THE EFFECTS OF TAI CHI ON PAIN AND FUNCTION
IN OLDER ADULTS WITH OSTEOARTHRITIS

by

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Finally, I dedicate this dissertation to the memory of Kathy Gray who left us too soon, and left us all with so much. This one is for you.
The Effects of Tai Chi on Pain and Function in Older Adults with Osteoarthritis

Abstract

by

PATRICIA ANN ADLER

Using a modified version of Nagi’s disability model, the purpose of this study was to assess the effects of Tai Chi on improving impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (mobility, gait), and disability (IADL, life tasks) in elders with osteoarthritis of the lower extremities. The sample consisted of 14 older adults (men = 1, women = 13), aged 60 years and older, randomly assigned to either an experimental (Tai Chi) or control (Bingo) group. Both groups attended 10 weekly, one-hour sessions that were conducted by the investigator. Participants in the Tai Chi group were expected to practice at least 3 times each week for 15 minutes using the videotape and handouts. At pre and posttest, measures were collected for impairment, functional limitations, and disability, and one measure of pain (WOMAC pain subscale) was measured weekly. Self-report measures were used to assess (1) impairment: pain (WOMAC pain subscale), anxiety (state subscale of STAI), depressive symptoms (CES-D), (2) functional limitations: mobility (advanced lower extremity subscale of Function Component of Late-Life FDI (FC-LLFDI), and (3) disability: IADL (OARS, lower extremity subscale of FC-LLFDI), and life tasks (Disability Component of LLFDI). In addition, performance measures were used to evaluate other (1) impairment variables including balance (balance subscale of Tinetti), muscle strength (dynamometer) and (2)
functional limitations variables including mobility (Get-Up and Go), and gait (gait subscale of Tinetti). Class attendance, analgesic use, change in health condition, and practice done at home were reported weekly before each Tai Chi class and Bingo session. The number of variables of interest was decreased from nine to two because of the small sample size and increased risk of type I error with multiple analyses. These were pain and muscle strength. The remaining seven variables were analyzed using descriptive statistics and examined for trends. Pain and muscle strength improved, but were not significantly different between groups. Eight of the nine dependent variables (89%), and two muscle strength component variables (40%) showed some improvement. Analgesic medication was not ruled out as a confounder of pain. The current study will serve as a feasibility study for future Tai Chi research.
Chapter I

Background and Significance

In 1990, an estimated 37.9 million Americans had arthritis, and another 21.5 million were expected to have chronic pain from osteoarthritis (OA) by 2020 (Center of Disease Control and Prevention [CDCP], 1994). Osteoarthritis is the leading cause of disability in older adults (Center of Disease Control and Prevention, 2001; Harris, 1993; Schnitzer, 1993). Approximately 50% of those with arthritis pain are persons aged 65 years and older, while the estimated prevalence in adults aged 44 years and younger, and children aged 16 years or less is 5.1% and 0.5%, respectively (CDCP, 1994). Arthritis pain increases as the destruction of the articular cartilage and soft tissue of the joint progress (Ashbum & Staats, 1999; Carr & Goudas, 1999; Loeser & Melzack, 1999).

Osteoarthritis is associated with increased impairment, functional limitations, such as mobility and gait, and disability (Moskowitz, 1993). Pain intensity (impairment) is related to a person’s ability to move with intent within the environment and perform activities of daily living (ADL) (Borjesson, Robertson, Weidenhielm, Mattson, & Olsson, 1996; Kee, Harris, & Booth, Rouser, & McCoy, 1998). Generally as pain decreases, the individual is more functional and disability (the ability to perform ADL) improves (Bautch, Malone, & Vailas, 1997; Maurer, Stern, Kinossian, Cook, & Schumaker, 1999; Meyer & Hawley, 1994). Furthermore, less arthritis pain is linked with improvements in other impairments including anxiety (vanBaar et al., 1998), depression (Magni, Caldieron, Rigatti-Luchini, & Merskey, 1990), balance (Messier, Glasser, Ettinger, Craven, & Miller, 2002), and muscle strength (Hurley, 1999).

Exercise has the potential to minimize impairment, such as arthritis pain, and
ameliorate functional limitations and disability. Aerobic and muscle strength training have been found to increase mobility, improve performance of ADL and reduce disability (Mangione et al., 1999; Meyer & Hawley, 1994; Schilke, Johnson, Hush, & O’Dell, 1996). Little is known of the effects of range of motion (ROM) exercise on function and disability.

