The Efficacy of a T’ai Chi Intervention on Functional Balance and Walking Speed in the Elderly

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The Efficacy of a T’ai Chi Intervention on Functional Balance and Walking Speed in the Elderly

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Thesis

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ABSTRACT

The Efficacy of a T’ai Chi Intervention on Functional Balance and Walking Speed

Melanie B. McKimmy
Sarah E. Teubert

Grand Valley State University, 1998

This study assessed the efficacy of a T’ai Chi exercise intervention on functional balance and walking speed. Twenty-two volunteer subjects over the age of 65 were included and categorized as near-frail or well elderly, based on their functional status. Subjects randomly selected for the intervention group participated in a 45 minute T’ai Chi group exercise class, bi-weekly for six weeks. Pre- and post-intervention data was on the Berg Balance Scale, and on self-selected and maximum walking speed. Analysis of Covariance (ANCOVA) revealed no statistical significant differences between the intervention group and the control group. Likewise, there was no statistical significant differences found between near-frail and well elderly subjects in the intervention group at post-testing. Further studies should be done on the efficacy of T’ai Chi in the near-frail or inactive elderly.
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CHAPTER 1

INTRODUCTION

Background of the Problem

The elderly population is growing at an unprecedented rate (Guccione, 1993). The 1990 census revealed that the growth rate of the population aged 65 years and older is twice that of the entire American population. In 1970, 9.8 percent of the population was over the age of 65. In 1990, 16.8 percent of the population was over the age of 65. By the year 2050, it is projected that 20.0 percent of the population will be over the age of 65 (U. S. Department of Commerce [USDC], 1996, p. 15). It is expected that the elderly population will continue to grow well into the first half of the 21st century.

The census also projects that the dramatic increase in the elderly population will lead to increased health care expenditures. As a person ages, he or she will spend significantly more for health care. For example, a person between the ages of 65 to 74 will spend 10.3 percent of his or her total expenditures on health care; likewise, a person over the age of 75 will spend 14.4 percent of total expenditures on health care. These percentages are notably high in comparison to a person age 45 to 54 who spends only 4.5 percent of total expenditures on health care (USDC, 1996, p. 118). The emphasis in health care delivery therefore, is shifting to prevention of illness and disability in order to limit costs of health care to individuals and society.

One significant health care concern is the increased risk of falls that is evident with advancing age. Accidents, including falls, are the sixth leading cause of death in
people aged 65 and over (USDC, 1996, p. 96). Englander, Hodson, & Terregrossa, (1996), project that in the year 2020 there will be 17,293,000 falls that result in injury, with the majority of these falls occurring in the elderly. These falls will cost individuals and society $85.37 billion dollars in health care costs. In addition to significant financial costs, falls also lead to fractures, serious soft tissue damage, hospitalization, decreased mobility, further physical decline, decreased quality of life, and premature death in the elderly (Tinetti, 1987).

Need for the Study

Many risk factors both intrinsic and extrinsic, contribute to falls in the elderly (Graafinans, et al., 1996). Some of the documented intrinsic risk factors for falling are use of sedatives, cognitive impairment, lower extremity weakness, presence of palmomental reflex, poor vision, hypotension, immobility, decline in postural stability, and presence of gait abnormalities. Some extrinsic factors that contribute to falls in the elderly are environmental hazards and housing conditions (Graafinans, et al., 1996; Tinetti, Speechley, & Ginter, 1988; Woollacott, Shumway-Cook, & Nashner, 1986). The literature suggests that the risk of falling in the elderly increases as the number of intrinsic and extrinsic risk factors increases (Graafinans, et al., 1996; Tinetti et al., 1988). Therefore, interventions that can reduce the number of risk factors may also be effective in reducing fall risk and the costly consequences of falls in the elderly.

Physical inactivity leads to an increase in the intrinsic risk factors contributing to falling and functional decline (Graafinans, et al., 1996; Tinetti et al., 1988). Physical inactivity in the elderly may be the beginning of a downward spiral leading to increased
susceptibility to falls and a life of disability. Barry and Eathorne (1994) proposed a vicious cycle that demonstrates the association between aging, physical inactivity, deconditioning, and increased intrinsic risk factors for falling. These researchers suggested that a reduction in physical activity result in deconditioning, weakness, and fatigue. All of these deficits are intrinsic risk factors contributing to falls. When disease, disability or injury are added to physical inactivity, further physical decline and increased risk of falling result. As an individual continues to decline physically, decreased quality of life including depression and poor motivation may occur, and further promote this vicious cycle (Barry, & Eathorne, 1994). Exercise interventions are needed in the elderly to address physical inactivity and prevent this vicious cycle that contributes to increased intrinsic risk factors for falling and functional decline.

Exercise interventions for the elderly may also affect quality of life which is an individual's perception of his or her own social, physical and emotional fitness (Blackwood, Mayou, Garnham, Armstrong, & Bryant, 1990). Researchers have noted that even if an intervention positively affects physical outcomes, like endurance and strength, the elderly population will not readily accept the intervention if it negatively impacts the subject's quality of life. When assessing exercise interventions it is important to include quality of life measures because an individual's quality of life is a key factor in the vicious cycle of aging and functional decline (Blackwood et al., 1990).

Recently there has been a flood of research published investigating the efficacy of exercise interventions in decreasing the risk of falling and improving function in the elderly. A wide variety of treatment interventions have been studied to examine their
effect on specific risk factors for falling and functional decline. These interventions include strengthening protocols, aerobic exercise, balance training, and individualized physical therapy (Judge, Underwood, & Gennosa, 1993; Mulrow, et al., 1994; Mac Rae et al., 1996; Wolfson et al., 1996). It still remains unclear which of these exercise interventions is the most effective in decreasing risk of falling and functional decline in the elderly. In addition, many of the studied exercise interventions require costly equipment and staffing. Further research is needed in identifying a cost-effective, preventative, exercise intervention that decreases the risk factors for falling and functional decline in the elderly.

One exercise intervention for the elderly that is gaining support in the literature is T’ai Chi. T’ai Chi is a gentle, dance-like form of exercise based on the oriental martial arts. A few recently published studies suggest that T’ai Chi may be a cost-effective, group exercise intervention for preventing falls and functional decline in the well elderly (Judge, Underwood et al., 1993; Wolf, Kutner, Green, & McNeely, 1993; Wolfson, et al., 1996; Wolf, Barnhart, Ellison, Coogler, 1997). These studies all utilized community dwelling, well elderly cohorts with no attempts made to identify those individuals who were at-risk for falls or for functional decline. Further research is needed to examine the effect of T’ai Chi in elderly who are at-risk for falls and functional decline. Research on preventative interventions is key to decreasing health care costs and maintaining mobility, function and quality of life in the elderly at-risk for falls.

Researchers have labeled functional groups within the elderly population using a variety of terms including: well elderly, frail elderly and near-frail (Buchner, Beresford,
Larson, LaCroix, Wagner, 1992). The majority of past research on exercise interventions with the elderly has focused on either the well elderly or the frail elderly. The results of these studies suggest that frail elderly who participate in exercise interventions tend to demonstrate more pronounced improvements in their function than well elderly who participate in similar exercise interventions (Buchner, et al., 1992). However, few studies have examined the efficacy of exercise interventions on the elderly population who's functional decline has put them in the category of near-frail. Near-frail individuals are defined as geriatric persons over the age of 65, who are able to independently carry out and perform all but one or two basic activities of daily living (such as toileting, feeding, dressing, grooming, ambulating, and bathing) and three or four instrumental activities of daily living (such as shopping, cooking, cleaning, driving, laundry and finances) (Brown, Renwick, & Raphael, 1995). Given this functional decline in the near-frail, these individuals may be at a greater risk for falls during basic and instrumental activities of daily living, when falls are most likely to happen.

Because these individuals require some assistance, near-frail elderly may reside in assisted living facilities within life care communities. A life care community is an elderly community that consists of independent living facilities and assisted living facilities. An assisted living facility is an elderly living community that provides assistance in the form of prepared meals and light housekeeping, allowing the elderly to maintain much of his or her independence. The life care community is an appropriate setting to investigate the effects of a T’ai Chi intervention as many of the individuals living in this setting may be classified as near-frail, and thus at a higher risk for falls and functional decline.
With the overwhelming projected medical cost of falls, it is obvious that interventions addressing intrinsic risk factors for falling need to be developed with the elderly who are at risk for falls and functional decline. Current literature indicates that T’ai Chi may be effective in fall prevention in the well elderly. Further research on the effect of T’ai Chi on intrinsic risk factors for falling, such as functional balance and walking speed, and quality of life outcomes is needed in the near-frail elderly.

Purpose of the Study

This study looked at the efficacy of a T’ai Chi exercise intervention on functional balance and walking speed in the elderly.

Hypotheses

This study addressed two primary hypothesis and one secondary hypothesis.

The Primary Hypotheses:

1. Elderly subjects who participate in a T’ai Chi exercise intervention will demonstrate a difference in the change of the Berg Balance scores from pre-test to post-test as compared to a group of non-exercising elderly subjects.

2. Elderly subjects who participate in a T’ai Chi exercise intervention will demonstrate a difference in the change of self-selected and maximal gait velocity from pre-test to post-test as compared to a group of non-exercising elderly subjects.

The Secondary Hypothesis:

3. Near-frail subjects who participate in a T’ai Chi exercise intervention will demonstrate a difference in the change of the Berg Balance scores and
walking velocity scores from pre-test to post-test when compared to well elderly subjects who participate in a T’ai Chi exercise intervention.
### Operational Definitions

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<td>Self-selected gait velocity</td>
<td>The speed at which a person normally walks.</td>
</tr>
<tr>
<td>Maximal gait velocity</td>
<td>The fastest speed a person can safely walk without running.</td>
</tr>
<tr>
<td>T’ai Chi</td>
<td>A gentle, dance-like exercises based on the oriental martial arts that utilize the upper and lower extremities in a continuous, coordinated movement pattern.</td>
</tr>
<tr>
<td>T’ai Chi Form</td>
<td>A combination of different T’ai Chi positions that are coupled together with transitions.</td>
</tr>
<tr>
<td>Near-Frail</td>
<td>Geriatric persons over the age of 65, who are able to independently carry out and perform all but one to two basic activities of daily living (such as toileting, feeding, dressing, grooming, ambulating, and bathing) and three to four instrumental activities of daily living (such as shopping, cooking, cleaning, driving, laundry and finances) (Brown, Renwick, &amp; Raphael, 1995).</td>
</tr>
<tr>
<td>Life Care Community</td>
<td>An elderly community that consists of independent living facilities and assisted living facilities.</td>
</tr>
<tr>
<td>Assisted Living Facility</td>
<td>An elderly living community that provides assistance in the form of prepared meals and light housekeeping allowing the elderly to maintain much of his or her independence.</td>
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CHAPTER 2
LITERATURE REVIEW

Functional Decline in the Elderly

With advancing age, susceptibility to functional decline increases. Normal age-related changes such as decreased strength of muscle contraction, aerobic capacity, flexibility, walking speed, postural control, and reflex reaction time result in a slowing down of functional performance in the elderly. Contrary to common belief, normal age-related changes do not result in serious physical deficits in the elderly (Guccione, 1993). Instead, normal age-related changes result in a decrease in functional reserve capacity.

Functional reserve capacity is the storage of ability, internal resources, and energy one draws upon during activities of daily living (ADL's) and emergencies (Guccione, 1993). Normal age-related decline in functional reserve capacity alone does not have a significant impact on functional ability because only a small percentage of a well individual’s total functional reserve capacity is required for the performance of ADL’s. Instead it is the combination of normal age related decline in functional reserve capacity influenced by inactivity and chronic diseases common to the geriatric population, that results in the observed functional limitations and functional decline commonly seen in the elderly (Buchner et al., 1992; Guccione, 1993). Thus, as one ages, he or she may be at increased risk for falling due to this impact of normal functional reserve decline, chronic diseases and inactivity on functional reserve capacity (Buchner, et al., 1992; Guccione,
Therefore, when an elderly individual is in a situation that is more functionally demanding than normal ADL’s, he or she may not have sufficient functional reserve to meet the needs of the situation and a fall may result (Barry & Eathorne, 1994; Englander, Hodson, & Terrgросса, 1996).

Terms Describing the Elderly Based on Their Functional Decline

Numerous terms have been used to describe elderly individuals who have experienced functional decline. These terms include: feeble, infirm, debilitated and frail. Frail, however, is the most commonly used term by researchers. Recently there has been a great deal of literature on the frail elderly. However, the definition of frailty has remained vague and ambiguous. Brown et al. (1995) proposed a working definition for frailty as the “diminished ability to carry out the important practical and social activities of daily living”. Frailty is further described by these authors as being part of a continuum, with hardiness at one end and frailty at the other end. Hardiness was described as meaning sturdy and robust, not sickly or feeble (Brown, et al., 1995). The concept of frailty “as part of a hardy-frail continuum” suggests that being frail is not a static state. Thus, elderly individuals defined as frail can become hardy, and a hardy individual can become frail. Brown et al., suggest that one factor influencing a person’s position along the frailty-hardiness continuum is functional reserve capacity. The hardy person has a larger functional reserve capacity than the frail person. As an individual’s functional reserve decreases, they move toward the frail end of the continuum.

Researchers have labeled elderly functional groups along the hardy-frail continuum using a variety of terms including: well elderly, near-frail elderly, moderate-
frail elderly and frail elderly. Well elderly are geriatric individuals who are able to independently perform all basic ADL’s (such as toileting, feeding, dressing, grooming, ambulating, and bathing) and IADL’s (such as shopping, cooking, cleaning, driving, laundry, and finances). Jette, Branch and Berlin (1990) defined frail elderly as geriatric persons who are dependent or require assistance in five basic ADL’s and five IADL’s. Brown, Sinacore & Host (1995), described moderate-frail elderly as geriatric persons who are unable to independently perform two to three basic ADL’s and three IADL’s. Based on these definitions, in our study, near-frail individuals are defined as geriatric persons over the age of 65, who are able to independently carry out and perform all but one to two basic activities of daily living and three to four instrumental activities of daily living (Brown, et al., 1995). Few studies have been done looking at the efficacy of preventative interventions on the elderly population who’s functional decline has put them in the near-frail category. When placed on the hardy-frail continuum, the near-frail individual who participates in a preventative intervention may move closer to the hardy end of the continuum and therefore, slow the process of functional decline.

**Age-Related Changes in Postural Control**

Many research studies have identified normal age associated changes in postural control, sensory integration, and postural strategies. Woollacott et al., (1986) compared postural strategies in elderly with young adults using an (Equitest) Balance Platform paradigm. The researchers monitored muscle activation in lower extremities during platform perturbations and under different sensory conditions. The changes that were documented in the elderly included a significant increase in the latency of distal muscle
activation in response to perturbations and increased variability of muscular responses within a postural strategy. In addition, Woollacott et al. documented a reversal of the normal activation of the distal to proximal muscles. Sensory processing decline with aging was also documented in this study. When the elderly subjects were presented with conflicting visual and somato-sensory information, some but not all of them lost their balance; whereas none of the younger subjects lost their balance.

Assessment of changes in postural control of the elderly have also been done using destabilizing forces at the hip in standing (Wolfson, Whipple, Amerman, & Kleinberg, 1986). Wolfson et al., (1986) utilized the postural stress test (PST), a pulley weight system that delivers a destabilizing moment at the hip. In this study the PST was used to evaluate the neuromuscular responses in elderly with and without a history of falls, as well as responses in younger adults. Non-faller elderly subjects displayed effective but slower postural responses to perturbations on PST compared to young adults. On the other hand, the elderly with a history of falling displayed ineffective and delayed responses, often resulting in a fall after perturbation.

