THE EFFECTS OF AQUATIC EXERCISE PROGRAM ON CARDIORESPIRATORY FUNCTION, MOTOR FITNESS, AND PHYSICAL ACTIVITY AFFECT FOR POSTSTROKE ADULTS

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To the Dean of the Graduate School:

I am submitting herewith a dissertation written by Gwang-Yon Hwang entitled "The Effects of Aquatic Exercise Program on Cardiorespiratory Function, Motor Fitness, and Physical Activity Affect for Poststroke Adults." I have examined this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Kinesiology.

Ronald W. Davis, Ph.D., Major Professor

We have read this dissertation and recommend its acceptance:

Vic Ben-Ezra, Ph.D.

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Accepted:

Dean of the Graduate School

DEDICATION

To God, who saved my life from a terrible parachute accident during a mission in the Korean Special Forces, inspired me to have a particular interest towards people with disabilities, and has guided me the best way to complete this advanced degree in order for me to serve individuals with disabilities across all ages, thank you for your unconditional love, mercy, and grace.

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ABSTRACT

GWANG-YON HWANG

THE EFFECTS OF AQUATIC EXERCISE PROGRAM ON CARDIORESPIRATORY FUNCTION, MOTOR FITNESS, AND PHYSICAL ACTIVITY AFFECT FOR POSTSTROKE ADULTS

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The purpose of this study was to determine the effects of a 6-week aquatic exercise program on cardiorespiratory function, motor fitness, and physical activity affect for poststroke adults. A 2 × 2 crossover design with a 2-week washout period was used for this study. Eleven poststroke adults (age range 50 to 80 years) were recruited from local rehabilitation centers, and the participants were randomly assigned to exercise and control phases. The participants in the exercise phase engaged in the individualized aquatic exercise program for 6 weeks. The participants in the control phase engaged in their normal daily activities without participation in any aquatic exercise sessions for 6 weeks. The participants in both phases were crossed over to the alternate phase (i.e., exercise and control) for another 6 weeks separated by a 2-week washout period.

All the participants were assessed at baseline, 6, 8, and 14 weeks for data analysis. The aquatic exercise program focused on improving cardiorespiratory function, motor fitness, and physical activity affect for the participants. The participants in the exercise phase participated in the individualized aquatic exercise sessions for 60 min, 3 times per week, for 6 weeks at 50-70% of their maximal heart rate reserve. In order to

examine the hypotheses of this study, a two-way ANOVA with repeated measures was applied for parametric variables, and Wilcoxon matched-pair test was applied for non-parametric variables. The significance level was set at $p \leq .05$.

Compared to the control phase, the poststroke participants demonstrated significant improvements in resting heart rate (-5%), mean arterial pressure (-5.4%), the ratio of forced expiration volume in 1 s to forced vital capacity (8.1%), normal gait speed (25.9%), Timed Up and Go (-17%), chronic positive affect (37.1%), negative affect (-69.2%), tranquility (28.9%), and fatigue (-54.7%) across the exercise phase. Within the limitations of the study and specific to the participants of the study, it was concluded that participation in the 6-week aquatic exercise program would be beneficial for the poststroke participants to maintain and improve their cardiorespiratory function, motor fitness, and physical activity affect.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Having a stroke can be debilitative and economically draining on a family. According to the World Health Organization (WHO, 2013) nearly 6 million people die each year from stroke. Stroke is not specific to gender according to the American Heart Association (AHA), who reported in 2010 that more than 6 million Americans over the age of 20 had a stroke (2,500,000 males and 3,900,000 females; AHA, 2010). In 2010, the economic impact of having a stroke is over $70 billion in the United States.

Stroke has been defined as having compromised oxygen and blood flow to the brain which results in impaired motor and sensory function (Bean, Vora, & Frontera, 2004; Dishman, Washburn, & Heath, 2004; WHO, 2013). The condition of stroke is considered in the category of brain injury, along with closed and open head injuries (Driver & Lox, 2007) and is reported as occurring in two types, ischemic and hemorrhagic. Ischemia or ischemic stroke is brought about by clogging of the brain's blood vessels (e.g., thrombosis, stenosis, or embolism). Hemorrhage or hemorrhagic stroke is characterized by bursting of weak blood vessels in the brain due to high blood pressure (AHA, 2010; WHO, 2013). The effects of the stroke can have a serious impact on functional performance on the human body.

Impact of Stroke

With regard to the impact of stroke on the body, individuals show cardiorespiratory dysfunction, muscle weakness, muscle shortening, and muscle atrophy along with spasticity, limited range of motion, poor balance, chronic pain, and negative emotional responses (Eng et al., 2003; Kelly, Kilbreath, Davis, Zeman, & Raymond, 2003; Prado-Medeiros et al., 2012; Sutbeyaz, Koseoglu, Inan, & Coskun, 2010). In addition, poststroke individuals show impairments in vision, hearing, cognition, speech and language, behavior responses, and social problems (Jung & Lee, 2010; Sims et al., 2009). In particular, depression in the stroke population contributes to inactive life patterns, as well as, abnormal muscle tone which can contribute to poor locomotor movements and poor postural balance (Jung & Lee, 2010; Noh, Lim, Shin, & Paik, 2008; Sims et al., 2009). The results of having a stroke can impact a person's desire to engage in an active lifestyle and enjoy a higher quality of life, and affect a person's desire to interact with society and live an independent lifestyle (Chu et al., 2004; Eng et al., 2003; Gordon et al., 2004).

Limitations to Exercise Caused by Stroke

Researchers have reported specific exercise limitations for poststroke adults such as a lower cardiorespiratory function (i.e., 40-50%) than the general healthy population with a sedentary lifestyle (Billinger, Coughenour, MacKay-Lyons, & Ivey, 2012; Kelly et al., 2003; MacKay-Lyons & Makrides, 2004; Sutbeyaz et al., 2010). Poststroke adults also demonstrate physical and emotional fatigue due to low maximal oxygen intake

(VO_2max), impaired cardiac conduction system, abnormal resting heart rate, low maximal heart rate, high blood pressure, high muscle tone, chronic muscle pain, and depression when compared to the general population (Durstine, Moore, Painter, & Roberts, 2009; Mackay-Lyons & Howlett, 2005). Poststroke individuals have been reported to have weaker diaphragm, and intercostals, coupled with poor abdominal muscles which contribute to lower lung capacity (e.g., total lung and forced vital capacity) and reduced lung volume (e.g., tidal, inspiratory reserve, and expiratory reserve volume; Billinger et al., 2012; Kelly et al., 2003; Mackay-Lyons & Howlett, 2005; Sutbeyaz et al., 2010). Exercise programs that occur in the water have been reported to provide a more successful, accessible, and accommodating environment for poststroke adults to improve their cardiorespiratory function, motor fitness, and physical activity affect when compared to land exercise programs (Chu et al, 2004; Jung & Lee, 2010; Noh et al., 2008; Verheyden, Kiekens, Vanlandewijck, Feys, & Daly, 2006).

Land and Aquatic Exercise Programs

Researchers have documented positive changes in cardiorespiratory function, motor fitness, and physical activity affect using land exercise programs for the stroke population (Eng et al., 2003; MacKay-Lyons & Makrides, 2004; Ramas, Courbon, Roche, Bethoux, & Calmels, 2007; Rimmer, Rauworth, Wang, Nicola, & Hill, 2009; Sims et al., 2009). However, there are limited scientific research findings to report the positive effects of aquatic exercise programs on cardiorespiratory function, motor fitness, and physical activity affect for the poststroke population (Daly & Lambeck, 2007; Daly

& Lambeck, 2008; Mehrholz, Kugler, & Pohl, 2011; Meredith-Jones, Waters, Legges, & Jones, 2011; Noh et al., 2008). Meredith-Jones et al. (2011) pointed out that aquatic exercise programs can be safe alternatives to land exercise programs for maintaining health and improving the fitness level of poststroke adults.

Waller, Lambeck, and Daly (2009) stated that an aquatic environment is an ideal workout medium for individuals with disabilities across all ages since it has several hydrodynamic characteristics that allow them to participate in regular physical activities. Five unique benefits provided by the water during aquatic exercises for this population are: buoyancy, water pressure, water resistance, sensory input, and varying water temperature (Daly & Lambeck, 2008; Getz, Hutzler, & Vermeer, 2006; Sova, 1992; Waller et al., 2009). Individuals with disabilities, to include those who have had a stroke, can take advantage of aquatic exercise programs to train paralyzed limbs, decrease muscle pain, improve cardiorespiratory system, increase range of motion, and improve balance and posture (Becker, 2009; Stan, 2012).

In addition, individuals with disabilities can enhance their body image and abilities to interact with peers, acquire social acceptance, and develop proper social behaviors through participation in an aquatic exercise program (Driver & Ede, 2009; Driver, Rees, O’Connor, & Lox, 2006; Sherrill, 2004; Stan, 2012). Aquatic exercise programs serve poststroke individuals by helping them develop physically and emotionally (Gordon et al., 2004; Mehrholz et al., 2011; Rimmer, Chen, McCubbin, Drum, & Peterson, 2010). Aquatic exercise programming has also been reported to increase participation rates (92%) and compliance for poststroke adults (Chu et al., 2004). Participating in an aquatic exercise program can have positive results on overcoming the physiological, motor, and psychological limitations caused by a stroke.

Four aquatic exercise methods have been documented in the literature to be used with the disabled populations. Meno (2000) indicated that the Bad Ragaz Ring Method is an aquatic exercise method to improve proprioception, muscular strength, range of motion, and muscular endurance. Lambeck and Stanat (2000) identified the use of the Halliwick method to promote independent movements in the water. This method also addresses improvement in water adaptation, breath control, and postural control for individuals with disabilities. Leathem and Egbert (2012) reported that Watsu is an aquatic exercise method to increase range of motion and improve emotional states for individuals with disabilities. According to Bayraktar et al. (2013), Ai Chi is an aquatic exercise method to improve range of motion, stability, and respiratory mechanism in the water. These aquatic exercise methods could be combined and individualized to develop an aquatic exercise program for individuals with disabilities.

Benefits for Aquatic Exercise

Participation in an aquatic exercise program on a regular basis makes positive contributions to improving cardiorespiratory fitness for adults with brain injuries, including poststroke adults (Driver, O’Conner, Lox, & Rees, 2004; Mehrholz et al., 2011). Driver et al. (2004) reported that an 8-week aquatic exercise program had a positive impact on cardiovascular fitness in adults with a brain injury as measured by cycle ergometry time and load during a sub-maximal cycle ergometer test. A total of 16 adults with a brain injury engaged in an 8-week aquatic exercise program 3 times per week for 60 min each session. These adults attained a significant improvement over the control group in ergometry time (3.7 ± 1.5 min) and load (56.2 ± 28.9 W) postprogram. Chu et al. (2004) reported an increase in cardiorespiratory function. Seven poststroke adults participated in an 8-week study of aquatic exercise for 3 sessions per week at 60 min per session. At the end of the study, the experimental group demonstrated a 22% increase in VO_2max (17.3 ± 3.0 to 21.2 ± 2.3 ml/kg/min), whereas the control group did not demonstrate a considerable change in VO_2max (17.1 ± 3.2 to 17.6 ± 4.7 ml/kg/min). The participants in the control group participated in an arm function program (3 sessions per week at 60 min) focused on improving gross upper-body movement, fine motor skills, and upper-body muscle strength.

Quality of Life and Physical Activity Affect

Maintaining functional mobility and postural balance are fundamental necessities for ensuring quality of life and independence for poststroke individuals (Brown, Nagpal, & Chi, 2005; Jung & Lee, 2010; Noh et al., 2008). However, abnormal muscle tone and synergy patterns (e.g., shoulder adduction and internal rotation, elbow flexion, forearm pronation, wrist and finger flexion, retracted pelvis, hip flexion and internal rotation, hip adduction, knee extension, foot inversion, and ankle plantar flexion) may increase risks for bone fractures due to abrupt falls (Sims et al., 2009). According to Jung and Lee

(2010), exercise in water can provide the stroke population with more motivation and physical support to engage in a regular physical activity than exercise on land. Chu et al. (2004) stated that an 8-week aquatic exercise program improved the gait speed of poststroke adults. The poststroke adults showed a 19% improvement in gait speed (0.99 ± 0.33 to 1.18 ± 0.44 m/s). Noh et al. (2008) reported that 13 poststroke adults gained significant improvement in postural balance and leg muscle strength as a result of an 8-week aquatic exercise program. The 13 adults engaged in the aquatic exercise program 3 times per week for 60 min each. Compared to 12 adults in a conventional therapy group, these 13 adults had a significant improvement in postural balance on the affected side (i.e., forward weight shifting performance, 68.7 ± 6.5 to 76.7 ± 10.2 N/s; backward weight shifting performance, 67.8 ± 11.5 to 77.9 ± 10.1 N/s) and a 16.2% improvement in isokinetic knee flexor strength on the affected side.

In addition to maintaining functional mobility and postural balance, participation in a physical activity program may enhance emotional health in the general population which could be applied to the stroke population (Driver & Lox, 2007; Kwan & Bryan, 2010). Regular physical activity and active social interaction might positively influence psychological affect in persons with a brain injury, including poststroke adults. According to Lox, Jackson, Tuholski, Wasley, and Treasure (2000), the measure of “affect” refers to exercise-induced psychological and emotional states. The experience of positive affective feelings immediately followed by a daily exercise session may positively influence health-related quality of life and exercise behavior (e.g., long-term physical activity habits). Driver and Lox (2007) noted that the benefits of regular exercise play a critical role to enhance positive affective feelings (e.g., positive affect and tranquility) and to reduce negative affective feelings (e.g., negative affect and fatigue).

According to Lox et al. (2000), the Physical Activity Affect Scale (PAAS) is used to assess acute and chronic feelings with a Likert scale rating from 0 (i.e., do not feel) to 4 (i.e., feel very strongly) for each item. The PAAS consists of four subscales and 12 items. The four subscales are positive affect, tranquility, negative affect, and fatigue (Lox et al., 2000). Driver, Lox, O'Connor, and Rees (2003) stated that the PAAS is used to measure acute and chronic feeling states caused by exercise. Driver and O'Connor (2003) reported the benefits of an 8-week aquatic exercise program on affective experiences for adults with brain injuries. The participants engaged in the 8-week exercise program three times per week for 60 min each. The participants in the exercise program attained a notable improvement in chronic positive feelings as reported with pre/post means (M = 1.9 to 2.5) and chronic tranquility (M = 1.8 to 2.5) and a notable decrease in chronic negative feelings (M = 1.6 to 0.5) and chronic fatigue (M = 1.5 to 0.5) in comparison to the control group. In a separate study, Driver et al. (2003) evaluated the effect of an 8-week aquatic exercise program on affective experiences for adults with a brain injury. The 8-week program consisted of 24 sessions, 3 times a week for 60 min a day. After completing the 8-week exercise program, the participants showed a significant increase in chronic positive feelings as reported with pre/post means (M = 2.1 to 2.8) and chronic tranquility (M = 2.0 to 2.7) and a significant decrease in chronic negative feelings (M = 1.3 to 0) and chronic fatigue (M = 1.0 to 0.4; Driver et al., 2003).

Summary

Stroke is one of the leading causes of death and disability in the world. The total direct and indirect health care costs for the stroke population have become a social and economic burden in the world (AHA, 2010). Researchers have documented exercise limitations of adults who have had a stroke and developed land exercise programs that have documented positive effects on cardiorespiratory function, motor fitness, and physical activity affect for this population (Eng et al., 2003; Rimmer et al., 2009; Sims et al., 2009). The benefits of exercise programs that have been completed in an alternative setting (e.g., aquatic exercise programs) have not been readily identified in the literature. The physiological, motor, and emotional benefits of aquatic exercise programs for poststroke adults have not been closely investigated. There is little scientific evidence to evaluate the positive effects of aquatic exercise programs on cardiorespiratory function, motor fitness, and physical activity affect for the stroke population (Daly & Lambeck, 2008; Getz et al., 2006; Mehrholz et al., 2011; Meredith-Jones et al., 2011). To address the lack of research on this topic, this study will identify the positive exercise effects for poststroke adults who have completed an aquatic exercise program.

Purpose

Aquatic exercise has been recommended as a lifestyle modification for poststroke adults to lower their stroke recurrence and mortality. However, strong scientific evidence on the benefits of aquatic exercise programs is limited to provide exercise guidelines and resources for professionals working with this population. Therefore, the purpose of this study was to determine the effects of a 6-week aquatic exercise program on cardiorespiratory function, motor fitness, and physical activity affect for poststroke adults.

Hypotheses

The following null hypotheses for this study were statistically investigated. Each of the null hypotheses was evaluated using a significance level ($p \leq .05$).

1. There is no significant main effect of exercise (i.e., aquatic exercise and control groups) on cardiorespiratory function, motor fitness, and physical activity affect of poststroke adults.

2. There is no significant main effect of time (i.e., at baseline and after 6 weeks) on cardiorespiratory function, motor fitness, and physical activity affect within the same group.

3. There is no significant interaction effect of group and time on cardiorespiratory function, motor fitness, and physical activity affect.

Definitions

The terms and concepts that are fundamental to this study were defined as follows:

1. Aquatic exercise – A planned, structured, and repetitive exercise program in the water for persons with and without disabilities (Waller et al., 2009).

2. Cardiorespiratory function – Resting heart rate and mean arterial pressure.

3. Dynamic balance – A balance between applied forces and internal forces for human movements (Hall, 2003).

4. Fatigue (FA) – A negative feeling state with low arousal (Lox et al., 2000).

5. Forced expiration volume in 1 s (FEV_1) – The maximal volume of air exhaled in 1 s after a maximal inhalation (Sutbeyaz et al., 2010).

6. Forced vital capacity (FVC or VC) – The total volume of air expelled after a maximal inspiration (Sutbeyaz et al., 2010).

7. Mean arterial pressure (MAP) – The average blood pressure in the arteries is estimated with systolic and diastolic blood pressure (Wilmore & Costill, 2004).

8. Motor fitness – Dynamic balance and normal gait speed.

9. Negative affect (NA) – A negative feeling state with high arousal (Lox et al., 2000).

10. Normal gait speed (NGS) – A self-selected normal pace (m/s) when the participants are instructed to walk over 10 m of a 14-m walkway as comfortable and safe as possible (Steffen, Hacker, & Mollinger, 2002).

11. Physical activity affect – Positive and negative feeling states caused by a particular stimulus (Driver & Lox, 2007).

12. Positive affect (PA) – A positive feeling state with high arousal (Lox et al., 2000).

13. Poststroke – Individuals who have had a stroke.

14. Resting heart rate (HR_{rest}) – Resting rate of cardiac cycles per min (Wilmore & Costill, 2004).

15. Stroke – Impairments in motor and sensory function resulting from injured or dead brain cells after compromised oxygen and blood supply (Dishman et al., 2004; WHO, 2013).

16. Tranquility (TR) – A positive feeling state with low arousal (Lox et al., 2000).

Assumptions

The study was subject to the following assumptions:

1. Participants did not have fear of water, uncontrolled hypertension, congestive heart failure, previous myocardial infarction, uncontrolled seizure, musculoskeletal problems, pneumonia, and unstable other medical conditions.

