A Comparison of the Effects of an Aquatic Therapy Program Versus a Combined Aquatic/Land Program on Functional Reach Measurements in the Elderly

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A COMPARISON OF THE EFFECTS OF AN AQUATIC THERAPY PROGRAM VERSUS A COMBINED AQUATIC/LAND PROGRAM ON FUNCTIONAL REACH MEASUREMENTS IN THE ELDERLY

By

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THESIS

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ABSTRACT

The purpose of this study was to compare the effects of an aquatic exercise program with a combination land/aquatic program on functional reach measurements in the elderly. Twenty volunteers, aged 65 and older, were selected and assigned to either an aquatic or a combination exercise group. Subjects participated in 4 weeks (12 classes) of exercise. Functional reach (FR) measurements were taken prior to exercise and weekly thereafter. To determine significant differences in overall and weekly FR measurements, a t-test for independent samples, the Mann-Whitney U-Wilcoxon Rank Sum W Test, and a t-test for paired samples were used. Both groups demonstrated significant improvements in overall and weekly FR (p<.05), however no difference was found between groups. Due to the limitations of this study, conclusions cannot be made for the general population. This study serves as a pilot study for future research regarding the optimal exercise program for the elderly.
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Balance: The ability to maintain one’s center of gravity over the base of support.

Dynamic Balance: The ability to maintain one’s center of gravity over the base of support while moving. (Also referred to as postural mobility)

Elderly: Over the age of 65.

Fall: Unintentionally coming to rest on the ground or floor.

Functional reach: The maximal distance one can reach forward beyond arm’s length, while maintaining a fixed base of support in the standing position. (Duncan, Weiner, Chandler, & Studenski, 1990)

Motor learning: The study of acquisition and/or modification of movement (Shumway-Cook & Woollacott, 1995, p. 23)

Osteoporosis: A disease characterized by low bone mass and microarchitectural deterioration of bone tissue leading to enhanced bone fragility and a consequent increase in fracture risk. (American College of Sport Medicine, 1995, p. i)

Postural control: The ability to control the body’s position in space for the purpose of stability and orientation. (Shumway-Cook & Woollacott, 1995, p. 366)

Stability Limits: Boundaries of an area of space in which the body can maintain its position without changing the base of support. (Shumway-Cook & Woollacott, 1995, p. 120)

Static Balance: The ability to maintain one’s center of gravity over the base of support while at rest. (Also referred to as postural stability)
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CHAPTER ONE
INTRODUCTION

Background to Problem

Falls represent one of the most serious health concerns in the elderly population. Approximately one-third of the elderly population in the community fall each year (Cutson, 1994). There are several physical consequences to falling, including fractures. Hip fractures are most serious, with only 50% of those who sustain a hip fracture regaining independence following surgery (Tideiksaar, 1996). There are also non-physical consequences to falling. Fear of falling is common in fallers as well as non-fallers and can lead to self-restriction of activity (Tinetti, Mendes de Leon, Doucette, & Baker, 1994). Simmons and Hansen (1996) outlined the “cyclic effects” that immobility can have on balance control in the elderly, stating that a decrease in movement errors secondary to immobility can lead to postural skill loss. This postural skill loss will further perpetuate unsteady posture and produce an increased fear of falling.

The etiology of falls in the elderly is multifactorial (Tinetti & Speechley, 1989). Factors such as muscle weakness, balance disturbances, decreased levels of physical activity, sensory deficits, and environmental hazards have been linked to falls (Cutson, 1994; Salgado, Lord, Packer, & Ehrlich, 1994; Tinetti, et al., 1994). The rehabilitation specialist faces a challenge when designing a treatment program aimed at decreasing the risk of falls because many factors have to be taken into consideration to get maximum benefit from such a program.
An individual who is fearful of falling is likely to be unwilling to attempt exercise outside of his or her stability limits. This fear will have detrimental effects on postural control and will inhibit motor learning and progression in an exercise program. In order to improve balance, practice must be somewhat difficult, and movement errors must occur. The exerciser will learn from his or her mistakes and balance will, consequently, improve (Schmidt, 1991). An environment which offers relative safety when moving and attempting new activities could be indicated early in treatment to facilitate learning (Simmons & Hansen, 1996). An example of such an environment available to physical therapists is water.

Aquatic exercise has been shown to be of great benefit to the elderly population (Kimble, 1986; McNeal, 1990). The water can provide a relatively safe environment to practice movements, which can help to prevent consequences of immobility in those with a fear of falling (Simmons & Hansen, 1996). Water also provides a variable environment with each movement. Turbulence caused by the patient’s own movements as well as those created by other group members changes the force needed with each trial. Water gives constant proprioceptive feedback, which may be necessary for early learning. Finally, the social aspect and relaxing environment is pleasing to elderly exercisers (McNeal, 1990).

While water exercise can be beneficial, there are some additional benefits which can be derived only from land exercise. The environment in which we are required to perform activities of daily living (ADLs) is land, therefore, land exercise has the advantage of specificity of exercise. The exerciser is also full weight bearing on land,
which is helpful in maintaining or increasing bone density to prevent osteoporotic changes (Cwikel et al., 1994; Marcus et al., 1992).

Bone density begins to decrease at the age of 30. Osteoporosis could result from excessive losses in bone mass, leading to an increased chance of fractures, especially after falls. There are several risk factors for osteoporosis, one of which is lack of weight-bearing exercise (Bellantoni, 1996). Loss of bone mass is more rapid when there is a lack of weight-bearing activity (American College of Sport Medicine, 1995). Weight-bearing exercise has been shown to help maintain and even improve bone density in elderly individuals (Cwikel, Fried, Galinsky, & Ring, 1994; Marcus et al., 1992), therefore weight bearing exercise should be included in treatment prescribed for the elderly population.

Simmons and Hansen (1996) compared water exercise and land exercise and the effects of each in reducing the risk of falls in the elderly. They found water exercise to be superior to land exercise. Water exercise has many benefits, but it can be argued that this type of exercise alone is not the most beneficial for the elderly population. It is important to “recommend a program of exercise to maintain and increase bone density, improve gait and balance, and improve postural reflexes or the response to balance loss” to help reduce the risk of falls in the elderly (Tideiksaar, 1996, p. 46). It seems that a combination of water and land exercise would be best suited to achieve these improvements.

Problem Statement

The elderly are at risk of osteoporosis, falls, and fractures. Immobility can further increase this risk. Exercise can be of benefit in preventing some of these consequences of immobility. Advantages exist for exercise in water and on land, but the optimal exercise
to improve balance and help reduce the risk of falls in the elderly has not been determined.

**Purpose**

The purpose of this study is to compare the effects of a combination program of water and land exercise with a program of water exercise alone on functional reach in the elderly. Functional reach is a reliable and valid measure of balance, and it has been correlated to the risk of falling (Duncan, et al., 1990; Duncan, Studenski, Chandler, & Prescott, 1992).