Despite exercise options, many older adults do not engage in exercise (Jones & Jones, 1997; O’Neill & Reid, 1991) because they perceive that there are barriers related to their age, illness or handicap (O’Neill & Reid, 1991), and they are afraid of injury. Tai Chi is safe (Kirsteins, Dietz, & Hwang, 1991) and is well suited for those with impairments (Fontana, Colella, Wilson, & Baas, 2000). The use of a gentle, slow-movement exercise program, such as Tai Chi, may be more acceptable to elders with arthritic pain, and may increase the likelihood of beginning and maintaining an exercise program. Hence, the purpose of this study is to test the effectiveness of Tai Chi on functional impairment and limitations, and disability in older adults with OA.

Exercise

Exercise has been found to decrease chronic pain (Daltroy & Liang, 1993; Ebener, 1999; Lam, 1999) and improve physical and mental health (Elward & Larson, 1992; Jones & Jones, 1997). However, the exact mechanism of exercise effects on mental health is unknown (American College of Sports Medicine [ACSP], 1998; Paluska & Schwenk, 2000). Less pain promotes greater function of the affected joint, and in turn, decreases the adverse mental health affects related to living with arthritic pain. Exercise increases circulation and stimulates repair of the damaged joint surface, and stabilizes the joint structure by strengthening soft tissue support of the joint. The types of exercise
recommended for chronic arthritis pain include aerobic, flexibility, and muscle
strengthening (Lam, 1999), with low to moderate intensity (ACSM, 1998). However,
researchers have primarily studied the effects of aerobic exercise (Kovar et al., 1992;
Mangione, Axen, & Haas, 1996; Mangione, et al., 1999), and muscle strength-training
(Maurer et al, 1999; O’Reilly, Muir, & Doherty, 1999; Schilke et al.,1996) on pain, but
not Tai Chi, which is an aerobic, muscle strengthening, and ROM exercise (Lam, 1999).

_Aerobic exercise_. Aerobic exercise requires oxygen for mitochondrial oxidation
(Brooks, Fahey, White, & Baldwin, 2000) and involves repetitive movements of the large
muscle groups (Tratora & Grabowski, 1993). Aerobic exercise improves cardiovascular,
respiratory and musculoskeletal function (Lam, 1999, and elevates mood, lowers blood
pressure, increases high-density lipoproteins, and inhibits osteoporosis (Tratora &
Grabowski, 1993). Low impact, moderate aerobic exercise strengthens large muscles that
support and protect the joint (Engels, Drouin, Zhu, & Kazmierski, 1998), and is
recommended for older adults with arthritic pain. Water-based aerobic exercise has the
advantage of unloading joint burden to relieve painful joints. However, land-based
aerobic exercise with proper joint load is recommended for seniors to maintain optimal
joint function (Bunning & Materson, 1991; Schnitzer, 1993). Although aerobic exercise
has been found to improve physical and mental health, and arthritic pain (Bautch et al.,
1997), most exercise programs do not generally accommodate the needs of the older adult
(Davis, Cortex, & Rubin, 1990).

_Muscle strengthening exercise_. Muscle strengthening exercise involves movement
against resistance (Lam, 1999). Muscle strength-training decreases joint pain and increase
the strength of muscles, tendons, and ligaments, and promote joint stability (Schnitzer,
Reduced quadriceps muscle strength has been found to be a predictor of pain and disability (Madsen, Bliddal, Egsmose, & Sylvest, 1995). Strength-training exercise also improves circulation to the joint and surrounding tissues (Lam, 1999). Generally, muscle strength-training programs, for seniors with arthritis pain, include isometric and isotonic exercises to prevent muscle atrophy and cartilage destruction (Bunning & Materson, 1991; Pollack, Graves, Swart, & Lowenthal, 1994).