2. Participants accurately and honestly reported how many days a week they received physical or occupational therapy.

3. Participants accurately and honestly responded to their interview questions for demographics.

4. Participants refrained from food, caffeine, alcohol, and nicotine intake at least 30 min prior to all experimental protocols.

Delimitations

The study was subject to the following delimitations:

1. Only outpatients from local hospitals in North Texas were included as participants in the study.

2. Only participants who experienced a stroke at least 6 months ago were recruited for this study.

3. Only participants with hemiparetic gait were selected for this study.

4. Only poststroke adults who could walk more than 10 m with or without assistive device were included for this study.

5. Only poststroke adults who had the cognitive ability to accurately follow verbal instruction during assessments and aquatic exercise sessions were selected for this study.

Limitations

The study was subject to the following limitations based on the methodology used:

1. A small sample size was a limitation to this study. The poststroke participants were recruited from neurological rehabilitation centers of local hospitals in Denton, Texas. Findings of this study may not be representative of all poststroke adults.

2. A specific age range for the poststroke participants was a limitation to this study. The age range was between 50 and 80 years. Findings of this study may not be representative of poststroke adults across all ages.

3. Participants who received a therapy session (e.g., occupational or physical therapy) on a weekly basis in a rehabilitation center, in addition to the aquatic exercise intervention, were included in this study.

4. This study did not control for daily medications taken by participants (e.g., beta blockers, angiotensin-converting enzyme inhibitors, and antidepressants).

5. A 2-week washout period was used for this study to rule out the carryover effects of the first treatment.

6. Target heart rate for the participants was estimated using the Karvonen Formula (ACSM, 2000).

7. This study did not measure participants' acute physical activity affect.

8. Varying stroke conditions were observed in the sample.

9. No adjustment was made during data analysis to account for the multiple comparisons made.

CHAPTER II

LITERATURE REVIEW

The purpose of this study was to examine if a 6-week aquatic exercise program was beneficial to improve cardiorespiratory function, motor fitness, and physical activity affect of poststroke adults. This chapter contains an overview of the most relevant articles on cardiorespiratory function, motor fitness, and physical activity affect for poststroke adults. The relevant literature review is presented in the following nine sections: (a) defining stroke, (b) history of aquatic exercise, (c) benefits of aquatic exercise environment, (d) cardiorespiratory function of poststroke adults, (e) motor fitness of poststroke adults, (f) physical activity affect of poststroke adults, (g) aquatic exercise methods, (h) aquatic exercise methods applied to poststroke adults, and (i) summary.

Defining Stroke

In the United States, nearly 2,300 people die every day as a result of cardiovascular disease (AHA, 2010). Cardiovascular disease is responsible for 50% of all deaths in developed countries; additionally, it accounts for 16% of deaths in developing countries (Dishman et al., 2004). In 2010, the AHA estimated that approximately 81,100,000 people in the U.S. have cardiovascular disease. The economic burden of cardiovascular disease in the country was more than $503.2 billion for 2010. More importantly, cardiovascular disease includes stroke, coronary heart disease, hypertensive diseases, and rheumatic heart diseases (AHA, 2010; WHO, 2013). People can experience blood vessel diseases such as cardiovascular disease (i.e., blood vessel disease to the heart) and cerebrovascular disease (i.e., blood vessel disease in the brain) due to the following common risk factors: hypertension, atherosclerosis, hyperlipidemia, diabetes mellitus, poor diet, smoking, and physical inactivity (AHA, 2010; Pringle et al., 2003). For instance, the buildup of plaque in the blood vessels can induce a heart attack or stroke. Indeed, plaque can be build up in the walls of the arteries in the brain and heart as results of inactive lifestyle, unhealthy eating pattern, and smoking habit. In addition, the blood flow in the brain and to the heart can be completely blocked by a traveling blood clot in the blood vessels. In this case, people can experience an ischemic heart attack or an ischemic stroke. Stroke is one of the leading causes of death in the U.S. (AHA, 2010). Therefore, a lifestyle modification such as physical activity and healthy diet pattern are necessary for poststroke adults to lower the stroke recurrence and mortality rates.

Stroke refers to impairments in motor and sensory function that comes from injured or dead brain cells after blocked oxygen and blood supply (Dishman et al., 2004; WHO, 2013). According to AHA (2010), it is estimated that roughly 6,400,000 American people more than 20 years of age experienced stroke. Approximately 2,500,000 are males, and approximately 3,900,000 are females. Strokes are caused by either ischemia such as cerebral infarction (87%), or intracerebral hemorrhage (10%), or subarachnoid hemorrhage (3%). In addition, transient ischemic attack (TIA) means temporal brain dysfunction as a result of compromised oxygen and blood supply to brain cells, spinal cord, or retina and is considered a predictor of future stroke accidents (AHA, 2010). The incidence of TIA is between 200,000 and 500,000 per year. AHA (2010) pointed out that the financial burden of stroke was roughly $73.7 billion for 2010 in the U.S. Participation in regular physical activities can reduce risks of either ischemic or hemorrhagic stroke.

History of Aquatic Exercise

According to Lepore, Gayle, and Stevens (2007), aquatic exercise has gradually evolved from the ancient healing spas of Mesopotamian, Egyptian, Indian, Chinese, and Native American civilizations. De Vierville (2004) noted that the ancient civilizations widely used thermal water as a healing means to treat disabilities, diseases, and illness before the development of physical medicine and rehabilitation as a professional field. In the Middle Ages, the belief of the Europeans regarding healing power of hot mineral water resulted in establishing a large mineral spa in Bath, England (De Vierville, 2004; Lepore et al., 2007). In 1630, the natural mineral spas of Bad Ragaz were built in the town of Bad Ragaz in Switzerland after the news of the spas' healing power spread (Meno, 2000).

Aquatic exercise refers to a planned, structured, and repetitive exercise program in the water for persons with and without disabilities (Waller et al., 2009). Aquatic exercise programs focus on improving physical and emotional health, functional independence, and postural mobility of the target population (Myers, Capek, Shill, & Sabbagh, 2013). In 2012, Stan stated that the term aquatic exercise is associated with aquatic therapy (hydrotherapy) and adapted aquatics. Specifically, aquatic therapy uses the medical process to rehabilitate persons with disabilities. One recognized program is Bad Ragaz Ring Method which is used to improve neuromuscular function and joint range of motion for individuals with disability on water surface. The instructor can use flotation equipment to float a participant on the water surface. The participant's proprioceptors can be stretched and stimulated by pushing arms or legs away from a fixed point of the instructor's hands and then pulling it back toward the fixed point (Meno, 2000).

Benefits of Aquatic Exercise Environment

According to Waller et al. (2009), water is a safe medium for individuals with disabilities to increase their physical activity level. Water has several unique properties to allow individuals with disabilities to engage in physical activity on a regular basis. Individuals with disabilities can take advantage of the following benefits of water: buoyancy, water pressure, water resistance, sensory input, and water temperature (Daly & Lambeck, 2008; Getz et al., 2006; Sova, 1992; Waller et al., 2009). Buoyancy can increase stability in human movements and performance. As a result, some individuals with impairments in walking ability and balance can stand and perform exercises more independently in the water than on land due to the effect of reduced gravity (Stan, 2012; Waller et al., 2009). Water pressure can decrease edema and increase venous blood return to the heart in the body. Because of this, it is greatly beneficial for persons with disabilities with poor blood circulation. Human movement and performance in the water can create considerable water resistance for individual disabilities. As a result of this, individuals with impairments can enhance their cardiorespiratory function, muscular strength, muscular endurance, mobility, balance, and flexibility thorough an aquatic exercise program (Getz et al., 2006; Sova, 1992). Water viscosity can maximize the sensory input mechanism; thus, it can benefit individuals with impaired sensory function (Stan, 2012). Warm water temperature can decrease the muscular tone and threshold; therefore, the body movements of individuals with disabilities can be easier in the aquatic environment (Jung & Lee, 2010).

Cardiorespiratory Function of Poststroke Adults

According to Sutbeyaz et al. (2010), the poststroke adults a demonstrated relatively lower total lung capacity, forced vital capacity, tidal volume, inspiratory reserve volume, expiratory and reserve volume resulting from impaired diaphragm, intercostals, and abdominal muscles as compared to the general population. Sutbeyaz et al. (2010) examined the effect of a 6-week respiratory muscle training on cardiorespiratory function in poststroke adults (6 times per week for 30 min each on the land). After completion of the 6-week program, adults (n = 15) in the experimental group showed significant improvement in forced vital capacity (3.2 ± 0.4 to 3.5 ± 0.3 L), forced expiratory volume in 1 second (2.5 ± 0.2 to 2.7 ± 0.1 L), maximum voluntary ventilation (60.3 ± 3.7 to 65.9 ± 4.8 cm H_2O), maximum inspiratory pressure (49.47 ± 5.9 to 57.33 ± 8.6 cm H_2O), and maximum expiratory pressure (60.7 ± 9.2 to 62.8 ± 9.9 cm H_2O) as compared with the control group.

In comparison to the healthy general population, the poststroke population showed approximately 50% lower VO_{2max} (Kelly et al., 2003). In this cross-sectional research study, VO_{2max} for 17 poststroke adults was assessed on the seated cycle ergometer. The values are represented as median and interquartile range (IQR). VO_{2max} for these participants was 1.09 L/min (IQR = 0.85 to 1.48), and maximal heart rate (HR_{max}) was 130 beats/min (IQR = 114 to 138) as presented as a percentage of predicted HR_{max} [208 - (0.7 × Age)]. The poststroke adults demonstrated relatively 15% lower HR_{max} as compared to the healthy adults in the same age group (Kelly et al., 2003).

In 2004, Driver et al. evaluated that the effects of an 8-week aquatic exercise program on cardiovascular endurance in persons with a brain injury which included poststroke adults. The 16 adults with a brain injury engaged in the aquatic exercise program 3 times per week for 60 min per day. The participants were randomly assigned into either an exercise or control group. Compared to the control group in the vocational rehabilitation therapy program (i.e., reading and writing), adults with a brain injury in the aquatic exercise group demonstrated a significant improvement in cardiovascular endurance as measured by cycle ergometry time and load during a sub-maximal cycle ergometer test. There were significant improvements in cycle ergometry time from a mean 5.9 ± 0.8 to 9.6 ± 2.1 min and load from a mean 87.6 ± 23.1 to 143.8 ± 34.7 kg in the aquatic exercise group after 8 weeks.

Moreover, Chu et al. (2004) reported the benefit of an aquatic exercise program on cardiovascular fitness for poststroke adults. The measure of VO_{2max} is considered as the best measure of cardiorespiratory function. In a randomized, controlled trial, 13 participants were assigned into an 8-week aquatic exercise program (experimental group) or an 8-week arm function program (control group). The participants in the experimental group (n = 7) engaged in the 8-week aquatic exercise program 3 times a week for 60 min each. Through aquatic exercise sessions, the participants gained 22% increase in VO_{2max} from a mean 17.3 ± 3.0 to 21.2 ± 2.3 ml/kg/min. However, the 8-week arm function program did not significantly increase VO_{2max} for the participants (n = 6) in the control group (3 times a week for 60 min each).

Motor Fitness of Poststroke Adults

In an effort to increase the likelihood of high quality of life and functional independence, good postural mobility and functional balance (i.e., motor fitness) are critical factors for the poststroke population (Brown et al., 2005; Jung & Lee, 2010; Noh et al., 2008). However, hyper tonicity and synergy patterns which impact the body from a stroke may increase risks for bone fractures due to abrupt falls (Sims et al., 2009). Jung and Lee (2010) indicated that poststroke adults showed slower gait speed, asymmetric gait, poor postural stability, and compensatory gait patterns (e.g., circumduction, vaulting, and pelvic hike). Persons with hemiparetic gait demonstrated a decrease in step length and single-limb support time during the gait cycle (Jung & Lee, 2010).

With regard to walking speed and endurance of the poststroke population, Kelly et al. (2003) noted that this population demonstrated relatively 50% lower maximal walking speed than the general healthy population. In this cross-sectional research study, the 10-m walk test was used to measure self-selected and maximal walking speed for 17 participants. The 6-min walk test was used to measure walking endurance for the 17 participants. The values are represented as median and interquartile range (IQR). Self-selected walking speed for the poststroke participants was 0.71 m/s (IQR = 0.55 to 0.96), and maximal walking speed was 1.03 m/s (IQR = 0.8 to 1.24). The walk distance for the participants during the 6-min walk test was 301.8 m (IQR = 202.8 to 384.9), and the average walking speed during the 6-min walk test was 0.84 m/s (IQR = 0.71 to 0.91).

Eng et al. (2003) investigated the effects of an 8-week land exercise program on gait speed and dynamic balance for poststroke adults (3 times per week for 60 min each). In a repeated measures design, 25 participants demonstrated a significant increase in normal gait speed (0.70 ± 0.27 to 0.79 ± 0.30 m/s) and dynamic balance (45.9 ± 5.3 to 48.0 ± 5.3; Berg Balance Test /56) after completion of the 8-week exercise program. The exercise program focused on improving functional mobility and dynamic balance of the 25 participants through participation in the following challenging motor tasks: rising from a chair, marching with ankle weights, weight shifting exercise, walking circuit, and stepping with steppers. The exercise intensity was set at 11-13 (fairly light to somewhat hard) of the 16-point Borg Rating of Perceived Exertion (RPE). The 8-week functional exercise program was led by three trainers. The 25 participants had to rate their RPE level during exercise, and the three trainers encouraged them to work out at their target RPE level for 8 weeks.

According to Jung and Lee (2010), an aquatic setting can provide the poststroke population with more motivation and a reduced gravity setting to engage in a regular physical activity as compared to a land exercise. In 2010, Jung and Lee stated that the use of ankle weights on the affected leg increased the stability of 22 poststroke adults during the aquatic treadmill walking test. Specifically, the use of an ankle weight increased the stance phase percentage of the affected leg (3%) and decreased the peak hip flexion of the affected leg (7.9%) during the gait cycle on the aquatic treadmill when compared to no ankle weight condition.

Chu et al. (2004) reported that the gait speed of poststroke adults was significantly improved through participation in an 8-week aquatic exercise program. Through a randomized trial, 13 adults were assigned into an experimental group (n =7) or a control group (n = 6). Seven participants in the experimental group participated in the aquatic exercise program for 8 weeks (3 times a week for 60 min each). Six participants in the control group participated in the arm exercise program for the same amount of time as the aquatic exercise group. The 8-week aquatic exercise group attained a 19% improvement in gait speed (0.99 ± 0.33 to 1.18 ± 0.44 m/s). The 8-week arm exercise group did not attain a significant change in gait speed (1.01 ± 0.29 to 1.04 ± 0.40 m/s). In addition, Verheyden et al. (2006) reported the effect of a 5-week aquatic exercise program on gait speed and functional mobility for poststroke adults. The 11 participants participated in 5 weeks of an aquatic exercise program three to four times per week. After completing the 5-week aquatic exercise program, the participants had a 16.7%

improvement in gait speed, a 39.1% improvement in gait speed during the 6-min walk test, and a 23.5% improvement in gait speed during the 10-m water movement test.

Physical Activity Affect of Poststroke Adults

"Emotional disturbances: Many stroke survivors experience fear, anxiety, frustration, anger, sadness, and a sense of grief for their physical and mental losses." (Durstine et al., 2009, p. 288). The physical and emotional benefits of participation in aquatic exercise programs have been documented by the previous researchers (Daly et al., 2009; Driver & Lox, 2007). Previous researchers have documented that participation in aquatic exercise programs can be beneficial for individuals with disabilities to train affected extremities, lower chronic muscle pain level, improve cardiac and respiratory function, enhance range of motion, improve balance, and enhance posture (Chu et al., 2004; Eng et al., 2003; Noh et al., 2008; Sutbeyaz et al., 2010). Additionally, participation in aquatic exercise programs can provide individuals with disabilities the opportunity to enhance their self-image, increase their social participation rate, obtain social acceptance, and learn appropriate social skills (Driver et al., 2006; Sherrill, 2004, Stan, 2012). Physical activity in the water can help poststroke adults profoundly improve physical and emotional well-being (Gordon et al., 2004; Mehrholz et al., 2011; Rimmer et al., 2010).

Engaging in a physical activity program may be beneficial to improve physical activity affect in the general population which could be applied to the stroke population

(Driver & Lox, 2007; Kwan & Bryan, 2010). According to Driver and Lox (2007), physical activity and active social interaction on a regular basis had a positive influence on psychological affect in adults with a brain injury including closed and open head injuries or stroke. The measure of "affect" represents exercise-induced psychological and emotional states. The Physical Activity Affect Scale (PAAS) is administered to score acute and chronic feeling states (Lox et al., 2000). More specifically, the PAAS is administered to score an acute feeling state before and after daily exercise sessions. The PAAS is also administered to score a chronic feeling state before and after an entire exercise program (Driver & O'Connor, 2003).

In 2003, Driver et al. reported the benefits of an 8-week aquatic exercise program on psychosocial experiences for adults with brain injuries. The participants engaged in the 8-week aquatic exercise program three times per week for 60 min each. The modified PAAS was administered to score acute and chronic feeling states (Lox, Tuholski, Jackson, & Woodford, 2002). The modified PAAS includes six subscales and 18 items. The six subscales consist of positive affect, negative affect, tranquility, fatigue, stress, and aggression. Each item was rated from 0 (do not feel) to 4 (feel very strongly). To score an acute feeling state, the participants were asked to indicate the level of each item before and after daily exercise sessions. To score a chronic feeling state, the participants were asked to indicate the level of each item at baseline and after 8 weeks. The acute and chronic feelings for the participants were reported with pre/post means. Throughout the 8-week aquatic exercise session, the participants showed a significant increase in acute positive feelings (M = 1.5 to 2.6), acute tranquility (M = 1.6 to 2.6), and acute fatigue (M = 0.3 to 0.9), and a significant decrease in acute negative feelings (M = 0.4 to 0.1), acute stress (M = 0.6 to 0.2), and acute aggression (M = 0.5 to 0.1) as compared to the control group. The participants in the 8-week aquatic exercise program also demonstrated a significant gain in chronic positive feelings (M = 1.9 to 2.5) and chronic tranquility (M = 1.8 to 2.5), and a significant reduction in chronic negative feelings (M = 1.6 to 0.5), chronic fatigue (M = 1.5 to 0.5), chronic stress (M = 1.3 to 0.5), and chronic aggression (M = 0.9 to 0.1) when compared to the control group (Driver et al., 2003).

Bandura (1986) stated that social cognitive theory is the theoretical foundation to explain a change of feelings which people experience through engaging in physical activity. Previous researchers have mentioned that poststroke adults can experience more physical inactivity and social isolation as a result of their impaired cardiorespiratory function, mobility, balance, coordination, muscle contraction, and joint movements (Eng et al., 2003; Kelly et al., 2003; Prado-Medeiros et al., 2012; Sutbeyaz et al., 2010). However, participation in regular physical activities can provide poststroke adults with the opportunities to experience more positive feelings and less negative feelings. When poststroke adults gain more solid belief by successfully completing a physical activity, their self-efficacy (capability) could be improved.