Other researchers have studied balance changes with aging using simpler methods, such as the one legged stance test (OLST) and the Sharpened Romberg (SR), a standing tandem balance test. In two similar studies, timed balance scores were compared to age, torque production, and history of falls in non-institutionalized elderly men and women (Iverson, Gossman, Shaddeau, & Turner, 1990; Briggs, Gossman, Birch, Drews, & Shaddeau, 1989). Both studies came to the same conclusion that balance times in OLST and the SR decreased with age. In the study that evaluated non-institutionalized
elderly men, a positive relationship between balance times and torque production of muscles of the lower extremity was evident (Iverson et al., 1990). On the other hand, there was no significant difference in performance on timed balance tests between those elderly women who had fallen and those who had not fallen (Briggs et al., 1989).

These aforementioned studies on age-related changes in postural control consistently document a reduction in the speed of postural responses to perturbations and decreased postural stability. This gradual decline in balance and postural control, influenced by inactivity and chronic diseases, contributes to decreased functional reserve capacity, to functional decline, and to increased risk of falls documented in the elderly. More research is needed on preventative interventions for the elderly that address balance and postural control decline.

Measuring Functional Balance

One clinical tool that is commonly used to measure functional balance in the elderly is the Berg Balance Scale. The Berg Balance Scale was created to assess three different items of balance: maintenance of a posture, adjustment to voluntary movements and reaction to external disturbances (Berg, Wood-Dauphinee, Williams, & Gayton, 1989). The Berg Balance Scale evaluates 14 functional balance activities that are commonly used in everyday life. The subject is scored on a scale of 0-4 for each activity, giving a total possible score of 56 points (Berg, Maki, Williams, Holliday, Wood-Dauphinee, 1992). The Berg Balance Scale has been shown to have high intra-rater reliability (.98) and inter-rater reliability (.97) (Berg, Wood-Dauphinee, & Williams, 1992; Berg, Wood-Dauphinee, & Williams, 1995). When Berg et al. assessed the intra-
rater reliability in their 1995 study, a variety of health professionals performed the testing including physical therapists, student physical therapists, occupational therapists, and nurses, which demonstrated that the Berg Balance Scale could be used reliably by a variety of trained health professionals. The scale also has strong internal consistency (.96) (Berg, Wood-Dauphinee, et al., 1992). In a recent study, Berg et al. (1995) compared scores for elderly residents with acute stroke patients and found that the Berg Balance Scale demonstrated internal consistency of .83 for the elderly residents and .97 for the stroke patients. Most importantly, the Berg Balance Scale has been shown to be have both construct validity and concurrent criterion validity when used to assess functional balance (Berg, Maki, et al., 1992).

A score of 45 out of 56 on the Berg Balance Scale has been proposed by Berg to be the “cutoff” for subjects who are at risk of falling. Subjects scoring less than 45 on the Berg are at a 2.7 times higher risk of experiencing multiple falls over the next 12 months than subjects scoring over 45 points (Berg, Wood-Dauphinee, et al., 1992). Thorbahn and Newton (1996) found that a higher percentage of subjects who scored between 31 - 45 on the Berg Balance Scale fell than subjects who scored below 31. These researchers described subjects who scored below 31 on the Berg Balance Scale as the most physically impaired population, requiring assistive devices and/or the support of another person to compensate for their balance deficits. Many of the subjects who scored less than 31 on the Berg had limited ability to ambulate or transfer and thus were not at a high risk for falling because they did not participate in these activities without assistance. Thorbahn and Newton (1996) suggested that the more physically able subjects scoring between 31 -
45 were less aware of their balance deficits and thus more likely to participate in risk-taking activities that placed them at a higher risk for falls. Thorbahn and Newton emphasized that further research needs to be done on the elderly population scoring between 31 - 45 on the Berg Balance Scale.

Recently the sensitivity of the Berg Balance Scale has been criticized. Thorbahn and Newton suggested that the Berg Balance Scale is more successful in identifying those who are not at a risk of falling better than those who are at risk of falling. In their 1996 study, Thorbahn and Newton found the Berg Balance Scale to have a sensitivity of 53% for identifying those who are at risk of falling and a specificity of 96% for identifying those who will not fall. While these researchers concluded that the Berg is not extremely useful for identifying individuals at risk of falling, different research shows that when compared to other available tools, the four point grading scale of the Berg demonstrates increased sensitivity to changes in balance function (Harada, et al., 1995).

**Age Related Changes in Walking Function**

Age related changes in walking have also been correlated with decreased gait velocity and changes in gait patterns in the elderly (Himann, Cunningham, Rechnitzer, & Peterson, 1988; Winter, Patla, Frank, & Walt, 1990). Intrinsic factors such as decreased strength of muscular contraction, slowed reflex response time, reduced balance and flexibility affect walking function. These intrinsic factors affect a variety of components of walking such as step length, stride length, and double leg stance. Himann et al., (1988) reported that during the seventh decade of life there is an accelerated decline in gait velocity in both men and women. The slowing of gait velocity in the elderly has been
shown to be associated with a decrease in the step length and stride length, but not in cadence (Hageman, & Blanke, 1986; Cunningham, Rechnitzer, Pearce, & Donner, 1982; Winter et al., 1990). In a study of walking patterns in the fit and healthy elderly, Winter et al., noted increased double stance time, decreased push off, and a flat footed heel strike in their elderly subjects. The authors concluded that some of the noted gait changes were not necessarily due to deterioration or functional decline, but rather a strategy to increase postural stability during walking and thus produce a safer gait pattern. These normal age related changes in walking are further magnified when combined with injuries and chronic diseases commonly seen in the geriatric population, such as arthritis, resulting in walking function decline.

**Decreased Walking Speed and Functional Decline**

Decreased walking speed is correlated with decreased functional ability in the elderly. Potter, Evans, and Duncan (1995) correlated decreased gait speed with decreased activities of daily living (ADL’s) in a study of 161 elderly inpatients and outpatients. They concluded that patients walking slower than .25 m/sec were more likely to be dependent in one or more ADL’s (Potter, et al., 1995). Holden, Gill, Magliootti, Nathan, & Piehl-Baker (1984) found a similar relationship between walking speed and function in the elderly. These researchers concluded that a linear relationship between gait velocity and functional ambulation speed exists. Other researchers suggest that measuring gait velocity is an inexpensive and reliable measure of functional walking ability in the elderly (Harada et al., 1995; Holden et al., 1984). Holden et al., measured elderly subjects gait velocity on a 30 ft walkway with a digital stopwatch. These researchers,
reported an inter-rater reliability of 1.00 for gait velocity measurements. These studies suggest that measuring walking velocity is a reliable method to determine changes in walking function and functional ability in the elderly during intervention studies.

The Impact of Age Related Changes on Quality of Life

Age related functional decline and change in life roles may impact quality of life in the elderly. Quality of life is a measure based on an individual’s perception of his or her own social, physical and emotional well being (Blackwood, et al., 1990). While an increase in age does not necessitate a decrease in quality of life, there are a number of issues that can affect an elderly individual’s feelings of well-being. Changes in life roles, declining physical function, loss of loved ones, decreased social contact, increased fear of falling, and an increased fear of dying all can affect the elderly individual’s sense of well-being (Guccione, 1993; Forsythe, 1996; Powell, Myers, 1995). Therefore, even though advanced age does not automatically result in a decreased quality of life, the life changes accompanying advancing age may make the elderly individual more susceptible to a decreased quality of life.

Blackwood et al., (1990) state that quality of life measures should be considered an important outcome measure for all therapeutic studies. According to Kutner et al., (1992) the assessment of quality of life is of key importance in evaluating treatment interventions in the elderly. Even if an intervention does not affect specific physical parameters, such as strength, the intervention may still have an important impact on a geriatric individual’s quality of life. Kutner et al. proposed that improvements in feelings of well-being that a subject gains during a treatment intervention are more crucial to the
subject's compliance in the treatment program than the actual physiologic benefits provided by the intervention. In addition, Kutner et al. stated that improvements in quality of life, like a subject's opportunity for increased socializing, may be the only reason a subject continues to participate in an intervention. Finally, Kutner et al. suggested that quality of life measures are important in determining whether a treatment intervention is worth its expense.

Measuring Quality of Life

The authors of the aforementioned studies noted that even if an intervention positively affects physical outcomes, like endurance and strength, the intervention will not be readily accepted by an elderly population if it negatively impacts the subject's quality of life. Therefore, it is important to include quality of life measures in evaluating intervention outcomes in clinical studies. In the literature, health status or health outcomes are the terms used to describe the behavioral aspect of health including quality of life.

One tool measuring health status that has recently been used in research with the geriatric population is the Medical Outcome Study 36-Item Short Form (SF-36). SF-36 measures eight health concepts related to quality of life: physical functioning, social functioning, role limitations due to physical problems, role limitations due to emotional problems, mental health, bodily pain, and general health perception (Ware & Sherbourne, 1992). Standardized answers are provided for each of the 36 questions. A higher score on the SF-36 indicates better overall perceived health status (Jette & Downing, 1996). The SF-36 takes only 10 minutes to complete. The SF-36 tool has demonstrated high
reliability values for internal consistency (.72 to .85) when used for patients (mean age 59.7) with cardiac disease (Jette & Downing, 1994). In a recent study by Jette and Downing (1996) the relationship between health status (measured by the SF-36) and physiological impairments commonly seen in patients (mean age 60.4) entering a cardiac rehabilitation was examined. The researchers concluded that psychological distress is directly related to poor health. Jette and Downing (1996) also concluded that both the psychological and physical dimensions of patients affected their psychological distress. The authors further discussed the importance of health care workers using a health status measures, such as the SF-36, when working with cardiac patients. In another study, Jette and Jette (1996) examined health outcomes in patients with spinal impairments (lumbar or cervical impairments) after physical therapy. Improvement in all health scales on the SF-36 except general health perceptions were noted (Jette & Jette, 1996). In our study, the use of an objective quality of life questionnaire would allow us to develop a better understanding of our treatment intervention’s effect on our subject’s perceived health and well being.

**Interventions for Functional Decline**

**Frailty Prevention Project**

Because our elderly population is growing at an unprecedented rate, a wide variety of research studies have focused on preventing functional decline, frailty, and falls in the elderly. One of the largest projects that has been undertaken is the Frailty and Injuries: Cooperative Studies and Intervention. The FICSIT trials are a multi-site collaborative study in which the efficacy of a variety of interventions are being examined
on a selected group of elderly people to reduce frailty and prevent fall related injuries (Buchner et al., 1993). Each of the nationwide sites examined a different type of elderly sample and used a different treatment intervention; however, all sites had a common data base of outcome measures and descriptors. The common data base is divided into four sections: psychosocial health and demographic measures, physical health measures, fall related measures, and cost and cost effectiveness measures (Buchner, et al., 1993).

Included in this common data base is the MOS SF-36 and gait speed. The FICSIT common data base was established so that meaningful comparisons could be made between the sites, allowing for further analyses to be completed on effective interventions on frailty (Buchner, et al., 1993).

The Yale FICSIT study is one of the FICSIT trials (Tinetti, Baker, et al., 1993). At this site, the effectiveness of a multi-factorial program, including adjustment of medications, home exercise program, and behavioral instructions at decreasing falls in independently living elderly was examined and compared to the control group that received only social visits. The elderly individuals that participated in the multi-factorial program demonstrated a reduction in the numbers of falls when compared to the control group that just received social visits (Tinetti, McAvay, Claus, 1996).

In Seattle, a FICSIT study was done to determine the effects of strength and endurance training on gait, balance, physical health status, fall risk and health services use in the elderly aged 68-85 (Buchner, Cress, et al., 1997). The researchers found no significant effects of exercise on gait or balance. The researchers also found that the subjects that had exercised had a significantly fewer falls than the subjects in the control
group. In addition, the control subjects utilized health services significantly more than the exercise group (Buchner, Cress et al., 1997).

The Atlanta FICSIT, another of the FICSIT trials, evaluated two treatments: balance feedback training and T’ai Chi and compared them to a control group that met only for educational purposes (Wolf, et al., 1993). More details on the Atlanta FICSIT are included on page 28 of the literature review. In addition to the FICSIT multi-site collaborative studies on the well and frail elderly, other studies have evaluated the efficacy of a variety of interventions in decreasing the risk of falls in the elderly.

**Strength Training**

Many studies have found that strength training is an effective means of remediating muscle weakness in the elderly. Judge, Underwood, et al. (1993) reported a 32% increase in strength of knee extensors in those subjects who participated in 12 weeks of resistance training. Fiatarone et al. (1994) evaluated the effect of a 10-week high intensity progressive resistance program on lower extremity muscle strength and found significant gains (up to 113%) in frail nursing home subjects. Most recently a study by Wolfson et al. (1996) reported a significant isokinetic strength increase of 1.1 Nm Kg in healthy community dwellers who participated in a 3-month, tri-weekly, lower extremity strengthening program. The cumulative findings of these studies indicate that strength training is effective in remediating muscle weakness in both the frail and well elderly.

Several studies evaluated strengthening interventions effect on improving functional balance and walking speed. Fiatarone et al., (1994) found that 10-weeks of progressive resistive strengthening of the hip and knee extensors was effective in
improving strength, walking speed and functional stair-climbing ability in the frail elderly. Judge, Lindsey, et al., (1993) also found that a lower extremity strengthening program resulted in significant gains in walking speed, including an 8% increase in self-paced walking speed and a 4% increase in maximal walking speed, in elderly life-care community residents. McMurdo, and Rennie (1993) reported that a seven month, biweekly, seated resistance training intervention resulted in improvements in grip strength, spinal flexion, chair to stand time and very low level activities of daily living (ADL's) in "residents of old people's homes". Unfortunately, the authors of this study failed to describe their population clearly. "Residents of old people's homes" is an inadequate description as it does not clarify the functional level of the population. Therefore, while the results of this study were positive, they are of limited value because the type of elderly population that benefited from the treatment is ambiguous.

Judge, Whipple and Wolfson (1994) compared the effects of strength training, balance training, and a combination of strength and balance training on gait speed, strength, and functional mobility. Their subjects were described as "relatively healthy" ambulatory older persons, age 75 or older. Judge et al. (1994), found that subjects participating in the strength training exercises improved in strength. However, neither the resistive exercise training, balance training nor combination strength and balance training improved the subjects' walking speed or sit to stand time. More recently, in a three month experimental study, Wolfson et al. (1996) compared the effect of strength training, balance training, and a combination of strength and balance training on functional base of support, single limb stance time, strength, gait velocity, and the ability to coordinate
appropriate balance strategies on unstable surfaces. The results of this study indicated that while resistance exercise did result in increased strength and single limb stance time; this intervention did not have an effect on balance, loss of balance on unstable surfaces, functional base of support, or walking speed. Findings from these reviewed studies provide evidence that strength training of specific muscle groups does result in increased strength of those specific muscle groups in the elderly. However, the effect of strength training on walking speed is inconclusive. Wolfson et al.'s (1996) research also indicates that a strengthening exercise intervention has minimal to no effect on balance. Therefore, other types of interventions that are directed at functional balance retraining in the elderly may be needed.

The results of strengthening intervention studies suggest that strength alone is not the only factor contributing to the geriatric decline in functional ability. Researchers postulate that other factors such as sensation, balance, visual input, range of motion, pain and fear may also have a significant effect on functional ability in the elderly (Brown, et al. 1995; Judge, Lindsey, et al., 1993). Because strengthening interventions alone seem to have a limited effect upon the risk factors for falling, researchers have studied other interventions such as a variety of different forms of aerobic exercise.

Aerobic Exercise Interventions: Dancing and Walking

Many elderly individuals participate in aerobic exercises programs such as walking and dancing. The effect of these aerobic exercise programs on walking speed, strength, balance, flexibility and functional fitness has been studied by a number of researchers.
Aerobic Dancing

Thirty-five community dwelling, well elderly women showed statistically significant improvements in physical fitness after a 12 week, tri-weekly, aerobics dance program. The exercise group demonstrated a 13% increase in cardiopulmonary endurance, a 12% improvement in balance, a 62% increase in strength, and a 9% improvement in flexibility. Coordination was not affected by the treatment intervention. The control group subjects, who were instructed to continue daily activities as usual, demonstrated deterioration of function, 4% in cardiopulmonary endurance and 6% in coordination (Hopkins, Murrah, Hoeger, Rhodes, 1990). The results of this study support the theoretical relationship between inactivity and functional decline in the elderly previously discussed.