**Range of motion.** Range of motion (ROM) exercise involves movement of the joints (Lam, 1999) that is joint-type specific (Tratora & Grabowski, 1993). For example, the knee (hinge joint) is capable of flexion and extension, and not rotation. Range of motion exercise improves joint flexibility and arthritic pain by gently stretching and strengthening the surrounding soft tissue of the joint (Dexter, 1992; Lam, 1999). Range of motion exercises are frequently used at the start of exercise programs to prepare joint tissue for more vigorous exercise, and at the end to “cool down” and relax the body, and have been found to increase ROM four months later (Van Deusen & Harlowe, 1987). Range of motion exercises are especially important for seniors who participate in an exercise program, since older adults have a higher risk of injury (Pollack et al., 1994).

**Tai Chi**

Tai Chi is an exercise that combines physical movement with meditation (Schaller, 1996), and offers aerobic, flexibility, and strength-training benefits (Lam, 1999). Tai Chi is a safe exercise for people with arthritis (Kirsteins et al., 1991) with physical and mental health benefits. Although significant improvements in cardiopulmonary functioning were found with Tai Chi (Lan, Lai, Chen, & Wong, 1998; Lan, Lai, Wong, & Yu, 1996), more recently, Tai Chi has been found to be a low aerobic
intensity exercise appropriate for American elders (Fontana et al., 2000; Young, Appel, Jee, & Miller, 1999). Most studies have focused on the benefits of Tai Chi to older adults (Jin, 1989; Lai, Lan, Wong, & Teng, 1995; Lan et al., 1998; Lan et al., 1996), yet the benefit of chronic pain relief has not been substantiated. Tai Chi movements or postures may be modified to meet the individual needs and body condition of the older adult. This is likely to be important to elders who have decided to start and maintain an exercise program to improve their health, or those who are considering their exercise options.

**Theoretical Framework**

This study was designed using a modified version of Nagi’s model of disability (see Figure 1) (Brandt & Pope, 1997). Roberts (1999) noted that impairment, functional limitations, and disability have different meanings in different models. Hence, this investigator will use nomenclature and definitions of Nagi (Brandt & Pope, 1997, p. 6).

![Figure 1. Exercise intervention with impairment, functional limitations and disability](image-url)

Exercise is a therapeutic modality and an external environmental variable, while impairment and functional limitations are factors of the person. Impairment is a psycho-emotional, physiological, structural or functional deficit. Functional limitation is an inability to perform an activity normally that results from impairment. Disability is the inability to perform socially-defined activities and roles. Disability is a potential outcome
of the interaction of environment (exercise) and person (impairments, functional
limitations) that is dependent upon a threshold effect of impairment and functional
limitation on disability. Tai Chi is an exercise intervention (therapeutic modality) aimed
at reducing impairment (pain, depression, anxiety, balance, muscle strength), functional
limitations (mobility, gait), and disability (IADL, life tasks).

Exercise and Impairment

Pain. Pain is an unpleasant sensory and emotional experience (Loeser & Melzack, 1999) that prevents many elders from exercising. Yet exercise is recommended for persons with chronic pain of arthritis (Elward & Larson, 1992; Jones & Jones, 1997; Lam, 1999). Aerobic exercise (Kovar et al., 1992; Mangione et al., 1999) and muscle-strength training (Maurer et al., 1999; O’Reilly et al., 1999; Schilke et al., 1996) are prescribed for seniors with arthritic pain (Daltroy & Liang, 1993; Ebener, 1999). Using treadmill aerobic exercise, however, pain relief was not obtained in older adults (Mangione et al., 1996). In contrast, range of motion exercise reduced pain (Simkin et al, 1999; Van Deusen & Harlowe, 1987).

Although Tai Chi has been used within the Chinese community for pain relief (Lam, 1999; Schaller, 1999), little research has focused on Tai Chi. Schaller (1996) was the first to evaluate Tai Chi and pain, and found no significant effects. In a recent 10-week pilot study (Adler, Good, Roberts, & Snyder, 2000) with a convenience sample of 16 seniors with arthritis who were randomly assigned to (Tai Chi) or control (no Tai Chi) groups, there were not significant group differences in physical and mental health, but those in the Tai Chi group had significantly lower pain intensity from pre to posttest, while control subjects experienced greater pain.
Anxiety and depression. Anxiety is an unpleasant emotional response associated with a perceived threat (NIMH, 1999; Walker, 1990), while depression is extreme sadness generally out of proportion to the cause (Osol, 1973). Anxiety is related to pain in elders (Creamer et al., 1999), and in most studies, anxiety is associated with depression (Creamer et al., 1999; Dieppe, Cushman, Tucker, Browning & Shepstone, 2000). Depression is higher in those with chronic pain (Magni et al., 1990) and is positively associated with pain intensity (Bautch et al., 1997; Werner, Cohen-Mansfield, Watson, & Pasis, 1998). Aerobic exercise has been found to improve mood, and decrease anxiety and depression (Brown et al., 1995; McMurdo & Burnett, 1992). The mental health benefits of Tai Chi have been studied (Jin, 1989, 1992) but to a lesser extent than the physical benefits.