According to Driver et al. (2003), adults with brain injuries enhanced their acute positive feelings and tranquility and reduced their acute negative feelings, stress, and aggression throughout aquatic exercise sessions for 8 weeks. The participants engaged in the 8-week aquatic exercise program three times per week for 60 min each. The modified PAAS was utilized to assess acute and chronic feeling states on a Likert scale scoring from 0 (do not feel) to 4 (feel very strongly; Lox et al., 2002). The acute and chronic feeling states for the participants were presented with pre/post means. The participants in the program attained a significant increase in acute positive feelings (M = 1.8 to 2.7) and acute tranquility (M = 1.7 to 2.8). In addition, Driver et al. (2003) reported that adults with brain injuries demonstrated a significant decrease in acute negative feelings (M = 0.5 to 0.1), acute stress (M = 0.7 to 0.2), and acute aggression (M = 0.6 to 0.1) after completing daily exercise sessions. Moreover, adults with brain injuries enhanced their chronic positive feelings and tranquility and reduced their chronic negative feelings, fatigue, stress, and aggression as a result of the 8-week aquatic exercise program (three times per week for 60 min each). Specifically, the participants attained a significant improvement in chronic positive feelings (M = 2.1 to 2.8), chronic tranquility (M = 2.0 to 2.7), and a significant reduction in chronic negative feelings (M = 1.3 to 0), chronic fatigue (M = 1.0 to 0.4), chronic stress (M = 1.4 to 0.3), and chronic aggression (M = 0.8 to 0) throughout the 8-week exercise program.

Aquatic Exercise Methods

Aquatic exercise methods may appear similar, but there are different methods with different goals. Meno (2000) stated that Bad Ragaz Ring Method is an aquatic exercise method to promote muscle proprioceptors, muscular strength, muscular endurance, and flexibility on the upper/lower limbs and trunk. The instructor can use flotation devices (e.g., a neck collar, a floatation belt, and floatation rings) to float a participant on the water surface. The participant supported by those flotation devices in a supine position can perform active range of motion exercises by pushing a part of the body (e.g., arms, trunk, and legs) away from a fixed point of the instructor's hands and then pulling it back toward the fixed point at the water surface. The participant can also receive passive range of motion exercises when the instructor pushes a part of the body of the participant away from the fixed point and then pulls it back to the fixed point on the water surface (Meno, 2000).

According to Lambeck and Stanat (2000), the Halliwick method is swimming instruction strategies for individuals with disabilities. The ultimate goal of the Halliwick method is to allow individuals with disabilities to independently move and swim in the water without any physical and flotation aids. The benefits of the Halliwick method are to improve water adaptation, breathing control, dynamic balance, coordination, and postural control for individuals with disabilities. The Halliwick method includes the following four phases: Phase I—mental adjustment to the aquatic environment; Phase II—vertical, horizontal, and combined rotations in the water; Phase III—control of movement in the water; and Phase IV—independent movement in the water (Lambeck & Stanat, 2000).

In 2012, Leathem and Egbert noted that Watsu is an aquatic exercise method for passive relaxation movements to stretch the spine, joints, and muscles of a participant at the water surface. The instructor can rotate and stretch the trunk, legs, and arms of the participant by using buoyancy and water resistance. The benefits of Watsu are to enhance range of motion, reduce muscle tone, and improve emotional states for the participant using relaxation techniques (Leathem & Egbert, 2012). When compared to Bad Ragaz Ring method, this method can provide more physical and manual supports for a participant and use more relaxation techniques to stretch the participant's whole body.

Bayraktar et al. (2013) stated that Ai Chi is an aquatic exercise method to improve body weight shifting, range of motion, coordination, body awareness, relaxation, strength, and breathing control in the water. Ai Chi is modified from Tai Chi (i.e., one of the Chinese martial arts) generally conducted on land. To increase range of motion and stability, the participants can perform Ai Chi activities (e.g., slow/broad rotations of the arms, trunk, and legs) in a standing position at chest-level water depth. Rotation is important for poststroke adults as it can contribute to functional movements on land (e.g., sitting on a chair, standing from a chair, walking, changing direction, opening a door, moving around the furniture, and stepping over an obstacle).

Aquatic Exercise Methods Applied to Poststroke Adults

According to Noh et al. (2008), using a combination of Halliwick and Ai Chi methods had a great impact on improving postural balance and leg muscle strength for poststroke adults. A total of 25 participants were randomized into either an aquatic exercise program or a conventional therapy program. The 13 participants participated in the 8-week aquatic exercise program combined Halliwick and Ai Chi methods three times a week for 60 min each. When compared to the conventional therapy group, the 13 participants in the aquatic exercise program showed a positive change in postural balance (i.e., forward and backward weight shifting performance) and a 16.2% improvement in isokinetic knee flexor strength on the affected limb. Specifically, forward weight shifting performance on the affected limb was improved from a mean 68.7 ± 6.5 to 76.7 ± 10.2 N/s, and backward weight shifting performance on the affected limb was improved from a mean 67.8 ± 11.5 to 77.9 ± 10.1 N/s.

In a similar randomized pilot study, Tripp and Krakow (2014) identified that an aquatic exercise program using the Halliwick method positively changed postural balance and functional gait of poststroke adults. Through a blocked randomization, 14 participants were assigned to the aquatic exercise group (i.e., Halliwick method in combination with physiotherapy) and 16 participants were assigned to the physiotherapy group. The participants in the aquatic exercise group received 3 exercise sessions per week and 2 physiotherapy sessions per week, 5 times per week for 45 min per session over a period of 2 weeks. The participants in the physiotherapy group received 5 therapy sessions per week for 45 min per session over a period of two weeks. The postural balance for the participants was measured at baseline and after two weeks using the Berg Balance Scale. The Berg Balance Scale has 14 indicators to score functional performance and dependency with a 5-point Likert scale each. The functional gait ability for the participants was measured at baseline and after two weeks using the Functional Ambulation Categories. In comparison to the physiotherapy group, the aquatic exercise group revealed more significant improvements in postural balance and functional gait.

In 2009, Chon, Oh, and Shim reported that the effect of Watsu method on spasticity and mobility in poststroke adults. In this case study, three adults post hemiplegic stroke received 40 aquatic exercise sessions based on Watsu method for 8 weeks, 5 times per week for 40 min per session. The tone assessment scale (TAS) was used to measure the muscle tone for the participants at baseline and after 8 weeks. The total score of the TAS was rated from 0 (i.e., no muscle tone) to 40 (i.e., severe muscle tone). The Rivermead Visual Gait Assessment (RVGA) was used to measure mobility function for the participants at baseline and after 8 weeks. The RVGA consists of 20 indicators each with a 4-point Likert scale: 2 indicators to score arm movements during the swing and stance phases of gait, 7 indicators to score the swing phase of gait, and 11 indicators to score the stance phase of gait. The total score for the RVGA was used to quantify the level of functional mobility for the participants [e.g., total = 0 (normal gait), total = more than 59 (grossly abnormal gait)]. The three participants demonstrated an increase in mobility function and a decrease in the spasticity level after the 8-week Watsu application.

Summary

To date, the effects of aquatic exercise programs on cardiorespiratory function, motor fitness, and physical activity affect for the poststroke population have not been rigorously investigated in a community setting. Participation in a community based aquatic exercise program may enhance cardiorespiratory function, motor fitness, and physical activity affect of the poststroke population. Therefore, planned, structured, and repetitive exercise in an aquatic setting may be implemented in order to improve cardiorespiratory function, motor fitness, and physical activity affect in this population.

CHAPTER III

METHOD

Research Design

A crossover design with a 2-week washout period (Yuen, Baker, & Rayman, 2002) was used to examine the effects of a 6-week aquatic exercise program on cardiorespiratory function, motor fitness, and physical activity affect for adults who have had a stroke (i.e., poststroke; see Appendix A). After random assignment, there were 6 weeks of intervention (i.e., exercise and control) followed by a 2-week washout period, followed by a crossover format. Participants from the aquatic exercise group moved to the control group and vice versa. The entire study lasted 14 weeks (Verheyden et al., 2006).

Jones and Kenward (2003) stated that a prominent feature of this crossover design was that all participants could experience both treatments in a different sequence. Comparison of two different treatments (i.e., exercise and control) within the same participants can eliminate not only any subject effect during measurements, but also measurement errors in different treatment phases. Washout periods separating two different treatments can be used to reduce the influence of the first treatment on the participants or the carryover effect (Jones et al., 2003).

A total of 14 poststroke adults (age range 50 to 80 years) participated in the current research study. The participants were recruited from neurological rehabilitation centers within local hospitals. The primary investigator (PI) contacted the program coordinators of the rehabilitation centers to schedule an informational meeting for potential participants with details of the study. At the conclusion of the meeting, the PI distributed consent forms to those who showed interest in participating. The PI collected the signed consent forms prior to the baseline assessment and then scheduled baseline test sessions for those consenting to participation (i.e., signed consent forms). All procedures and consent forms were approved by the University's Institutional Review Board.

After completion of the baseline assessment, the 14 participants (8 males, 6 females) were randomly assigned to two groups: an aquatic exercise (n = 7) or control group (n = 7). The PI put the numbers from 1 to 14 in an opaque bag and asked the participants to select a number. The participants who chose odd numbers were assigned into an aquatic exercise group and those who chose even numbers were assigned into a control group. The first treatment phase for both groups lasted 6 weeks (i.e., aquatic exercise or control). After the first treatment phase, the participants received a washout period for 2 weeks without participation in any aquatic exercise sessions. Following the washout period, the participants in both groups crossed over to the alternative treatment group for 6 weeks. The participants in the aquatic exercise group attended 18 sessions of the planned, structured, and repetitive exercise program for 6 weeks (i.e., 3 times per week for 60 min per session). Attrition occurred for three of the 14 participants due to personal issues: an unexpected fall at home, a transportation issue, and relocating to another state. All data for cardiorespiratory, motor fitness, and physical activity affect were collected at baseline, after the first treatment period (6 weeks), after the washout period (8 weeks), and after the second treatment period (14 weeks) in a room free of distractions in Pioneer Hall. The PI contacted each participant to schedule date and time for all data collection. All the participants were measured using the following test order: (1) a rest time of 10 min on a chair, (2) heart rate and blood pressure assessment, (3) physical activity affect assessment, (4) respiratory function assessment, (5) the 10-Meter Walk assessment, and (6) the Timed Up and Go assessment.

Participants

The participant inclusion criteria were the following: (1) time since stroke onset (more than 6 months); (2) outpatient status from a rehabilitation center; (3) hemiparesis; (4) adequate walking ability (10 m with or without assistive device); and (5) adequate cognitive ability to follow verbal instruction correctly with minimal assistance in testing and aquatic exercise sessions. The MacArthur competence assessment (Grisso & Appelbaum, 1995) was used to measure cognitive impairment of the potential participants during the consent process. The MacArthur competence scale consists of the following five indicators: (1) "What is the purpose of this research?"; (2) "How many study visits are you asked to participate in?"; (3) "In what way might you benefit by volunteering in this study?"; (4) "Tell me about possible risks associated with participating in this project"; (5) "What will you do if you decide that you no longer want to participate in this study?”. The PI read each indicator to the potential participants and their responses were recorded on a Likert scale ranging from 0 to 2: 0 = inadequate, 1 = partial understanding, and 2 = adequate understanding. Participants who scored more than 8 out of 10 on the assessment were included in this study (Grisso & Appelbaum, 1995). To describe the physical activity level of each participant, the Physical Activity and Disability Scale (PADS; Rimmer et al., 2000) was administered through a personal interview session prior to this study by the PI. The PADS measured total physical activity such as exercise, leisure activity (e.g., hiking, boating, dancing, sports activities), general activity (e.g., household activities, gardening), therapy sessions (e.g., physical and occupational therapy), and employment-related physical activity (see Appendix B).

Procedures

Cardiorespiratory Function Assessment

The resting heart rate and blood pressure for each participant were measured two times by an Omron Hem-780 automated blood pressure cuff (Omron Instruments, Bannockburn, IL) following 10 min of seated rest at baseline, 6, 8, and 14 weeks. The average of two trials was recorded for data analysis. Each participant was asked to refrain from having caffeine at least 30 min prior to cardiorespiratory function measurement (ACSM, 2000). The mean arterial pressure (MAP; Wilmore & Costill, 2004) for each participant was estimated from systolic blood pressure (SBP) and diastolic blood pressure (DBP), and calculated using the MAP Formula: MAP = DBP + 0.333 × (SBP – DBP).

The respiratory function for each participant was measured by an Astra 200 portable spirometer (SDI Diagnostics Inc., Easton, MA) at baseline, 6, 8, and 14 weeks. Forced vital capacity (FVC) and forced expiration volume in 1 s (FEV_1) for each participant were measured in a sitting position, and the ratio of FEV_1 to FVC (FEV_1/FVC) was calculated (Sutbeyaz et al., 2010). The participant was asked to adhere to the following procedure: (a) fit the nose clip before the spirometry test, (b) take a deep breath as much as possible, and (c) blow into a mouthpiece that was connected to the spirometer to perform a forced maximum expiration for 6 s. The PI helped the participants hold the spirometer until they successfully finished performing the forced maximum expiration assessment. The spirometer automatically beeped when the maximum expiration performance was satisfactory enough to collect reliable data. Each participant was asked to blow into the mouthpiece at least two times. One practice trial was given to each participant for familiarization prior to the two actual trials. The interval between trials was 30 s and the average of the two trials was used for data analysis.

Motor Fitness Assessment—Gait Speed

The 10-Meter Walk Test (10-MWT; Rossier & Wade, 2001) was used to assess gait speed (m/s) for each participant at baseline, 6, 8, and 14 weeks. Gait speed was measured by timing the participants with two 240-Econosport digital stopwatches (Sportline Inc., Yonkers, NY) over 10 m of a 14-m walkway. Floor tape was used to mark a 10-m walkway along with additional 2 m at the start and stop lines each to minimize the effects of acceleration and deceleration. Gait speed for each participant was determined from the average speed of two trials. Each participant was asked to walk the 14-m walkway using a normal pace and all walking started on the command “go.” Instruction for each participant was: “I am going to measure your normal walking speed. When I say ‘go,’ walk safely in a straight line as normally as you can, until you pass the last floor tape marked with two visible disc cones.” The PI started timing when the participant’s first foot (i.e., toe) passed the start line. The PI stopped timing when the first foot passed the stop line—the participant continued walking the additional 2 m as part of deceleration. The PI walked to the side of the participant to offer encouragement and minimize risk of falling. To avoid fatigue, a rest time of 30 s was given to the participants after each trial. To reduce measurement errors, demonstration and one practice trial were provided to each participant prior to an actual trial. Two trials were given to the participants to measure their gait speed. The reliability, when applied to poststroke participants using the 10-MWT, was reported as .93 by Rossier et al. (2001).

Motor Fitness Assessment—Dynamic Balance

Dynamic balance for each participant was measured using the Timed Up and Go (TUG; Podsiadlo & Richardson, 1991) test at baseline, 6, 8, and 14 weeks. The TUG test is a field based test designed to measure dynamic balance by asking the participant who is seated in a standard folding chair to stand up, walk 3 m, turn, walk back to the starting location, and sit down. To conduct the TUG test, the participants were asked to sit in a folding chair with back straight, feet flat on the floor, one foot slightly in front of the other one, and lean slightly forward. Next they were asked to stand up from the chair on the signal “go,” walk forward a distance of 3 m as quickly and as safely as possible, walk around a cone, return to the chair, and sit down. The PI started two 240-Econosport digital stopwatches (Sportline Inc., Yonkers, NY) with the signal “go” and stopped the stopwatches at the moment the participants sat down on the chair. The PI stood beside the participant during measurement and followed the participant one step behind to ensure safety. The participants were asked to complete two trials of the TUG test, and the average of two trials was calculated with the best time recorded in seconds for data analysis. The participants had a 1-min rest time on the chair between trials to prevent fatigue. Each participant received a demonstration from the PI and then had one practice trial for familiarization before the two actual trials. The reliability, when applied to poststroke participants using the TUG test, is reported as .99 (Ng & Hui-Chan, 2005; Podsiadlo et al., 1991).

Physical Activity Affect Assessment—Physical Activity Affect Scale

Exercise-induced feeling states for each participant were assessed using the Physical Activity Affect Scale (PAAS; Lox et al., 2000). The PAAS is a brief and comprehensive survey designed to measure the level of positive and negative feeling states (Driver & Lox. 2007). The PAAS was used to rate a chronic feeling state at baseline, 6, 8, and 14 weeks. The 12-indicator PAAS has four subscales [i.e., positive affect (PA), negative affect (NA), tranquility (TR), and fatigue (FA)]. Each indicator had the following levels: 0 = do not feel, 1 = feel slightly, 2 = feel moderately, 3 = feel strongly, and 4 = feel very strongly (see Appendix C). The PI read each indicator to the participants and recorded their response in a room free of distractions in Pioneer Hall. According to Lox et al. (2000), the reliability of PAAS is reported as PA = .94, NA = .86, TR = .84, and FA = .91.

Aquatic Exercise Program

The aquatic exercise program focused on improving cardiorespiratory function, motor fitness, and physical activity affect for the participants (see Appendix A and Appendix D). The participants in the experimental group engaged in a 6-week aquatic exercise program 3 times per week for 60 min each. All aquatic exercise sessions were individually administered with few exceptions. The PI individualized the participants' schedule to increase their attendance rate to the program. The exercise sessions were offered between 10 am and 6 pm from Monday through Friday. The participants were scheduled for the same times each week. However, if the participants had a conflict, the session was scheduled for a different time during the same week to ensure each participant completed 3 sessions each week. Each exercise session was led by the PI in the shallow pool (water temperature range 82-85˚F), with a maximum of two participants per session. The program consisted of the following: warm up, main exercise, and cool down. During the warm up (5 min), the participants executed stretching with water barbells in a standing position (at chest level). During the main exercise (50 min), the participants used water barbells to increase stability and perform walking, stepping, rotation, breathing control, and swimming activities supported by a combination of aquatic exercise methods (i.e., Bad Ragaz Ring, Halliwick, Watsu, and Ai Chi; see explanation of each method in Appendix D). Exercise intensity was set at 50-70% of maximal heart rate (HR_{max}) reserve for the main exercise (Swain & Leutholtz, 2002). Each participant's target HR was calculated using the modified Karvonen Formula: HR_{max} = 210 – Age; Target HR = (HR_{max} – HR_{rest}) × Exercise Intensity (%) + HR_{rest} (ACSM, 2000). The participants always wore a wrist HR monitor with a transmitter (Polar Electro Inc., Kempele, Finland) to track changes in HR during exercise. In addition, the PI wore a wrist HR monitor to ensure each participant's target HR zone (Appendix D). During the cool down (5 min), the participants again conducted stretching with water barbells in a standing position. The participants in the control group participated in their normal daily activities for 6 weeks. The participants did not receive any aquatic exercise sessions over the control phase (see Appendix B).

Data Analysis

This study used a crossover design that included a treatment (i.e., aquatic exercise and control) by time (i.e., pre and post) analysis. The participants were randomly distributed to two treatment groups: aquatic exercise and control. The study implemented a 6-week treatment session, followed by a 2-week washout session, ending with another 6-week treatment session. At the conclusion of the first 6-week session and following the washout session, the participants in the aquatic exercise group were switched to the control group, and the participants in the control group switched to the aquatic exercise group. All data were collected at baseline, 6, 8, and 14 weeks. Kolmogorov-Smirnov normality test was used to screen if each dependant variable was normally distributed. In order to examine the hypotheses of this study, two-way analysis of variance (ANOVA) with repeated measures was applied for parametric variables, and the Wilcoxon matched-pair test was applied for non-parametric variables.

