether it is filling of the ventricles or the ejection fraction (EF). Many studies have suggested that heart failure (HF) patients should not participate in water exercise because of reported ventricular complications (Volaklis, Spassis & Tokmakidis 2007). One of the first researchers to study this effect was Magder, Linnarsson and Gullstrand (1981) and they explained that patients with ischemic heart disease might not be able to handle the shift of blood volume from peripheries to central within the body. "The compressive effect of the water on the extremities and the decreased skin blood flow all increase the left ventricular afterload and thus might decrease the subjects' peak work level" (Magder, Linnarsson & Gullstrand 1981). A study completed by Meyer and Bucking (2004) observed the overall function of the heart during water exercise at different immersion levels. The patients who participated in the study had moderate myocardial infarction (MI), severe MI, moderate congestive heart failure (CHF), compensated CHF and healthy volunteers. The patients first went through a swimming test to assess baseline measures, and then on a different day within three weeks of testing, they completed two days of sitting and supine tests on an electrically braked cycle ergometer (Magder, Linnarsson & Gullstrand 1981). They showed that for immersion at the xiphoid process and the neck, patients with moderate heart disease showed a slight improvement in left ventricular function but was not statistically significant. Though, patients with severe heart disease (both MI and CHF patients) had left ventricle function decreases and this becomes a concern for severe patients when immersed in the same water levels as compared to moderate patients. “According to the Starling Law, the preload increase could have shifted the working point of the resting-volume curve far to the right, thus exceeding the crucial point; in consequence, left ventricular overload occurred, and the stroke volume decreased” (Meyer and Bucking 2004). In conclusion for Magder, Linnarsson and Gullstrand (1981), they recommended that patients should avoid swimming if diagnosed with ischemic heart disease because the function or output of the heart may not be able to handle the workload that swimming requires.

However, more recent studies have indicated how water aerobic exercises can lead to multiple physiological responses including cardiovascular adaptations, biventricular function and volumes and systemic vascular resistance. (Schmid et al. 2007; Svealv, Cider, Tang, Angwald, Kardassis & Andersson 2009). Svealv et al. (2009) completed a study focusing on stable CHF patients in hydrotherapy exercise compared to land exercise. The exercise protocol consisted of one baseline session, then eight weeks of no exercise, and then finished with eight weeks of hydrotherapy. The hydrotherapy sessions included 45-minutes of water exercise twice a week in a pool with a temperature of 33-34 degrees Celsius (91-93 degrees Fahrenheit). For systolic function, they found significant improvements in stroke volume and left ventricular ejection fraction (LVEF). Stroke volume and LVEF significantly increased about 20.5 ± 15 milliliters (mL) and about 4 ± 8.5 percent, respectively. Cardiac output also increased significantly going from 3.1 ± 0.8 to 4.2 ± 0.9 liters per minute (L/min). Diastolic volumes and filling pressure also demonstrated signs of improvement but the results were not significant. “A lower heart rate alleviates ventricular filling and prolonged diastasis eases myocardial perfusion and is associated with improved systolic function” (Svealv et al. 2009). The final results from the study are shown in Table 4. This is one of the first studies to investigate biventricular function after hydrotherapy. With these results, it can be concluded cardiac patients can improve cardiac function and physiologically through water exercise with careful supervision and exercise prescription.

Table 4

Average Improvements in Ventricular Function After Water Exercise

Variables	**Baseline**	**After Water Exercise**
Cardiac Output (L/min)	3.1 ± 0.8	4.2 ± 0.9
Stroke Volume (mL)	43.9 ± 13.6	64.4 ± 16.5
LVEF (%)	31 ± 9	35 ± 8
DFV (cm/sec)	8.3 ± 1.8	9.5 ± 1.8

Adapted from Svealv et al. (2009); LVEF – left ventricular ejection fraction; DFV – diastolic filling velocity; L/min – liters per minute; cm/s – centimeters per second.

Recommendations for Cardiac Patients and Water Exercise Instructors

When working with cardiac patients in the water, it is important to constantly check on them to prevent strain on the heart during exercise. Since patients typically do not have access to equipment to help monitor their HR and EKGs in the water, instructors and patients must be mindful of how they are feeling throughout exercise. There are a few steps that water exercise instructors should remember for when working with cardiac patients.