**Significance of the Problem**

There has been no research comparing water exercise to a combination water/land exercise program aimed at reducing the risk of falls in the elderly. Theoretically, the benefits of both water and land exercise could give the elderly patient a comprehensive program, addressing all of their needs including a risk-free environment in which to practice, weight-bearing activities, and exercise in the environment specific to their daily activities. The results can assist the rehabilitation specialist in designing the optimal program for the elderly patient who may or may not be at risk of falling.

**Hypothesis**

Our hypothesis is that a combination program of water and land exercise will produce greater improvements in functional reach than a program of water exercise alone.
CHAPTER TWO
LITERATURE REVIEW

Introduction

The leading cause of death from injury in persons over the age of 65 is falls (Chandler & Duncan, 1993). Falls represent a significant health threat to the elderly population, and health care providers are constantly looking for effective treatment programs to help reduce the risk of falls. The etiology leading to an increased fall risk involves many factors (Chandler & Duncan, 1993; Tinetti et al., 1994), and this makes treatment planning difficult. The following will serve as a review of the literature regarding exercise and fall risk in the elderly, as well as special considerations for this population.

Exercise

Elderly individuals are not immune to the benefits of exercise. It has been shown that “frail elderly men and women, well into their tenth decade of life, retain the capacity to adapt to progressive resistive exercise training with significant and clinically relevant muscle hypertrophy and increases in muscle strength” (Evans, 1995, p.150). With appropriate strength training, elderly individuals demonstrate similar or greater gains in strength than their younger counterparts (Evans, 1995). Aerobic capacity, joint flexibility, and balance have also been found to increase with exercise in the elderly (Evans, 1995; Mills, 1994).

Water Exercise

Water exercise is a popular form of physical activity prescribed for the elderly (McNeal, 1990). “The water can be used for support, assistance, and resistance”
(McNeal, 1990, p. 916). Exercises performed in water are easier for some elderly individuals to perform. The unloading properties of water (Green, Cable, & Elms, 1990) and non-impact environment (Koszuta, 1989) decrease stress on joints. Standing in various depths of water relative to one's height will produce various amounts of unloading. If the water level is at waist level, 50% of the body weight is being supported while water to the chest level unloads 75% of one's body weight (McNeal, 1990).

Newton's Second Law of Motion states that "the acceleration of an object is directly proportional to force applied" (McNeal, 1990, p. 923). As speed of movement in the water increases, the resistive force supplied by the water increases (McNeal, 1990), therefore water provides isokinetic resistance to movement. Water exercise can be useful for people of all fitness levels because speed of movement and resistance can be dictated by exerciser tolerance.

People of all ages find water exercise to be enjoyable and beneficial. While low-impact land exercises geared toward the elderly are more appealing to those who are already fairly active (Heyneman & Premo, 1992), water exercise may attract elderly individuals who are less active and, therefore, in need of an exercise program. Participation in a water exercise program has also been shown to positively affect mood, self-esteem, and motivation in the elderly population (Kimble, 1986). In addition, compliance with water exercise programs has been found to be greater when compared to land exercise programs (Simmons & Hansen, 1996).

Subjective pain ratings may decrease while in the water because of increased mental and social stimulation serving as a distraction from the pain (McNeal, 1990). In addition, less muscle activity is required for stabilization due to the unloading properties
of water, thus exercising heart rate is lower when working in water than in other
environments. Therefore, “a greater level of exercise may be tolerated in the water”
(McNeal, 1990, p. 917), however, no difference in long-term physiologic benefits in
terms of resting heart rate and blood pressure have been found between water and land
exercise (Stevenson, Tacia, Thompson, & Crane, 1988). Kimble (1986) has anecdotally
observed that patients who have plateaued on land may make further functional gains in
ADLs with their rehabilitation programs with water exercise.

There are some disadvantages to water exercise. Some individuals who are
fearful of water may not be willing to participate in a water exercise program. Another
disadvantage to water exercise for some elderly is the decrease in weight-bearing.
Elderly individuals lose bone mass at a rate of up to 8% per year depending on gender
and type of bone lost (Netter, 1987) and may be at risk for developing osteoporosis.
Therefore, exercise that incorporates full weight-bearing may be more advantageous to
the elderly.

Land Exercise

Osteoporosis is defined as “a disease characterized by low bone mass and
microarchitectural deterioration of bone tissue leading to enhanced bone fragility and a
consequent increase in fracture risk” (American College of Sport Medicine (ACSM),
1995, p. i). It has been estimated that “54% of 50-year-old women will sustain
osteoporosis-related fractures during their remaining lifetime” (Bellantoni, 1996, p. 986).

There are several risk factors for developing osteoporosis, one of which is lack of
weight-bearing exercise (Bellantoni, 1996). This risk factor must be taken into account
when designing a treatment program for the elderly. Several authors advocate the use of
weight-bearing exercise to maintain or even improve bone density (ACSM, 1995; Bellantoni, 1996; Cwikel et al., 1995; Lanyon, 1996; & Prior et al., 1996). Lanyon (1996, abstract) states that "load-bearing is an important, if not the most important, functional influence on bone mass and architecture."

The American College of Sport Medicine's (ACSM) position stand on osteoporosis and exercise proposes that:

"Weight-bearing physical activity is essential for the normal development and maintenance of a healthy skeleton... The optimal program for older women would include activities that improve strength, flexibility, and coordination that may indirectly, but effectively, decrease the incidence of osteoporotic fractures by lessening the likelihood of falling" (ACSM, 1995, p. i).

Exercises performed on land provide this essential weight-bearing and also give opportunities to increase strength, flexibility, and coordination. Weight-bearing activity and strength training should be included for people with osteoporosis as well as elderly individuals who show no current signs or symptoms of osteoporosis. These components of exercise can help to prevent future age-related decreases in bone density in addition to improving muscle mass, strength, dynamic balance, and overall physical activity, all of which can decrease the risk of osteoporotic fractures (Evans, 1995).

A disadvantage of land exercise is the risk of injury from falls. Should the exerciser perform activities which are too difficult for his or her skill level, serious injury could result (VanCamp & Boyer, 1989).
Balance/Postural Mobility

Falls

A fall is defined as unintentionally coming to rest on the ground or floor (Province et al., 1995). An estimated one-third of community dwelling elderly persons and approximately one-half of elderly nursing home residents will fall each year (Cutson, 1994). Falls resulting in serious injury, such as fractures, can cause long-term declines in functional independence (Tideiksaar, 1996). Falls account for more than 90% of all hip fractures (Flanagan et al., 1995) and only 50% of those individuals who sustain a hip fracture will regain independence following surgery (Tideiksaar, 1996).

The etiology of falls is complex. Several risk factors have been identified including intrinsic and extrinsic factors (Tinetti & Speechley, 1989). Intrinsic factors that have been found to be common among fallers include musculoskeletal impairments, decreased balance and muscle weakness (Galindo-Ciocon, Ciocon, & Galindo, 1995). Extrinsic factors include environmental risks such as poor lighting, clutter, and sliding throw rugs (Tideiksaar, 1996).