Two-way (2 × 2) ANOVA with repeated measures was used to test statistically significant main and interaction effects for each dependent variable. In this research study, the participants received two treatment conditions (i.e., aquatic exercise and control) in a different sequence. The levels of the first within-subjects factor were two treatment conditions (i.e., aquatic exercise and control). The levels of the second within-subjects factor were two different times (i.e., before and after implementing each treatment). As a follow-up test, simple effect analysis was used to test a direct effect within each treatment phase and a pure mean difference between two treatment groups for each of the following dependent variables: resting heart rate (HR_{rest}), mean arterial pressure (MAP), and normal gait speed (NGS). Wilcoxon matched-pair test was used to test statistically significant effects for each of the following dependent variables: Timed Up and Go (TUG), chronic positive affect (PA), negative affect (NA), tranquility (TR), and fatigue (FA). The significance level was set at $p \leq .05$ to reject the null hypotheses for this research.

The effect size (ES) was calculated to determine a practical significant difference across time in each dependent variable using Cohen's D formula. The ES was calculated (see Equation 1), where M_1 represents the premean of each dependent variable, M_2 represents the postmean of each dependent variable, and SD_{pre} represents the standard deviation of premean of each dependent variable. According to Cohen (1988), and Sutlive and Ulrich (1998), an ES = .20 to .50 is considered a small effect, .50 to .80 is considered a medium effect, and greater than .80 is considered a large effect.

$$\text{ES} = \frac{M_1 - M_2}{SD_{\text{pre}}} \qquad (1)$$

In addition, the percent change was calculated to describe a change in mean values over time as a percentage. To determine the extent of the percent change, the mean difference over time in each dependent variable was computed by subtracting premean from postmean then divided by premean, and that value was multiplied by 100. The percent change before and after a treatment (i.e., aquatic exercise and control) was calculated using the following formula: $\Delta\%$ = [(postmean – premean)/premean] × 100.

CHAPTER IV

RESULTS

This chapter will address the statistical results of the effects of an aquatic exercise program on cardiorespiratory function, motor fitness, and physical activity affect of poststroke participants. The statistical results of the participants who received two different treatments (i.e., aquatic exercise and control) in a crossover format are reported. The results are presented in the following order: (a) demographics; all treatment data represents mean changes following aquatic exercise and control phases; (b) mean changes in resting heart rate (HR_{rest}); (c) mean changes in mean arterial pressure (MAP); (d) mean changes in the ratio of forced expiration volume in 1 s to forced vital capacity (FEV_1/FVC); (e) mean changes in normal gait speed (NGS); (f) mean changes in Timed Up and Go (TUG); (g) mean changes in chronic positive affect (PA); (h) mean changes in chronic negative affect (NA); (i) mean changes in chronic tranquility (TR); and (j) mean changes in chronic fatigue (FA).

Demographics

Eleven participants (5 males, 6 females) successfully completed the aquatic exercise and control phases in a crossover format for this research study. Participant demographic information and descriptive statistical data are addressed in Table 1. The number of the participants, mean, standard deviation, and range for gender, age, type of stroke, affected side, mobility aids, time since stroke, height, weight, MacArthur competence scale (MACS) score, and exercise adherence are reported in Table 1.

Table 1

Participant Demographic Characteristics

Variable	*n*	*M*	*SD*	Range
Gender (M/F)	5/6			
Age (years)		68.1	8.8	53-80
Type of stroke (ischemia/hemorrhage)	7/4			
Affected side (L/R)	7/4			
Mobility aids (walker/cane/cane and AFO/none)	2/2/4/3			
Time since stroke (years)		6.1	3.8	0.8-12.7
Height (cm)		167.3	14.9	152.4-190.5
Weight (kg)		77.4	18.6	48.1-113
BMI (kg/m^2)		27.6	5.6	18.8-38.0
MACS score (/10)		9.3	0.9	8-10
Adherence to program (%)*		100	0	100

Note. *n* = number; *M* = mean; *SD* = standard deviation; M = male; F = female; L = left; R = right; AFO = ankle-foot orthotic; BMI = body mass index; MACS = MacArthur competence scale; * = Adherence was supported by an individualized schedule.

Mean Changes in HR_{rest}

Two-way ANOVA with repeated measures was used to test statistically significant main and interaction effects for HR_{rest} (i.e., resting heart rate). No significant main effect between treatment groups was observed for HR_{rest}, $F(1,10) = 2.367$, $p = .155$. No significant treatment effect was reported for HR_{rest} over treatment phases, $F(1,10) = 3.997$, $p = .073$. However, a significant interaction effect between treatment groups and phases was revealed for HR_{rest}, $F(1,10) = 8.659$, $p = .015$. Figure 1 displays the mean changes in HR_{rest} (bpm) across two treatment groups and the interaction effect.

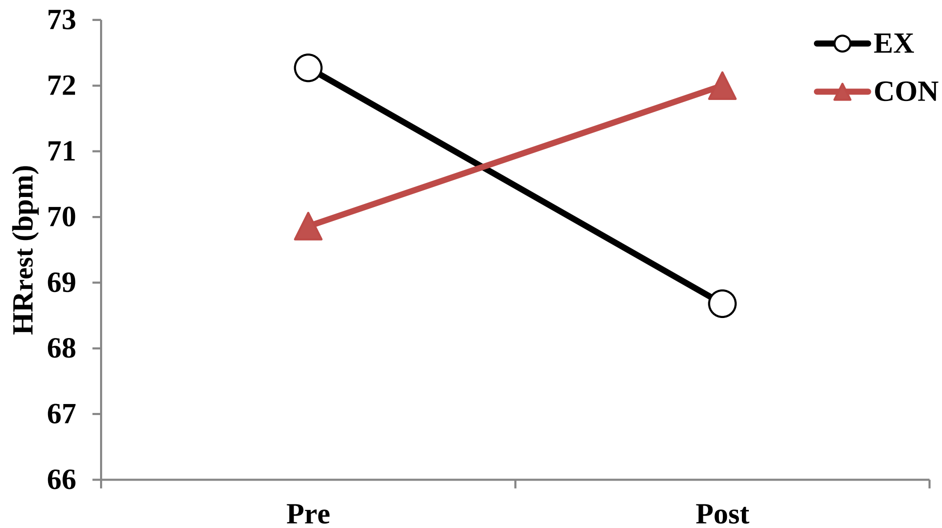

Figure 1. Mean HR_{rest} for exercise and control groups. EX = exercise group, CON = control group, HR_{rest} = resting heart rate (bpm).

Simple effect analysis was performed as a follow-up test in order to explain more clearly about a direct treatment effect for HR_{rest} within each treatment phase. As presented in Table 2, the level of HR_{rest} was significantly reduced in the participants following the exercise phase (p = .005, ES = .44). The aquatic exercise significantly reduced the mean of HR_{rest} from 72 ± 8 to 68 ± 7 bpm (-5%). However, no significant treatment effect for HR_{rest} was reported in the participants after implementing the control phase (p = .073, ES = .33).

In addition, simple effect analysis was performed in order to explain more clearly about a pure mean difference in HR_{rest} between two different treatment groups at pre and posttreatment phases. A significant mean difference was reported in HR_{rest} between two treatment groups at the pretreatment phase (p = .043). The level of HR_{rest} was significantly higher in the exercise group as compared to the control group at the pretreatment phase, 72 ± 8 to 70 ± 6 bpm (-3.3%). A significant mean difference was observed in HR_{rest} between two treatment groups at the posttreatment phase (p = .007). The level of HR_{rest} was significantly lower in the exercise group as compared to the control group at the posttreatment phase, 68 ± 7 to 72 ± 8 bpm (4.8%; see Table 2). During the exercise phase, the target HR for 11 participants had been gradually increased from 50 to 70% of HR_{max} determined using the modified Karvonen Formula.

Table 2

Mean Changes in HR_{rest} Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
HR_{rest} (bpm)	72 ± 8	68 ± 7**	70 ± 6†	72 ± 8‡‡

Note. HR_{rest} = resting heart rate, ***p* < .01 statistically significant difference between pre and post data, $^{\dagger}p$ < .05 statistically significant difference between pre and pre data, $^{\ddagger\ddagger}p$ < .01 statistically significant difference between post and post data.

Mean Changes in MAP

No significant main effect on MAP (i.e., mean arterial pressure) was observed across treatment groups, $F(1,10) = .160$, $p = .698$. In addition, no significant main effect on MAP was seen over treatment phases, $F(1,10) = 2.632$, $p = .136$. However, there was a significant interaction effect of time by group on MAP, $F(1,10) = 7.803$, $p = .019$. The mean changes in MAP (mmHg) across two treatment groups and the interaction effect is displayed in Figure 2.

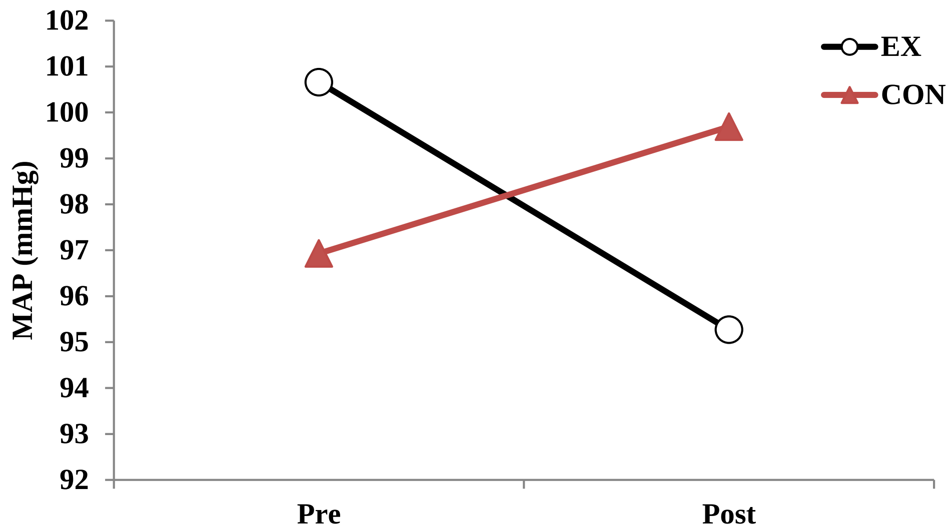

Figure 2. Mean MAP for exercise and control groups. EX = exercise group, CON = control group, MAP = mean arterial pressure (mmHg).

Simple effect analysis was conducted to report a direct treatment effect in exercise and control phases. A significant mean reduction in MAP was demonstrated following completion of the exercise phase (p = .011, ES = .45). The participants showed a notable decrease in MAP from 101 ± 12 to 95 ± 8 mmHg (-5.4%) during the exercise phase. However, no significant mean difference in MAP was found following completion of the control phase (p = .115, ES = .34; see Table 3).

Additionally, simple effect analysis was conducted to report a pure mean difference in MAP between two different treatment groups at pre and posttreatment phases. As stated in Table 3, there was a significant mean difference in MAP across treatment groups at the pretreatment phase (p = .042). The participants in the exercise group showed higher level in MAP at the pretreatment phase when compared to the control group, 101 ± 12 to 97 ± 8 mmHg (-3.7%). A significant mean difference in MAP was revealed across treatment groups at the posttreatment phase (p = .033). The participants in the exercise group demonstrated lower level in MAP at the posttreatment phase when compared to the control group, 95 ± 8 to 100 ± 11 mmHg (4.6%).

Table 3

Mean Changes in MAP Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
MAP (mmHg)	101 ± 12	95 ± 8*	97 ± 8†	100 ± 11‡

Note. MAP = mean arterial pressure, *p < .05 statistically significant difference between pre and post data, $^{\dagger}p$ < .05 statistically significant difference between pre and pre data, $^{\ddagger}p$ < .05 statistically significant difference between post and post data. Resting diastolic blood pressure (RDBP) for the participants was reduced from 83 to 79 mmHg (4 mmHg) across the exercise phase; however, no significant main effect of group, no significant main effect of time, and no significant interaction effect of group by time were observed (See Appendix H).

Mean Changes in FEV_1/FVC

The main and interaction effects on FEV_1/FVC (i.e., the ratio of forced expiration volume in 1 s to forced vital capacity) were examined by using two-way ANOVA with repeated measures. As illustrated in Table 4, no significant main effect on FEV_1/FVC occurred between treatment groups, $F(1,10) = 4.817$, $p = .053$. However, a significant main effect on FEV_1/FVC was revealed across treatment phases, $F(1,10) = 4.945$, $p = .05$. No significant interaction effect between treatment groups and phases was demonstrated for FEV_1/FVC, $F(1,10) = 3.189$, $p = .104$. Figure 3 shows the mean FEV_1/FVC in both treatment groups and the interaction effect. The FEV_1/FVC mean was positively elevated from 71.1 ± 14.7 to 76.8 ± 11.4 (8.1%) across the aquatic exercise phase. However, the FEV_1/FVC mean was slightly diminished from 70.6 ± 11.9 to 70.2 ± 14.6 (-.6%) across the control phase.

Table 4

Mean Changes in FEV_1/FVC *Following Exercise and Control Phases*

Variable	Exercise		Control	
	Pre	Post	Pre	Post
FEV_1/FVC	71.1 ± 14.7	76.8 ± 11.4*	70.6 ± 11.9	70.2 ± 14.6

Note. FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity, $*p < .05$ statistically significant difference between pre and post data.

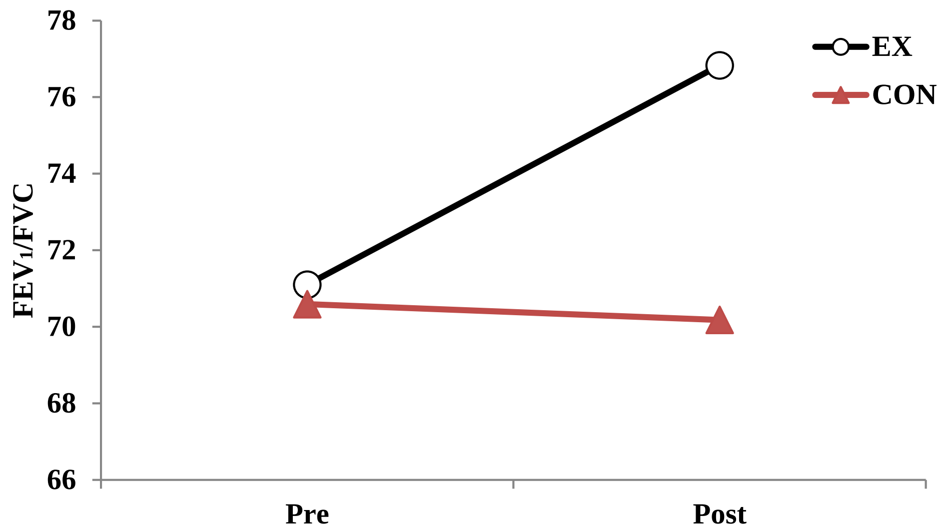

Figure 3. Mean FEV_1/FVC for exercise and control groups. EX = exercise group, CON = control group, FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity.

Mean Changes in NGS

The analysis of two-way ANOVA with repeated measures reported the main and interaction effects of the two treatments on NGS (i.e., normal gait speed). There was no significant main effect in NGS between treatment groups, $F(1,10) = .673$, $p = .431$. However, a significant main effect was shown over treatment phases, $F(1,10) = 8.877$, $p = .014$, and a significant interaction effect was identified between treatment groups and phases of NGS, $F(1,10) = 9.268$, $p = .012$. The mean change in NGS (m/s) over two different treatment phases and the interaction effect is displayed in Figure 4.

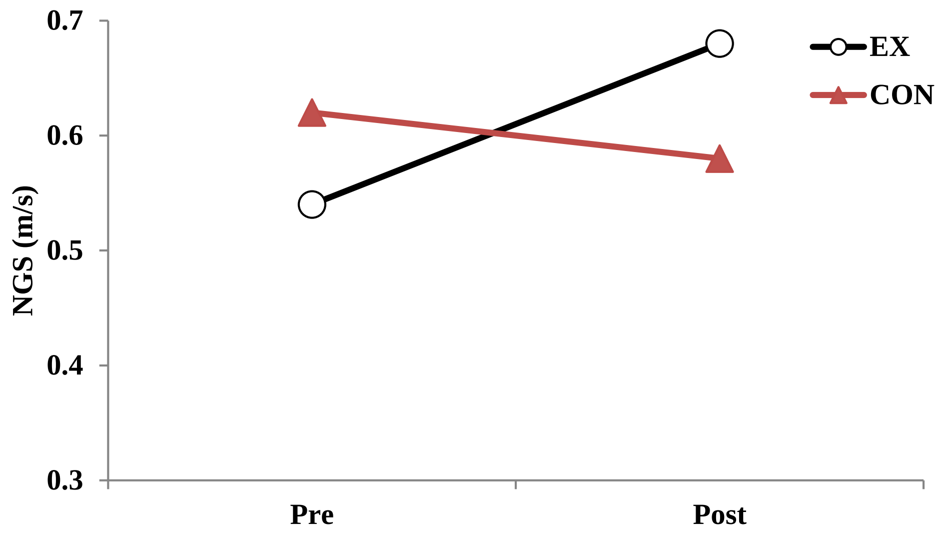

Figure 4. Mean NGS for exercise and control groups. EX = exercise group, CON = control group, NGS = normal gait speed (m/s).

Simple effect analysis revealed the direct effect of each treatment on NGS. The NGS in the exercise phase was significantly increased in the participants (p = .012, ES = .55) as described in Table 5. The NGS of the participants became faster from 0.54 ± 0.24 to 0.68 ± 0.36 m/s (25.9%) after implementing the exercise phase. However, the NGS in the control phase was significantly decreased in the participants (p = .03, ES = .12). The NGS of the participants became slower from 0.62 ± 0.32 to 0.58 ± 0.28 m/s (-6.5%) after implementing the control phase.

In addition, simple effect analysis revealed a pure mean difference in NGS between two different treatment groups at pre and posttreatment phases. As shown in Table 5, the NGS across treatment groups was significantly different at the pretreatment phase (p = .028). Compared to the control group, the NGS of the exercise group was slower at the pretreatment phase, 0.54 ± 0.24 to 0.62 ± 0.32 m/s (14.8%). The NGS across treatment groups was significantly different at the posttreatment phase (p = .011). The NGS of the exercise group was faster at the posttreatment phase when compared to the control group, 0.68 ± 0.36 to 0.58 ± 0.28 m/s (-14.7%).

Table 5

Mean Changes in NGS Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
NGS (m/s)	0.54 ± 0.24	0.68 ± 0.36*	0.62 ± 0.32†	0.58 ± 0.28*‡

Note. NGS = normal gait speed, *p < .05 statistically significant difference between pre and post data, $^{\dagger}p$ < .05 statistically significant difference between pre and pre data, $^{\ddagger}p$ < .05 statistically significant difference between post and post data.