In a similar study by Lord et al., (1996) 60 to 83-year-old independent community dwelling women participated in biweekly one hour aerobic dance sessions for 22-weeks. Elderly exercise group subjects in this study significantly improved in both their lower extremity strength (up to 20.6% in the knee extensors) and walking speed (5.9%). The control group subjects, who were instructed to continue daily activities as usual, demonstrated no improvements in strength or walking speed. Another secondary benefit that the researchers proposed was that the aerobic exercise classes provided social interaction for the treatment group that lead to high compliance and attendance rate in the study. A major limitation of this study, however, was that neither the subjects nor the researchers performing the pre- and post-testing were blind to the group assignment, thus allowing for potential bias in the post-test results (Lord et al., 1996). Both Lord et al.'s,
and Hopkins et al.’s, (1990) findings provide evidence that aerobic exercise has a direct effect on cardiovascular endurance, flexibility, strength, walking speed, and in some cases balance in the well elderly. Their results also indicate that treatment interventions with social interaction may promote high compliance and attendance rates by elderly participants.

**Walking Programs**

Researchers have also investigated the effects of aerobic walking programs on functional balance, perceived balance, walking endurance, and the performance of activities of daily living in the well elderly. Roberts, (1988) evaluated the effect of a 6-week walking program on balance performance, measured by the Berg Balance Scale, and perceived balance, measured on the Balance Perception Questionnaire, in ambulatory well elderly. Roberts found that the high intensity walking intervention did improve the exercise group’s balance scores significantly more than the control group’s scores. Roberts (1988) also found that the walking intervention did not effect the subjects’ perceived balance scores.

MacRae et al. (1996) studied the effects of a 12-week versus a 22-week self paced walking program on deconditioned, cognitively impaired, ambulatory nursing home residents. These researchers evaluated the impact of the walking programs on speed of function on the Timed-Up-and-Go-Test, balance based on the Tinetti Mobility Assessment, and quality of life, as measured by a combination of the Geriatric Depression Scale, Body Pain Scale and COOP chart of physical work. MacRae et al., (1996) reported that staff-assisted, self-paced walking had no effect on functional
mobility, grip strength, balance, or quality of life. These researchers also concluded that
the supervised, self-paced walking intervention in their study may be an inappropriate
exercise intervention in nursing home facilities because this intervention is extremely
time and staff intensive. MacRae et al. proposed that other, cost effective exercise
programs are needed for use in elderly residential facilities.

Individualized Physical Therapy

Past studies have also looked at the efficacy of individualized physical therapy on
functional ability in the elderly. Mulrow et al., (1994) studied the effect of 4-months of
physical therapy on mobility, self perceived health status, observer-reported activities of
daily living, and rate of falls in 100 frail nursing home residents who were dependent in
at least two activities of daily living. Control group subjects received one-on-one
friendly visits three times a week for 4 months. The results of this study indicated that
long term, individualized physical therapy intervention had only a limited effect on
mobility and no effect on self-perceived health status and observer-reported activities of
daily living. Finally, the physical therapy treatment resulted in an actual increase in the
rate of falls in the study subjects. Mulrow et al., (1994) concluded that frail elderly with
chronic disabilities may benefit only modestly from expensive, intensive physical therapy
intervention.

Harada, Chiu, Fowler, et al. (1995) investigated the effect of individualized
physical therapy on balance, gait speed, and functional performance of 71 to 97-year-old
residential facility subjects who exhibited impaired balance and difficulty in performing
one or more functional activities. A secondary purpose of this study was to determine the
sensitivity of the Tinetti POMA Balance Subset and the Berg Balance Scale. The
treatment intervention consisted of individualized physical therapy programs designed to
improve the subjects' functional activities, gait and balance. Treatment subjects
participated in treatment sessions three times a week for five weeks. No control group
was used in this study. Harada, Chiu, Fowler, et al., (1995) found that while
individualized physical therapy had no effect on gait speed, the intervention was effective
in improving balance and functional performance of activities in elderly subjects with
balance and function deficits. Harada, Chiu, Fowler, & et al., postulated that a longer
treatment interval may be required in order to have an effect on gait speed. Lack of a
control group, however, confounds this study, as it is difficult to determine if the
individualized physical therapy intervention was the cause of the noted improvements in
balance and functional performance. The researchers pointed out in their conclusions that
even though this individualized physical therapy was an effective intervention, medical
insurance will not cover the high costs of a long term therapy. Thus, Harada, Chui,
Fowler, et al., suggested the need for further research of alternative, low cost, group
exercise interventions that can be administered by trained personnel at elderly residential
care facilities.

These studies indicate that while prolonged, individualized physical therapy is of
limited benefit to the very frail elderly with chronic disabilities, it has a significant effect
on balance and functional performance in elderly individuals. Unfortunately, the costs of
long term physical therapy preclude it from use as a means of improving balance and
mobility in the elderly population as a whole. Further research is needed on the
development of a cost-effective, group exercise intervention to prevent functional decline and risk factors for falling in the elderly.

T'ai Chi

One such exercise intervention that is gaining support in the literature is T'ai Chi. T'ai Chi is a gentle, dance-like form of exercise based on the oriental martial arts that utilizes both the upper and lower extremities in a continuous, coordinated movement pattern. In Asian countries like China, T'ai Chi has been practiced for centuries by both the young and old alike. For years, T'ai Chi practitioners and non-refereed Asian journals have touted the many benefits of T'ai Chi in the elderly, including increased energy, flexibility, balance, relaxation, and spiritual harmony (Robinson, 1996). Because the majority of Asian studies on T'ai Chi lack experimental design and control group comparisons, Western medicine has ignored the proposed merits of T'ai Chi suggested by these studies (Robinson, 1996). However, recently Western researchers have begun to evaluate T'ai Chi as a means to promote and maintain wellness in the elderly. Researchers have discussed several therapeutic elements of T'ai Chi including: continuous movement performed slowly; small to large degrees of motion; knee flexion and weight shifting; straight and extended use of the head and trunk; combined rotation of the head and trunk, use of both the trunk and extremities; asymmetrical diagonal arm and leg movements about the waist; and unilateral weight bearing with constant weight shifting (Wolf, et al.1993). These therapeutic elements of T'ai Chi, combined with its cost-effective, group format, support the view that T'ai Chi may be a possible exercise intervention to prevent functional decline and risk factors for falling in the elderly (Wolf
et al., 1993). Current Western studies have investigated the effects of T’ai Chi on postural control, balance, strength and gait in well elderly individuals.

The researchers conducting the Atlanta FICSIT study chose to use a T’ai Chi intervention because it “appears to dynamically tax balance mechanisms while facilitating concentration of body position within immediate environment” (Wolf et al., 1993). In addition, T’ai Chi is an inexpensive group exercise that uses internal feedback to emphasize flexibility, strength, and cardiovascular improvement. The Atlanta FICSIT experimental study randomly placed 200 community ambulating subjects in three groups: a balance platform training group that met one hour each week, a education-control group that met one hour each week to discuss educational topics, and the T’ai Chi exercise group that met for two one hour sessions a week. All three groups met for 15 weeks. Each week the subjects in the T’ai Chi group learned a T’ai Chi ‘form’, which consisted of specific exercises with transitions between each exercise. The T’ai Chi subjects were also encouraged to practice T’ai Chi on their own twice a day for 15 minutes (Wolf et al. 1996).

Wolf et al., (1996) found notable gains in their T’ai Chi exercise group. Subjects in the T’ai Chi group had several statistically significant changes including lower systolic blood pressure after a twelve minute walk, and a decreased fear of falling when compared to the balance training and education-control group. The T’ai Chi group also had a statistically significant reduction in rate of falls, and most surprisingly, a decrease in the rate of left hand grip strength loss when compared to the balance training group. The T’ai Chi group subjects also demonstrated a decreased walking speed, whereas the
Balance training group and the education-control group had a small increase in walking speed. Wolf et al., (1996) could not explain why the subjects in the T’ai Chi group demonstrated a decrease in gait speed; however, they suggested that this be further investigated in future studies. The most notable gains in their study subjects, however, were the reduction in fall rate and fear of falling after the T’ai Chi intervention.

A second Atlanta FICSIT study was done on 72 inactive participants, living in a resident living facility. This study evaluated the efficacy of two exercise interventions: balance platform training and T’ai Chi, on minimizing postural sway when compared to a control group (Wolf, et al.1997). The balance platform exercise subjects demonstrated significantly improved postural stability after a fifteen-week exercise intervention. On the other hand, the T’ai Chi subjects and the control subjects demonstrated no significant changes in postural stability. The subjects in the T’ai Chi group, however, were less afraid of falling after their intervention when compared to other groups with similar covariates (Wolf, et al. 1997). Wolf et al. suggested that T’ai Chi has become a popular treatment intervention for the elderly because it promotes confidence in stability rather than decreasing postural sway.

Judge et al., (1993) evaluated the effect of resistance training, T’ai Chi and balance training on isokinetic strength and maximal gait speed in independently ambulating, well elderly volunteers, age 75 and older. Exercise subjects performed individual one hour exercise sessions three times weekly for 12-weeks. The balance intervention included anterior-posterior and lateral weight shifting and 5 to 10 minutes of simple T’ai Chi exercises. The anterior-posterior and lateral T’ai Chi movements were
performed in single stance. The control group met 30 minutes weekly for 12-weeks, performing stretching and posture exercises while seated in a chair. Self-report instruments were used to assess subjects’ medical history, medications, and history of falls. Self-selected and maximal gait speed and lower extremity strength was measured pre- and post-training. Judge et al. (1993), found that T’ai Chi and balance training combined with resistive exercises was effective in significantly improving self-selected gait velocity by 8%, maximal gait velocity by 4%, and isokinetic strength by 25%, in the intervention group as compared to the control group. Because two different treatment interventions (resistance training and T’ai Chi balance training) were used in this study, it is unclear which intervention produced the favorable results. Additionally, Judge et al., failed to adequately describe the specific T’ai Chi intervention exercises used in their study. This study, however, indicates the need for further research on the effects of T’ai Chi interventions alone on strength, balance, and walking speed in the elderly.

Researchers have also used retrospective studies to evaluate the effect of T’ai Chi on balance. In a comparison study, Tse and Bailey, (1992) evaluated, retrospectively, the balance performance of nine elderly T’ai Chi practitioners with the balance performance of nine elderly non-T’ai Chi practitioners, matched for age and sex, on a series of five balance tests. The subjects were timed on a heel to toe walking test and four single leg stance tests with their eyes open and closed. The T’ai Chi trained subjects did significantly better than the non-T’ai Chi subjects on the right and left single leg stance tests with their eyes open, and on the heel to toe walking test. Tse and Bailey (1992), concluded that while their results suggest a link between T’ai Chi and postural
control, their findings cannot be generalized to the elderly population as a whole due to their non-scientific study design. The authors believed that their results indicated a need for further research on T'ai Chi's effect on postural control in the well elderly (Tse & Bailey).

In the Connecticut FICSIT study, Wolfson et al., (1996) compared the effects of a balance intervention, strength intervention, combined balance and strength intervention, and no intervention, on balance and strength measures in the elderly. Additionally, these researchers examined the effectiveness of group T'ai Chi as a follow-up intervention in maintaining strength and balance gains achieved. The researchers randomly assigned the 110 healthy, independent community dwelling elderly individuals (mean age 80 years old) to one of four study groups. The training programs were 45 minute, individualized exercise sessions, three times a week for three months. After the strength and balance gains from the original interventions were documented, subjects in all four groups were asked to participate in a 26-week T'ai Chi follow-up intervention. The T'ai Chi exercises used in this treatment emphasized combinations of weight shifts, turning with the knees bent, steps, proper body alignment, directional changes with rotation at the hips, proper breathing, relaxation and increased body awareness. The exercise methods applied were adapted from the book, "T'ai Chi," by Cheng Man-ch'ing and Robert W. Smith (1967). During this maintenance phase, subjects attended one 60 minute T'ai Chi group session each week. In addition, they were asked to practice two times a week at home and to maintain a practice journal. Attendance during the T'ai Chi maintenance intervention for their elderly sample was reported to average around 72%. Compliance with the home
practice sessions and journaling was reported as infrequent and inconsistent. Wolfson et al., (1996) then re-tested the subjects after the T'ai Chi maintenance program. These researchers found the T'ai Chi maintenance program did effectively maintain the majority of the well elderly subjects’ balance and strength improvements. This study supports the use of T’ai Chi in well elderly to maintain optimal balance and function. Wolfson et al., suggested a need for further research on the effect of a T’ai Chi intervention alone on walking speed and balance in the elderly.

In our study we examined the effects of a group T’ai Chi intervention on the functional balance and walking speed of an elderly population living in a life care community. Special attention was paid to the post-intervention walking speed and functional balance changes seen in the near-frail subjects as compared to the well elderly subjects.
CHAPTER 3

METHODOLOGY

Overview of Study Design

In this experimental design, 26 elderly volunteers from a life care community were randomly placed in either the intervention group or the control group. Subject randomization was done by first dividing the subjects into well-elderly and near-frail elderly based upon their Modified Lawton-Brody functional assessment scores (defined on page 11). All near-frail subject's names were put into a hat and half the names were drawn. The selected individuals were placed into the intervention group, and the non-selected names were placed into the control group. This same process was repeated for the well-elderly subjects. A T'ai Chi group exercise program was used as the intervention. Therefore, the independent variable in this study was participation or non-participation in the T'ai Chi exercise program. Berg Balance Scale performance, self-selected and maximal walking speed scores were measured pre- and post-intervention. Data were statistically analyzed to determine if there was a significant difference between the intervention and control groups' change in balance and walking speed scores.

When initially proposing this study we had planned to also look at the effects of the T'ai Chi intervention on MOS SF-36 quality of life questionnaire scores. Unfortunately, due to institutional and time constraints, we were unable to procure the MOS SF-36 for use in our study. Thus, we were unable to look at quality of life related to exercise interventions.
MOS SF-36 for use in our study. Thus, we were unable to look at quality of life related to exercise interventions.

**Subject Selection**

Life care communities' directors and physical therapists were contacted regarding their willingness to participate in this study. A life care community is an elderly residential community that consists of independent living facilities and assisted living facilities. A written proposal and a videotape of the proposed T’ai Chi intervention were sent out to facility directors who expressed interest in the study. Based on directors' interest and availability of subjects, one facility (Porter Hills Retirement Community) was selected as a site for this study. Therefore, this study was based on a sample of convenience and subject participation was voluntary.

Assistance of the Activity Director(s) at the selected life care community was requested in subject recruitment. During the subject recruitment phase, residents were invited to an informational meeting regarding the study via verbal and written advertisement. The purpose and significance of the study, safety precautions, required medical approval, participant time requirements, confidentiality, and the need for volunteers was discussed at this meeting. A videotape introducing T’ai Chi was also presented.

During the information meeting, interested individuals filled out a health questionnaire (Appendix A) and a Modified Lawton-Brody Self Report (MLB-SR) (Appendix B) functional assessment (Lawton & Brody, 1969; Lawton, 1971). The data gathered on MLB-SR was used by the researchers to describe the subject population in
terms of functional ability (Lawton, 1971). The researchers assisted individuals with filling out the forms upon request. Responses on the health questionnaire and the MLB-SR were used to exclude volunteers with health problems that made them inappropriate for participation in this study. Exclusion criteria for subjects based on health questionnaire responses were as follows (Wolfson et al., 1996):

1. No medical history of previous neurologic disease including: Huntington’s Chorea, Parkinson’s Disease, traumatic brain injury, cerebral vascular accident, or a progressive neurological disorder.
2. No debilitating arthritis, recent lower limb surgery resulting in physician ordered range of motion limitations, or an acute musculoskeletal dysfunction.
3. No serious cardiac problems or uncontrolled hypertension.
4. No current metastatic cancer.
5. No use of medication that may cause vertigo or serious balance problems.
6. No reported symptoms of shortness of breath, dizziness or chest pain with daily activities.
7. Unable to walk 75 feet without assistance.
8. Unable to perform 3 or more Basic Activities of Daily Living (ADL’s on Self - Maintenance Scale of MLB-SR).