Balance and muscle strength. Balance is postural equilibrium (Danis, Krebs, Gill-Body, & Sahrmann, 1998; Maki & McIlroy, 1996) that permits the person to control upright posture under various conditions (Berg & Norman, 1996). Muscle strength is the maximum force produced by a muscle or related muscle groups (McArdle, Katch, & Katch, 2001). Balance impairment is associated with decreased muscle strength and increased pain and risk of falls in elders (Messier et al., 2002). Tai Chi has been found to improve balance in elders (Chen & Sun, 1997; Tse & Bailey, 1992; Province et al., 1995; Wolfson et al., 1996), velocity of sway (Shih, 1997), lateral body stability (Jacobson, Chen, Cashel, & Guerrero, 1997), and muscle strength (Lan et al., 1998).

Exercise and Functional Limitation

Most investigators of exercise interventions on arthritic pain also investigated functional limitations (mobility, gait). Mobility is the ability to move with intent within
the environment (Creason, 1990; Roberts, 1999), and gait is the pattern or manner of ambulation that is integral to mobility needed for daily activities (Roberts, 1999; Tinetti, 1986). Land-based aerobic exercise including running (Fries, 1996), low-intensity cycling (Mangione et al., 1999) and water aerobics (Meyer & Hawley, 1994) increased function. Muscle strength-training also improved pain and increased mobility (Schilke et al., 1996), physical performance (Ettinger et al., 1997), and knee stability (Hurley & Scott, 1998; O’Reilly et al., 1999).

Many studies have demonstrated the health benefits of aerobic exercise (Brown et al., 1995; Engels et al., 1998; McMurdo & Burnett, 1992) including increased muscle strength and endurance related to mobility (Brown et al., 1995; Engels et al., 1998; Howze, Smith, DiGilio, 1989), and gait and balance (Roberts, 1989). Yet, some studies have not found a significant effect of exercise on functional limitations of gait (Cress et al., 1999; Topp, Mikesky, Dayhoff, & Holt, 1996) and mobility (Rubenstein et al., 2000). Tai Chi has been shown to decrease impairment by improving balance (Chen & Sun, 1997; Province et al., 1995; Tse & Bailey, 1992; Wolfson et al., 1996), and improve muscle strength (Jacobson et al., 1997) and flexibility (Lan et al., 1998). However, little is known of the effects of Tai Chi on the functional limitations of elders (mobility, gait).

Exercise and Disability

Exercise has been found to decrease disability (inability to do ADL, IADL). Activities of daily living (ADL) are functions that people routinely perform (Katz, Ford, Moskowitz, Jackson, & Jaffee, 1963), and instrumental activities of daily living (IADL) are routine tasks that people perform to maintain self in the home (Lawton, Moss, Fulcomer, & Kleban, 1982). Most studies of exercise and disability assess aerobic (Fries,
1996; Mangione et al., 1999; Penninx et al., 2001) and muscle-strength training (Engels et al., 1998; Miller, Rejeski, Reboussin, Ten Have, & Ettinger, 2000; Penninx et al., 2001). Little focus has been on the use of ROM exercise to reduce disability.

Furthermore, the effect of Tai Chi on disability (ability to do ADL, IADL) among older adults with OA is favorable, yet limited to several studies (Judge, Schechtman, & Cress, 1996; Kutner, Barnhart, Wolf, McNeely, & Xu, 1997; Li et al., 2001).

Recently disability has been defined by Jette and colleagues (2002) in terms of life tasks that extend beyond the traditional focus of I/ADL to include role-related activities categorized as social, personal, instrumental, and management (Jett et al., 2002). Results are limited to the psychometric testing and development of the Disability Component of the Late Life Function Disability Instrument (LLFDI).