Postural control is defined as "the ability to control the body’s position in space for the purpose of stability and orientation" (Shumway-Cook & Woollacott, 1995, p. 366). Good postural control is essential to everything we do since all tasks require postural stability (Shumway-Cook & Woollacott, 1995). Deficits in postural control and balance have been correlated to increased risk of falls (Wolfson et al., 1996). There are several age-associated changes that affect an elderly person’s ability to maintain proper balance. These changes include decreases in psychomotor performance, muscle strength, joint flexibility, sensation - especially proprioception, physical work performance,
coordination, short-term memory and the ability to process new information (Cutson, 1994; Flanagan, Ragnarsson, Ross, & Wong, 1995; Mills, 1994; Panton, Graves, Pollock, Hagberg, & Chen, 1990). In addition, auditory and visual systems are impaired (Flanagan et al., 1995). Strength decreases approximately 33% between the ages of 25 and 65 years-old (Evans, 1995). Postural sway has also been found to increase with aging (Judge, Lindsey, Underwood, & Winsemius, 1993).

Despite these changes, elderly individuals can remain independent. However, functional reserve in elderly individuals is diminished, which lowers the threshold for observable loss of function. Elderly individuals may have compromised compensatory abilities which are. Therefore, it is important to incorporate preventative education and exercise to increase reserve and reduce the risk of dependency (Guccione, 1993).

Fear of Falling

A serious non-physical consequence of falling that is common among fallers is fear of falling. Maki, Holliday, & Topper (1991) propose that this fear may be more of a problem than injury resulting from falls, and that loss of confidence and reduced activity which result from fear of falling can lead to loss of independence. “Up to 50% of those who have fallen admit to avoiding activities because of fear of falling” (Tideiksaar, 1996, p. 44). Cutson (1994) states that this self-restriction of activities can lead to social isolation. Arfken, Lach, Birge, & Miller (1994) found that subjects in their study who were very fearful of falling, reported decreased satisfaction and quality of life.

Tinetti and Ginter (1988, p. 1190) further define self-restriction of activity as “spiraling immobility,” stating “immobility begets immobility.” Other authors have supported this cyclic theory of immobility and have stressed the importance of breaking
the cycle (Simmons & Hansen, 1996). Simmons and Hansen (1996) proposed that water is a relatively safe environment in which to practice movement, compared to land. They found that exercise in water lead to higher gains in functional reach than exercise on land, and they attribute this to exercisers' ability to move without fear in the water.

Balance and Exercise

Wolfson et al. (1996, p. 498) wrote that "there is no consensus regarding which of the critical elements of motor behavior need to be trained to result in improved balance." It is generally accepted that physical activity is essential to maintain and/or increase balance in the elderly population. Flanagan et al. (1995, p. 86) suggest that an exercise program "should include muscle strengthening and endurance exercises to reverse the effects of physical deconditioning and exercises to improve balance, coordination, and body posture." Province et al. (1995, p. 1342) submit that since falls occur "at least in part because of physical deficits in strength, reaction time, and flexibility, then it is plausible to believe that exercise targeted to improve these deficits might result in fewer fall and/or injury events."

Wolfson, et al. (1996) compared balance and strength training and found that balance training should be specific to the desired outcome. One hundred ten subjects with a mean age of 80 were recruited. Subjects were divided into groups and participated in balance training, strength training, or balance and strength training. Those subjects in the balance training group demonstrated improved balance without increases in strength, while those in the strength training group did not show increases in balance. Therefore, if increases in balance are desired, balance activities must be included in treatment. Strength training alone is not sufficient to improve balance.
A multicentered study called Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) was jointly sponsored by the National Institute on Aging and the National Institute for Nursing Research. Eight study sites across the country performed research to determine the efficacy of a variety of treatment techniques to address balance deficits. Province, et al. (1995) performed a pre-planned meta-analysis of the 8 sites involved in this study and analyzed the effects of the various treatments used. They found that the interventions which included balance training as part of the treatment protocol significantly reduced the frequency of falls.

Simmons and Hansen (1996) propose that, because of the fear of falling that many fallers and non-fallers express, postural skills should be practiced in a safe environment. An example of such an environment is water. In this medium, individuals are able to practice movements more confidently and will consequently make more movement errors critical for motor learning (Simmons & Hansen, 1996). For elderly individuals with a fear of falling, water exercise may be very beneficial.

Some motor learning experts don’t agree with this rationale, however. Winstein (1991, p. 72) wrote:

“One potentially important principle to keep in mind is that practice of any variation of a task that considerably changes the nature of that task could be detrimental to transfer and learning... Practice of some less difficult variations of the to-be-learned task, although intuitively appealing, may facilitate control strategies that are not only inappropriate for performance of the task, but also interfere with that performance.”

Elderly individuals who practice postural skills exclusively in the water are not only practicing an easier variation of the task, but could be using control strategies in the water that will not help them on land. Jarus (1994, p. 815) suggested that “the focus of treatment should be the types of activities encountered in daily life.”
Simmons and Hansen (1996) studied 52 well-elderly volunteers aged 74-90 and compared the effectiveness of water and land exercise on postural mobility. Subjects were divided into four groups: water exercisers, land exercisers, water sitters, and land sitters. All groups met for 45 minutes twice a week for five weeks. Subjects in the water exercise and land exercise groups performed the same exercise routines, with the only difference being the medium in which they exercised. The subjects in the water sitter and land sitter groups simply sat and socialized in their respective environment. Functional reach measurements were taken after each week. Simmons and Hansen found that those who exercised in the water demonstrated greater improvements in postural mobility over the 5-week period, as measured by FR, than those who exercised on land, and they found no improvements in FR in water and land sitters.

For those with a fear of falling and significant deficits in postural mobility, water can be an excellent medium to increase confidence (Kimble, 1986). “Performance abilities may depend substantially on self-confidence about one’s physical capabilities” (Schultz, 1995, p. 61), therefore exercise to increase confidence will increase performance. However, exercising exclusively in water may not be appropriate to affect postural mobility skills on land. Individuals also need to practice movements on land and learn control strategies that will assist them in improving function in this environment.

Simmons and Hansen (1996) found that elderly individuals in their study demonstrated greater compliance with water exercise than with land exercise, as noted by analysis of absences. In the last three weeks of their study, land exercisers totaled eight absences while water exercisers only totaled three. Motivation, self-esteem, and confidence also subjectively increase with water exercise (Kimble, 1986). Therefore,
inclusion of a water exercise component to an exercise program could serve an additional purpose as motivation to comply with the program.