Mean Changes in TUG

Wilcoxon matched-pair test identified a significant treatment effect for TUG (i.e., timed up and go) within each treatment. As stated in Table 6, the exercise phase resulted in a significant mean change in TUG. The TUG mean became faster from 25.2 ± 19.3 to 22.6 ± 18.8 s (-17%) over the exercise phase (z = -2.312, p = .021, ES = .13). In addition, the control phase resulted in a significant mean change in TUG. The TUG mean became slower from 24.7 ± 20.1 to 25.5 ± 20.0 s (6.2%) in the control phase (z = -2.001, p = .045, ES = .04). Figure 5 shows the mean TUG for the exercise and control groups.

Table 6

Mean Changes in TUG Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
TUG (s)	25.2 ± 19.3	22.6 ± 18.8*	24.7 ± 20.1	25.5 ± 20.0*

Note. TUG = timed up and go, **p* < .05 statistically significant difference between pre and post data.

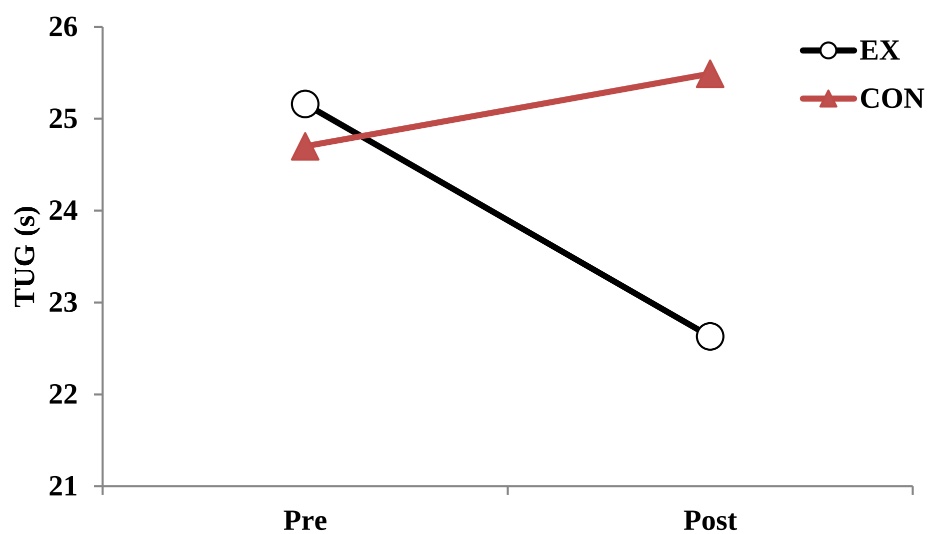

Figure 5. Mean TUG for exercise and control groups. EX = exercise group, CON = control group, TUG = timed up and go (s).

Mean Changes in PA

The treatments effects on PA (i.e., chronic positive affect) were examined by using Wilcoxon matched-pair test. Table 7 describes a significant mean increase in PA following the exercise phase (z = -2.710, p = .007, ES = 1.81). The PA mean increased from 2.2 ± 0.5 to 3.0 ± 0.4 (37.1%) during the exercise phase. However, no significant mean change in PA was found during the control phase (z = -1.403, p = .161, ES = .28). Mean changes in PA for the exercise and control groups are displayed in Figure 6.

Table 7

Mean Changes in PA Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
PA	2.2 ± 0.5	3.0 ± 0.4**	2.4 ± 0.4	2.3 ± 0.5

Note. PA = chronic positive affect, ***p* < .01 statistically significant difference between pre and post data.

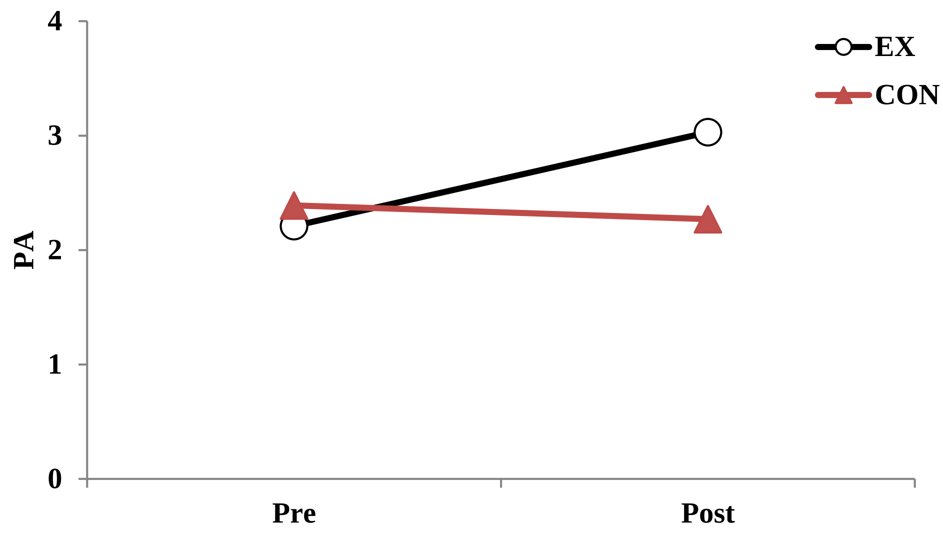

Figure 6. Mean PA for exercise and control groups. EX = exercise group, CON = control group, PA = chronic positive affect.

Mean Changes in NA

As reported in Table 8, results of Wilcoxon matched-pair test indicated that a significant treatment effect of the aquatic exercise on NA (i.e., chronic negative affect) was observed in the participants (z = -2.203, p = .028, ES = .97). The exercise phase significantly decreased the level of NA from 0.8 ± 0.6 to 0.2 ± 0.6 (-69.2%) in the participants. Also, the control phase significantly changed the level of NA in the participants (z = -1.973, p = .049, ES = 1.09). The level of NA in the participants significantly increased from 0.4 ± 0.4 to 0.8 ± 0.5 (115.4%) across the control phase. Figure 7 shows the mean NA for the exercise and control groups.

Table 8

Mean Changes in NA Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
NA	0.8 ± 0.6	0.2 ± 0.6*	0.4 ± 0.4	0.8 ± 0.5*

Note. NA = chronic negative affect, *p < .05 statistically significant difference between pre and post data.

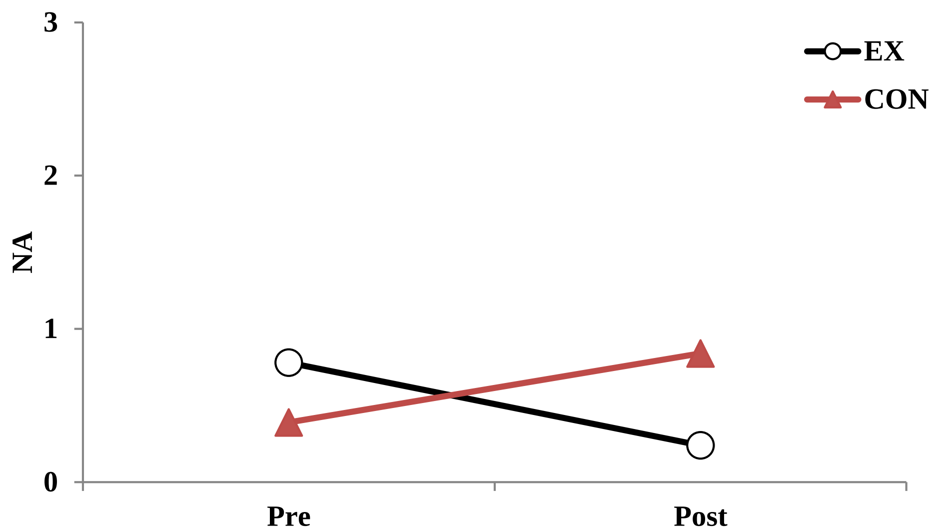

Figure 7. Mean NA for exercise and control groups. EX = exercise group, CON = control group, NA = chronic negative affect.

Mean Changes in TR

The treatments effects on TR were investigated by using Wilcoxon matched-pair test. The mean value of TR (i.e., chronic tranquility) was significantly improved in the participants as a result of the aquatic exercise phase (z = -2.157, p = .031, ES = 1.48; see Table 9). The TR of the participants became elevated from 2.2 ± 0.4 to 2.8 ± 0.5 (28.9%) after implementing the exercise phase. However, no significant mean change in TR was found during the control phase (z = -1.930, p = .054, ES = .49). The mean TR across the exercise and control groups is displayed in Figure 8.

Table 9

Mean Changes in TR Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
TR	2.2 ± 0.4	2.8 ± 0.5*	2.3 ± 0.4	2.1 ± 0.4

Note. TR = chronic tranquility, *p < .05 statistically significant difference between pre and post data.

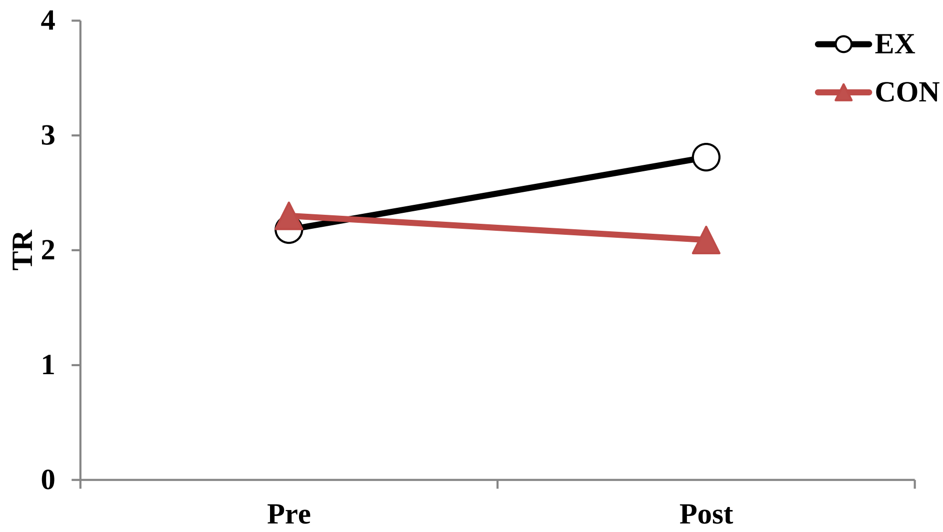

Figure 8. Mean TR for exercise and control groups. EX = exercise group, CON = control group, TR = chronic tranquility.

Mean Changes in FA

The analysis of Wilcoxon matched-pair test indicated that a significant treatment effect of the aquatic exercise on FA (i.e., chronic fatigue) occurred in the participants. As reported in Table 10, the exercise phase resulted in a significant mean reduction in FA ($z = -2.565$, $p = .01$, ES = 1.24). The participants reported a notable decrease in FA from 1.1 ± 0.5 to 0.5 ± 0.7 (-54.7%) following completion of the exercise phase. However, no significant mean change in FA was observed in the participants during the control phase ($z = -1.892$, $p = .058$, ES = .55). Figure 9 shows the mean changes in FA across the exercise and control groups.

Table 10

Mean Changes in FA Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
FA	1.1 ± 0.5	0.5 ± 0.7*	0.7 ± 0.6	1.0 ± 0.6

Note. FA = chronic fatigue, **p* < .05 statistically significant difference between pre and post data.

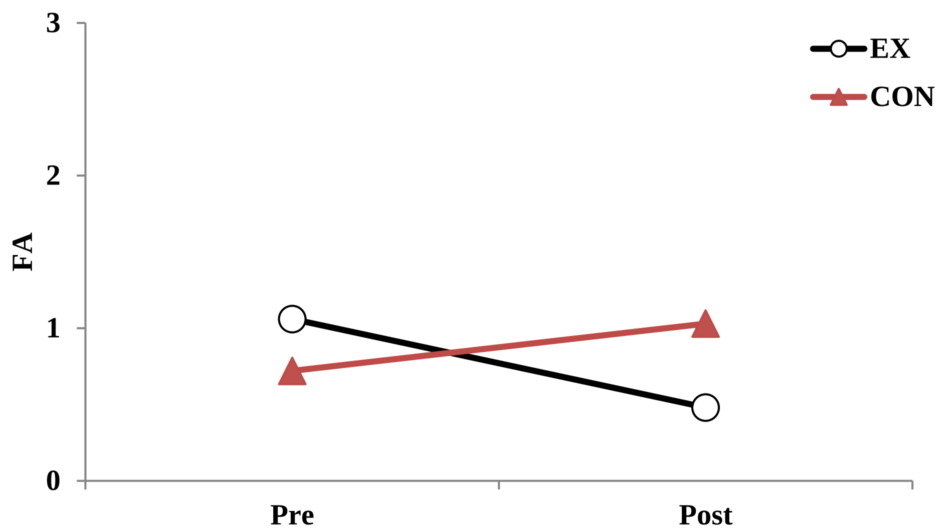

Figure 9. Mean FA for exercise and control groups. EX = exercise group, CON = control group, FA = chronic fatigue.

CHAPTER V

SUMMARY, DISCUSSION, CONCLUSION, AND RECOMMENDATIONS FOR FURTHER STUDY

This chapter will discuss the results of this investigation, provide a conclusion, and make recommendations for future investigations. The discussion of the results will be addressed with previous research and relevant literature in the following order: (a) cardiorespiratory function, (b) motor fitness, (c) physical activity affect, and (d) recognizing limitations.

Cardiorespiratory Function

Reduction in HR_{rest}

Participation in an aquatic exercise program had an effect on HR_{rest} for the participants. The participants demonstrated a significant reduction (5%) in HR_{rest} over the aquatic exercise phase verses the control phase. Interestingly, the mean HR_{rest} of the participants became declined by approximately 4 bpm across the aquatic exercise sessions. These results suggest that an aquatic exercise program could influence the participants in lowering their $HR_{rest.}$ However, it is unclear if the change in HR_{rest} is clinically relevant. Further studies are necessary to elucidate any mechanisms of this change.

Reduction in MAP

A significant reduction occurred with MAP, or mean arterial pressure. It is important to note that the participants showed a significant decrease (5%) in MAP after the aquatic exercise phase. The MAP mean was reduced by approximately 5 mmHg. Participants did not experience a change in MAP after the control phase. This could imply that the participants may enhance their blood flow in the systemic circuit through regular exercise in the water. However, it is not clear if the reduction in MAP is clinically relevant. Further studies are needed to support and generalize this finding.

Improvement in FEV_1/FVC

Positive effects of the aquatic exercise program on FEV_1/FVC, or the ratio of forced expiration volume in 1 s to forced vital capacity, for the participants were reported. The participants showed a positive increase (8%) in FEV_1/FVC across the aquatic exercise phase. These data indicate that breath control activities and rhythmic breathing over the aquatic exercise phase could strengthen respiratory muscles and enhance respiratory mechanism.

Motor Fitness

Increment in NGS

To measure the NGS, or normal gait speed, the participants were asked to walk safely over 10 m of a 14-m walkway as normally as they could. The NGS was significantly improved (26%) following the aquatic exercise phase. The NGS of the participants was 0.54 m/s before the start of the aquatic exercise phase and increased by 0.68 m/s as a result of the aquatic exercise intervention at the conclusion. In contrast, the NGS was significantly reduced (6%) following the control phase, which indicates their gait speed remained slower.

Improvement in TUG

The TUG, or Timed Up and Go test, required the participants to sit in a chair, rise up on command, and walk forward to a point 3-m away, turn around, and return to the chair in a seated position. Following the exercise phase, the participants demonstrated a significant decrease (10%) in TUG. The TUG mean was 25.2 s before the aquatic exercise phase and was reduced by 22.6 s following this phase. A significant increase (3%) in TUG occurred following the control phase.

Physical Activity Affect

Improvement in PA, NA, TR, and FA

Exercise-induced feeling states for the participants were measured using the Physical Activity Affect Scale (PAAS; Lox et al., 2000). The PAAS is a brief survey designed to measure the level of positive and negative feeling states followed by an exercise program (Driver et al., 2007). The PAAS has four dimensions: positive affect (PA), negative affect (NA), tranquility (TR), and fatigue (FA). The participants felt more positive feelings and fewer negative feelings at the conclusion of the aquatic exercise sessions. Results indicated a significant increase in PA (37.1%) and TR (28.9%) and a significant decrease in NA (69.2%) and FA (54.7%) following the aquatic exercise phase. However, the participants felt more negative feelings and reported a significant increase in NA (115.4%) following the control phase.

Interpretation with Literature Support

Cardiorespiratory Function

HR_{rest}. In the present study, participation in a 6-week aquatic exercise program resulted in a significant reduction in HR_{rest} for the participants. The participants completed all exercise sessions at 50-70% of their maximal heart rate reserve determined using the modified Karvonen Formula. This observation is similar to the findings of the previous study performed by Tanaka et al. (1997), in which adults with hypertension demonstrated a significant decrease (10 bpm on average) in HR_{rest} after completion of the 10-week aquatic exercise program (3 times per week for 60 min each session at 60% of the maximal heart rate reserve). Tanaka et al.'s (1997) research used a longer intervention, but their exercise intensity and frequency were similar to those of the present study. These results implied that participation in an exercise program may reduce HR_{rest} for poststroke adults. Previous researchers have postulated that the HR_{rest} reduction may be the result of an increase in stroke volume and an increase in parasympathetic nerve activity, or a decrease in sympathetic nerve activity in the heart (Billinger et al., 2012; Broman, Quintana, Lindberg, Jansson, & Kaijser, 2006). The physiological mechanism to account for HR_{rest} reduction following an aquatic exercise program has not been precisely elucidated.

One of the possible explanations for HR_{rest} reduction in the present study is that the planned, structured, and repetitive exercise sessions in the water may improve blood circulation of the poststroke participants (Broman et al., 2006). Becker (2009) stated that water immersion at chest level could result in an increase in central venous return. The increased central blood volume could result in an increase in stroke volume. Average stroke volume at rest is approximately 71 ml/bpm. Immersion in the water increases the average stroke volume at rest by 100 ml/bpm. The increase in resting stroke volume in the water is almost equal to maximal stroke volume for individuals with a sedentary lifestyle on land (Becker, 2009). According to Meyer and Leblanc (2008), water pressure could increase venous blood return to the heart when the participants performed aquatic exercises (e.g., fast walking, rotation activities, stepping on aqua steps) in the standing position (i.e., exercises at the chest depth) and the supine position (i.e., exercises at the water surface). The increased venous blood return could increase stroke volume of the participants (Broman et al., 2006; Meyer & Leblanc, 2008). The HR_{rest} would be reduced as a result of repetitive aquatic exercise sessions.

Another reasonable explanation is that the repetitive exercise sessions in the water could contribute to a decrease in sympathetic neural activity in the heart (Perini, Milesi, Biancardi, Pendergast, & Veicsteinas, 1998). As the participants received repetitive exercise sessions across the aquatic exercise phase, sympathetic responses in the heart might be less activated as a result of autonomic system adjustments to exercise stimuli (Perini & Veicsteinas, 2003). Thus, this phenomenon would make a contribution to a reduction in HR_{rest}. However, it is not clear if the reduction in HR_{rest} is clinically relevant.