The original research questions were:

1. Do seniors in a 10-week Tai Chi program have less impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (mobility, gait) and disability (IADL, life tasks) than those who do not use Tai Chi?

2. Do the effects of Tai Chi on pain hold while controlling for analgesic medication usage?

3. Do the effects of Tai Chi on anxiety and depression hold while controlling for pain?

Because the sample size was smaller than planned, the research purpose was changed to describe the dependent and control variables by group over time to compare the groups on changes in two impairment variables (pain and muscle strength).
Definitions

Tai Chi

Tai Chi is exercise that combines physical movement with meditation (Schaller, 1996) and was measured using weekly class attendance, and reported practice during the previous week before the start of each class.

Impairment

Impairment is a psycho-emotional, physiological, structural or functional deficit (Brandt & Pope, 1997). In this study impairment included pain, anxiety, depression, balance, and muscle strength.

Pain. Pain is an unpleasant sensory and emotional experience (Loeser & Melzack, 1999). In this study, pain lasted more than three months and was related to joint degeneration, and was measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale.

Anxiety. Anxiety is an unpleasant emotional response associated with a perceived threat (NIMH, 1999; Walker, 1990) and was measured by the State Anxiety Inventory (STAI-S).

Depression. Depression is extreme sadness generally out of proportion to the cause (Osol, 1973). Depression can be conceptualized in terms of the symptoms of depression (Pasacreta, 1997, p. 349). In this study, depressive symptoms were measured by scores on the Center of Epidemiologic Studies Depression Scale (CES-D).

Balance. Balance is postural equilibrium (Danis et al., 1998; Maki & McIlroy, 1996) that permits the person to control upright posture under various conditions (Berg & Norman, 1996) and was measured by the balance subscale of the Tinetti Mobility Assessment Instrument.
Muscle strength. Muscle strength is the maximum force produced by a muscle or related muscle groups (McArdle, Katch, & Katch, 2001) and was measured by using a dynamometer to assess strength of five muscle groups of the dominant lower extremity (in kg) during hip flexion, knee flexion and extension, plantar flexion, dorsi flexion, and foot inversion.

Functional Limitations

Functional limitation is an inability to perform an activity normally that results from impairment (Brandt & Pope, 1997). In this study, functional limitations included mobility and gait.

Mobility. Mobility is the ability to move with intent within the environment (Creason, 1990) and was measured by the Get-Up and Go test and the advanced lower extremity subscale of the Function Component of the Late Life Function Disability Instrument (LLFDI).

Gait. Gait is the pattern or manner of ambulation that is integral to mobility needed for daily activities (Roberts, 1999; Tinetti, 1986) and was measured by the gait subscale of the Tinetti Mobility Assessment Instrument.

Disability

Disability is the inability to perform socially-defined activities and roles, and is a potential outcome of a threshold effect of impairment and functional limitation on disability (Brandt & Pope, 1997). In this study, disability included instrumental activities of daily living and life tasks.

Instrumental activities of daily living. Instrumental activities of daily living (IADL) are routine tasks that people perform to maintain their self in the home (Lawton
et al., 1982) and were measured by the self-care capacity subscale of the Older Americans Resource Survey (OARS).

Life tasks. Life tasks are role-related activities that involve a variety of social areas beyond the standard ADL and IADL (Jette et al., 2002) and were measured by the Disability Component of the LLFDI.

Osteoarthritis is the leading cause of disability in older American adults. Exercise has the potential to improve impairment and ameliorate functional limitations that may potentially reduce the chance of a disability outcome. Tai Chi is an alternate form of low impact exercise that offers aerobic, flexibility, and strength-benefits. Yet, little is known of the benefits of Tai Chi on impairment, functional limitations, and disability in older adults with OA pain and functional deficits. Therefore, research is needed to substantiate these claims.
Chapter II
Review of Literature

The purpose of this study was to determine the effects of Tai Chi on impairment, functional limitations, and disability of older adults with chronic osteoarthritis (OA) pain. This chapter begins with a discussion of OA and mechanisms of disability, followed by a modified version of Nagi’s model of disability and factors known to influence functional limitations and disability in OA. In addition, the literature was reviewed for impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (gait, mobility), disability (IADL, life tasks), and exercise (Tai Chi) in elders. Furthermore, the literature was reviewed for gaps in the literature and confounding variables (covariates) that have been shown to affect the outcomes of interest.