**Balance Assessment**

A large percentage of research regarding the elderly has been focused on developing an objective and quantitative measure of balance (Thapa, Gideon, Fought, Kormicki, & Ray, 1994). “A number of clinical and laboratory measures of balance have been developed and utilized, yet few of them have demonstrated clinimetric characteristics of reliability, validity, and sensitivity to change” (Duncan et al., 1992, p. M93). “There is no consensus regarding... what measures of balance validly reflect its complexity and multidimensionality” (Wolfson et al., 1996, p 498 ). Advantages and limitations of balance assessment techniques must be analyzed in order to select an appropriate tool for this study.

Many sophisticated techniques for measuring balance have been developed. Some of these techniques assess static balance, while others assess dynamic balance. Biomechanical platforms measure static standing balance. There are also computerized dynamic posturography devices that assess balance responses to postural pertubations (Means, Rodell, & O’Sullivan, 1996). Some of the dynamic balance assessment tools include center of pressure excursion (COPE) and the platform perturbation test (Duncan, et al., 1990). Biomechanic platforms and posturography are very technical and provide useful objective information (Means et al., 1996). These tests, however, require specialized equipment which limits their clinical accessibility (Duncan et al., 1990). They are also relatively expensive to purchase and maintain, and require training to operate (Means et al., 1996). In addition, biomechanical platforms and dynamic
posturography measure balance in artificial situations and may not reflect the same performance that occurs during normal activity (Tinetti & Ginter, 1988).

Some examples of static measures of balance include the Romberg test and the one-legged stance test. The static measures of balance may not reflect the postural ability of someone during normal daily activities, which often include movement. Duncan et al. (1990, p. M192) reported that “…in general, dynamic balance measures, which assess the ability to maintain equilibrium in response to either self-motivated or external perturbation, are superior to static tasks.”

Some tests are difficult for even the healthy elderly to perform, such as the one-legged stance and tandem walking (Duncan et al., 1990). Other tools used to assess balance, such as the Berg balance test and the Tinetti performance-oriented mobility assessment, contain components that are difficult to perform. The Berg Balance Test includes one-legged standing and tandem standing (Berg, 1993). These two components, along with reaching forward with an outstretched arm, are the most difficult of the subtests for subjects to perform (Thorbahn & Newton, 1996). Components of the Tinetti performance-oriented mobility assessment, such as sternal nudge, tandem stand, and standing on one leg, have also been found to be stressful to subjects (Thapa, Gideon, Brockman, Fought, & Ray, 1996). The Tinetti performance-oriented mobility assessment can, however, be altered to exclude the challenging maneuvers.

Other methods that are relatively inexpensive and easy to administer tend to yield subjective data. Among these tests, Means et al. (1996) identifies the postural stress test, timed balance test, get up and go test, and Tinetti’s performance-oriented mobility assessment. In addition, the get up and go test and the Tinetti performance-oriented
mobility assessment have not demonstrated significant test-retest reliability (Duncan, et al., 1992). Also, except for Tinetti's performance-oriented assessment of mobility, few of these methods have been studied in the community-dwelling elderly population (Means et al., 1996).

A test's sensitivity to change is clinically important (Weiner, Bongiomi, Studensky, Duncan, & Kochersberger, 1993). Very few measures of balance are sensitive to change. Many tests, such as the postural stress test, use ordinal scoring, which decreases the sensitivity of the assessment when compared with a continuous measurement system (Duncan et al., 1990). This type of assessment makes it difficult to finely discriminate levels of postural impairment. Duncan et al. (1992) identified six laboratory measures of balance and seven clinical measures of balance which had not demonstrated significant sensitivity to change. Some of these included tests, mentioned previously, such as postural sway, center of pressure excursion, platform perturbation, Romberg test, one-legged stance, postural stress test, Tinetti performance-oriented mobility assessment, and the get up and go test.

Some tools for balance assessment are affected by factors other than balance. Walking speed, which is incorporated in many tests, is strongly influenced by endurance (Weiner et al., 1993). This may indicate, therefore, that tests, such as the get up and go and the timed ten foot walk, are not purely measurements of balance. Tests that examine performance on mobility skills, including Tinetti performance-oriented mobility assessment, Berg balance test, obstacle courses and timed chair stands, are measuring balance, along with strength and flexibility. These tests, therefore, are assessing overall physical function versus strictly balance (Weiner et al., 1993).
Weiner et al. (1993) studied male inpatient veterans aged 40-105 undergoing rehabilitation for various conditions and compared functional reach to other physical performance measures such as the Mobility Skills Protocol, Ten-Foot Walking Speed, and the Functional Independence Measure. The results of this comparison show only a modest correlation between functional reach and these physical performance measures. Although walking time and physical performance measures both rely on postural control mechanisms, Weiner et al. (1993, pp. 798-9) propose that “functional reach seems to be less heavily influenced by strength and endurance, and represents a more ‘pure’ balance measure.”

Functional reach (FR) has been used in many studies. The test is easy to administer, clinically accessible, and is suitable for frail elderly subjects (Thapa et al., 1994). FR uses a continuous, objective scoring system, a yardstick, and is sensitive to change (Duncan et al., 1992). FR is also inexpensive and is relatively simple for subjects to perform (Duncan et al., 1990).

Another advantage, making FR appealing to researchers, is that FR has both construct and criterion validity. Duncan et al. (1992) studied 217 elderly community-dwelling volunteers aged 70-104 who underwent functional reach testing and reviewed each subject’s fall history for the next six months. Duncan et al. found that FR score was highly correlated to the number of falls during this period, with a lower FR score predicting an increased risk of falling.

FR has been proven to be a reliable and valid measurement of balance (Duncan et al., 1990; Duncan et al., 1992). Duncan et al. (1990) compared FR measurements of 17 volunteers taken independently by two individuals who were unaware of the results of the
other's measurements. In addition, 14 volunteers returned one week later for retesting by the same individuals. Duncan found FR to have both interrater and test-retest reliability. The interobserver correlation coefficient was .98 and the test-retest correlation coefficient was .92 (Duncan et al., 1990).

Despite the advantages of FR, there have been some limitations noted regarding the test. Thapa et al. (1994) has reported that FR may be difficult for the elderly to perform. Duncan et al. (1992) found 11% of their sample were unable to reach compared to Thapa et al. (1994) who reported this finding for 19% of their sample. The discrepancy may be the difference in the subjects used (Thapa et al., 1994). Duncan's study used community dwelling individuals, whereas, Thapa's study used individuals living in nursing homes. Nevertheless, depending on the population, FR may be challenging for some subjects. FR may also have limited use in patients with severe dementia, extreme spinal deformities, severely restricted upper extremity function, or frail individuals unable to stand unsupported (Duncan et al., 1990). FR is limited in that it only addresses anterior-posterior stability.

FR increases with height because taller individuals usually have a longer reach (Duncan et al., 1990). However, when FR is normalized to body height (FR divided by body height), there are no significant anthropometric differences (Hageman, Leibowitz, & Blanke, 1995).