MAP. The significant MAP reduction (5%) was evident in the participants across the aquatic exercise phase but did not occur across the control phase. The MAP mean for 11 participants was lowered by 5 mmHg following the aquatic exercise phase. This observation may imply that the average arterial pressure for the participants could be reduced though regular exercise sessions in the water. Similarly, a significant reduction in MAP (6 mmHg on average) was reported by Farahani et al. (2010), who evaluated the effects of a 10-week aquatic exercise program on MAP for 12 adults with hypertension (3 times per week for 55 min each session). The 12 participants engaged in the exercise sessions at 60-65% of their maximal heart rate and gradually increased their target heart rate up to 70-75% of their maximal heat rate across aquatic exercise sessions. Farahani et al. reported that compared to the control group, a significant decrement in MAP was illustrated in the participants at the conclusion of the 10-week aquatic exercise program. Previous investigators suggested that the possible mechanism to lower the average arterial blood pressure may be influenced by an increase in cardiovascular capacity and a decrease in sympathetic activity in the heart (Farahani et al., 2010; Tanaka et al., 1997).

Few longitudinal studies have speculated the specific mechanism in the water which caused the MAP reduction for the poststroke participants. The reduced MAP may be explained by the following possible physiological response: a reduction in diastolic blood pressure and a decrease in total peripheral resistance (Tanaka et al., 1997). The authors reported that the 10-week aquatic exercise program decreased resting diastolic blood pressure (3 mmHg) and MAP (4 mmHg) in 12 participants. In the present study, similarly, resting diastolic blood pressure for the participants was reduced from 83 to 79 mmHg (4 mmHg) across the exercise phase; however, no significant main effects of exercise and time were observed, and no significant interaction effect of group by time were observed. According to the literature, MAP reduction is influenced by reduction in resting diastolic blood pressure which is related to a decrease in total peripheral resistance (Farahani et al., 2010; Meyer & Leblanc, 2008; Tanaka et al., 1997).

Another potential reason for the MAP reduction could be explained by a decrease in total peripheral resistance. Total peripheral resistance represents the resistance to blood flow in the systemic circulation (Billinger et al., 2012). To reduce heat loss on the skin, the acute peripheral resistance for the participants could be increased in their superficial vessels during initial immersion at the normal pool temperature. During the aquatic exercise phase, however, the total peripheral resistance for the participants on land might be reduced due to the vasodilation of the peripheral arteries. For instance, as the participants were repetitively exposed to the cold water and warm air temperatures in the summer (82-85˚F versus 95-100˚F) across the exercise sessions, the diameter of their peripheral vessels could be increased as a result of the repetitive stimuli. Thus, the reduced peripheral resistance caused by the vasodilation may also be associated with the MAP reduction for the participants (Farahani et al., 2010; Meyer & Leblanc, 2008;

Tanaka et al., 1997). However, it is unclear if the reduction in MAP is clinically relevant. Within the limitations of this study, caution is required to generalize this finding to the wider poststroke population.

FEV_1/FVC. In comparison to the general population, poststroke adults demonstrate relatively lower lung capacity (e.g., total lung and forced vital capacity) and lung volume (e.g., tidal, inspiratory reserve, and expiratory reserve volume) most likely due to weaker diaphragm, intercostal, and abdominal muscles (Billinger et al., 2012; Kelly et al., 2003; Mackay-Lyons & Howlett, 2005; Sutbeyaz et al., 2010). According to Sutbeyaz et al. (2010), a 6-week respiratory muscle training program improved respiratory function in poststroke adults. In that study, 15 poststroke adults engaged in the 6-week respiratory training program 6 days per week for 30 min each on the land. The results reported a significant increase in $FEV_1$and FVC compared to the control group.

Previous researchers stated that the ratio of forced expiration volume in 1 s to forced vital capacity (FEV_1/FVC) is an indicator to determine restrictive and obstructive respiratory function (Celli, Halbert, Isonaka, & Schau, 2003). In the present investigation, the FEV_1/FVC value for the participants was positively increased by approximately 8% over the aquatic exercise phase whereas the FEV_1/FVC value did not greatly alter over the control phase. In a similar study by Kurabayashi et al. (2000), the repetitive aquatic exercise sessions considerably increased the FEV_1/FVC for adults with chronic pulmonary emphysema (5 days per week for 30 min each for 2 months). These data indicate that participation in an aquatic exercise program using water pressure and resistance may be useful in improving respiratory function for poststroke adults.

Water immersion has been considered as a potent stimulus for improving respiratory function for the poststroke population. Some evidence on respiratory responses and adaptations to aquatic exercise has been documented in the literature. Stan et al. (2012) reported that water immersion can result in an increase of respiratory work by approximately 60%. The authors suggested that breath control activities and rhythmic breathing in an aquatic exercise program could strengthen respiratory muscles and improve respiratory mechanism. In addition, Kurabayashi et al. (2000) noted that water immersion can provide more workload on the thoracic and abdomen areas during the inspiration phase and suppress the diaphragm muscles during the expiration phase. In addition, the authors stated that the anatomical dead space (i.e., the volume of the conducting airways) can be minimized during aquatic exercise sessions as a result of an increased pressure on the abdominal side of the diaphragm muscles.

The most likely explanation for the FEV_1/FVC increment in the present study is that breath control activities and rhythmic breathing during the exercise sessions could improve the respiratory mechanism and strengthen respiratory muscles (e.g., diaphragm and external intercostals during inspiration, abdominals and internal intercostals during expiration). During the exercise sessions, the participants may have had to forcefully contract respiratory muscles to overcome the increased workload which resulted from water pressure and resistance with the water at chest level. In addition, the participants may have had to also frequently breathe to supply sufficient oxygen to the lungs. Therefore, the forced breathing muscle contraction and increased respiratory rate over the exercise phase might have contributed to the positive increment in FEV_1/FVC in the participants.

Motor Fitness

NGS. With regard to gait speed, Kelly et al. (2003) stated that poststroke individuals showed approximately 50% slower maximal gait speed in comparison to the general healthy population. In that cross-sectional study, the 10-m walk test was used to measure normal and maximal gait speed for 17 poststroke adults. Normal gait speed for the poststroke adults was 0.71 m/s, and maximal gait speed was 1.03 m/s. Jung and Lee (2010) noted that water immersion can provide the poststroke population with more physical supports and motivation to engage in regular physical activities than on land.

Recent research has illustrated the benefits of aquatic exercise programs on gait speed for poststroke adults. Chu et al. (2004) stated that an 8-week aquatic exercise program contributed to a positive impact (19%) in gait speed of poststroke adults. Through a randomized trial, 13 participants were assigned into an aquatic exercise group or an upper-body circuit exercise group. The 7 participants engaged in the 8-week aquatic exercise program (3 times per week for 60 min each). The aquatic exercise program significantly increased gait speed whereas the upper-body circuit exercise program did not change gait speed. In addition, Verheyden et al. (2006) reported the effect of a 5-

week aquatic exercise program on gait speed for poststroke adults. The 11 participants engaged in a 5-week study of aquatic exercise for 3 to 4 sessions per week. After completion of the 5-week aquatic exercise program, the participants demonstrated an improvement in gait speed (16.7%) and an improvement (23.5%) in gait speed during the 10-m water movement test. These results suggest that an aquatic exercise program may have a positive impact for poststroke adults to improve their gait speed.

Similarly, the present study identified that participation in an aquatic exercise program was effective for poststroke adults in improving normal gait speed (NGS; 26%) from the initial gait speed (0.54 m/s). Interestingly, the participants showed a significant decrease in NGS (6%) following the control phase. This suggests that physical inactivity over the control phase might have contributed to a negative change in NGS for the participants. The findings in the present study are in agreement with those from the previous studies (Chu et al., 2004; Kelly et al., 2003; Verheyden et al., 2006). It is likely that an aquatic exercise program may be an effective way to enhance NGS for poststroke adults.

According to Chu et al. (2004), participation in an 8-week aquatic exercise program had a significant effect on lower-body muscular strength for poststroke adults. Through aquatic exercise sessions, the participants demonstrated a significant increase in muscle strength scores (2.75 to 2.97 Nm/kg) for their affected leg, which were calculated through muscle torques (isokinetic flexor and extensor muscle strength of knee and hip joints). In the present study, the improvement in NGS might have been possible for the following reasons: an increase in lower-body muscular strength as well as an increase in dynamic balance (i.e., stepping exercise in the exercise phase). Participants performed the stepping exercise using aqua steps on the floor of the pool. This stepping exercise was designed to improve lower-body muscular function (e.g., strength, coordination, range of motion) and dynamic balance (e.g., stepping, walking, and turning) using two different water depths. Following a placement pattern of a square (e.g., each aqua step representing a corner of the square) the participants had to step up and then down, moving forward to the next step. With each transition to a new aqua step, the participants changed water level (e.g., waist level to chest level to waist level). After one complete cycle, the participants repeated the square pattern using a different lead leg for each step up (e.g., if right leg used for cycle one, left leg was used for the second cycle). The participants had to practice turning skills (e.g., left turn, right turn, and turn around) to return to the starting position for the obstacle course at conclusion of each cycle.

The fast walking in the water may be another possible explanation for the improvement in NGS. The participants had to walk forward a distance of 10 m with the water at chest level as fast as possible, walk around, return to the starting position, and then repeat this walking practice while holding a water barbell and wearing an ankle weight on the affected leg. Jung and Lee (2010) identified that the use of ankle weights on the affected leg increased the stance phase stability (3%) of 22 poststroke adults during aquatic treadmill walking. In addition, the use of an ankle weight decreased the peak hip flexion of the affected leg (7.9%) during the gait cycle on the aquatic treadmill.

These data indicate that the use of ankle weights might have contributed to an increase in stability and a decrease in the unwanted flotation of the affected leg during the fast walking. Thus, the lower-body muscular strength and functional mobility for the participants might have been improved as the participants performed these exercises (i.e., stepping and fast walking) over the aquatic exercise phase.

TUG. According to ACSM (2012), the Timed Up and Go (TUG) test is a reliable and valid test to measure dynamic balance and functional mobility for people with disabilities. Ng and Hui-Chan (2005) identified that compared to the general healthy population, poststroke adults demonstrate considerably lower dynamic balance and functional mobility resulting from weaker muscle strength of the affected lower-extremity, increased muscle tone, and poor balance control. In their study, the TUG test was used to measure the time taken to complete a series of motor tasks for 11 poststroke adults. Results of this cross-sectional research indicated that the TUG mean score for the poststroke adults was significantly slower (22.6 s) than the general healthy adults (9.1 s). Dean, Richards, and Malouin (2000) reported the effects of circuit training program (circuit training versus upper-limb exercise group comparison) on TUG for 12 poststroke adults. Six poststroke adults engaged in a 4-week circuit exercise program 3 times per week for 60 min each. The participants in the circuit exercise group demonstrated a more positive reduction of TUG, from 27.4 to 19.5 s, in comparison to the upper-limb exercise group.

In additional literature to support aquatic exercise measuring TUG, Katsura et al. (2010) reported that an 8-week aquatic exercise program led to a positive change in TUG for healthy elderly. Through a randomization, 12 participants participated in an aquatic exercise group designed with the use of water-resistance equipment on the lower legs, and 8 participants participated in an aquatic group designed without the use of water-resistance equipment. The 8-week aquatic exercise programs for both groups were implemented 3 times per week for 90 min each. The participants in both groups revealed significant effects in TUG following completion of the 8-week aquatic exercise program. The authors noted that both exercise programs were effective in improving dynamic balance since the exercise intensity (i.e., walking speed during exercise) for the participants could be adjustable depending on the magnitude of water resistance. The results of the 8-week aquatic exercise programs suggested that regular exercise using buoyancy, consistent water resistance, and different water depths may be beneficial to improve dynamic balance and functional mobility for poststroke individuals.

In the current study, the participants demonstrated a significant decrease (10%) in TUG following the aquatic exercise phase. However, the participants demonstrated a significant increase (3%) in TUG following the control phase. These observations are similar to the findings in the previous research by Katsura et al. (2010). The findings of this present study suggest that participation in challenging motor tasks (e.g., walking, stepping, and turning) and rotation activities (e.g., sagittal, transversal, and combined rotation activities) in the water may positively influence dynamic balance and functional mobility for poststroke adults.

Physical Activity Affect

PA, NA, TR, and FA. Results of the present investigation are comparable with the previous study by Driver et al. (2003), which investigated the effects of an 8-week aquatic exercise program on affective feeling states for adults with brain injuries (3 times per week for 60 min each). The authors noted that the participants reported a significant increase in PA and TR and a significant decrease in NA and FA following the 8-week aquatic exercise program. It may be plausible that the successful motor tasks perceived by the poststroke participants over the aquatic exercise phase could lead to an increase in positive feelings (e.g., energetic, peaceful) and a decrease in negative feelings (e.g., discouraged, fatigued).

Bandura (1986) stated that social cognitive theory is the theoretical basis to account for a change of feeling states which individuals experience through participation in physical activities. Indeed, more positive feelings and less negative feelings could be experienced as the poststroke participants successfully completed a motor task (e.g., walking, stepping, and turning) across the aquatic exercise phase. In addition, through the individualized exercise sessions, more positive feelings and less negative feelings could be perceived as the participants became more comfortable with the aquatic environment. Through the repetitive exercise stimuli over the aquatic exercise phase, the participants could attain more strong belief in the capability to complete a motor task in a more secure and independent setting. As a result of the gained strong belief, the participants might have felt more competent to engage in regular physical activities in the water and on land, and their self-efficacy (i.e., capability) could be gradually enhanced. Therefore, physical activities in the water may be an ideal setting for poststroke adults in order to enhance their emotional well-being (Driver et al., 2007; Kwan et al., 2010).

Recognizing Limitations

The present investigation had to be finalized within a limited amount of time (i.e., 14 weeks) since the university pool facility was scheduled for annual maintenance to repair the pool bottom and water replacement. This affected the amount of time available for the washout period with this crossover design (i.e., a 2-week washout period between two treatments each for 6 weeks). This may not have been long enough to reduce the effects of the first treatment (Fleiss, 1989; Jones et al., 2003). For further investigations, it is critical to provide sufficient length of time when using a crossover design and avoiding constraints caused by facility access.

In addition, no adjustment was made during data analysis to account for the multiple comparisons made. Therefore, the chance of a Type I error was increased. Relatively small sample size, varying characteristics in the sample, and no acute measure of physical activity affect were considered as additional limitations of this study.

Conclusion

With consideration to the limitations of this study and using the findings from the statistical analysis, the following conclusions can be made: (a) changes in cardiorespiratory function: resting heart rate (HR_{rest}), mean arterial pressure (MAP), the ratio of forced expiration volume in 1 s to forced vital capacity (FEV_1/FVC); (b) changes in motor fitness: normal gait speed (NGS), Timed Up and Go (TUG); and (c) changes in physical activity affect: chronic positive affect (PA), negative affect (NA), tranquility (TR), and fatigue (FA). Given the small sample size, caution is advised in generalizing the findings of this study to the poststroke adults across all ages.

1. The HR_{rest} mean for the participants was significantly reduced following the exercise phase when compared to the control phase.

2. A significant reduction for MAP was found in the participants across the exercise phase but not across the control phase.

3. The FEV_1/FVC mean was positively increased over the exercise phase as compared the control phase.

4. The participants demonstrated a significantly faster NGS following the exercise phase whereas they demonstrated a significantly slower NGS following the control phase.

5. The time for TUG became significantly reduced in the participants following the exercise phase. However, the time for TUG became significantly increased in the participants following the control phase.

6. The PA level in the participants became increased during the exercise phase. However, no significant change in PA was identified in the participants during the control phase.

7. The level of NA was reduced in the participants across the exercise phase. However, the level of NA was increased in the participants over the control phase.

8. The TR of the participants became increased after implementing the exercise phase. However, no significant treatment effect on TR was identified in the participants following the control phase.

9. The participants showed a significant reduction in FA following the exercise phase. However, no statistical significant change in FA was reported in the participants across the control phase.

Within the limitations of the study and specific to the participants of the study, it appears that participation in the 6-week aquatic exercise program would be beneficial for the participants to maintain and improve their cardiorespiratory function, motor fitness, and physical activity affect. The participants demonstrated a positive change in $HR_{rest,}$ MAP, FEV_1/FVC, NGS, TUG, PA, NA, TR, and FA following the exercise phase.

However, no positive changes in those variables were observed in the same participants following the control phase. Therefore, it is suggested that more physical activity programs in the water should be developed and provided for the poststroke population in order to enhance their cardiorespiratory function, motor fitness, and physical activity affect in a more secure, independent, and motivated environment. Further research projects should be conducted to support and generalize the meaningful findings of the present investigation using an expansive sample size, a different experimental design, and an effective long-term program.

Recommendations for Further Study

The following recommendations are suggested for future research based on the results of the present investigation:

1. A further need for evidence-based research comparing the benefits of an exercise program on cardiorespiratory function, motor fitness, and physical activity affect in water and on land for poststroke adults.

2. Research investigating the effects of an aquatic exercise program on further cardiorespiratory parameters in poststroke adults: oxygen consumption (VO_2) at rest, VO_2 when walking, the net VO_2 (e.g., walking - resting VO_2), oxygen consumption per meter when walking, respiratory exchange ratio, and respiratory rate.

3. A need for further research using a 3-D motion capture system on motor fitness (i.e., normal gait speed, dynamic balance) should be implemented to determine the effects of an aquatic exercise program on the following parameters: cadence, stride length, gait cycle time, foot contact time in swing and stance phases, and stability.

4. Further investigations determining the effects of an aquatic exercise program on motivation, self-confidence, and self-esteem in the stroke population may be a potential area of interest for researchers who need to consider developing and providing aquatic exercise programs for poststroke individuals.

5. Research designed through extensive sample sizes, multiple outcome measures, various functional levels, wider age range, better exercise protocols, and longer exercise programs should be conducted to provide a well-designed exercise program in a safer environment for poststroke adults, as well as to improve the quality of their lives.