During the informational meeting, interested volunteers who were not excluded based on their health questionnaire responses and the MLB-SR were asked a few questions adapted from the Mini Mental Screening Examination (Appendix C). These questions involved orientation and a three step command. Any volunteer who was unable
to answer one of the two orientation questions or perform the three step command, after it had been repeated three times, was excluded from the study as his or her inability to follow directions may have interfere with participation in the exercise intervention.

Volunteers not excluded based on their responses to the orientation questions, filled out a personal informed consent form (Appendix D) and were given a one hour pre-screening appointment.

Pre-screening appointments were held in a private room within the life care community. During the pre-screening appointments, the volunteers were asked a series of questions regarding current activity level, co-morbidities, and visual and hearing impairments (Appendix E). Then each volunteer was assessed using the Berg Balance Scale (Appendix F). Volunteers who scored below 31 on the Berg were excluded from this study as their balance deficits made them too frail for our T’ai Chi intervention (Thorbahn & Newton 1996). All qualified individuals who were not excluded from joining in the study based on their Berg Balance Scale performance were given self-selected and maximum walking velocity tests. If a potential subject used an assistive device, such as a cane, walker, or brace, during the majority of their basic ADL’s, he or she was allowed to use the assistive device during the Berg Balance Scale and gait velocity assessments.

The names of all potential subjects were submitted to and reviewed by the Porter Hills medical staff and activities directors. In response to this submission the Porter Hills facility recommended that further medical consent by a personal physician not be required as the recruited volunteers were all healthy, independently functioning.
individuals who had given informed personal consent to participate in the study. This recommendation was approved by the Grand Valley State University Human Subjects Review Committee (Appendix G).

**Procedures**

Subjects randomly selected for the intervention group were instructed verbally and in writing as to location, time and dates for the 45-minute, bi-weekly T’ai Chi group intervention. The use of bi-weekly, 45-minute intervention session was recommended by our T’ai Chi instructor based on his experience working with elderly T’ai Chi practitioners. A similar bi-weekly intervention time frame was also used by the authors of the Atlanta FICSIT (Wolfson et al., 1996). All T’ai Chi classes were held in a community room within the life care facility. The classes were led by a T’ai Chi instructor with three years of training and experience instructing elderly individuals in the Five Family Style form of T’ai Chi. The T’ai Chi group exercise classes were 45 minutes in duration, consisting of: (a) three to five minute warm-up and breathing exercises, (b) 25 minutes of T’ai Chi exercises performed in standing, and (c) a three to five minute cool down. Music was played during the exercise session. Each week, four new T’ai Chi exercises were introduced and the components practiced individually. After practicing each move separately, all four exercises were incorporated into a form with slow transitions between each exercise. The T’ai Chi instructor clearly explained that subjects were not expected to learn all the moves right away. Emphasis was placed on a slow and gradual development of competency in each exercise. Subjects were frequently reminded to do only as much as they can at their own pace. A total of ten T’ai Chi exercises was
used during the 6-week intervention (See exercises in Appendix H). If a subject used an assistive device, such as a cane, walker, or brace, during the majority of their basic ADL's, he or she was allowed to use the assistive device during the T'ai Chi intervention. During each of the T'ai Chi classes, attendance was taken (Appendix I). Subjects that attended at least 60% of the classes (7 out of the 12 classes) were included in the analysis of the study's results. In addition, the progress of each subject was monitored and recorded weekly by the T'ai Chi instructor (Appendix J).

All subjects in T'ai Chi group were instructed on the exercise warning signs (Appendix K) and safety precautions during the first exercise session. The T'ai Chi instructor and researcher monitored subjects for any signs and symptoms of fatigue or over-exertion during all exercise sessions. No subjects experienced any symptoms requiring medical attention during the T'ai Chi intervention. A chair was provided, placed within two to three feet behind each participant, during all intervention sessions. Participants were instructed to sit down and rest whenever they needed to during the exercises. Participants were also instructed to perform the T'ai Chi movements in a sitting position if they preferred. Subjects were encouraged to practice the T'ai Chi forms twice a week on their own at home.

Subjects in the control group were instructed to continue their daily activities as usual. These control subjects were also requested not to participate in any new exercise activities until the conclusion of the study. At the end of the six-week study all control group subjects were invited to join a T'ai Chi class provided by the Porter Hills Retirement Community.
using the Berg Balance Scale, and gait velocity has been shown to be an effective screening tool for community-dwelling elderly at risk for falling and functional decline. This combination had the highest sensitivity (91%) when compared to Tinetti POMA Balance Scale and the Tinetti Falls Efficacy Scale and combinations of these four screening tools (Harda, Chiu, Fowler, et al., 1995). Therefore in our study, we choose to use a combination of the Berg Balance Scale and both self-selected and maximum gait velocity to assess the effects of T’ai Chi on functional balance and walking. Examiners for the balance and gait assessments were blinded to the group assignment. Pre-testing of both intervention and control group subjects was completed at least one week before the T’ai Chi intervention and post-testing was done within one week after the conclusion of the intervention.

To determine inter-rater reliability, each rater was asked to individually view and score a videotaped recording of three geriatric individuals and a live presentation of three geriatric individuals performing the Berg Balance Test. Rater scores were statistically compared using an Intra-class Correlation coefficient to assess inter-rater reliability. An inter-rater reliability of \( r = 0.90 \) or greater is considered acceptable (McEwen, 1996).

Previous research has examined exercise intervention effects on both self-selected gait velocity, the speed at which a person normally walks, and maximal velocity, the speed at which a person can walk without running (Judge, Underwood, et al., 1993). Because of the importance of maximal walking speed in activities such as crossing the street, and use of self paced walking velocity in everyday activities, we decided to include both gait measures in our study. A standardized set of instructions was used for self-selected and maximum gait velocity tests (Appendix L). A single rater measured and
speed at which a person can walk without running (Judge, Underwood, et al., 1993). Because of the importance of maximal walking speed in activities such as crossing the street, and use of self-paced walking velocity in everyday activities, we decided to include both gait measures in our study. A standardized set of instructions was used for self-selected and maximum gait velocity tests (Appendix L). A single rater measured and recorded all gait velocity trials. During the gait velocity testing, subjects were asked to stand at one end of a thirteen-meter carpeted, level walkway. A starting line, three-meter line, and finish line were clearly marked with tape on the floor. For both self-selected and maximum tests, the first three-meters were not timed, in order to allow the subject to reach normal walking speed. A ten-meter distance was then timed with a stopwatch by the examiner. Subjects performed three trials of walking for both the self-selected and maximum gait velocity tests. They were allowed a two-minute standing rest between each trial. No subjects required a seated rest between trials. No subjects used an assistive device during the walking trials. Any trials in which the subject tripped, stumbled or did not maintain steady walking speed was not used for study analysis. The average speed of three walking trials was calculated (m/sec) and recorded.

**Data Analysis**

This study used a pre-test/post-test experimental design to compare intervention and control groups' scores on the Berg Balance Scale, and self-selected and maximal gait velocity. Descriptive statistical group means and standard deviations for pre-test and post-intervention scores on the Berg Balance Scale, and self-selected and maximum gait
velocity tests were calculated. These mean scores were then used for further data analyses on group comparisons.

**Efficacy of T'ai Chi on Functional Balance and Walking Speed Scores**

Pre-test and post-test data collected on the Berg Balance Scale, and self-selected and maximum gait speed tests were analyzed using an Analysis of Covariance (ANCOVA) statistical technique to determine if significant mean differences in the change in functional balance and walking speed outcomes were present between the T'ai Chi intervention and control groups. We choose an ANCOVA because it allowed us to statistically adjust for extraneous pre-existing differences between the control and intervention group such as age, sex, balance scores, pre-activity levels and functional status scores. This statistical test allowed the effect of the independent variable to be seen more clearly. We predicted that our T'ai Chi intervention would result in significantly different change in Berg Balance Scores, and self-selected and maximum gait speed scores from pre-test to post-test in the intervention group as compared to the control group.

**Efficacy of T’ai Chi on Balance and Gait Velocity in Near-Frail Vs. Well-Elderly:**

Intervention subjects were separated into near-frail and well-elderly groups, as defined earlier (page 11), based upon their self-reported responses on the Modified Lawton Brody Self Report (MLB-SR). The subjects’ average Berg Balance scores, and self-selected and maximum gait speed scores, pre-test and post-test data, were then analyzed using an ANCOVA to determine if significant differences were present between the near-frail and well-elderly subjects who participated in the T’ai Chi intervention. We choose an ANCOVA based on the reasons stated above. We predicted that our near-frail
subjects who participated in a T’ai Chi intervention would demonstrate a significant
different change in Berg scores, and self-selected and maximal gait speed scores when
compared to the well elderly subjects who participated in a T’ai Chi intervention.
CHAPTER 4

RESULTS

The purpose of this study was to explore the efficacy of a six-week, bi-weekly, T’ai Chi intervention on functional balance and self-selected and maximum gait velocity in near-frail and well-elderly individuals. Pre-test and post-test measures on the Berg Balance Scale and on gait velocity timed with a stopwatch were used to determine balance and gait velocity outcomes.

Subject Characteristics

Twenty-six individuals from the Porter Hills Retirement Community met the required inclusion criteria to become subjects. Subjects characteristic data are summarized in Table 1. At the beginning of the study, 14 subjects were placed in the control group and 12 subjects in the experimental group. At the time of post-testing, 22 subjects remained, 10 in the experimental group and 12 in the control group. Three subjects did not complete the study secondary to illness. An additional subject dropped out due to a lack of interest in the T’ai Chi intervention. The mean age of our subject pool was 85 years old with an age range of 77-95 years old. Sixteen subjects were classified as well elderly and six subjects were classified as near-frail, all of which were female. Overall, our subjects were active elderly with walking velocity faster than average for their age group. Only 14% of our subjects reported that they did not exercise regularly. In addition our subject pool reported very few pre-morbid conditions. (See Table 1).
Table 1

Summary of Subject Characteristics

<table>
<thead>
<tr>
<th>Subject Characteristics</th>
<th>Intervention Group (n=10)</th>
<th>Control Group (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>x = 83.6</td>
<td>x = 86.08</td>
</tr>
<tr>
<td></td>
<td>SD = 4.54</td>
<td>SD = 5.96</td>
</tr>
<tr>
<td>Female</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Well Elderly</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Near-Frail Elderly</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Activity Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent Vigorous Exercise</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Frequent Long Walker</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Frequent Short Walker</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>No Regular Exercise</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Berg Pre-Test</td>
<td>x = 49.7</td>
<td>x = 48.4</td>
</tr>
<tr>
<td></td>
<td>SD = 3.34</td>
<td>SD = 3.96</td>
</tr>
<tr>
<td>Self-Selected Gait Velocity</td>
<td>x = 1.17 m/s</td>
<td>x = 1.09 m/s</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>SD = 0.23</td>
<td>SD = 0.19</td>
</tr>
<tr>
<td>Maximum Gait Velocity</td>
<td>x = 1.61 m/s</td>
<td>x = 1.50 m/s</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>SD = 0.47</td>
<td>SD = 0.38</td>
</tr>
<tr>
<td>Co-Morbidity Diagnosis</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>(arthritis, angina, knee replacements)</td>
<td>(arthritis, angina, fibromyalgia, psoriasis, osteoporosis)</td>
</tr>
</tbody>
</table>
Inter-rater Reliability

Four certified physical therapists were used as raters for the Berg Balance Scale both for pre-testing and post testing. Prior to the pre-testing session, each rater was asked to individually view and score a videotaped recording of three geriatric individuals and a live presentation of three geriatric individuals performing the Berg Balance Scale test. All of the raters Berg Balance Scale scores were then statistically compared using an Intra-class Correlation coefficient to assess inter-rater reliability ($r= 0.91$). This score of 0.91 reflects high inter-rater reliability (McEwen, 1996).

The Relationship of the Changes in Berg Balance Scores Intervention Vs. Control Group

We predicted that our T’ai Chi intervention would result in significant change in Berg Balance Scale scores, pre-test to post-test, in the intervention group as compared to the control group. The mean change in Berg Balance scores for the intervention group was 1.30 with a standard deviation of 3.20. Likewise, the mean change in Berg Balance scores for the control group was 1.33 with a standard deviation of 2.53. No statistical significance was found between the intervention and control groups’ mean change in Berg Balance Scale scores at post-testing ($\alpha = .05$, $p = .433$). The ANCOVA results also indicate no significant effect of the covariants on the changes of Berg Balance scores pre-test and post-test. In the graphical representation of this data, (Figure 1) it appears that both the intervention group and the control group have a trend toward improvement on the Berg Balance Scale at post-test. There was, however, no significant difference in the degree of improvement between intervention and control group. A summary of ANCOVA statistical results for Berg data for each covariant can be found in Table 2.
Table 2
Effect of Covariants on Changes of Berg Balance Scores from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Covariant</th>
<th>ANCOVA (significance of p) $\alpha=.05$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$p \leq .05$ indicates the covariant has significant effect on Berg Scores.</td>
</tr>
<tr>
<td>Change in Berg Score, Pre-test to Post-test</td>
<td></td>
</tr>
<tr>
<td>(Control vs. Intervention Group)</td>
<td>$p = .433$</td>
</tr>
<tr>
<td>Gender</td>
<td>$p = .775$</td>
</tr>
<tr>
<td>Age</td>
<td>$p = .715$</td>
</tr>
<tr>
<td>Pre-Activity Level</td>
<td>$p = .125$</td>
</tr>
<tr>
<td>Frailty</td>
<td>$p = .253$</td>
</tr>
<tr>
<td>Pre-test Gait Velocity (Self-selected)</td>
<td>$p = .670$</td>
</tr>
<tr>
<td>Post-test Gait Velocity (Self-selected)</td>
<td>$p = .225$</td>
</tr>
<tr>
<td>Pre-test Gait Velocity (Maximal)</td>
<td>$p = .432$</td>
</tr>
<tr>
<td>Post-test Gait Velocity (Maximal)</td>
<td>$p = .975$</td>
</tr>
</tbody>
</table>

Note. Represented are the effects of covariants on changes in of Berg Balance scores from pre-test to post-test. The statistical values of $p$ represent a lack of significant effect of each covariant.
Figure 1. Change in mean Berg Balance scores pre-test to post-test for the intervention vs. the control group. Statistical analysis of the data indicate no significant difference in change in Berg scores.
The Relationship of the Changes in Gait Velocity Scores Between the Intervention and Control Groups

Self-Selected Gait Velocity

We predicted that our T’ai Chi intervention would result in significant change in self-selected gait velocity pre-test to post-test in the intervention group as compared to the control group. The mean change in self-selected gait velocity for the intervention group was 0.00 with a standard deviation of 0.10. Likewise, the mean change in self-selected gait velocity for the control group was 0.01 with a standard deviation of 0.08. No statistical significance was found between the intervention and control groups’ mean change in self-selected gait velocity at post-testing ($\alpha = .05$, $p = .765$). The ANCOVA results also indicate that the covariants had no significant effect on the self-selected gait velocity. In the graphical representation of this data, (Figure 2) no change is observed in the intervention and control groups’ self-selected gait velocity at post-testing. (Note: this figure maybe potentially misleading because the graph does not start at zero.) There was no significance difference in the degree of improvement between the intervention and control group. A summary of the ANCOVA results for self-selected gait velocity can be found in Table 3.
Table 3

The Effect of Covariants on Changes in Self-Selected Gait Velocity from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Covariant</th>
<th>ANCOVA (significance of p) α=.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Self-Selected Gait Velocity, Pre-test &amp; Post-test (Control vs. Intervention)</td>
<td>p = .765</td>
</tr>
<tr>
<td>Gender</td>
<td>p = .375</td>
</tr>
<tr>
<td>Age</td>
<td>p = .537</td>
</tr>
<tr>
<td>Pre-Activity Level</td>
<td>p = .660</td>
</tr>
<tr>
<td>Frailty</td>
<td>p = .769</td>
</tr>
<tr>
<td>Pre-Test Berg Balance Score</td>
<td>p = .788</td>
</tr>
<tr>
<td>Post-Test Berg Balance Score</td>
<td>p = .379</td>
</tr>
<tr>
<td>Pre-Test Gait Velocity (Maximal)</td>
<td>p = .980</td>
</tr>
<tr>
<td>Post-Test Gait Velocity (Maximal)</td>
<td>p = .770</td>
</tr>
</tbody>
</table>