Summary and Implications for the Study

There has been a study which compared water to land exercise (Simmons & Hansen, 1996), however there have been no studies to compare a combination program of water and land exercise with a program of land exercise alone. We believe a combination
program of water and land exercise could produce greater gains in functional reach than a program of water exercise alone. Exercisers would have the opportunity to practice in a relatively safe environment (water) as Simmons and Hansen (1996) advocate, gaining confidence and increasing mobility. On alternate days, participants would engage in land exercises to apply skills learned in the water and make them useful in "their" environment. The land environment presents a greater challenge than water in that movements are unassisted.

Motor learning experts support variability of practice to improve retention and transfer of new skills (Schmidt, 1991; Shumway-Cook & Woollacott, 1995; Winstein, 1991). Water provides a variable environment during practice sessions. Turbulence produced by the exerciser as well as other exercisers make each trial somewhat different from the others (McNeal, 1990). By including land exercise, there is also a variability of practice environments, which will further improve learning, retention, and transfer (Schmidt, 1991; Shumway-Cook & Woollacott, 1995).
CHAPTER THREE
METHODS

Subjects

Upon approval from the Grand Valley State University Human Subjects Review Committee (Appendix A), twenty independent volunteers were recruited from an independent living community for the elderly in Western Michigan. Fliers regarding an informational meeting were distributed to all residents in the elderly community. An informational meeting was held to describe the study to interested volunteers and to eliminate ineligible subjects. All eligible volunteers were included in the study. In order to be considered for the study, the subjects must have been at least 65 years old, an independent ambulator with or without an assistive device, and independent with ADLs. Physician approval for aerobic exercise in water and on land was obtained for each subject prior to participation in this study. Subjects were excluded from the study if they lacked at least 100 degrees of shoulder flexion which would prevent accurate functional reach measurements. No individuals participated in the study if they were currently enrolled in another study of aging. Subjects were also screened and eliminated if they had participated in vigorous sports within the last month or were currently involved in an exercise program. One subject was included that participated in an arm chair exercise program three times a week during the four week study.

After signing an informed consent form (Appendix B), the twenty eligible subjects were assigned to one of two experimental groups, A or B. The researchers attempted to randomly assign the subjects into groups A or B, however due to difficulty recruiting subjects, this was not possible. Originally, this study was designed to separate
the water exercise group from the combination exercise group by holding exercise sessions at different times of the day. Subjects were given a choice of time without being aware of which exercise would be held at which time. In this way, subjects were placed into two groups: water exercise (morning session) and water/land exercise (afternoon session). Due to scheduling conflicts, all exercise sessions were held at the same time (morning), however subjects remained in their original exercise group.

Study Site

All intervention and data collection took place in an independent living community for the elderly in Western Michigan. Verbal approval was received by the site administrator granting permission to use this facility’s pool and recreation room to conduct this study. The depth of the pool was between each subject’s waist and chest. A lifeguard was present during all water exercise. The area where the land component of the water/land intervention took place was a carpeted room with chairs arranged in a circle. The room was kept at a temperature of 65-70 degrees Fahrenheit, which is within the range of 40-75 degrees Fahrenheit that is generally recognized as ideal for exercise (Brannon, Foley, Starr, & Black, 1993).

Study Design

The study was a quasi-experimental design consisting of two independent variables (water exercise and water/land exercise) and one dependent variable (balance, as measured by functional reach). The study was a between-subject design with 20 subjects assigned to one of two treatment groups. Twelve subjects assigned to group A participated in a water exercise program. Eight subjects assigned to group B participated in a combination program consisting of alternating days of water and land exercise.
Baseline functional reach measurements were taken in all 20 subjects prior to the start of any intervention. Functional reach measurements were taken weekly thereafter in the following manner: measurements for weeks 1, 2, and 3 were taken at the beginning of weeks 2, 3, and 4 respectively prior to exercise; measurements for week 4 were taken at the cessation of the four-week exercise program approximately one hour after subjects exercised. By taking weekly measurements, trends in functional reach changes and plateaus in improvements could be identified over the 5 week period.

**Equipment and Instruments**

Functional reach (Duncan et al, 1990) was used to measure experiment outcomes. Materials necessary to measure functional reach included: velcro, yardstick, and a trained individual to administer and record the results. Chairs arranged in a circle were used during land exercise sessions. Subjects were instructed to use the back of the chairs for support only when necessary.

**Procedure**

All eligible subjects were asked to sign a consent form (Appendix C) to permit the researchers to make physician contact. A form letter (Appendix D) was delivered to each subject’s physician to seek approval for participation in this study. After receiving physician approval and informed consent from all eligible subjects, participants were assigned to one of two groups (A or B).

Functional reach (FR) as described by Duncan et al (1990) was measured in all subjects by one researcher. Functional reach was measured according to protocol with specific directions (Appendix E). Each subject performed five trials with their dominant upper extremity (all subjects were right-hand dominant). The last three trials were
recorded on a formal data sheet (Appendix F). The average of the last three trials was calculated and used for data analysis.

**Intervention**

Following initial FR measurements, all subjects participated in one of two groups. Twelve subjects in group A participated in a water exercise program. Eight subjects in group B participated in a combination exercise program, exercising in water and land on alternate days. Groups A and B exercised simultaneously, three times a week at the same time of day. Both groups exercised together in water 6 out of 12 sessions. During the remaining 6 sessions, the groups were separated, with group A exercising in water and group B exercising on land. The exercises performed on land were identical to the exercises performed in the water. The water and combination programs were of equal duration (approximately 25 minutes) and frequency (3 times per week for 4 weeks). The exercise routine for both groups was similar to a previous study comparing a water exercise program versus land exercise program (Simmons & Hansen, 1996) and consisted of:

- walking forward x 2 minutes
- walking backward x 2 minutes
- marching forward x 2 minutes
- marching backward x 2 minutes
- walking forward with knees straight x 2 minutes
- toe raises x 10 repetitions
- heel raises x 10 repetitions
- standing partial squats x 10 repetitions
- kicking in a diagonal x 2 minutes
- kicking in a sagittal plane x 2 minutes
- twisting x 2 minutes
- side stepping without crossing legs, right x 1 minute, left x 1 minute
- side stepping while crossing legs, right x 1 minute, left x 1 minute
- heel to toe walking forward x 2 minutes
- marching in place x 2 minutes
VanCamp & Boyer (1989) suggest using the Rating of Perceived Exertion Scale using the revised 10-grade Borg Scale (Borg, 1982) to monitor intensity of the exercise. Subjects were instructed to maintain their intensity between “fairly light” and “somewhat hard” (Appendix F). These descriptive terms correlate with intensity levels 4-6 on the Borg Scale (VanCamp & Boyer, 1989). Subjects were asked to complete the routine with the minimal amount of assistance required to complete the activities. Assistance was provided only when requested by the participant. If necessary, subjects exercising on land were able to hold onto the back of a chair in order to maintain their balance, and subjects in the water were able to hold onto the side of the pool. The 60 minute program was under the supervision of the experimenters (CK and MS).