One of the first steps an instructor can follow is to make sure that they have a general idea of the different types of heart disease and treatments that are used for patients. For example, a CHF patient's HR will increase more rapidly than other patients and might have a different exercise HR range to stay in for safety reasons. In this case, instructors can try and make sure that those patients take more breaks and are consistently checking their HR throughout the water exercise sessions. Another example would be if a patient had open-heart surgery. Instructors should make sure that the cardiologist or physician has cleared them for exercise and make sure the incision is properly healed before being able to submerge in water.

Another step to follow is to make sure that the patients check their HR throughout water exercise. When entering the water, the HR decreases a certain amount depending on the level of immersion along with water temperature. As described earlier in this review, the HR can decrease anywhere between zero to 25 bpm depending on depth and temperature of the water and how cool the water is where the patients are exercising. The average HR range with the water immersion level being between the hip and the shoulders is 8-17 beats per minute. Even though the HR decreases, it still responds to exercise in the same manner as on land and increases when putting forth exertion and effort. Also, the temperature of the water becomes a factor for patients causing changes in thermoregulation of the body and blood distribution as well (Heithold & Glass, 2002). To assure the safety of the patients while exercising, the instructors and practitioners might want to try to check HR every 10 minutes throughout exercise and to also check water temperatures prior to starting the session. Also, making sure they patients are in the appropriate level of immersion during water exercise is something instructors should be observant of as well.

Other important steps to remember when working with cardiac patients have to do with emergency response in case of cardiac events. Also, having plenty of seating around the pool would be significant for patients when getting out of the pool so that they can rest and take their HR when needed. By working with cardiac patients are always at risk for having another cardiac event, it would be beneficial to have emergency procedures in place and medical personnel at the facility. If this is not possible, then having water exercise classes in close proximity to a hospital is also essential. This will reassure the patients and the instructors that if an emergency was to occur procedures and equipment are available to respond to cardiac emergencies.

Table 5

Water Exercise Recommendations for Instructors and Patients

Instructors	**Patients**
Allow breaks for patients throughout water exercise; every 10 minutes if possible	Take breaks during exercise about every 10 minutes if possible
Set pool to the correct temperature for each exercise	Be able to check HR properly either manually or with underwater HR monitor
Choose appropriate water immersion levels for each exercise session	Be careful with temperature, water immersion, and intensity during exercise for safety
Make sure to have medical personnel and/or hospital close by in case of emergency with patients	Check with instructor about medical personnel and/or hospital nearby in case of emergency

Conclusions

In conclusion, water exercise can provide many cardiovascular benefits for cardiac patients through different forms of water exercise training. Though, there still needs to be further research specifically for cardiac patients who perform water exercise and their physiological responses to transition from land to water environment. Recommendations to consider when going from land exercise to water exercise is that a person's (healthy or cardiac patient) heart rate and blood pressure decrease automatically due to the body's adjustments to water pressure. Although, these two measures still react to exercise in water the same way as they do on land in that they increase as the exertion or intensity increases. After performing water exercise training, researchers have reported improvements in heart rate, blood pressure, exercise capacity, and muscles function. In addition, studies have also shown changes in ventricular function by using echocardiography and echocardiogram, which was done by Svealv et al. (2009). In the end, training in water is an alternative form of exercise that can have many benefits for cardiac patients after treatment and cardiac rehabilitation.

Future Research

Summaries of research on water exercise and training have been presented in this review. There is a wide range of factors to be studied and measured to document the benefits of water exercise. Future studies need to focus on cardiac patients when comparing land to water intensities. Many previous studies have recruited older adults instead of cardiac patients to reduce the risk of an emergency situation during exercise. More data on cardiac patients will help instructors and practitioners understand how various cardiac populations respond to training in the water, and how they can provide the best exercise prescriptions individualized for specific cardiac diseases/abnormalities. Another research area that could be investigated is how patients should warm-up and cool down when exercising in water. Few specifics for these transitions from rest to water exercise are described in the literature. Because previous decreases in heart rate and blood pressure just by immersion into the water have been documented in the literature, observations specifically for cardiac patients exercising on the land and in the water, could be an area for further research.

Although numerous researchers have studied water exercise and the cardiovascular benefits of this type of exercise, there is still much left to be documented in this field for cardiac patients. Possibly updating previous studies using newer technology to measure cardiac patients while actually transitioning to and from the water environment as well as exercising in the water could provide important information into how cardiac patients today may further benefit from water exercise training.

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