Osteoarthritis

Arthritis is major health problem that affects over 70 million Americans (Center for Disease Control and Prevention, 2002). Osteoarthritis (OA), also known as degenerative joint disease, is the most common type of arthritis that effects 60% of people 65 years and older. The cause of primary or idiopathic OA is unknown; however, secondary OA is generally related to trauma or an underlying medical condition, such as diabetes and obesity. Clinical characteristics of OA are stiffness in the morning < 30 minutes, bony tenderness and enlargement, and no palpable warmth (Moskowitz, 1993). The weight bearing joints of the lower extremities, including the knee and hip, are primarily affected in older adults with OA.

Osteoarthritis is associated with increased impairment, functional limitations, such as mobility and gait, and disability (Moskowitz, 1993). Pain intensity (impairment)
is related to a person’s ability to move with intent within the environment and perform activities of daily living (ADL) (Borjesson et al., 1996; Kee et al., 1998). Generally as pain improves, the individual is more functional and disability (or the ability to perform ADL) improves (Bautch et al., 1997; Maurer et al., 1999; Meyer & Hawley, 1994). Furthermore, less arthritis pain is linked with improvements in other impairments including anxiety (van Baar et al., 1998), depression (Magni et al., 1990), balance (Messier et al., 2002), and muscle strength (Hurley, 1999).

Exercise has the potential to improve impairment, such as arthritis pain, and ameliorate functional limitations and disability. Most studies suggest that exercise reduces impairment and functional limitations in elders, while evidence to support the claim of exercise on disability is not as compelling (Keysor & Jette, 2001). Yet, aerobic and muscle strength training have been found to increase mobility and the performance of ADL and reduce disability (Mangione et al., 1999; Meyer & Hawley, 1994; Schilke et al., 1996). Little is known of the effects of range of motion (ROM) exercise on function and disability, and even less is known of the effects of Tai Chi.

**Mechanisms of Disability**

This study was designed using a modified version of Nagi’s model of disability (Brandt & Pope, 1997). Disability is the potential outcome of the relationship between impairment and functional limitations of the person, and a product of the interaction of person and environment. The movement of impairment in the direction of functional limitations and subsequent disability is influenced by transitional factors on a person level, and a therapeutic modality such as exercise intervention (external environmental) can potentially affect these factors that influence disability outcome. Hence, in this
model, the interaction of person and environment has the capability of possibly preventing the development of disability.

Factors known to influence functional limitations and disability in OA are considerable, and primarily related to the consequences of degenerative joint disease. Physical (pain and poor, balance) and psychological (anxiety and depression) factors are linked with impairment in this model and oftentimes manifest in functional limitations and subsequent disability. Physical factors of gait and mobility are linked with functional limitations, which in turn influence the outcome of disability, or inability to perform social roles and tasks. However, exercise (external environment) is a widely accepted intervention used to modify the factors associated with impairment and functional limitations that affect the potential outcome of disability in people with OA. In this model, disability is a potential outcome that is dependent upon a threshold effect of impairment and functional limitation on disability.

Impairment

Pain. Pain is an unpleasant sensory and emotional experience (Loeser & Melzack, 1999) that is classified in terms of physical-time. Acute pain is analogous with tissue injury of short duration (Carr & Goudas, 1999), while chronic pain may or may not be related to tissue injury, and is long-term in nature (Loeser & Melzack, 1999). Chronic pain is generally linked with age-related conditions, such as OA, and usually lasts more than three months.

Pain sensation is initiated by tissue trauma and inflammation that stimulates nociceptors resulting in the ascent of impulses to the dorsal horn. At this level, impulses may be modulated by influences in the medulla (Chapman & Gavrin, 1999; Urban &
Adler

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Gebhart, 1999), such as opioids, stress and pain that originate from higher levels in the central nervous system (Ferrell, 1991) or continue on a pathway to the pons and thalamus to the cerebral cortex (Chapman & Gavrin, 1999). In addition, stimulation of the hypothalamus by cytokines from tissue injury, and by dorsal horn and pons pathways initiates a stress response characterized by complaints such as fatigue and impaired functioning (Chapman & Gavrin, 1999). Neurotransmitters are located in the ascending and descending pathways, and other areas of the brain, spinal cord, nerves and ganglia that mediate the body’s response to pain (Ferrell, 1991).