**Reliability**

Only one of the researchers (MS) was involved in taking functional reach measurements. This individual participated in a practice trial taking functional reach measurements of 18 subjects on two consecutive days. Eleven of these subjects were elderly individuals living independently, aged 65 – 74. The remaining seven subjects ranged in age from 21 – 50 and were also living independently. The FR measurements from day one to day two were analyzed to ensure intrarater reliability, and a test-retest correlation coefficient of 0.97 was attained.

**Data Analysis**

Subjects who missed more than four exercise sessions were excluded from analysis. A t-test for independent samples and a Mann-Whitney U-Wilcoxon Rank Sum W Test were used to determine statistical differences in overall improvement in
functional reach from week 0 to week 4 between groups. The differences in functional reach from week to week within each group across the four weeks were analyzed using a series of t-tests for paired samples. Due to the small number of subjects in this study, variables such as age and gender were not analyzed between groups.
CHAPTER FOUR
RESULTS

Subjects

A total of 12 subjects (7 water exercisers, 5 water/land exercisers) completed the four-week exercise program and met the inclusion criteria regarding attendance. The remaining eight subjects, of the initial twenty that started the exercise program, were not included in data analyses secondary to poor attendance (more than 4 of 12 exercise sessions missed). Descriptions of attendance are further described in Table 1 and Table 2. Three subjects from the water exercise group and one subject from the water/land exercise group were absent secondary to illness or hospitalization. Three subjects (1 water, 2 water/land) did not give any reason for their absenteeism. One additional subject from the water exercise group was excluded from data analysis due to her inability to complete the full exercise session. The subject consistently left the pool area at least ten minutes early each session.

The mean age of all subjects included in the study was 83.92 years. Further description of age and sex are presented in Table 3. Analysis of age or sex between groups was not performed due to the small sample size. Two subjects from the water group and one subject from the water/land group were involved in an armchair exercise class 2-3 times per week prior to involvement in this study. The subject from the water/land group was the only subject to continue with the armchair exercise class during this four-week study. All other subjects denied participation in any type of formal exercise routine or program prior to or during the study.
### Table 1

**Absences During the Four-week Experimental Period for Each Group**

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Water/Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Week 2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Week 3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Week 4</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 2

**Absences During the Four-week Experimental Period for the 5 Subjects in the Water / Land Group**

<table>
<thead>
<tr>
<th>SUBJECT NUMBER</th>
<th># OF ABSENCES THAT OCCURRED ON WATER-EXERCISING DAYS</th>
<th># OF ABSENCES THAT OCCURRED ON LAND-EXERCISING DAYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 3

Description of Subjects Included in the Study

<table>
<thead>
<tr>
<th>GROUP</th>
<th>SEX</th>
<th>MEAN AGE (years)</th>
<th>AGE RANGE (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water exercisers</td>
<td>5 Females 2 Males</td>
<td>82.80</td>
<td>74 – 88</td>
</tr>
<tr>
<td>Water / Land exercisers</td>
<td>4 Females 1 Male</td>
<td>84.71</td>
<td>80 – 93</td>
</tr>
</tbody>
</table>

Results

In order to analyze results, a week 4 measurement was needed for one of the subjects (water/land group) who was ill on the date of the final measurement. Due to the inability to obtain a final measurement for this subject within the following week, the week 4 functional reach measurement was obtained using linear interpolation. This measurement was used in place of an actual week 4 measurement when the data was analyzed.

Mean functional reach values for each group were calculated for weeks 0-4 (Table 4 & Figure 1). T-tests for paired samples were used to determine where differences existed across the weeks within each group (Table 5). All subjects in both the water and water/land exercise groups demonstrated significant improvement in functional reach from the initial baseline measurement (week 0) to the final measurement (week 4) (p<.05). Significant improvements in functional reach were also demonstrated between
weeks 1 and 2, weeks 2 and 3, and weeks 3 and 4 for the water/land exercise group (p<.05). There was not a significant change found between weeks 0 and 1 (p=.076) for the water/land group. The water exercise group showed significant improvements each week for four consecutive weeks (p<.05).

A t-test for independent samples was used to determine if a significant difference existed in overall improvement in functional reach from week 0 to week 4 between the two groups. No significant difference was demonstrated using this test (p=.41). A Mann-Whitney U-Wilcoxon Rank Sum W Test also was used to detect significant difference between groups from week 0 to week 4. Again, no significant difference was found (p=.50).

In addition to the objective data regarding improvement in functional reach across the weeks, subjects also self-reported improvements in activities of daily living. Some subjects reported improvement in walking balance during the second half of the study. Others reported an ability to perform the exercises with greater ease. The researchers also observed a decrease in the subjects' dependence on upper extremity support over the four weeks when performing the exercises.
Table 4.
Weekly Functional Reach Measurements (in cm)

<table>
<thead>
<tr>
<th>Week</th>
<th>Water</th>
<th>Water/Land</th>
<th>Water</th>
<th>Water/Land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Baseline</td>
<td>16.45</td>
<td>4.45</td>
<td>22.18</td>
<td>10.45</td>
</tr>
<tr>
<td>Week 1</td>
<td>17.24</td>
<td>4.44</td>
<td>22.72</td>
<td>9.83</td>
</tr>
<tr>
<td>Week 2</td>
<td>18.44</td>
<td>4.94</td>
<td>24.14</td>
<td>9.56</td>
</tr>
<tr>
<td>Week 3</td>
<td>19.91</td>
<td>5.34</td>
<td>26.60</td>
<td>10.21</td>
</tr>
<tr>
<td>Week 4</td>
<td>22.63</td>
<td>5.06</td>
<td>28.70</td>
<td>10.20</td>
</tr>
</tbody>
</table>

Table 5. t-Values/p-Values for Improvements in Functional Reach between Weeks

<table>
<thead>
<tr>
<th>Week</th>
<th>Water</th>
<th>p-value</th>
<th>Water/Land</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 0-1</td>
<td>5.81</td>
<td>.001</td>
<td>1.77</td>
<td>.076</td>
</tr>
<tr>
<td>Week 1-2</td>
<td>2.08</td>
<td>.042</td>
<td>2.73</td>
<td>.027</td>
</tr>
<tr>
<td>Week 2-3</td>
<td>3.02</td>
<td>.012</td>
<td>4.00</td>
<td>.008</td>
</tr>
<tr>
<td>Week 3-4</td>
<td>4.36</td>
<td>.003</td>
<td>2.24</td>
<td>.044</td>
</tr>
<tr>
<td>Week 0-4</td>
<td>7.45</td>
<td>.000</td>
<td>4.57</td>
<td>.005</td>
</tr>
</tbody>
</table>
Figure 1. Mean Functional Reach During the 4 Week Experimental Period (in cm)
CHAPTER FIVE
DISCUSSION

This study was designed to compare the effects of a water exercise program to a combination program of land and water exercise on functional reach (FR) measurements in the elderly. Two groups of subjects participated in four weeks of exercise either in water or a combination of water and land environments, and FR measurements were taken at baseline and weekly throughout the study period. The results of the data analyses of the FR measurements show that both groups significantly improved their ability to reach after the four week exercise period. While the average FR of the combination exercise group improved slightly more than the water exercise group, this was not statistically significant (p=.41). Therefore, there appeared to be no difference in the effects of a water exercise program and the effects of a combination water/land exercise program on FR measurements in these subjects. However, this finding may be due to the small sample size in this study. With such a small sample size, it is less likely that differences between groups will be recognized (Portney & Watkins, 1993). In a larger sample group, the difference between groups may have been significant.