Note. Represented are the effects of covariants on changes in self-selected gait velocity from pre-test to post-test. The statistical values of p represent a lack of significant effect of each covariant.
Figure 2. Change in mean self-selected gait velocity pre-test to post-test for the intervention group vs. control group. Statistical analysis of the data indicate no significant difference in change in self-selected gait velocity.
Maximal Gait Velocity

We predicted that our T’ai Chi intervention would result in significant change in maximal gait velocity pre-test to post-test in the intervention group as compared to the control group. The mean change in maximal gait velocity for the intervention group was 0.17 with a standard deviation of 0.19. The mean change in maximal gait velocity for the control group was 0.00 with a standard deviation of 0.13. No statistical significance was found between the intervention and control groups’ mean change in maximal gait velocity at post-intervention ($\alpha = .05$, $p = .472$). The ANCOVA results also indicated that the covariants had no significant effect on the maximal gait velocity scores. Through visual analysis of the scores, it appears that the intervention group had a slight trend towards improvement in maximal gait velocity at post-testing. On the other hand, there was no notable change observed in the control group’s maximal gait velocity at post-testing. Again, this figure is potentially misleading because the graph does not start at zero. A summary of the ANCOVA results for maximal gait velocity data can be found in Table 4. A graphical representation of these results can be found in Figure 3.
Table 4

The Effect of Covariants on Changes in Maximal Gait Velocity from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Covariant</th>
<th>ANCOVA (significance of p) ( \alpha = 0.05 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in Maximal Gait Velocity, Pre-Test to Post-Test (Control Vs. Intervention)</td>
<td>( p = 0.472 )</td>
</tr>
<tr>
<td>Gender</td>
<td>( p = 0.715 )</td>
</tr>
<tr>
<td>Age</td>
<td>( p = 0.547 )</td>
</tr>
<tr>
<td>Pre-Activity Level</td>
<td>( p = 0.935 )</td>
</tr>
<tr>
<td>Frailty</td>
<td>( p = 0.522 )</td>
</tr>
<tr>
<td>Pre-Test Berg Balance Score</td>
<td>( p = 0.218 )</td>
</tr>
<tr>
<td>Post-Test Berg Balance Score</td>
<td>( p = 0.555 )</td>
</tr>
<tr>
<td>Pre-Test Gait Velocity (Self Selected)</td>
<td>( p = 0.434 )</td>
</tr>
<tr>
<td>Post-Test Gait Velocity (Self Selected)</td>
<td>( p = 0.828 )</td>
</tr>
</tbody>
</table>

Note. Represented are the effects of covariants on changes in maximal gait velocity from pre-test to post-test. The statistical values of \( p \) represent a lack of significant effect of each covariant.
Figure 3. Changes in mean maximal gait velocity pre-test to post-test for the intervention vs. the control group. Statistical analysis of the data indicate no significant difference in change in maximal gait velocity.
We predicted that our near-frail intervention group would demonstrate a significant difference in the change of Berg Balance Scores, self-selected and maximal gait velocity, pre-test to post-test, as compared to the well elderly intervention group. Dividing the intervention group into near-frail and well elderly sub-populations resulted in very small sample sizes. Our near-frail sub-population consisted of three subjects and the well elderly sub-population consisted of seven subjects. The mean change in Berg Balance scores pre-test and post-test for the near-frail intervention group was 2.00 with a standard deviation of 1.00. The mean change in Berg Balance scores pre-test and post-test for the well elderly intervention group was 1.00 with a standard deviation of 3.83. The mean change in self-selected gait velocity pre-test and post-test for the near-frail intervention group was 0.00 with a standard deviation of 0.08. Likewise, the mean change in self-selected gait velocity pre-test and post-test for the well elderly intervention group was -0.01 with a standard deviation of 0.12. The mean change in maximal gait velocity pre-test and post-test for the near-frail intervention group was 0.13 with a standard deviation of 0.17. The mean change in maximal gait velocity pre-test and post-test for the well elderly intervention group was 0.19 with a standard deviation of 0.20. No statistical significance was found between our near-frail and well elderly groups' change Berg Balance Scale scores ($\alpha = .05, p = 1.0$), self-selected gait velocity scores ($\alpha = .05, p = 1.0$) and maximal gait velocity scores ($\alpha = .05, p = 1.0$) at post-testing. The ANCOVA results indicate no significant effect of the covariants on our balance scores and gait.
near-frail’s Berg Balance Score had a trend towards improvement at post testing. In addition, there was no change observed in either the well elderly’s or the near-frail’s self-selected and maximal gait velocity at post-testing. A summary of the ANCOVA results for the near-frail vs well elderly data can be found in Table 5. Graphical representations of these results can be found in Figures 4, 5 and 6.

**Assumptions of the ANCOVA**

Because the ANCOVA is a parametric test, several assumptions needed to be met. Three assumptions were addressed to ensure that a valid analysis of our data was made. Based on statistical analysis through the Levine Test our data met the assumption of homogeneity of variance. A graphical display comparison to a normal Bell curve demonstrated that our data met the assumption of reasonable normality. Finally, based upon linear regression analysis of our data, the assumption of parallelism has been satisfied.
Table 5

Effect of Covariants on Change in Berg Balance Scores and Gait Velocity in Near-Frail and Well Elderly Intervention Subjects

<table>
<thead>
<tr>
<th>Covariate</th>
<th>ANCOVA (significance of p) $\alpha=.05$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in Self Selected Gait Velocity, Pre-</td>
<td></td>
</tr>
<tr>
<td>Test to Post-Test, (NF Vs. WE Intervention)</td>
<td>p = 1.0</td>
</tr>
<tr>
<td>Change in Maximal Gait Velocity, Pre-</td>
<td></td>
</tr>
<tr>
<td>to Post-Test, (NF Vs. WE Intervention)</td>
<td>p = 1.0</td>
</tr>
<tr>
<td>Change in Berg Balance Scores, Pre-</td>
<td></td>
</tr>
<tr>
<td>to Post-Test, (NF Vs. WE Intervention)</td>
<td>p = 1.0</td>
</tr>
<tr>
<td>Gender</td>
<td>p = .386</td>
</tr>
<tr>
<td>Age</td>
<td>p = .178</td>
</tr>
<tr>
<td>Pre-Activity Level</td>
<td>p = .224</td>
</tr>
<tr>
<td>Frailty</td>
<td>p = .297</td>
</tr>
</tbody>
</table>

Note. Represented are the effects of covariants on changes in Berg scores and gait velocity from pre-test to post-test in the near-frail and well elderly intervention group subjects. The statistical values of p represent a lack of significant effect of each covariant. NF = near-frail elderly; WE = well elderly
Statistical analysis of the data indicate no significant difference in change in Berg scores.
Figure 5. Change in self-selected gait velocity pre-test to post-test for near-frail & well elderly in the intervention group. Statistical analysis indicates no significant difference in change in self-selected gait velocity.
**Figure 6.** Change in maximal gait velocity pre-test to post-test for near-frail & well elderly in the intervention group. Statistical analysis indicates no significant difference in change in maximal gait velocity.
Trends Discovered Through Descriptive Analysis

A Trend in a Berg Balance Scale Task

Although there was no statistical significance noted in the Berg Balance Scores of the intervention group versus the control group, the raw data was examined to note any trends that may have existed. No trend was found when examining the changes in the Berg of the intervention group versus the control group. In fact, while the intervention group demonstrated either an increase or stabilization in their Berg score after the intervention, 50% of the control group demonstrated a decline in their Berg Score. The other 50% of the control group demonstrated an increase or stabilization in their Berg Score similar to the experimental group. A trend was noted, however, when considering individual tasks on the Berg Scale. A trend in our data was found when analyzing the bilateral weight shifting with forward reaching task (item number eight on the Berg Balance Scale). The forward reaching task was examined because many of the T’ai Chi postures incorporated this bilateral weight shifting movement pattern. A number of subjects, four in the intervention and two in the control group, received the highest possible score during both pre-testing and post-testing on this task. We eliminated these six subjects who displayed “ceiling effect” on this task and examined if any trends in the remaining subject pool existed. In the intervention group, 66.7% demonstrated an improvement of one point in the forward reaching task, 16.7%, (one subject) maintained the same score, and 16.7% demonstrated a one point drop in the forward reaching score. In the control group, 40% demonstrated an improvement of one point in the forward reaching task, 30% (3 subjects) maintained the same score, and 30% demonstrated a one or two point decline in the forward reaching task. Therefore, when considering the
task. Therefore, when considering the individual task of bilateral weight shifting with forward reaching on the Berg Balance Scale, a majority of the subjects in the intervention group demonstrated an improvement in score on that task when compared to the control group.

A Trend in Gait Velocity

Another interesting finding was discovered when comparing our subjects’ self selected and maximal gait velocity scores to published normative data for gait velocity in the elderly. Subjects in this study walked considerably faster than the average normative speeds established for elderly persons of a similar age. Established norms for self selected walking speed in women (age 79) is 0.92 m/s, and 1.03 m/s for men (age 79) (Lundgren-Lindquist, Aniansson, & Rundgren, 1983). All of the subjects in our study walked at a pace equal to or faster than these established norms.

Established norms for maximal walking speed in women (age 79) is 1.18 m/s, and 1.43 m/s for men (age 79) (Lundgren-Lindquist, et al., 1983). Most of our subjects walked equal to or faster than these established norms. Three of our subjects (one in the exercise group and two in the control group) walked notably slower than the established norms for maximal walking speed. While examining the change in gait velocity of the three subjects with “slower than average” gait velocities, only the subject in the exercise group showed an improvement in gait velocity.

No further trends were discovered through the comparative analysis of the self selected and maximal gait velocity scores and subjects’ pre-activity levels. Additionally, no trends were found through comparing the subjects’ balance scores and subjects’ pre-activity levels.
CHAPTER 5
DISCUSSION

Research Summary

This study was guided by the following three research questions: (1) Will a bi-weekly, six-week, T’ai Chi intervention have an effect on balance of elderly individuals as compared to a group of non-exercising elderly subjects?; (2) Will a bi-weekly, six-week, T’ai Chi intervention have an effect on self-selected and maximal gait velocity of elderly individuals as compared to a group of non-exercising elderly subjects?; and (3) Will there be a difference in the change of Berg Balance Scores and walking velocity from pre-test to post-test for functionally defined, near-frail subjects who participate in a T’ai Chi exercise intervention as compared to well elderly subjects who participate in a T’ai Chi exercise intervention?

Discussion of Findings related to the Hypotheses

Exercise Intervention Effect on Berg Balance Scores

Both the intervention and control groups displayed an increase in Berg Balance Scale scores during post-testing. However, no statistically significant difference was found in the change in Berg Balance Scale scores between the intervention and control groups. As reported earlier, the mean change in Berg scores was 1.30 with a standard deviation of 3.68 for the intervention group. The mean change in Berg scores was 1.33 with a standard deviation of 2.53 for the control group.

Several factors may have contributed to the lack of statistical significance that was found between our intervention and control groups’ Berg Balance scores. A primary
factor that may have affected our results was our small sample size. With only 22 subjects, any individual scores that differed from the mean could have a large effect on the results. In this study, a few subjects had a change in the Berg scores that differed significantly from the group mean. This high variability was evident in the mean of our control group's Berg scores 48.4 with a standard deviation of 3.96 and the mean of our intervention groups' Berg scores 49.7 with a standard deviation of 3.34. High variability makes it difficult to find significant results because this variability can prevent general trends in data from being evident. Another factor influencing our findings may have been the short intervention time. Six weeks may have been an insufficient treatment duration to impact changes in balance functioning. An additional factor that may have contributed to the results was the researchers' inability to control physical or social activity outside of the T'ai Chi intervention classes or prior to re-testing. Several participants reported that they had participated in a social party prior to the post-testing, which may have adversely affected their balance scores. Therefore, these subjects' Berg Balance scores were probably not a true reflection of their functional balance.

Another factor that may explain the insignificant results is the researchers' lack of regulation of the control group's activity level during the intervention phase. Although the control subjects were told to maintain their previous level of activity, they may have increased their activity level because they knew they were in an "exercise study". If the subjects in the control group increased their daily activity, this may be one explanation for the trend in improvement in the Berg scores at post-testing for both the intervention and the control. Another explanation for the trend toward improvement is that subject's may have performed better on the post-test Berg Scale because they were familiar with
the Berg from pre-testing, and therefore felt more comfortable with the tasks and what
was expected of them. Likewise, another factor that may explain the lack of insignificant
results is that the researchers were unable monitor the T’ai Chi intervention group’s
activity outside of structured class time. Although, the intervention group was
encouraged to practice T’ai Chi daily, no daily log was used to record the frequency or
the intensity of T’ai Chi practice. In addition to the lack of control in monitoring the
frequency or the intensity of Tai Chi, the selected T’ai Chi exercises may not have been
challenging enough for the subjects of this study. Given the subjects’ high activity levels,
more difficult T’ai Chi exercises, such as single limb exercises, may have been more
appropriate to effectively challenge our subjects’ balance, thus potentially producing a
change in balance scores.

Several other factors that may explain our insignificant results related to the
measurement tools used in this study. One measurement factor is the decreased
sensitivity of the Berg Scale observed in our sample resulting from the ceiling effect.
One subject scored the maximum possible points on the Berg Scale during pre-testing.
Several other subjects scored greater than 95% of the maximum on the Berg Scale.
Because four subjects scored so high on the Berg Scale and one subject exhibited the
ceiling effect, this tool’s sensitivity was limited in measuring improvements of balance
for these five subjects, which was 23% of our sample. Another factor is that the Berg
Scale and gait velocity are outcome measures that are not task specific to the skills that
the T’ai Chi intervention emphasize. For example, T’ai Chi focuses on weight shifting in
bilateral stance and use of upper extremities; whereas the Berg Scale focuses on single
limb activities and transfer activities. Therefore, improvements in the exercise group may
have been shown if the outcome measures had been more task specific to the T'ai Chi training.

**Berg Inter-rater Reliability**

Although the overall inter-rater reliability ($r = 0.91$) for the Berg Balance Scale in this study was reflective of high consistency as reported earlier, some problems with inter-rater agreement on individual test items may have occurred due to individual raters’ interpretations of the Berg scoring criteria. For example, in item #10 on the Berg, subjects were instructed to “Turn to look over your shoulder.” Our raters disagreed on the scoring criteria for the actual performance of looking over the shoulder. Some of the raters believed that the subject had to weight shift, rotate the trunk, turn the shoulder, and then turn the head fully over their shoulder in a smooth, coordinated fashion in order to receive a full score of four points. Other raters, however, believed that the subject should receive four points for completing the weight shift without the trunk rotation component. The Berg scoring criteria does not clearly differentiate between these two different responses. Therefore, in order to minimize inter-rater error, prior to our initial testing the four raters agreed upon how they should interpret and score vaguely defined scoring criteria on several items on the Berg. Not all possible subject responses could be considered during this initial session. Therefore, the vaguely defined scoring criteria on the Berg may have resulted in some inter-rater error in this study.

**Exercise Intervention Effect on Gait Velocity Scores**

We predicted that our T'ai Chi intervention would result in significantly different changes in self-selected and maximal gait velocity in the intervention group as compared to the control group; however, no statistical significance was found. We suspect that a
number of unforeseen factors may have contributed to this result.

One factor influencing gait velocity results was exercise specificity; that is the T’ai Chi intervention involved no gait activities. All of the T’ai Chi exercises focused on weight shifting in bilateral stance with bilateral upper extremity use. It was expected that any changes in functional balance resulting from the T’ai Chi intervention would be reflected in the post-intervention gait velocity scores. The assumption that functional balance changes will be reflected in gait was made because gait velocity is considered to be a very sensitive measure of functional ability in the elderly. It is possible, however, that the lack of change in gait velocity outcomes is due to a lack of transfer effect from the T’ai Chi intervention to dynamic walking function.