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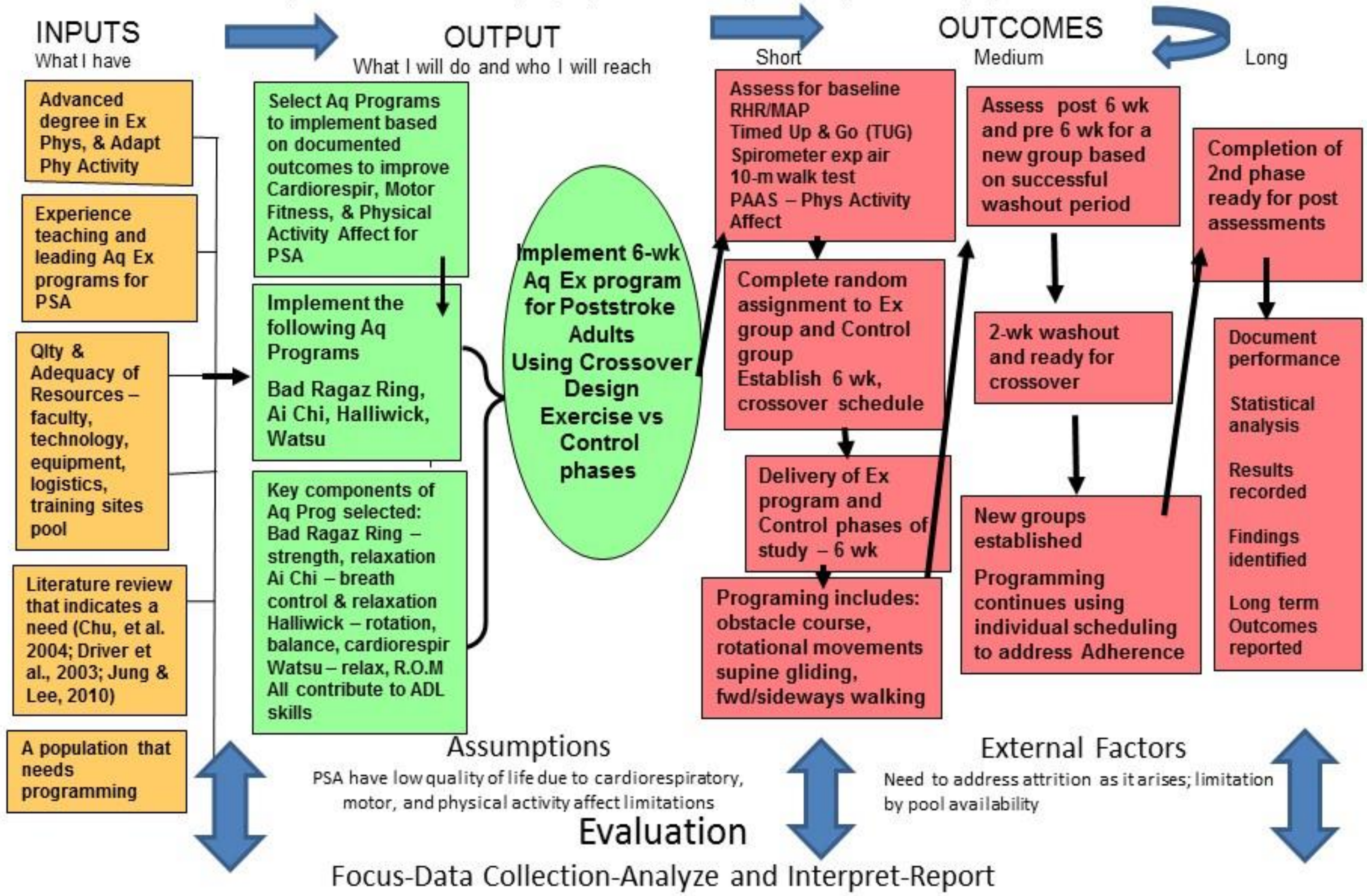
APPENDIX A

Dissertation Logic Model: Effects of Aquatic Exercise

Dissertation Logic Model: Effects of Aquatic Exercise Program on Poststroke Adults

SITUATION: Lack of documentation in literature for the effects of aquatic exercise on cardiorespiratory, motor fitness, and physical activity affect for poststroke adults (PSA)

- Arrows and feedback loops show the links between inputs, outputs and outcomes; Arrows depict the underlying causal connections



APPENDIX B

Physical Activity and Disability Scale

Physical Activity

ID	Total Physical Activity
1	1. Exercise: Walking – 3 days/week, 2 min/day Stretching – 2 days/week, 10 min/day Exercise Intensity: Light 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): No 4. Therapy Sessions: Physical/Occupational – 1 day/week, 60 min each 5. Employment-related Activity: No
2	1. Exercise: Treadmill – 3 days/week, 8 min/day Cycling – 3 days/week, 20 min/day Stretching – 6 days/week, 20 min/day Exercise Intensity: Light 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): No 4. Therapy Sessions: Physical/Occupational – No 5. Employment-related Activity: No
3	1. Exercise: No Exercise Intensity: N/A 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Cooking – 420 min/week, Vacuuming – 15 min/week, Laundry – 60 min/week, Washing plates – 30 min/week 4. Therapy Sessions: Physical/Occupational – 3 days/week, 60 min each 5. Employment-related Activity: No
4	1. Exercise: Walking – 2 days/week, 30 min/day Exercise Intensity: Light 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Cooking – 360 min/week 4. Therapy Sessions: No 5. Employment-related Activity: No
5	1. Exercise: No Exercise Intensity: N/A 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Gardening – 7 days/week, less than 60 min/day 4. Therapy Sessions: No 5. Employment-related Activity: No

Note. ID = identification number, N/A = not available. Physical Activity and Disability Scale (PADS; Rimmer et al., 2000).

Physical Activity

ID	Total Physical Activity
6	1. Exercise: No Exercise Intensity: N/A 2. Leisure Activity: Horseback riding – 1-2 days/week, 30 min/day 3. General Activity (i.e., indoor/outdoor household activities): Gardening 1 day/week, 30 min/day 4. Therapy Sessions: No 5. Employment-related Activity: No
7	1. Exercise: Walking – 3-4 days/week, 30 min/day Elastic Band – 1 day/week, 10 min/day Stretching – 5 days/week, 10-20 min/day Exercise Intensity: Light 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Gardening – 3 days/week, 30 min/day 4. Therapy Sessions: No 5. Employment-related Activity: No
8	1. Exercise: No Exercise Intensity: N/A 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Gardening – 6 days/week, 4. Therapy Sessions: No 5. Employment-related Activity: No
9	1. Exercise: No 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): No 4. Therapy Sessions: Acupuncture therapy – 1 day/week, 60 min 5. Employment-related Activity: No
10	1. Exercise: Walking – 3 days/week, 20 min/day Exercise Intensity: Light 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Laundry – 30 min/week 4. Therapy Sessions: Physical/Occupational – 2 days/week, 30 min each 5. Employment-related Activity: No
11	1. Exercise: No 2. Leisure Activity: No 3. General Activity (i.e., indoor/outdoor household activities): Laundry – 30 min/week, Cooking – 30-45 min/week, Gardening – 1 day/week, 15 min/day 4. Therapy Sessions: No 5. Employment-related Activity: No

Note. ID = identification number, N/A = not available.

NCPAD Physical Activity and Disability Scale

DEMOGRAPHICS

NAME:____________________________ **DATE:** _____________

AGE: ______ **years**

GENDER

☐ Male
☐ Female

TYPE OF DISABILITY __________________________________

ASSISTIVE DEVICES (Check all that apply)

☐ Walker
☐ Braces
☐ Cane
☐ Wheelchair

USE OF ARMS (Check one)

☐ Full
☐ Partial
☐ No Use

USE OF LEGS

☐ Full
☐ Partial
☐ No Use

Directions: On the following pages are a list of questions related to physical activity and exercise. There are no right or wrong answers and your responses will be kept anonymous. Note that your answers to certain questions in the survey may cause your browser to skip other questions and move to a later item in the survey. Don't worry--this is how the survey was designed in order to save time. Please answer each presented question as accurately and as completely as possible. When you have finished the survey, press the "Submit" button. Your survey responses will be checked and used to create scores reflecting your level of physical activity. A window presenting your scores will then appear.

1. EXERCISE

1.00 Do you currently exercise?

☐ Yes
☐ No

↳ **IF NO, PLEASE GO TO THE LEISURE ACTIVITY SECTION.**

1.01 What kind of exercise do you do?

Directions: List up to four (4) activities below that you do on a regular basis for primary purpose of increasing or maintaining fitness. Aerobics are done for a sustained period of time and result in an increase in your heart rate and breathing rate. Examples include walking, jogging, attending an aerobics class, and bicycling. Strength activities include lifting weights or using elastic bands or weight training machines. Flexibility refers to activities that involve muscle stretching

Activity Type

Code:	Description
A:	Aerobic Exercise
S:	Strength Exercise
F:	Flexibility Exercise

Activity Type (check one)	Activity	Days/Week	Minutes/Day	Months/Year
☐ A ☐ S ☐ F				
☐ A ☐ S ☐ F				
☐ A ☐ S ☐ F				
☐ A ☐ S ☐ F				

1.02 Have you been exercising for more than one year or less than one year?

☐ More than one year
☐ Less than one year

1.03 How would you describe the average intensity of your exercise program?

☐ Light exercise: Don't sweat or breathe heavily
☐ Moderate exercise: Breathe a little harder and may sweat
☐ Vigorous: Breathe hard and sweat

2. LEISURE ACTIVITY

2.0 Do you engage in leisure time physical activity?

☐ Yes

☐ No

IF NO, GO TO THE GENERAL ACTIVITY SECTION ON THE NEXT PAGE.

2.1 What type of activities do you do?

Directions: List up to four (4) activities below that you do for leisure or recreation. These activities can be done on a regular or irregular basis and may not necessarily result in sustained increases in heart rate and breathing rate. Examples include hiking, boating, skiing, dancing and sports activities. Please indicate whether the activity is an endurance activity or a Non-Endurance activity. Examples of endurance activities include: hiking, tennis, dancing, skiing. Non-endurance activities include boating, softball and horseback riding. Do not list activities here that you already listed under exercise.

Activity Type

Code	Description
E	Endurance
NE	Non-Endurance

Activity Type (check one)	Activity	Days/Week	Minutes/Day	Months/Year
☐ E ☐ NE				
☐ E ☐ NE				
☐ E ☐ NE				
☐ E ☐ NE				

3. GENERAL ACTIVITY

3.00 From Monday through Friday, how many waking hours a day do you usually spend inside your home?

☐ Less than 6 hours a day
☐ 6 to 10 hours a day
☐ More than 10 hours a day

3.01 On Saturday and Sunday, how many waking hours a day do you usually spend inside your home?

☐ Less than 6 hours a day
☐ 6 to 10 hours a day
☐ More than 10 hours a day

3.02 On average, how many hours a day do you sleep including naps?

________________ hours

3.03 On average, how many hours a day are you sitting or lying down, excluding sleeping?

________________ hours

3.04 Are most of your indoor household activities done by you or someone Else?

☐ Done by you
☐ Done by someone else

IF DONE BY SOMEONE ELSE, GO TO QUESTION 3.06.

3.05 Please list up to four (4) indoor household activities you do and the number of minutes a week you spend on each activity.

Activity	Minutes/Week

3.06 Do you do any outdoor household activities such as gardening?

☐ Yes
☐ No

IF NO, GO TO QUESTION 3.08.

3.07 Please list up to four (4) outdoor household activities you do and the number of minutes a week you spend on each activity.

Activity	Days/Week	Minutes/Day	Months/Year

3.08 How much assistance do you need to perform activities of daily living such as dressing and bathing?

☐ No assistance
☐ Some assistance
☐ Full assistance

4. THERAPY

4.00 Do you currently receive physical or occupational therapy?

☐ Yes
☐ No

IF NO, GO TO EMPLOYMENT SECTION ON THE NEXT PAGE.

4.01 How many days a week do you receive therapy?

_________ Days.

4.02 How long does each therapy session usually last?

__________ Minutes

5. EMPLOYMENT / SCHOOL

5.00 Are you currently employed / attending school?

- ☐ Employed
- ☐ Not employed
- ☐ Retired
- ☐ Attending school

IF UNEMPLOYED OR RETIRED, GO TO WHEELCHAIR SECTION ON THE NEXT PAGE.

5.01 For most of your work / school day, do you:

- ☐ Move around
- ☐ Stand
- ☐ Sit

5.02 Do you climb any stairs during the work / school day?

- ☐ Yes
- ☐ No

IF NO, GO TO QUESTION 5.04.

5.02a How many flights of stairs do you climb? ___________ flights

5.02b How many times a day do you climb the stairs? __________

5.03 In your transportation to and from work / school, do you get any physical activity?

- ☐ Yes
- ☐ No

IF NO PLEASE GO TO WHEELCHAIR SECTION ON THE NEXT PAGE.

5.04 Please list up to four (4) employment-related physical activities you do and the number of minutes a week you spend on each activity.

Activity	Days/Week	Minutes/Day	Months/year

6. WHEELCHAIR USERS

6.00 **Do you use a wheelchair?**

- ☐ Yes
- ☐ No

IF NO, STOP HERE.

6.01 **How many years have you used a wheelchair? ______ years?**

6.02 **During the time that you are awake, how much time do you: spend in your wheelchair?**

- ☐ All day
- ☐ Most of the day
- ☐ A few hours

6.03 **What type of wheelchair do you primarily use?**

- ☐ Manual wheelchair
- ☐ Powered wheelchair

IF POWERED WHEELCHAIR, STOP HERE.

6.04 **Who usually pushes your wheelchair?**

- ☐ Myself
- ☐ Someone else

IF SOMEONE ELSE, STOP HERE.

6.05 **On average, how many minutes a day do you push yourself in your wheelchair?**

- ☐ Less than 60 minutes
- ☐ Sixty minutes or more

Thank you for completing this survey!

PADS Questionnaire 01.18.2006
revised 1/11/2006

APPENDIX C

Physical Activity Affect Scale

PHYSICAL ACTIVITY AFFECT SCALE

Instructions: Please use the following scale to indicate the extent to which each word below describes **how you feel** **IN GENERAL (OVERALL)**. Record your response for each item by circling the appropriate number.

		Do Not Feel	Feel Slightly	Feel Moderately	Feel Strongly	Feel Very Strongly
1.	Awful	0	1	2	3	4
2.	Calm	0	1	2	3	4
3.	Fatigued	0	1	2	3	4
4.	Crummy	0	1	2	3	4
5.	Relaxed	0	1	2	3	4
6.	Tired	0	1	2	3	4
7.	Energetic	0	1	2	3	4
8.	Discouraged	0	1	2	3	4
9.	Enthusiastic	0	1	2	3	4
10.	Peaceful	0	1	2	3	4
11.	Worn-out	0	1	2	3	4
12.	Upbeat	0	1	2	3	4

Note. Physical Activity Affect Scale (PAAS; Lox et al., 2000).

APPENDIX D

Aquatic Exercise Program

Based on Aquatic Exercise Methods

Aquatic Exercise Program Based on Aquatic Exercise Methods

Methods	Rationale for Selection
Halliwick (Tripp et al., 2013)	1. Rotation activities: sagittal, transversal, and combined rotations to improve functional mobility, dynamic balance, and cardiorespiratory function 2. Breath control and rhythmic breath activities to strengthen respiratory muscles and improve respiratory mechanism using water pressure and water resistance 3. Independent movement in the water: the ultimate goal of Halliwick method is to allow the participants to independently move and swim in the water without the use of any floatation devices
Bad Ragaz Ring (Meno, 2000)	1. The use of floatation devices to support the participants in a supine position during exercise sessions 2. Kicking the poolside with both feet in a supine position and gliding on the back supported by the PI's hands and floatation equipment 3. Passive range of motion exercises by the PI when a participant is floating on the back
Watsu (Leathem et al., 2012)	1. Passive relaxation movements to the spine, joints, and muscles of a participants at the end of a daily exercise session 2. Stretching and rotating a participant's trunk, legs, and arms on the water surface by using buoyancy and water resistance
Ai Chi (Bayraktar et al., 2013)	1. Slow and broad rotations of the arms, trunk, and legs using a water barbell in a standing position for warm-up and cool-down exercises 2. Increasing active range of motion exercises and stability 3. Deep and rhythmic breath control activities to strengthen respiratory muscles

Aquatic Exercise Program

Exercise Phase	Exercise Description and Methods	Goal
Warm Up (5 min)	Ai Chi Method Trunk rotation with a water barbell support on the water surface (10 repetitions [reps] × 2 to 5 sets) Holding a water barbell on the water surface and lifting up the water barbell with both hands (10 reps × 2 to 5 sets) Pushing and pulling a water barbell forward and backward on the water surface (10 reps × 2 to 5 sets)	Increase in range of motion and stability
Main Exercise (50 min)	A combination of Halliwick and Bad Ragaz Ring Methods Pool floor walking with a water barbell: walk forward as fast as possible over a 10-m distance at chest level, walk around, and return to the start position (15 min) Stepping up and down on aqua steps on the floor of the pool to practice motor skills such as stepping, walking, and turning in an obstacle course (15 min) Rotation activities with a water barbell (15 min) 1) Sagittal rotation: weight shifting from right to left or left to right. 2) Transversal rotation: changing positions from standing to front or from standing to back. 3) Combined rotation: a combination of sagittal and transversal rotations Breath control activities (5 min) 1) Blowing bubbles in the water 2) Blowing a ball on the water surface	Improvement in mobility and cardiorespiratory function Increase in dynamic balance and functional mobility Improvement in cardiorespiratory function and dynamic balance Improvement in respiratory muscles and mechanism
Cool Down (5 min)	Ai Chi Method Trunk rotation with a water barbell support on the water surface (10 reps × 2 to 5 sets) Passing a beach ball at the water surface to the PI by using both fists when walking sideways over a distance of 10 m (1 to 2 laps) Pushing and pulling a water barbell forward and backward on the water surface (10 reps × 2 to 5 sets)	Increase in range of motion and stability Improvement in dynamic balance and range of motion Increase in range of motion

Target Hear Rate Zone for the Participants

ID	Target Heart Rate (bpm)		
	50%	60%	70%
1	103	110	116
2	101	107	114
3	120	127	134
4	113	120	127
5	103	108	113
6	112	118	124
7	96	103	110
8	109	116	123
9	101	109	116
10	107	116	125
11	111	117	123

Note. ID = identification number.

APPENDIX E

Institutional Review Board Approval Letter

TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

Institutional Review Board
Office of Research and Sponsored Programs
P.O. Box 425619, Denton, TX 76204-5619
940-898-3378
email: IRB@twu.edu
http://www.twu.edu/irb.html

DATE: March 6, 2014

TO: Mr. Gwang Yon Hwang
Department of Kinesiology

FROM: Institutional Review Board - Denton

Re: Approval for Effects of an Aquatic Exercise Program on Cardiorespiratory Function, Motor Fitness, and Physical Activity Affect for Adults with Brain Injury (Protocol #: 17599)

The above referenced study has been reviewed and approved at a fully convened meeting of the Denton Institutional Review Board (IRB) on 2/7/2014. This approval is valid for one year and expires on 2/7/2015. The IRB will send an email notification 45 days prior to the expiration date with instructions to extend or close the study. It is your responsibility to request an extension for the study if it is not yet complete, to close the protocol file when the study is complete, and to make certain that the study is not conducted beyond the expiration date.

If applicable, agency approval letters must be submitted to the IRB upon receipt prior to any data collection at that agency. A copy of the approved consent form with the IRB approval stamp is enclosed. Please use the consent form with the most recent approval date stamp when obtaining consent from your participants. A copy of the signed consent forms must be submitted with the request to close the study file at the completion of the study.