The researcher who measured FR (MS) attained high intrarater reliability (0.97) in a pilot study of 18 subjects who were measured on two consecutive days. This reliability lends credibility to the measurements obtained in this study. Therefore, it can be said that weekly measurements taken in this study are accurate.

When data of both groups were analyzed week to week, it was noted that both groups demonstrated significant improvements in FR after each week of
exercise, with one exception. While the mean FR of the combination group improved from baseline to week one, this improvement was not statistically significant ($p<.076$).

Since FR has been proven to be a reliable and valid measurement of balance in the community-dwelling elderly (Duncan et al., 1990; Duncan et al., 1992), it can be said that both exercise programs used in this study significantly enhanced these subjects' balance.

The exercises chosen for this study had a significant effect on FR measurements in all subjects. The researchers found that they are easy to explain and most subjects did not have difficulty performing these tasks. In addition, these exercises can be used clinically in any environment. Future research in the area of balance activities for the elderly can include these standing tasks to determine if the exercises will improve balance in the general population.

Simmons and Hansen (1996) found water exercise to be superior to land exercise to improve FR in the elderly, stating the water provides a relatively risk-free environment in which to practice movement. Their results are in contrast, however, to various authors who propose that exercises for the elderly population should contain a weight-bearing component (ACSM, 1995; Bellantoni, 1995; Evans, 1995). The results of this study seem to support the use of a combination program of exercise in water and on land to retrain balance in the elderly population. Such a program gives exercisers the opportunity to practice movement in a risk-free environment as well as in the environment in which they are required to function. In this way, exercisers can make movement errors in the water and improve postural mobility and then use these improvements while they practice on land, which may further improve postural mobility.
Limitations

The most limiting factor in this study was its small sample size. This small sample size is presumably not a good representation of the entire population. In addition, significant differences between groups may not be detected due to the small sample size (Portney & Watkins, 1993). Therefore, it is difficult to make conclusions and apply these conclusions to the population as a whole based on the results of this study. Further study is needed with a much larger sample size so that conclusions regarding the elderly population in general can be made.

This study was of a relatively short duration. Upon completion of the four week study, each subject demonstrated continued improvements in FR. It is unknown whether one type of exercise leads to greater long-term gains in FR while plateaus are reached sooner using the other form of exercise. Subjects in this study may have only reached the acquisition stage of learning (Shumway-Cook & Woollacott, 1995), and therefore were still selecting movement strategies. This would explain similar improvements in FR seen across both groups. A longer duration study is warranted to determine the true effects of water and combination exercise programs on FR in the elderly. In addition, studies using a variety of functional outcomes as measurements of improvement are needed. While the subjects subjectively reported improvements in function, no formal measures of function were used in this study.

Subjects in this study were chosen by convenience (on a volunteer basis) and were not truly randomized into groups. In addition, all subjects were residents of an independent living community in Western Michigan, and were therefore not representative of the population as a whole in terms of socioeconomic status. Subjects
were not given a choice as to which exercise program they would participate in, but were
given a choice between exercise time. This lack of true randomization introduces a large
amount of variability into this study. It may be possible that a difference in functional
ability existed between those who preferred morning exercise to afternoon exercise.
Some subjects subjectively stated that they chose morning exercise because they would
not have to perform ADLs such as showering and dressing more than once per day. A
future study should recruit subjects across socioeconomic backgrounds, and true
randomization of subjects would help to eliminate bias.

This study did not attempt to match the exercise groups with regard to age, initial
FR, sex, or previous medical history. Lack of similarity from group to group regarding
these areas could have lead to differences in balance between the three groups
independent of the exercise program they participated in. The subjects in the
combination group demonstrated higher initial FR measurements than the subjects in the
water group. It is unknown as to whether this difference is due to functional ability or
differences in height between the two groups as FR was not normalized for height in this
study. Subjects with higher initial FR measurements because of increased functional
ability may have had limited room for improvement and therefore experienced smaller
overall gains. Since these differences in improvement may have impacted statistical
significance, attempts should be made to control these variables in a larger study.

There was no control group of subjects in this study who simply underwent
weekly FR measurements without participating in an exercise program. Improvements in
FR could occur secondary to practice of the measurement task independent of exercise.
While the improvements seen in this study appear to be too great to be caused by practice
of the task alone, a control group could have helped to distinguish how much of the improvements in FR were due to practice. It is recommended that future studies look at the effects of practice on improvements in FR by including a control group to monitor gains in FR due to exercise versus practice alone.

There was no attempt to progress the land exercise portion of this study, which may have also affected the results. Water exercisers theoretically experienced some progression of exercise intensity due to increased resistance of the water with faster movement. Land exercisers, however, did not use weights or other equipment to increase the intensity of exercise. This lack of progression may have lead to a plateau of improvements in the land exercise group.

The researcher who assessed the FR of all subjects (MS) was not blinded to subject group assignment. It is recognized that it is ideal to have measurements read by one who is blinded to group assignment in order to reduce the possibility of experimental bias. A second researcher (CK) observed FR measurements in order to reduce the possibility of bias, however there is still some potential for bias in this research design. Future studies should consider measurements taken by a person who is blinded to group assignment in order to reduce the chance of bias.

Three of the subjects reported that they participated in an armchair exercise class prior to participation in the study, and one of these subjects stated she continued to participate in the armchair exercise class throughout the duration of the study. The armchair exercise program involved no standing tasks, and these subjects demonstrated similar improvements in FR compared to the other subjects, therefore these subjects were not excluded from the study. The additional activity these subjects experienced,
however, may have increased their exercise tolerance and affected their performance with FR.

Due to scheduling conflicts, exercise classes were held for both groups at the same time. Therefore, on days in which the combination group exercised on land, one researcher instructed the land group while the other researcher instructed the water group. Attempts were made to objectify the exercise program and decrease variability in instruction styles of the researchers in order to maintain consistency in program instruction. In addition, the researchers alternated instructing each group to decrease the influence of instruction style on performance. It is unknown, however, the extent to which instructor variability affected exercise performance. Feedback and exercise instruction may have varied somewhat, which could have led to enhanced or decreased performance. In future studies, videotaped instruction may eliminate some variability in exercise instruction.