An additional factor influencing gait velocity outcomes was that the majority of our subjects in our opinion, 86% in both the control and intervention group, were “regular walkers”. Regular walkers were those subjects who walked greater than three blocks three times a week. The impact of the subjects’ walking exercise may have had a much greater effect on their gait velocity outcomes than the T’ai Chi intervention, which was not task specific to gait activities.

A final key factor that may have influenced a lack of significant gait speed findings was the possible “ceiling effect” on gait speed in our particular sample. The majority of our elderly (mean age 85) subjects’ self selected and maximal gait velocities were considerably faster than average normative data for a younger, elderly population (mean age 79) (Lundgren-Lindquist et al., 1983). This fact may indicate that our sample was already at the top of their functional walking capacity before the study began, making it difficult to impact their gait velocity with our T’ai Chi intervention.
One interesting finding was the improvement in gait velocity gained by a single subject in the intervention group who pre-tested slower than the normative standards for maximal gait velocity. During post-testing, this intervention subject showed a notable improvement in maximal gait velocity (0.2 m/s). This single finding, while not statistically significant, suggests that T’ai Chi may have a greater impact on elderly persons with reduced functional walking speed compared to their age matched norms. Because the majority of our subjects demonstrated normal or better than normal, functional walking speeds, the impact of the T’ai Chi intervention on gait velocity may have been minimal in our particular sample.

A final factor that may have influenced our gait speed results was the use of only one rater to record all gait velocity data. The use of one rater was implemented into our study in order to eliminate any inter-rater error. However, the use of only one rater to both measure gait velocity and to guard the patient during the gait test, may have resulted in inaccuracy with the timing of gait velocity. The rater noted difficulty with the coordination of the guarding and timing activities, with the faster walkers.
The Impact of Frailty Level on Differences in Balance Scale and Gait Velocity Scores in Exercise Subjects

We predicted that our near-frail exercise group would demonstrate significantly different change in Berg Balance Scores, and self-selected and maximal gait velocity as compared to the well-elderly exercise group. However, no statistical significance was found between our near-frail and well elderly groups’ post-test scores. We suspect that both our small subject sample (near-frail n = 3, well elderly n = 7) and the method used for categorizing our subjects’ frailty may have contributed to this result.

An additional factor that may have affected our findings was the validity of our subjects’ frailty categorization. All potential subjects were required to fill out a Modified Lawton-Brody questionnaire, which was given a in self-assessment format. The directions for the questionnaire clearly stated the subjects should only mark the activity responses they actually currently performed, such as cooking meals and doing laundry. Unfortunately, a number of our subjects marked the activities they felt they could still do, rather than what they actually did. For example, when asked whether they plan, prepare and serve their own meals independently, a number of subjects, who had all meals prepared for them by the Porter Hills staff, marked that they were independent in this category. Thus, a number of our subjects ranked themselves higher than their actual activity level. As a result, these subjects were placed at a higher functional level. Clearly a one-on-one interview format, with the researcher determining the appropriate functional activity level, would have been a more accurate way to categorize subjects’ frailty level.

A Comparison of Findings to Previous T’ai Chi Studies

Wolf et al. (1997) found that T’ai Chi did not improve balance platform measures
of postural stability, but did decrease fear of falling. In an earlier study by Wolf et al., (1996) the T’ai Chi exercise group demonstrated a reduction in the rate of falls, a decrease in walking speed and a decrease in fear of falling. Judge et al., (1993) found that T’ai Chi and balance training combined with resistive exercises was effective in significantly improving self selected gait velocity by 8% and maximal gait velocity by 4% in the exercise group. In our study, however, subjects did not demonstrate a statistically significant change in walking speed, nor did they demonstrate a significant change in Berg Balance Scores. There are several factors differentiating our study from these other researchers’ studies that may have resulted in our subjects’ lack of walking speed and balance changes.

The sample size in our study and the sample characteristics were significantly different from the aforementioned T’ai Chi studies. Wolf’s et al. earlier study (1996) was comprised of 200 elderly living independently in the community and assisted living facilities. Wolf’s et al. 1997 study included 72 elderly subjects residing in assisted living facilities. The Judge et al. (1993) study was comprised of 110 community dwelling elderly subjects. In contrast, our study included only 22 subjects residing in both independent and assisted living facilities. This difference in sample size and sample characteristics between our study and other T’ai Chi researchers may account for our different results. As noted earlier any significant deviations from the mean in an individual subject’s score may have had a significant impact on our research results due to our small and variable sample.

Another contrasting factor between this study and the aforementioned T’ai Chi studies is that our sample was made up of a group of very physically active elderly
individuals. Only three subjects, less than 14%, of our sample reported a pre-study activity level involving no regular exercise. Of the remaining subjects, 36% were frequent short walkers, 27% were frequent long walkers and 23% were frequent vigorous exercisers. Additionally, the majority of our subjects were faster than average walkers. Wolf's et al. (1996) sample included both active and sedentary individuals; however, gait velocity with this sample was not discussed. Wolf's et al. (1997) study cohort was made up of the relatively inactive sub-sample taken from his 1996 study. Wolf et al. (1997) reported that these subjects tended to be sedentary and were reluctant to leave their rooms to participate in any social events or physical activities. The pre-study activity level of subjects in Judge's et al. (1993) study was not explicitly stated. The difference in pre-activity levels and pre-intervention gait velocity scores between our study and Wolf's et al. study (1996, & 1997) may account for our different results. As noted before, the impact of our subjects' high pre-activity level and fast pre-intervention gait velocity may have resulted in a "ceiling effect" in gait speed in our particular sample, making the detection of gait velocity improvements difficult.

The duration of the intervention phase is yet another significant difference between our study and previous T'ai Chi studies. In Wolf's et al. studies (1996 & 1997), the T'ai Chi intervention consisted of one hour, bi-weekly classes for fifteen weeks. Judge et al. (1993) incorporated approximately 5 to 10 minutes of T'ai Chi exercises into a one hour, once a week exercise intervention for thirteen weeks. In contrast, our T'ai Chi intervention consisted of bi-weekly, one hour, T'ai Chi classes for only six weeks. The weekly progress notes of our T'ai Chi instructor indicated that the majority of subjects took 5 weeks to begin to demonstrate confident movement in the T'ai Chi
patterns. This observation may reflect that it takes time for the elderly to begin to feel comfortable with the new motor patterns that are practiced in T’ai Chi. It is possible that the elderly may not be willing to challenge their balance with new activities until after they feel comfortable with those activities. Therefore, the longer fifteen week T’ai Chi intervention, used in Wolf et al. (1996 & 1997) studies, may have allowed their elderly subjects to gain confidence in the T’ai Chi movement patterns, and challenge themselves and their balance with the T’ai Chi exercises. The subjects in our study, however, may have only had enough time to begin to feel comfortable with the T’ai Chi movement patterns.

Another contrasting factor between this study and previous T’ai Chi studies is in the comparison of balance measures and selected outcomes. In Wolf et al. (1997) postural sway of a T’ai Chi intervention group and a balance platform training group were compared using force platform measures. Wolf et al. (1997) reported that after intervention, the T’ai Chi group did not improve in postural stability on the balance platform instrument, which is a highly sensitive measure for changes in postural sway. These results are similar to our results, in that no significant differences in balance were noted. Wolf et al. concluded that the T’ai Chi intervention actually caused an increase in postural instability in quiet standing. Critics of the Wolf et al. study suggest that measuring sway in quiet stance is not an accurate indicator of postural stability during daily activities (Horak, 1997). In contrast, our selected outcome measure, the Berg Balance Scale, has been supported as a sensitive measure of functional balance in the elderly by the literature (Berg, Dauphinee, et al. 1992, & Harada, Chiu, Damon-Rodriquez, et al. 1995). This measure of dynamic balance in our study did not detect
significant change in balance post-T’ai Chi intervention.

Findings from both our study and Wolf et al. study (1997) suggest that balance training should be task specific for the particular balance problem (Horak, 1997). The balance platform measures used in Wolf et al. (1997) were task specific to the computer balance trained exercise group, but not to the T’ai Chi exercise group. Not surprisingly, the Wolf et al. (1997) results revealed a statistically significant improvement in postural stability in the computer balance trained group, but not in the T’ai Chi group. Similarly, in our study, all of the ten T’ai Chi exercises performed by our subjects were task specific to one skill (item number eight, forward reaching in bilateral stance) on the Berg Balance Scale. While our balance results were not statistically significant, our T’ai Chi subjects did demonstrate a trend toward improvement on this task specific skill. This trend emphasizes the point that consideration of more task specific outcome measures based upon the type of T’ai Chi intervention, should be a considered in future research.

An additional finding reported in Wolf et al. (1996 & 1997) studies was that subjects in the T’ai Chi intervention group demonstrated a decreased fear of falling. In his conclusions, Wolf et al. (1997) suggested that while T’ai Chi was ineffective in decreasing postural sway, T’ai Chi facilitated increased confidence in movements requiring functional independence. Retrospectively, a fear of falling measure may have been beneficial to include in our study. Although our study did not include an outcome measure to assess subjects’ perception of fall risk, our researchers did receive many unsolicited anecdotal comments from our participants after the post-testing that reflected a perceived decreased fear of falling. Subject made comments such as “I am not as afraid of falling as I was before!” and “I am no longer afraid to pick up objects off of the floor.”
These anecdotal comments suggest that if a fear of falling measure had been used in this study, results similar to those of Wolf et al. (1996 & 1997), may have been found. Future researchers should make certain to include a fear of falling measure into T'ai Chi efficacy studies.

Wolf et al. (1996) also utilized the Center for Epidemiological Studies’ Depression Scale, a measure of psychosocial well being. Our study did not utilize a quality of life measure. In our research proposal, it was our intent to have our subjects fill out the MOS SF 36 quality of life measure as an outcome tool. However, secondary to a lack of funding, we were unable to include this outcome measure in our study. Although our study did not use the MOS SF 36 measure to consider the impact of T'ai Chi on quality of life, the researchers did receive many anecdotal comments from our participants, both during and after the post-testing, that reflected the intervention subjects’ perceived impact on quality of life issues. For example, one exercise subject remarked “After only two weeks of T’ai Chi, I am able to bend my neck and turn my head up to look at the ceiling. The pain from my arthritis has been cut in half.”. In addition, the majority of the subjects in the exercise intervention planned to continue the T’ai Chi exercises after the conclusion of the study. Moreover, a number of the control group subjects expressed interest in participating in the planned post-study T’ai Chi exercise class. The control subject stated, “I’m excited to finally get to participate in the T’ai Chi.” These type of subjective comments suggest that the use of the MOS SF 36 in our study may have allowed us to see an impact on quality of life resulting from the T’ai Chi intervention. These comments also suggests that perhaps T’ai Chi has more of an effect on the subjects’ sense of well being than on specific balance measures.
The Impact of T’ai Chi on Social Interaction

In addition to utilizing the MOS SF 36 to measure health status in our individual subjects, it was our intent to utilize the MOS SF 36 to measure social functioning. Attending group classes, such as T’ai Chi, allows the elderly to not only take part in a structured exercise group, but also provides an opportunity to interact with other people. In our study, the subjects in the T’ai Chi intervention group became very socially active with the group. Several of the intervention group members got together socially outside of the T’ai Chi classes to watch a video about T’ai Chi. Other intervention subjects shared music tapes with each other to practice their T’ai chi patterns outside of class. In addition, several of the intervention subjects reportedly met on a regular basis to practice T’ai Chi outside of class. No social interaction between control group members was reported during the intervention phase; although this social interaction was not formally monitored. This increased social interaction exhibited by the intervention group, however, demonstrates the need for a quality of life measure like the MOS SF 36 to assess this important aspect of quality of life. Future research evaluating the efficacy of a T’ai Chi exercise intervention in the elderly population should include a quality of life outcome measure, as this may reflect a change in the individuals’ well being as a result of the intervention.

Continuation of T’ai Chi Upon the Conclusion of This Study

Secondary to this research study being carried out at the Porter Hills Life Care Community, a number of residents in this community have become interested in participating in a T’ai Chi exercise group. As a result of this increased interest, Porter Hills hired the volunteer T’ai Chi instructor used in this experiment to conduct regular
T'ai Chi classes at their center. Since the conclusion of our study, a bi-weekly, T'ai Chi class has been offered to all of the Porter Hills residents, including the subjects (control and experimental) from this study.

Clinical Implications

A number of current research studies have demonstrated that long term T'ai Chi intervention provides a wide variety of physiologic and psychological benefits for the well elderly (Judge et al., 1995; Wolf et al., 1996; Wolf et al., 1997). In this study, due to time constraints, the researchers examined the efficacy of a short term T'ai Chi intervention on balance and walking speed in the well and near frail elderly. Unlike past studies which report beneficial effects of longer T'ai Chi interventions, the findings of this study suggest that a short term, bi-weekly, T'ai Chi intervention may not have an impact on functional balance and gait speed in the active elderly. T'ai Chi intervention programs of a longer duration, eight to twelve weeks, may be needed to determine benefits in client's functional balance. However, before the clinical usefulness of short term T'ai Chi interventions on balance and gait velocity can be clearly determined, a number of factors should be examined by clinicians. In our study, the participants were older, but very active and high functioning individuals. Clinicians should look at the efficacy of short term T'ai Chi exercise interventions on balance and gait velocity in more sedentary elderly. T'ai Chi may have a more profound impact on balance and gait velocity in the lower functioning, frail elderly population with slower than normative gait velocity. Clinicians developing clinical T'ai Chi interventions for fall prevention should also consider varying the intensity and duration of T'ai Chi exercises used. Perhaps short term T'ai Chi interventions of a greater intensity, such as three times a week or
daily, would have an impact on functional outcomes in the elderly.

One other clinically relevant trend revealed in this study and in Wolf et al. (1997) study is that task specific balance training impacts specific balance problems. Clinicians should consider the possible clinical use of task specific T’ai Chi in fall prevention intervention to train for specific balance problems, such as instability during activities requiring single leg support. A T’ai Chi intervention specifically designed to train for enhancing postural stability and confidence in positions of unilateral stance may be clinically useful in fall prevention.

Although this study did not reveal any statistically significant benefits, a number of subjective improvements were reported by the participants. These subjective improvements included a decreased fear of falling, increased functional use of upper extremities, an increased ability to pick up objects off the floor, and finally decreased symptoms of arthritic pain. These subjective outcomes suggest that T’ai Chi may be useful clinically as prevention program to decrease fear of falling and to increase quality of life in the elderly. Decreasing fear of falling in the elderly directly impacts their functional decline, as elderly individuals who are not afraid of falling are less likely to self-limit their physical activity level. T’ai Chi could be offered as a cost effective, group exercise program to the widely varied functional population of elderly in senior centers, life care communities, and nursing homes. Additionally, inpatient rehabilitation and outpatient rehabilitation settings could consider the use of T’ai Chi as a therapeutic group exercise intervention that would also serve to improve patient social interaction and quality of life. Therapists could use T’ai Chi cost effectively as a therapeutic intervention for a wide variety of patients. Clinicians who design and implement T’ai Chi as a
component of fall prevention programs should be careful to measure balance and gait outcomes, as well as fall reduction measures, in order to determine the efficacy of this intervention.

**Study Limitations**

This study had a number of limitations. Due to limited time, manpower and resources, the entire study took place within a single geriatric life care community. Because all of the subjects for this study were selected from a single geriatric life care community, the generalizability of this study’s results are limited to a similar geriatric sample living in a comparable geriatric life care community only. Additionally, this study was also limited by its small sample size. Four subjects dropped out of the initial subject pool of 26 subjects. The remaining 22 subjects completed the study, with ten subjects in the T’ai Chi intervention group and twelve subjects in the control group. A small sample size is a limitation because the smaller the sample size, the greater the chance for a TYPE II error and the larger the change must be from pre-testing to post-testing to be considered statistically significant. In our study a few of the subjects had changes in their Berg Balance Scores that significantly deviated from the group mean, which had a larger impact on our results than if we would have had a larger sample size.