Arthritis pain is attributed to the movement of roughened joint surfaces that produce a local tissue response. Arthritis pain increases as the destruction of the articular cartilage and soft tissue of the joints progresses (Ashburn & Staats, 1999; Car & Goudas, 1999; Loeser & Melzack, 1999). Arthritis pain is associated with anxiety (van Baar et al., 1998), depression (Magni et al., 1990), balance impairments (Messier et al., 2002), and gait and mobility functional limitations that often times result in disability (Moskowitz, 1993). As pain improves, generally the person is better able to perform daily roles and tasks (Bautch et al., 1997; Maurer et al., 1999; Meyer & Hawley, 1994). In this study, however, pain well be measured by self-report on the pain subscale.

In clinical practice, pain is usually measured in terms of pain intensity (Herr & Mobily, 1993). Self-report measures of pain are considered the norm, because pain is a subjective and unique to the individual. However, other methods of pain measurement are used, including direct observation and (indirect) functional assessment (Herr, 1998), because the relationship between pain and functional status is well documented.
Anxiety. Anxiety is an unpleasant experience associated with a perceived threat (Walker, 1990), and recognized by many as a common response to the degenerative process of OA in older adults (Dieppe et al., 2000; van Baar et al., 1998). Yet, it is unclear as to whether anxiety is a risk factor for subsequent disability or the consequence of the inability of the person to perform daily roles and tasks (Creamer, Lethbridge-Cejku, & Hochberg, 2000).

Anxiety is a response based on fear to a real or perceived threat that stimulates the amygdala and triggers the body’s “fight-or-flight” response mediated by the sympathetic autonomic nervous system (National Institute of Mental Health [NIMH], 1999). Sympathetic impulses incite visceral effectors that produce increased heart rate, vasoconstriction of most viscera and skin, vasodilation of heart, lungs, brain, and skeletal muscle, contraction of spleen, liver gluconeogenesis, sweating, dilation of airways, and inhibition of digestion (Tortora & Grabowski, 1993). In addition, hypothalamic hormones known as corticotropin releasing hormone (CRH), growth hormone releasing hormone (GHRH), and thyrotropin releasing hormone (TRH) are produced long-term (resistance reaction) to stimulate the secretion of cortisol, growth hormone, and thyroid, respectively, to restore homeostasis (Tratora & Grabowski, 1993). Yet, chemical triggers that initiate this physiological response may vary. For example, a common type of anxiety in women is generalized anxiety disorder (GAD) that is associated with an imbalance in neurotransmitters gamma amino butyric acid and epinephrine (Lark, 1996).

Anxiety is related to pain (Creamer et al., 1999) and disability in elders with OA (Creamer et al., 2000; van Baar et al., 1998), and in most studies, anxiety has also been associated with depression. However, a recent study of older adults with lower limb OA
found that depression was not significantly linked with disability, yet anxiety was shown to be statistically significant (Creamer et al., 2000). Measures used in Creamer et al. study were the Center for the Epidemiological Studies depression scale (CES-D) modified for arthritis patients and the trait section of the State-Trait Anxiety Inventory (STAI), respectively. Results may have been related to the predominance of a lower depression in the sample at baseline (only 15.4% possibly depressed).

**Depression.** Depression as a diagnostic category is characterized by subjective or personal feelings of extreme sadness generally out of proportion to the cause (Osol, 1973) and, like anxiety, is associated with arthritis pain in older adults (Creamer et al., 1999). Depression is higher in those with chronic pain (Magni et al., 1990) and increases with greater pain (Bautch et al., 1997; Werner et al., 1998). Depression in elders is also linked with functional decline (Wang, van Belle, Kukull, & Larson, 2002) and increased risk of disability (NIMH, 1999; Penninx, Leveille, Ferrucci, van Eijk, & Guralnik, 1999). In this study, depressive symptoms will be measured.