**Conclusions**

In conclusion, both the water and combination exercise programs used in this study yielded significant improvements in FR measurements after four weeks of exercise. Because of the benefits of both water and land exercise, a combination program may offer a more complete exercise program than a water program alone. Alternating exercise in water and on land provides an adequate balance of practice in a risk-free environment and practice on land, the environment in which they are required to function. The findings of this study support the use of weight-bearing exercise in combination with exercise in a risk-free environment (i.e., water) for elderly individuals in need of balance retraining,
however, further studies are warranted to generalize these findings to the elderly population as a whole.
Bibliography


July 9, 1997

Caroline Kuether, Michelle Smith
6200 Warner St.
Allendale, MI 49401

Dear Caroline and Michelle:

The Human Research Review Committee of Grand Valley State University is charged to examine proposals with respect to protection of human subjects. The Committee has considered your proposal, *"A Comparison of the Effects of an Aquatic Therapy Program Versus a Combined Aquatic/Land Program on Functional Reach in the Elderly"*, and is satisfied that you have complied with the intent of the regulations published in the *Federal Register* 46 (16): 8386-8392, January 26, 1981.

Sincerely,

[Redacted]
Paul Huizenga, Chair
Human Research Review Committee
Appendix B

CONSENT FORM

I understand that this is a study performed by two students in the graduate program of physical therapy at Grand Valley State University to compare two exercise programs and the effects each has on balance. I understand that the knowledge gained is expected to help physical therapists design a treatment program to improve balance in appropriate individuals.

I also understand that:

1. participation in this study will involve performing a series of functional reach measurements every Monday for four weeks. Participation in this study may also consist of a 45 minute water exercise program or a 45 minute water and land exercise program.

2. I have been selected for participation because I am at least 65 years old and able to ambulate independently with or without an assistive device.

3. it is not anticipated that this study will lead to physical or emotional risk to myself, however, I may experience mild muscle soreness following the first few days of exercise. Participation in this study may improve my balance and overall fitness.

4. the information I provide will be kept strictly confidential and the data will be coded so that identification of individual participants will not be possible.

5. a summary of the results will be made available to me upon my request.

6. I am one of 20 subjects participating in this study.

I acknowledge that:

"I have been given an opportunity to ask questions regarding this research study, and that these questions have been answered to my satisfaction."

"In giving my consent, I understand that my participation in this study is voluntary and I may withdraw at any time by notifying Caroline Kuether or Michelle Smith."

45
"I hereby authorize the investigators to release the information obtained in this study to scientific literature. I understand that I will not be identified by name."

"I have been given Caroline Kuether and Michelle Smith's phone numbers so that I may contact either of them at any time if I have any questions regarding this study. I have been given the phone number of Karen Ozga, M.M.Sc., P.T., who is the advisor for this study. I have also been given the phone number of Professor Paul Huizenga, Chair of the Human Research Committee at Grand Valley State University so that I may contact him if I have any questions regarding my rights as a participant in this study (see attached)."

"I acknowledge that I have read and understand the above information, and that I agree to participate in this study."

__________________________  ________________________________
Witness                                           (Participant Signature)

__________________________  ________________________________
Date                                           (Date)

_____ I am interested in receiving a summary of the study results.
Phone Numbers  
(to be given to individual participants)

Researchers:  
Caroline Kuether: 895-4438  
Michelle Smith: 892-6901

Advisor:  

Chair of the Human Research Committee:  
Professor Paul Huizenga: 895-2472
Appendix C

Consent to contact physician

I acknowledge that participation in this study requires approval from my physician. I have been given a copy of the form that will be sent to my physician, and I give my consent to Caroline Kuether and Michelle Smith to contact my physician via mail to obtain approval for my participation in this study. I have been given the phone number of Karen Ozga, M.M.Sc., P.T., advisor of this study. I understand that I may contact her with any questions I may have regarding consent to contact my physician.

I understand that my physician will not disclose any of my medical records or other confidential information to Ms. Kuether or Ms. Smith, but will only grant or deny permission to participate in this study.

_________________________________________  _____________________________
Participant Signature                      Date

_________________________________________  _____________________________
Witness Signature                         Date

Appendix D

January 28, 1998

Dr. ____________________________.

We are two students in the master's program of physical therapy at Grand Valley State University. We are in the process of completing a research study to fulfill the requirements needed to earn our degree. This study will compare the effects of water and land exercise on balance in the elderly, as measured by functional reach. Subjects who volunteer for this study will participate in an exercise program for four weeks, consisting of either water exercise or a combination of land and water exercise. Each subject will be given instruction on how to monitor exercise intensity using the modified Borg scale, and will be taught to exercise at a level 2-4 on this 10-point scale. A certified lifeguard will be present during all pool activities. This research project has been approved by the Human Subject Review Board at Grand Valley State University and by our advisor in the physical therapy department, Karen Ozga, M.M.Sc., P.T.

________________________ has volunteered to be included in our study. Your patient's participation in the study may include an aerobic program of moderate intensity in water or a combination of water and land exercise, lasting approximately 45 minutes, 3x/week for 4 weeks.

It would be greatly appreciated if you could please check one of the following statements.

_____ Patient has physician approval to participate in the study.

_____ Patient needs to be re-evaluated before physician approval can be given.

________________________

Physician signature

Thank you for your time and cooperation. We will plan to return to your office on Thursday, January 29 to collect this form. Please do not hesitate to call either of us for further information at the numbers given below.

Sincerely,

Caroline Kuether, SPT (895-4438)  Michelle Smith, SPT (892-6901)

Karen Ozga, M.M.Sc., P.T. (895-2679)
Appendix E

Functional Reach Instructions

A leveled yardstick will be secured to the wall horizontally at the height of the subject’s acromion on the dominant side. The subject will be asked to stand with his or her arm flexed forward 90 degrees at the shoulder (statement 1). The position at the end of the third metacarpal is recorded as position 1.

The subject will then be asked to reach forward as far as he or she can without losing balance (statement 2). The position of the end of the third metacarpal at the end of the subject’s reach is recorded as position 2.

If a subject touches the wall or moves his or her feet during the reach, the measurement will be considered invalid and must be repeated. Each subject will be given 5 trials with functional reach defined as the mean difference between position 1 and position 2 over the last 3 trials.

Statements to subject:

Statement 1: “Stand comfortably, make a fist with your right (left) hand and raise your arm so that it is parallel with the yardstick.”

Statement 2: “Reach forward as far as you can without moving your feet, touching the wall, or losing your balance.”
Appendix F

Data Collection Sheet

DATE: __________________________

<table>
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Appendix G

Modified Borg Scale

0 nothing at all

.5 very, very weak (just noticeable)

1 very weak

2 weak (light)

3 moderate

4 somewhat strong

5 strong (heavy)

6

7 very strong

8

9 very, very strong
(almost maximal)

10 maximal