The short duration of the intervention may be considered another limitation of this study as time is required to learn the T’ai Chi movement forms. A additional limitation may have been the frequency of the intervention. The T’ai Chi intervention was only performed two times a week. By increasing intensity of T’ai Chi to three times a week, the effects on balance and rate of falls may be seen in less than 15 weeks. Finally, only the immediate effects of the T’ai Chi intervention were examined; therefore, no
predictions could be made about the long term effects of a T’ai Chi intervention on improving balance and gait velocity.

Another possible limitation of this study was the researchers’ inability to control the subjects’ compliance with home T’ai Chi practice sessions. Daily home practice would have allowed the subjects to become more comfortable with the movement patterns and increase their confidence more quickly than if the subjects were just performing the movements during the class. By increasing their confidence earlier in the intervention, through daily home practice, subjects may have been able to challenge their balance with the T’ai Chi postures earlier in the intervention. Additionally, the researchers were not able to control the intensity with which the subjects performed the exercise intervention during the group classes. Nor were the researchers able to control the subjects’ progress and mastery of the T’ai Chi movement forms, although the researchers did monitor the subjects’ progress through the instructors notes on the subjects’ performance. Because the T’ai Chi intervention was taught in a group format, subjects were not provided with individualized support that might have helped them to progress more rapidly. A trained instructor in T’ai Chi was used in our study, however, to maximize the quality of this group format intervention. Finally, no means were taken to differentiate patients that had T’ai Chi experience prior to being included into the study. Previous participation in T’ai Chi may have limited the ability of the T’ai Chi intervention to provide a balance challenge in any T’ai Chi experienced subjects.

Furthermore, although the researchers did request that subjects in the control group not alter their pre-study activity levels, compliance with this request could not be controlled and may have influence the results of this study. In addition, subjects were
volunteer participants that may have been more active and motivated than the geriatric population as a whole.

Further limitations of this study were directly related to the subject characteristics. A few subjects who were at a high level of function did “ceiling out” on the Berg Balance Scale during pre-testing leaving no room for improvement. Subjects that were classified as near-frail had on the average lower Berg Balance scores than the subjects who were classified as well elderly. Therefore, the Berg Balance Scale may be a more appropriate outcome measure for the near-frail population as compared to the more active well elderly population. Although, we did not find a significant difference in the change in Berg Balance Score between our near-frail and our well elderly in our study, this finding may have been due to our small near-frail sample. Another limitation that was directly related to the participants was the influence of external factors which may have limited balance or gait speed prior to pre- and post-testing sessions. Some examples of external factors, that the researchers noted, that may have impaired balance or gait speed in our subjects include fatigue, illness, or consumption of alcohol prior to the post-testing.

Another limitation was that the gait measure used in this study only evaluated gait velocity on a level surface. This measure did not take into account the wide variety of functional tasks that are typical with daily walking activities, such as reaching or carrying objects. A functional gait measure may be more sensitive to picking up changes from T’ai Chi because T’ai Chi focuses on body awareness and upper extremity movement. Therefore, using a functional gait measure, such as carrying an object or walking on uneven surfaces, in addition to gait velocity on level surface may increase the sensitivity of gait as an outcome measure.
The procedures used to measure gait velocity may have been an additional limitation in the study. The tendency for subjects to slow down as they approached the “finish” line may have biased the study’s gait velocity results. However, the subjects demonstrated this slowing down tendency consistently during both the pre- and post-testing gait trials. Future studies utilizing this same method to record gait velocity should consider the addition of a three meter “deceleration” section, added to the end of the walkway, to ensure a more accurate measurement of gait velocity. Human error in using the stopwatch may also have affected the accuracy of the gait velocity scores.

Finally, any improvements noted in the exercise intervention group may have been a result of the motivational influence of the social interaction that occurred in conjunction with the T’ai Chi rather than to the exercise intervention itself. Unfortunately, because the researchers were unable to obtain quality of life impact data via the MOS SF-36, no conclusions can be drawn about the effect of T’ai Chi on the group social interaction.

The key limitation of this study, in the researchers’ opinion, may have been the scope of the outcome measures, which were restricted to the Berg Balance Scale and gait velocity during a ten meter walk. If a quality of life and psychosocial measure, such as the MOS SF-36 would have been included, it may have reflected benefits of a T’ai Chi intervention. Likewise, a fear of falling measure could have been included to reflect potential benefits of T’ai Chi intervention beyond balance and gait measures.

Suggestions for Future Research

Past research has shown that a bi-weekly, fifteen-week, T’ai Chi group intervention does affect gait velocity, rate of falling and fear of falling in the elderly
(Wolf, et al 1996). However, Wolf’s et al. (1996) study did not consider T’ai Chi’s effect on balance. Wolf and associates’ 1997 study did consider the effects of T’ai Chi on postural sway but not on a functional measure of balance, such as the Berg Balance scale. Our study attempted to look at the effects of a short term T’ai Chi group intervention (bi-weekly, six-weeks) on functional balance and gait velocity. Suggestions for future research include varying the length and intensity of the T’ai Chi intervention, examining the effect of T’ai Chi on different sub-populations of elderly (frail, near frail or well elderly), changing the selected T’ai Chi exercises, and examining the effect of a combination of interventions such as T’ai Chi and a walking program, or T’ai Chi and a strengthening program on a broader scope of outcome measures.

In future studies, varying the length and intensity of the T’ai Chi intervention may help to determine at what level of intensity and frequency of exercise the effects of T’ai Chi on balance and fear of falling become measurable in an elderly population. Therefore, these type of studies may provide information regarding recommendations for community based preventative T’ai Chi programs.

Additionally, future studies should include a variety of educational supplements to assist their elderly T’ai Chi subjects with learning the T’ai Chi forms. The results from this study indicate that the elderly subjects required ten sessions before they began to exhibit confident learning in the T’ai Chi patterns. Elderly persons who are struggling to learn the new exercise forms may benefit from additional instruction. Home exercise program video tapes and daily 15 minute practice sessions might be beneficial to reduce the time required by future elderly subjects to learn the T’ai Chi moves.
Future researchers may also examine the effects of T’ai Chi on different elderly populations. Studies on the effects of T’ai Chi on the near-frail population are vitally important as this elderly population continues to grow within our aging society. Preventive interventions that will prolong the time before the near frail population hit that critical threshold of functional decline are much more cost effective than attempting to improve function once an individual is in that vicious cycle of functional decline. Research is also needed to evaluate the long-term effects of a two year, five year or ten year T’ai Chi intervention on frailty levels in an elderly population.

Future researchers should consider using a broader scope of outcome measures when looking at the effects of T’ai Chi in the elderly. We suggest the inclusion of quality of life measures, Falls Efficacy Scales, fall rate, and psychosocial outcome measurements. In addition, future researchers should examine the effects of T’ai Chi on impairment measures that are related to functional decline, increased frailty and increased falls in the elderly. Potential impairment-based outcome measures to examine are strength, range of motion, sensation, endurance, attention to the environment and the appropriate use of balance strategies on unstable surfaces. In addition, alternative balance measures that are less likely to demonstrate ceiling effect in the elderly, could be used to measure balance. Examples of tests are the Dynamic Gait test, Functional Reach, Sharpened Romberg, and the single limb stance test. By measuring a broad scope of outcomes, researchers could develop a better understanding of the effects of T’ai Chi on the elderly from a holistic perspective.

There are 108 T’ai Chi postures that may be incorporated into a T’ai Chi intervention. In this study only ten, double stance postures were used for the T’ai Chi
intervention. Future researchers may want to consider using a wider range of T’ai Chi postures, including single limb stance postures. In addition, future studies could consider the effects of a T’ai Chi intervention that is performed in sitting, with the emphasis being placed on upper extremity movement and weight shifting in sitting, for the frailer individual that is unable to stand or has poor sitting and standing balance.

Finally, a future research consideration is the assessment of T’ai Chi in conjunction with other interventions. For example, examining the efficacy of a T’ai Chi exercise program combined with a strength training program on balance and walking speed. Likewise, studies could examine the efficacy of a T’ai Chi combined with a walking program on improving balance and walking speed. It is possible that the combination of T’ai Chi and another intervention such as strength training or a walking program may have a greater impact on functional outcomes in the elderly than T’ai Chi alone.

Conclusion

No statistical differences were found in the changes in mean gait velocity and Berg Balance Scale scores in the control group as compared to the six-week T’ai Chi intervention group. Subjective comments from the subjects in this study suggest an impact of the T’ai Chi intervention on quality of life and fear of falling. Future research should include these important outcome measures when evaluating the short-term and long-term effects of T’ai Chi. No significant difference was found in the change in mean gait velocity and Berg Balance Scale scores between the near-frail elderly and well elderly intervention group subjects in this study, possibly owing to our small sample size. Future research should focus on evaluating the efficacy of T’ai Chi in a larger sample of
the near-frail elderly. Because many of these near-frail elderly are approaching the critical threshold of functional decline, these subjects may benefit more from a T’ai Chi intervention than higher functioning well elderly. Physical inactivity in both the near-frail and well elderly may be the beginning of a downward spiral leading to increased susceptibility to falls, disabling injuries, and increased health care expenditures. Studies examining the efficacy of exercise interventions, such as Tai Chi, in preventing functional decline are of utmost importance to decreasing health care costs, maintaining mobility, function, and quality of life in the elderly.
Bibliography


Appendix A

Health Questionnaire
Subject Code #: 

**Health Questionnaire**
Please fill out the questions to the best of your knowledge

Name: ____________________________________________

Age: __________  Sex: M or F

Do you have vision problems? ______ If so how is it corrected? ________________

Do you have trouble with hearing? ______ If so how is it corrected? ________________

Do you currently use a cane or walker? ______ If so when do you use it? ________________

Can you walk one city block by yourself? ______

Please indicate if you have ever had or are currently suffering from the following:

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<th>Condition</th>
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<th>No</th>
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<td>Previous Traumatic Head Injury</td>
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<td>Other</td>
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<td>tendonitis</td>
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<td>sprain or strain</td>
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<td>Ever experienced a fall</td>
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<td>If so how many in last year?</td>
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Are you currently taking any medications? Yes ____ No ____

If so, please list them. If you don't know their names, check here □

________________________________________________________________________

________________________________________________________________________
Appendix B

Modified Lawton-Brody Functional Assessment
Modified Lawton-Brody Functional Assessment of ADL’s & IADL’s - Self Report

Physical Self-Maintenance Scale (ADL’s)

Directions: Listed below are several different functional activities. Please circle one letter (A or B) under each category that BEST describes your ability to perform the task.

1. Toilet
   A. I care for myself at the toilet completely; no incontinence.
   B. I need to be reminded to use the toilet, or I need help in cleaning myself after using the toilet, or I have accidents (once a week at most).

2. Eating
   A. I eat meals without assistance.
   B. I eat with minor assistance. (I need help cutting my food or cleaning myself up after eating a meal.)

3. Dressing
   A. I dress, undress and select clothes from my own wardrobe without help.
   B. I dress and undress myself with minor assistance.

4. Grooming
   A. I always neatly dress and groom myself, without assistance.
   B. I groom myself adequately with occasional minor assistance, (e.g. shaving).

5. Physical Ambulation
   A. I walk about my residence, the Porter Hills grounds and city, without help.
B. I can walk within my residence only, or about a one block distance.

6. **Bathing**
   A. I bath (tub, shower, sponge bath) myself without help.
   
   B. I wash my face and hands only, but cannot bath the rest of my body.

**Instrumental ADL’s**

*Directions: Please circle one letter (A, B, or C) under each category that BEST describes your ability to perform the task.*

7. **Ability to use telephone**
   A. I operate the telephone on my own; looking up the numbers & dialing.
   
   B. I can only dial a few well-known numbers.
   
   C. I can only answer the phone, I do not dial numbers.

8. **Shopping**
   A. I independently take care of all my shopping needs.
   
   B. I shop independently for small purchases only.
   
   C. I need to be accompanied on all shopping trips.

9. **Food Preparation**
   A. I plan, prepare and serve my meals independently.
   
   B. I heat and serve prepared meals.
   
   C. I need to have meals prepared and served.

10. **Housekeeping**
    A. I maintain my house / apartment alone or with occasional help with heavy work.
B. I perform light daily tasks such as dish washing and bed making.

C. I need help with all home maintenance tasks.

11. Laundry
A. I do my personal laundry completely.

B. I launder small items (such as rinsing socks and stockings, etc.).

C. All of my laundry must be done by others.

12. Mode of Transportation
A. I travel independently on public transportation or drive my own car.

B. I arrange my travel via taxi, but do not otherwise use public transportation.

C. I travel on public transportation, in a taxi or automobile with assistance of another.

13. Responsibility for Own Medications
A. I take responsibility for taking my medications, (correct dosages and times).

B. I take responsibility for taking my medication if it is prepared by another in advance in separate dosages.

C. I do not dispense my own medication.

14. Ability to Handle Finances
A. I manage my financial matters independently (budget, write checks, pay rent and bills, go to the bank or ATM machine); collect & keep track of income.

B. I manage day-to-day purchases, but I need help with my banking, & major purchases, etc.

C. I do not handle my money and finances.
Appendix C

Orientation and Three Stage Command Questions
Orientation and Three Stage Command Questions
(Adapted from the Mini-Mental State Exam)

**Orientation Questions**

1. What is the date? (At least get month and year)

2. Where are we? (Porter Hills)

**Three-Stage Command**

3. Take the paper in your right hand, fold it in half and put it on the floor.

** If subject is able to perform the three-stage command and answer at least one of the orientation question, set up a pre-assessment appointment for the subject.
Appendix D

Personal Informed Consent
LETTER OF CONSENT

I understand that the purpose of this study is to evaluate the effects of a T’ai Chi exercise program on balance, walking function and health status in 40 elderly individuals. I understand that I may be randomly selected for either the T’ai Chi exercise group or the non-exercise group. The T’ai Chi exercise program will involve use of arm, legs, and trunk in standing to perform slow dance-like movements. The participants in the control group will be requested to not change their current activity level. I understand that the result of this study will be used by health care professionals to maintain optimal function and independence in the elderly population.

I understand that:

1. In order to qualify as a participant in this study, I must complete all screening procedures for this study including a written health questionnaire and written consent form from a medical program coordinator.

2. My participation in either of the groups will involve two one hour screening and assessment sessions. Functional balance, self selected and fast walking speed, and a self report quality of life questionnaire will be evaluated at assessment sessions.

3. If I am selected to participate in the T’ai Chi exercise, it will involve 45 minute exercise sessions, twice a week for 6 weeks (total of 9 hours). The exercise classes will take place at Porter Hills. The T’ai Chi intervention will consist of group classes instructed by a T’ai Chi instructor.

4. It is not anticipated this study will cause physical or emotional risk to myself. During all screening and assessment procedures, a gait belt will be worn for safety. Participants in the T’ai Chi exercise group will be educated regarding the warning signs for exercise overexertion. It is not expected that the participants will experience exercise soreness or excessive fatigue.

5. 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.

6. A summary of the results will be made available upon my request.

I confirm that

“All of my questions regarding this research study have been answered fully and to my satisfaction. I understand that any future questions I might have will be answered by the researchers.”

“I understand that participation in this study is voluntary and I may withdraw at anytime.”
“I authorize the researchers to release the data and results obtained in this study to scientific literature and that my name will not be identified.”

“I have read the above statement and release Porter Hills and the researchers, Melanie McKimmy and Sarah Teubert, from any liability in the unlikely event that I experience physical injury during this research.”

I agree to participate in this research study.

______________________________  ______________________________
Subject’s Signature            Witness

______________________________  ______________________________
Date                           Date

If you have any questions or concerns, please contact the researchers: Melanie McKimmy at (616) 530-2971 or Sarah Teubert at (616) 791-6157 or Professor Paul Huzinga of Grand Valley State University at (616) 895-2472.
Appendix E

Preassessment Questions
Pre-assessment Questions

1. How many active diagnoses does this subject have?  
   (In addition to those listed on the health questionnaire, such as diabetes...)