Any modifications to this study must be submitted for review to the IRB using the Modification Request Form. Additionally, the IRB must be notified immediately of any adverse events or unanticipated problems. All forms are located on the IRB website. If you have any questions, please contact the TWU IRB.

cc. Dr. Charlotte Sanborn, Department of Kinesiology
Dr. Ronald Davis, Department of Kinesiology
Graduate School

APPENDIX F

Participant Consent Form

TEXAS WOMAN'S UNIVERSITY
CONSENT TO PARTICIPATE IN RESEARCH

Title: Effects of an Aquatic Exercise Program on Cardiorespiratory Function, Motor Fitness, and Physical Activity Affect for Adults Post Stroke

Investigator: Gwang Yon Hwang, MS..ghwang@twu.edu [redacted]
Advisor: Ronald Davis, PhD .... rdavis4@twu.edu [redacted]

Explanation and Purpose of the Research

You are being asked to participate in a research study for Gwang Yon Hwang's dissertation. The purpose of this study is to determine if an aquatic exercise program is beneficial for adults post stroke to improve their cardiorespiratory function, motor fitness, and physical activity affect. The entire study will last 14 weeks (i.e., 6 weeks of the first treatment, 2-week washout period, 6 weeks of the second treatment). You will be asked to attend 18 sessions of the aquatic exercise program for 6 weeks (3 days per week for 60 min per session = 18 hrs of total time commitment) at the indoor swim pool in Pioneer Hall at TWU. You will not receive any aquatic sessions for 6 weeks while you are assigned into the control group. After random assignment to an exercise and control group, you will receive the first treatment for 6 weeks (i.e., aquatic exercise or control). After the first treatment phase, you will receive a washout period for 2 weeks without participation in any aquatic exercise sessions. Washout period refers to separating the two different (i.e., exercise and control) treatment periods in order to reduce the effects of the first treatment period on the exercise group. Following the washout period, you will cross over to the alternative treatment group for another 6 weeks. All data for cardiorespiratory, motor fitness, and physical activity affect will be collected at baseline, after the first treatment period (6 weeks), after the washout period (8 weeks), and after the second treatment period (14 weeks). The PI will contact you to schedule date and time for data collection.

The aquatic exercise program will focus on improving your cardiorespiratory function, motor fitness, and physical activity affect. The daily aquatic exercise program will consist of the following sessions: warm up, main exercise, and cool down. During the warm up session (5 min), you will execute stretching with water barbells in a standing position at the chest-level shallow pool. During the main exercise session (50 min), you will hold water barbells to increase stability and perform walking, stepping, rotation, and breathing control activities as you move around the pool. During the cool down session (5 min), you will conduct stretching with water barbells in a standing position.

As a participant for this study, data for your cardiorespiratory function, motor fitness, and physical activity affect will be collected at baseline, after the first treatment period (6 weeks), after the washout period (8 weeks), and after the second treatment period (14 weeks) using non-identifiable code in a room free of distractions in Pioneer Hall. Also, data for your physical activity affect will be collected before and after daily aquatic exercise sessions.

1) Cardiorespiratory function: Your resting heart rate and blood pressure [i.e., systolic blood pressure (SBP) and diastolic blood pressure (DBP)] will be measured by a digital heart rate monitor and sphygmomanometer following 10 min of seated rest at baseline, after 6, 8, and 14 weeks. You will be asked to refrain from having caffeine and food at least 30 min prior to cardiorespiratory function measurement. Your respiratory function will be measured by a portable spirometer at baseline, after 6, 8, and 14 weeks. Your forced vital capacity (FVC) and forced expiration volume in 1 s (FEV_1) will be measured in a sitting position.

_______ Initials

2) Motor fitness: The 10-Meter Walk Test (10-MWT) will be used to assess your normal gait speed at baseline, after 6, 8, and 14 weeks. The gait speed will be measured by timing you with a digital stopwatch over 10 m of a 14-m walkway. Digital video recording will also take place as back up for timing your 10-m walk by using the camera's counter. Videotaping your walking is necessary as back up in order to accurately measure total amount of time to calculate the gait speed (m/sec). If the PI fails to accurately measure total amount of time with a digital stopwatch, the gait speed will be calculated by viewing the interval clock on the video camera monitor. The PI will walk next to you to minimize risk of falling. To avoid fatigue, a sufficient rest time and a drink of water will be given to you after each of the two trials (Mean will be recorded). Demonstration and one practice trial will be provided to you prior to an actual trial.

   Your dynamic balance will be measured using the Timed Up and Go (TUG) test at baseline, after 6, 8, and 14 weeks. The TUG test is a field based test to measure dynamic balance that requires you to stand up from a seated position in a chair on the signal "go", walk forward a distance of 3 m as quickly and as safely as possible, walk around a cone, return to the chair, and sit down (2 trials; Mean will be recorded). The PI will start the stopwatch with the signal "go" and stop it at the moment you sit down on the chair. You will have a 2-min rest time between trials to address fatigue. Digital video recording will be used as back up to measure timing by using the camera's counter. The PI will stand beside you during measurement and follow you one step behind to ensure safety.

3) Physical activity affect: Your exercise-induced feeling states (i.e., affect) will be assessed using the Physical Activity Affect Scale (PAAS). The PAAS is a paper pencil assessment to measure the level of exercise-induced feeling from "Do not feel" to "Feel very strongly" for 12 indicators (i.e., awful, calm, fatigued, crummy, relaxed, tired, energetic, discouraged, enthusiastic, peaceful, worn-out, and upbeat). Each indicator has the following levels: 0 = do not feel, 1 = feel slightly, 2 = feel moderately, 3 = feel strongly, and 4 = feel very strongly. The PAAS will be used to rate your acute physical activity affect before and after daily exercise sessions. The PAAS will also be used to rate your chronic physical activity affect at baseline, after 6, 8, and 14 weeks.

4) Physical activity level: To describe your demographic information, your physical activity level will be recorded using the Physical Activity and Disability Scale (PADS) prior to this study by the PI. The PADS will also be used to measure your physical activity level in the control group before and after the control period in a room free of distractions in Pioneer Hall. The PADS will measure total physical activity such as exercise, leisure activity (e.g., hiking, boating, dancing, sports activities), general activity (e.g., household activities, gardening), therapy sessions (e.g., physical and occupational therapy), and employment-related physical activity. The PI will read each question on the PADS to you and record your response in a room free of distractions in Pioneer Hall.

Potential Risks

Risk associated with drowning and falling:

Potential risk related with the aquatic exercise program (e.g., drowning) will be minimized by the presences of the PI, research assistants, and lifeguards. A guardian or spouse will be responsible for escorting you to the pool area before and after each daily exercise session. In order to protect against falling on the deck, the battery powered Hoyer lift can be used to lift you from the deck into the pool. In case of emergency, the PI will call the medical professionals. At the same time, the lifeguards will perform first aid or cardiopulmonary resuscitation (CPR) as needed.

_______ Initials

Risk associated with falling during the motor fitness assessments:
Potential risk is present during the gait speed and dynamic balance measures in the quiet room in Pioneer Hall. Risk will be minimized by physical assistance from the PI and research assistants. In order to protect against falling, the PI and research assistants will escort the participants from the hallway into the room for the motor fitness assessments. The PI and a research assistant will protect a participant from falling during the motor fitness measures by positioning on each side of the participant as the participant walks down the floor.

Risks associated with loss of confidentiality:
Confidentiality will be protected to the extent that is allowed by law. Key steps in minimizing confidentiality loss are: 1) your information will be coded using a 3 digit number code, 2) all data files will be coded using a 2 letter and 3 digit number code, and 3) all records related to this study will be stored on hard copy in a file cabinet during the duration of this study. This file cabinet will be kept in PH 119 B and locked by Dr. Davis. Only the PI and Dr. Davis will have access to this information.

Risks associated with loss of anonymity:
Steps to minimize anonymity will include 1) not identifying which of the participant's data are being used; the data of tests will be discussed only by the research team members, 2) communication between the participant and the researchers will be difficult to minimize but we will not reveal any personal information of the participant such as name and address to the public during the study.

The researchers will try to prevent any problem that could happen because of this research. You should let the researchers know at once if there is a problem and they will help you. However, TWU does not provide medical services or financial assistance for injuries that might happen because you are taking part in this research.

Participation and Benefits
Participation in this study is voluntary and you may withdraw at any time without any penalty. The advantages to this study are acquiring direct knowledge and information regarding the benefits of aquatic exercise such as improved cardiorespiratory function, motor fitness, and physical activity affect.

Questions Regarding the Study
You will be given a copy of this signed and dated consent form to keep. If you have any questions about the research study you should ask the researchers; their phone numbers are at the top of this form. If you have questions as a participant in this research or the way this study has been conducted, you may contact the Texas Woman's University Office of Research and Sponsored Programs at 940-898-3378 or via e-mail at IRB@twu.edu.

____ ______________
Signature of Participant Date

*If you would like to know the results of this study tell us where you want them to be sent:

Email: ________________________________ or Address:

____

____

____

Approved by the
Texas Woman's University
Institutional Review Board
Date: 2-7-14

APPENDIX G

Data Recording Form

Name:

DOB: Onset:

Age: F/M Ht: Wt:

Ischemia/hemorrhage Affected side: Lt/Rt

Mobility aid: walker/quad cane/mono cane/AFO/none

Medication:

Assessments: baseline/6 wk/8 wk/14 wk

BP_{rest}						
HR_{rest}						
FVC		%		%		%
FEV_1		%		%		%

10-m Walk Test

Timed Up & Go

APPENDIX H

Raw Data Set for Dissertation

Participant Demographic Characteristics

ID	Age (years)	Ht (cm)	Wt (kg)	BMI (kg/m^2)	TSS (years)	MAC (/10)	Gender (M/F)	TOS (L/R)	MA
1	73	190.5	113	31.1	9	9	M	L	C + A
2	76	177.8	73.4	23.2	5.4	10	M	R	C + A
3	53	167.6	84.7	30.2	1.3	10	F	L	N
4	62	143.5	78.2	38.0	9.8	9	F	L	W
5	80	165.1	58.3	21.4	0.8	8	F	R	N
6	67	185.4	99.8	29.0	5.5	10	M	L	C + A
7	79	165.1	76.9	28.2	12.7	10	M	L	C
8	65	152.4	58	25.0	9.5	10	F	R	N
9	71	160	48.1	18.8	6	8	F	L	C
10	56	180.3	82.7	25.4	4.9	8	M	R	C + A
11	67	152.4	78.3	33.7	2.4	10	F	L	W
Mean	68.1	167.3	77.4	27.6	6.1	9.3			
SD	8.8	14.9	18.6	5.6	3.8	0.9			
n							5/6	7/4	2/2/4/3

Note. ID = identification number, Ht = height, Wt = weight, BMI = body mass index, TSS = time since stroke, MAC = MacArthur competence scale, TOS = type of stroke, MA = mobility aids, M = male, F = female, L = left, R = right, C = cane, C + A = cane and ankle-foot orthotic, N = none, W = walker, SD = standard deviation, n = number.

Predata Set for the Exercise Phase

ID	MAP	RDBP	RHR	FEV1/ FVC	NGS	TUG	PA	NA	TR	FA
1	94.98	76	70	86.68	0.25	43.92	2.67	0.67	2.67	0
2	92.47	70	68	44.46	0.16	66.75	2	0	2	1
3	107.64	86	83.5	85.46	0.86	8.09	3.33	0	2	1
4	118.64	101	78.5	76.4	0.56	15.87	2	1	1.33	1
5	89.15	78	76	49.38	0.76	10.42	2	1.33	2	1.33
6	97.98	81	81	77.71	0.21	49.31	1.67	1.33	2.33	1.67
7	100.47	74.5	61	72.65	0.56	18.05	2.33	1	2	1
8	116.31	102	74	78.75	0.67	17.32	2	1.33	2.33	0.67
9	85.65	69.5	64	82.74	0.43	23.45	2	0	3	1
10	88.65	75.5	60	72.58	0.77	13.98	2	1.33	2.33	1.33
11	115.31	95	79	55.32	0.71	9.62	2.33	0.67	2	1.67
Mean	100.66	82.59	72.27	71.10	0.54	25.16	2.21	0.78	2.18	1.06
SD	12.00	11.80	8.20	14.66	0.24	19.34	0.45	0.56	0.43	0.46

Note. ID = identification number, MAP = mean arterial pressure (mmHg), RDBP = resting diastolic blood pressure (mmHg), RHR = resting heart rate (bpm), FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity, NGS = normal gait speed (m/s), TUG = timed up and go (s), PA = positive affect, NA = negative affect, TR = tranquility, FA = fatigue, SD = standard deviation.

Postdata Set for the Exercise Phase

ID	MAP	RDBP	RHR	FEV1/ FVC	NGS	TUG	PA	NA	TR	FA
1	93.31	76	68	90.84	0.26	41.06	3.33	0	3	0
2	87.31	68	64.5	57.27	0.17	58.29	2.67	0	2.67	0.33
3	101.98	84	72.5	86.95	1.37	6.39	3	0	3.33	0
4	107.98	94	73.5	89.95	0.65	15.16	3	0.33	2.67	0
5	92.32	82	78	69.41	0.90	10.09	2	2	2	1.33
6	99.98	83	78	73.33	0.22	52.83	3.33	0.33	3	0.67
7	94.97	73.5	57	73.87	0.77	13.65	3	0	3	0.33
8	102.31	87	71	80.72	0.78	12.26	3.67	0	3	0
9	81.65	66.5	62.5	85.58	0.49	19.76	3	0	2	0.66
10	85.32	73	58.5	77.14	0.97	11.73	3.33	0	3	0
11	100.81	77.5	72	60.13	0.85	7.765	3	0	3.33	2
Mean	95.27	78.59	68.68	76.83	0.68	22.63	3.03	0.24	2.81	0.48
SD	8.18	8.31	7.23	11.40	0.36	18.80	0.43	0.59	0.45	0.65

Note. ID = identification number, MAP = mean arterial pressure (mmHg), RDBP = resting diastolic blood pressure (mmHg), RHR = resting heart rate (bpm), FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity, NGS = normal gait speed (m/s), TUG = timed up and go (s), PA = positive affect, NA = negative affect, TR = tranquility, FA = fatigue, SD = standard deviation.

Predata Set for the Control Phase

ID	MAP	RDBP	RHR	FEV1/ FVC	NGS	TUG	PA	NA	TR	FA
1	94.65	78	70	87.22	0.27	43.64	2.67	0.67	3	0
2	94.31	75.5	66	47.23	0.17	67.73	2	0	1.67	1
3	106.81	90	72	88.86	1.20	7.75	3	0	3	0.33
4	107.65	92	76.5	73.6	0.62	16.16	2	0.33	2.33	0.33
5	87.82	77.5	75.5	64.04	0.89	10.29	2.33	1	2	1
6	98.48	84	78.5	71.52	0.21	51.08	2	0.67	2	1
7	98.30	74.5	59	72.67	0.66	14.58	2	1	2	1
8	103.98	88	71.5	70.9	0.77	14.64	3	0.67	2.67	0.33
9	83.98	68	64.5	69.16	0.41	22.48	2	0	2	2
10	86.98	73.5	61	74.55	0.83	14.69	3	0	2.33	0.67
11	103.31	80	74	56.76	0.79	8.65	2.33	0	2.33	0.33
Mean	96.93	80.09	69.86	70.59	0.62	24.70	2.39	0.39	2.30	0.72
SD	8.17	7.55	6.44	11.92	0.32	20.10	0.44	0.41	0.43	0.55

Note. ID = identification number, MAP = mean arterial pressure (mmHg), RDBP = resting diastolic blood pressure (mmHg), RHR = resting heart rate (bpm), FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity, NGS = normal gait speed (m/s), TUG = timed up and go (s), PA = positive affect, NA = negative affect, TR = tranquility, FA = fatigue, SD = standard deviation.

Postdata Set for the Control Phase

ID	MAP	RDBP	RHR	FEV1/ FVC	NGS	TUG	PA	NA	TR	FA
1	91.81	75.5	68	90.6	0.26	43.77	2.33	0.67	3	0
2	94.97	74.5	67	56.41	0.16	67.38	2	0	1.67	2
3	108.81	92	84	88.59	1.07	8.25	3.33	0.33	2.67	0.67
4	110.31	94.5	78.5	76.31	0.59	16.45	1.67	1	2	1
5	90.48	79.5	77	49.72	0.82	10.27	2	1.33	2.33	1
6	100.15	84.5	79.5	76.19	0.21	53.21	2	1	1.67	1
7	100.64	76	61	75.62	0.62	16.64	2	1	2	0.67
8	121.98	104	74.5	68.89	0.75	18.00	2.33	0.33	2	0.33
9	84.98	70	64	70.47	0.44	22.1	2.33	0.67	2	2
10	87.15	74.5	62.5	74.23	0.72	15.07	3	1	2	1
11	105.31	82	76	44.94	0.763	9.27	2	2	1.67	1.67
Mean	99.69	82.45	72.00	70.18	0.58	25.49	2.27	0.84	2.09	1.03
SD	11.26	10.41	7.78	14.56	0.28	19.96	0.48	0.54	0.42	0.64

Note. ID = identification number, MAP = mean arterial pressure (mmHg), RDBP = resting diastolic blood pressure (mmHg), RHR = resting heart rate (bpm), FEV_1/FVC = the ratio of forced expiration volume in 1 s to forced vital capacity, NGS = normal gait speed (m/s), TUG = timed up and go (s), PA = positive affect, NA = negative affect, TR = tranquility, FA = fatigue, SD = standard deviation.

Mean Changes in RDBP Following Exercise and Control Phases

Variable	Exercise		Control	
	Pre	Post	Pre	Post
RDBP (mmHg)	82.59 ± 11.80	78.59 ± 8.31	80.09 ± 7.55	82.45 ± 10.41

Note. RDBP = resting diastolic blood pressure, according to results of two-way ANOVA with repeated measures, no significant main effect of group, $F(1, 10) = .408$, $p = .537$, no significant main effect of time, $F(1, 10) = 1.005$, $p = .340$, and no significant interaction effect of group by time, $F(1, 10) = 4.206$, $p = .067$, were observed for RDBP.

APPENDIX I

Medications Taken by the Participants

Medications Taken by the Participants

ID	Medication Lists
1	Ambien 10 mg, Gabapentin 600 mg, Omepraze dr 40 mg, Metoprolol tartate 25 mg, Leyothyroxine 200 mg, Clopiologrel 75 mg, Baby aspirin, Atorrastatin 10 mg, Epitol 200 mg, Vesicare 10 mg, Levemir flex Den 50 unit, nuedexta 20/10 mg
2	Simvastatin 20 mg, Amlodiphine 5 mg, Tolterodine 2 mg, Amiodarome 100 mg
3	Atorvastatin 20 mg, Hydrochlorothiazide 12.5 mg, LevETIRAcetam 500 mg, Lisinopril 40 mg, NIFEdipine XL 60 mg
4	Fenofibrate 54 mg, Levothyroxine 125 mcg, Simvastatin 40 mg, Amlodipine Besylate 5 mg
5	Metoprolol, Aspirin, Furosemide, Ranitidine, Warfarine
6	Levothyroxine, Lorotadine 10 mg, Niacine 500 mg, Ronitidine HCL 150 mg, Oxibutynin Chloride 5 mg, Synthroid .05 mg, Clopidogrel 75 mg, Crestor 40 mg
7	Byscolic 5 mg, Clopidogrel 75 mg, Sertraline (zoloft) 50 mg, Aspirin 81 mg, Nifedipine 60 mg
8	Aspirin, Paravastatin sodium 30 mg, Nifedipine ER 30 mg
9	Hydrochlorthiazide 12.5 mg, Symvastatin 20 mg, Carveditol 25 mg, Lisinopril 20 mg
10	Keppara 500 mg, Buspirone 10 mg, Citalopram 20 mg
11	Amiodarone 100 mg, Baby aspirin 81 mg, Doxycycline hyclate 100 mg, Nabetatol 200 mg, Lisinopril 20 mg, Protonix 40 mg, Crestor 40 mg

Note. ID = identification number.