2. What is subject's current activity level? (Adapted from Reuben, D., Laibert, L., Hiris, J., and Mor, V., 1990)
   - Frequent Vigorous exerciser (swimming, tennis, aerobics, jogging... etc at least three times a week)
   - Frequent Long Walker (walks at least one mile (8-12 blocks) with no rest at least three times a week)
   - Frequent Short Walker (walks at least 2-3 blocks at least three times a week)
   - Not a regular exerciser

3. If on the health questionnaire, there is a problem with vision or hearing ask these further questions:

   Visual:
   1. Are you able to see a person from 15 feet away? (Point to object in room and see if subject can see it) YES NO
   2. If subject has trouble with vision how can we accommodate him or her during T'ai Chi intervention?

   Hearing:
   1. Is the subject able to hear you when you speak with a normal voice during these questions? YES NO
   2. If subject has trouble with hearing, how can we accommodate him or her during the T’ai Chi intervention?
Appendix F

Berg Balance Scale
Berg Balance Scale

1. Sitting to standing
Instruction: Please stand up. Try not to use your hands for support
Grading Scale: Please mark the lowest category which applies.
   (4) able to stand, no hands and stabilize independently
   (3) able to stand independently using hands
   (2) able to stand using hands after several tries
   (1) needs minimal assist to stand or to stabilize
   (0) needs moderate or maximal assist to stand

2. Standing unsupported
Instruction: Stand for two minutes without holding on to anything
Grading Scale: Please mark the lowest category which applies
   (4) able to stand safely for 2 minutes
   (3) able to stand 2 minutes with supervision
   (2) able to stand 30 seconds unsupported
   (1) needs several tries to stand 30 seconds unsupported
   (0) unable to stand 30 seconds unassisted

IF SUBJECT ABLE TO STAND 2 MINUTES SAFELY, SCORE FULL MARKS FOR NEXT QUESTION (SITTING UNSUPPORTED). PROCEED TO POSITION CHANGE STANDING TO SITTING.

3. Sitting unsupported feet on floor
Instruction: Sit with arm folded for two minutes
Grading: Please mark the lowest category which applies.
   (4) able to sit safely and securely for 2 minutes
   (3) able to sit for 2 minutes under supervision
   (2) able to sit 30 seconds
   (1) able to sit 10 seconds
   (0) unable to sit without support 10 seconds

4. Standing to sitting
Instruction: Please sit down
Grading: Please mark the lowest category which applies.
   (4) sits safely with minimal use of hands
   (3) controls descent by using hands
   (2) uses back of legs against chair to control descent
   (1) sits independently but has uncontrolled descent
   (0) needs assistance to sit

5. Transfers
Instruction: Please move from chair to bed and back again. One way toward a seat with armrests and one way toward a seat without armrests.
**Grading:** Please mark the lowest category which applies.

- (4) able to transfer safely with only minor use of hands
- (3) able to transfer safely with definite use of hands
- (2) able to transfer with verbal cueing and/or supervision
- (1) needs one person to assist
- (0) needs two people to assist or supervise to be safe

6. **Standing unsupported with eyes closed**

**Instruction:** Close your eyes and stand still for 10 seconds

**Grading:** Please mark the lowest category which applies.

- (4) able to stand 10 seconds safely
- (3) able to stand 10 seconds with supervision
- (2) able to stand 3 seconds
- (1) unable to keep eyes closed 3 seconds but stays steady
- (0) needs help to keep from falling

7. **Standing unsupported with feet together.**

**Instruction:** Place your feet together and stand without holding

**Grading:** Please mark the lowest category which applies.

- (4) able to place feet together independently and stand for 1 minute safely
- (3) able to place feet together independently and stand for 1 min. with supervision
- (2) able to place feet together independently but unable to hold for 30 seconds
- (1) needs help to attain position but able to stand 15 seconds feet together
- (0) needs help to attain position and unable to hold for 15 seconds

**THE FOLLOWING ITEMS ARE TO BE PERFORMED WHILE STANDING UNSUPPORTED**

8. **Reaching forward with outstretched arm**

**Instruction:** Lift arm to 90 degrees. Stretch out your fingers and reach forward as far as you can (Examiner places a ruler at end of fingertips when arm is at 90 degrees. Fingers should not touch the ruler while reaching forward. The recorded measure is the distance forward that the fingers reach while the subject is in the most forward lean position)

**Grading:** Please mark the lowest category which applies.

- (4) can reach forward confidently >10 inches
- (3) can reach forward >5 inches safely
- (2) can reach forward >2 inches safely
- (1) reaches forward but needs supervision
- (0) needs help to keep from falling

9. **Pick up object from the floor (Was UE Support used? __________)**

**Instruction:** Pick up the shoe/slipper which is placed in front of your feet

**Grading:** Please mark the lowest category which applies.

- (4) able to pick up slipper safely and easily
- (3) able to pick up slipper but needs supervision
- (2) unable to pick up but reaches 1-2 ins. from slipper and keeps balance indep.
(1) unable to pick up and needs supervision while trying
(0) unable to try/needs assistance to keep from falling

10. Turning to look behind/over left and right shoulders
**Instruction:** Turn to look behind you over left shoulder. Repeat to the right
**Grading:** Please mark the lowest category which applies.
- (4) looks behind from both sides and weight shifts well
- (3) looks behind one side only; other side shows less weight shift
- (2) turns sideways only but maintains balance
- (1) needs supervision when turning
- (0) needs assistance to keep from falling

11. Turn 360 degrees
**Instruction:** Turn completely around in full circle. Pause. Then turn a full circle in the other direction.
**Grading:** Please mark the lowest category which applies.
- (4) able to turn 360 safely in <4 seconds each side
- (3) able to turn 360 safely to one side only in <4 seconds
- (2) able to turn 360 safely but slowly
- (1) needs close supervision or verbal cueing
- (0) needs assistance while turning

**DYNAMIC WEIGHT SHIFTING WHILE STANDING UNSUPPORTED**

12. Stool touch
**Instruction:** Place each foot alternately on the stool. Continue until each foot has touched the stool four times.
**Grading:** Please mark the lowest category which applies.
- (4) able to stand independently and safely and complete 8 steps in 20 seconds
- (3) able to stand independently and complete 8 steps >20 seconds
- (2) able to complete 4 steps without aid with supervision
- (1) able to complete >2 steps needs minimal assistance
- (0) needs assistance to keep from falling/unable to try

13. Standing unsupported, one foot in front
**Instruction:** (Demonstrate to subject) Place one foot directly in front of the other. If you feel that you cannot place your foot directly in front, try to step far enough ahead that the fall of your forward foot is ahead of the toes of the other foot.
**Grading:** Please mark the lowest category which applies.
- (4) able to place foot tandem independently and hold 30 seconds
- (3) able to place foot ahead of other independently and hold for 30 seconds
- (2) able to take small step independently and hold for 30 seconds
- (1) needs help to step but can hold 15 seconds
- (0) looses balance while stepping or standing

14. Standing on one leg
**Instruction:** Stand on one leg as long as you can without holding

**Grading:** Please mark the lowest category which applies.

1. able to lift leg independently and hold >10 seconds
2. able to lift leg independently and hold = or > 3 seconds
3. able to lift leg independently and holds 5-10 seconds
4. able to lift leg independently and hold >10 seconds

(0) unable to try or needs assistance to prevent fall

**TOTAL SCORE ______________/ 56**
Appendix G

Waiver of Formal Medical Consent
To: Professor Huizenga  
Human Subjects Review Committee Chair

Date: June 23, 1997

From: Melanie McKimmy and Sarah Teubert

Regarding: A proposed change in methodology

As required by Porter Hills Policy the names of the recruited Porter Hills volunteers for the study "The Efficacy of a T'ai Chi Intervention on Balance and Gait Velocity in the Elderly" were submitted to and reviewed by the Porter Hills medical staff and activities directors. In response to this submission the Porter Hills facility has recommended that further medical consent by a personal physician not be required as the recruited volunteers are all healthy, independently functioning, elderly persons who have attended an informational session regarding the study, and given informed personal consent to participate in the study. The researchers feel this recommendation is sound and would like your approval to continue the study without requesting formal medical consent from the volunteers personal physicians.

Deanne Prill, Recreational Director, Porter Hills  
Date: June 23, 1997

Melanie McKimmy, SPT Researcher  
Date: June 23, 1997

Paul Huizenga, HSRC Chair  
Date: 6-24-97
Appendix H

T'ai Chi Home Exercises
(1) COMMENCEMENT

1. ARMS AT SIDE-

2. RAISE ARMS TO CHEST
   SHOULDER LEVEL INHALE
   DEEPLY AS YOU RAISE ARMS

3. BRING ARMS DOWN
   TO SIDE EXHALING
   SLOWLY.
(2) CLOUD HANDS

1. RIGHT/LEFT ARM IS IN FRONT

2. RAISE ARM UP TO CHEST

3. CONTINUE RAISING ARM AND HAND TO FACE

4. CONTINUE MOVING ARM UNTIL IT IS STRAIGHT AS YOU MOVE ARM ROTATE YOUR SHOULDERS SLIGHTLY

5. CONTINUE MOVING ARM UNTIL IT IS BACK TO #1
(3) POLISH THE MIRROR

1. BEGIN WITH HANDS AT SIDE

2. RAISE ARMS

3. CONTINUE RAISING ARMS

4. ARMS MEET AT THE TOP

5. AS YOU BRING ARMS AND HANDS DOWN IN FRONT OF YOU... SINK DOWN BY BENDING KNEES SLIGHTLY

6. BRING ARMS AND HANDS BACK TO POSITION #1
(4) CROSS THE HEAVENS

1. ARMS AT LEFT OR RIGHT SIDE

2. BRING ARMS ACROSS THE BODY MOVING IN A DIAGONAL UPWARD

3. CONTINUE "CROSSING" TO THE OTHER SIDE OF THE BODY AS YOU REACH ACROSS SHIFT YOUR WEIGHT ONTO THAT LEG

4. LOWER ARMS TO SIDE AND REPEAT TO STEP #1
(5) PRAYER WHEEL
(SIDE VIEW)

1. HANDS AND ARMS IN FRONT

2. BRING ARMS UP TOWARD FACE
SHIFT YOUR WEIGHT ONTO YOUR FRONT LEG

3. CONTINUE TO BRING YOUR HANSD TOWARD YOUR FACE

4. BRING YOUR HANDS DOWN
REPEAT STEP #1 SHIFT YOUR WEIGHT ONTO YOUR BACK LEG
Repulse Monkey

1. Move arms in opposite directions / Front to back alternating their positions.

2. Repeat by going back to #1

3. 

4. 
(7) GATHER CHI
(SWEEPING MOTION WITH ARMS)

1. SWEEP ARM ACROSS YOUR WAIST FROM LEFT SIDE TO THE RIGHT SHIFTING YOUR WEIGHT ON TO YOUR RIGHT LEG

2. NOW SWEEP ARM ACROSS FROM YOUR RIGHT SIDE TO YOUR LEFT SIDE SHIFTING YOUR WEIGHT TO YOUR LEFT SIDE

3. CONTINUE SWEEPING MOTIONS AND SHIFT YOUR WEIGHT
Brush Knee

1. Brings arms and hands down to your side.

2. Lean slightly forward bend at the knees let arms and hands follow through.

3. Hand "brushes" front knee. Opposite hand is at shoulder level.
1. Begin in a "closed" position with arms closed.
2. Begin to lean to either side. Each arm begins to go in opposite direction.
3. Continue. Lift the hands and arm that you are leaning towards. Other arm is lowered at side.
4. Final position.
Cross Heavens and Single Whip

1. Cross the arms across the body while shifting weight to side arms are moving

2. Make a hook with one arm

3. Final position
Appendix I

Attendance Sheet
### Attendance Sheet

<table>
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Appendix J

Weekly Progress Notes on Intervention Subjects
**Weekly Progress of T'ai Chi Intervention Subjects**

<table>
<thead>
<tr>
<th>Subject's Name</th>
<th>Progress (Yes, No, Partial)</th>
<th>Comments (Does pt sit or stand during class)</th>
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Appendix K

Warning Signs for Over-exertion
Over-exertion Warning Signs

The following are a list of physical over-exertion warning signs:

- Chest Pain
- Shortness of Breath
- Excessive Sweating
- Lightheadedness or Dizziness
- Nausea
- Excessive Fatigue
- Palpitations and/or irregular pulse
- Pain in neck, shoulders, arms, jaw

If you experience any of these physical signs of excessive effort, **discontinue the exercises and sit down to rest.** The researcher and/or T’ai Chi instructor will check with you regarding the signs you are experiencing.
Appendix L

Standardized Instructions for Gait Velocity
Standardized Instructions for Gait Velocity Tests

Timing and Course Description
Subjects will be asked to stand at one end of a 13 meter walkway.

A starting line, 3 meter line, and finish line will be clearly marked with tape on the level carpeted floor.

For both gait velocity test the first 3 meters will not be timed, in order to allow the subject to reach the selected walking speed.

A 10 meter distance will then be timed with a stop watch by the examiner.

Subjects will perform three trials of walking for both the self paced and maximum gait velocity.

Three trials will be performed by the subject for both the self paced and maximal gait velocity. The subject will be allowed to rest for 2 - 5 minutes between each trial.

Any trials in which the subject trips or stumbles will not be used.

Self Paced Gait Velocity Verbal Instructions

* Walk at your normal pace when I say ‘go’.

Maximal Gait Velocity Verbal Instructions

* Walk as fast as you can, without running, when I say ‘go’.
Appendix M

Data Collection Sheets
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Postmeasurement

Subject Code:__________________________

Berg Balance Score _______________________

Was assistive device used?________ If so what kind?__________

When was assistive device used?____________________________

Pt unable to follow directions on Berg when repeated three time  YES / NO

Self Selected Gait Velocity 1____________________________

Self Selected Gait Velocity 2____________________________

Self Selected Gait Velocity 3____________________________

Self Selected Gait Velocity Average________________________

Maximum Gait Velocity 1____________________________

Maximum Gait Velocity 2____________________________

Maximum Gait Velocity 3____________________________

Maximum Gait Velocity Average________________________

MOS SF-36____________________________
Premeasurement

Subject Code: __________________________

Berg Balance Score ______________________

Was assistive device used? ______ If so what kind? _______

When was assistive device used? __________________________

Pt unable to follow directions on Berg when repeated three time  YES / NO

Self Selected Gait Velocity 1 __________________________

Self Selected Gait Velocity 2 __________________________

Self Selected Gait Velocity 3 __________________________

Self Selected Gait Velocity Average __________________________

Maximum Gait Velocity 1 __________________________

Maximum Gait Velocity 2 __________________________

Maximum Gait Velocity 3 __________________________

Maximum Gait Velocity Average __________________________

MOS SF-36 __________________________
Appendix N

Grant Funding
February 26, 1998

Melanie McKimmy
Sarah Teubert
4325-7 Wimbledon Dr. SW
Grandville MI 49418

Dear Ms. McKimmy and Ms. Teubert:

On behalf of the Michigan Physical Therapy Association Institute for Education and Research Inc., we extend our congratulations to you on being approved to receive a $65.00 research award. The research committee and the MPTA Institute for Education and Research are pleased to support your project entitled "The Efficacy of a T'ai Chi Intervention on Functional Balance, Walking Speed and Quality of Life in the Elderly". Enclosed is check #2255 in the amount of sixty-five dollars ($65.00).

As a condition of acceptance of this award, please sign the enclosed form and mail it to the MPTA Institute for Education and Research, Inc., at the above address. This form acknowledges your receipt of the $65.00 check and your commitment to spend funds as indicated on your original application. In addition, within one (1) year, please provide a summary abstract, including results and/or a letter stating how the award money was spent.

We wish you success in your continuing research endeavors.

Sincerely,

Louis Amundsen, PT, PhD
MPTA Institute Trustee

Kathleen A. Hinderer, MS, MPT, PT
Chairman, Research Committee

Enclosures