Depression is a brain disorder of dysfunctional neural circuits that regulate mood, thinking, sleep, appetite, with neurotransmitter imbalance (NIMH, 1999). Evidence suggests that the pathology of depression is related to low serotonin levels caused by an overactive cellular protein inhibitor known as 5-HT1b (Neumaier, 1999), although genetic research demonstrates the notion of susceptibility to mood disorder because of the interaction of genetic and environmental factors (NIMH, 1999). The link between depression with hormones and the stress response is under investigation. In this study, depression was conceptualized in terms of the symptoms of depression (Pasacreta, 1997, p. 349).
**Balance.** Balance is postural stability or equilibrium (Danis et al., 1998; Maki & McIlroy, 1996), and is described as having static and dynamic properties. The difference between these two properties is movement, whereby dynamic balance involves postural stability during gait, and static balance does not (Roberts, 1999). Balance requires the center of mass (COM) located in the pelvis to be positioned over the base of support (Maki & McIlroy, 1996) that permits the person to control upright posture under various conditions (Berg & Norman, 1996). Balance impairment is associated with decreased muscle strength and increased pain and risk of falls in elders with OA (Messier et al., 2002).

Balance or postural equilibrium is initiated by stimulation of sensory receptors of the inner ear (utricle, saccule, semicircular ducts) in response to movement of the head that synapse with the vestibulocochlear nerve (VCN-VII) and motor efferent fibers. Fibers from the VCN-VII extend to the cerebellum and the vestibular nuclei (pons) that continue on to the cervical spinal cord and cranial nerves III, IV, VI, and XI, and form the vestibulospinal tract. The vestibulospinal tract conducts impulses that adjust skeletal muscle tone in response to head movement, although the recruitment of specific skeletal muscles to maintain balance initiate in the motor cortex in response to feedback from the cerebellum (Tratora & Grabowski, 1993, pp. 444-465, 494-498).

Recent investigation of balance and elders with OA has focused on those with knee involvement. One study found significant increase in static postural sway and less dynamic standing balance, using a swaymeter and step test, respectively (Hinman, Bennell, Metcalf, & Crossley, 2002), while another study of standing balance showed significantly more postural sway, using a computerized Balance System (Wegener,
A third study assessed balance and lower extremity muscle strength in elders with chronic knee pain and found a decline of both, yet those with better muscle strength demonstrated less decline in balance (Messier et al., 2002).

**Muscle Strength.** Muscle strength is the maximum force produced by a muscle or related muscle groups that diminishes with age because of neuromuscular deterioration and inadequate loading (McArdle, Katch, & Katch, 2001). The structural competence and function of the joint is dependent upon muscle strength. Skeletal muscles provide soft tissue support to the joints that also act as shock absorbers (Hurley, 1999). Joint laxity often found in those with OA is related to decreased muscle strength and is associated with pain and balance impairments (Lane & Buckwalter, 1999).

**Functional Limitations**

**Gait.** Gait is integral to mobility needed for daily activities (Tinetti, 1986). Gait requires an intact neuromuscular system for the coordination of alternating movements of the legs in an upright posture, while maintaining control over the position of the center of gravity (Berg & Norman, 1996). The gait cycle begins with the contact of the heel of the foot with the ground, continues through the stance and swing phases of gait, and ends when the same foot comes in contact with the ground once again (Judge, Ounpuu, & Davis, 1996). The stance phase of gait starts with the initial contact of the foot and transitions into the second phase with “toe off.” The swing phase begins with “toe off” and ends when the same foot comes in contact with the ground. In a sense, the “pattern is one of loss and recovery of equilibrium” (Berg & Norman, 1996, p. 707).

Changes in gait occur with age, including slower pace, shorter stride length, more time using double support stance, increase stance time, and reduced swing phase (Judge
et al., 1996), and with joint pain and instability that negatively impact the body
to move the body using the legs. These consequences contribute to
the risk and fear of falls in older adults with OA (Rubenstein et al., 2000). Furthermore,
gait is associated with mood (Buchner et al. 1996), flexibility, strength and balance
(Brown et al., 2000), social and physical activity (Cwikel, Fried, Galinski, & Ring, 1995),
pain relief (Fransen, Margiotta, Crosbie, & Edmonds, 1997), and exercise (Scandalis,
Bosak, Berliner, Helman, & Wells, 2001; Topp et al., 1996).

Mobility. Mobility is the ability to move with intent within the environment
(Creason, 1990) that is contingent upon an intact neuromuscular system and gait
competence (Roberts, 1999). Mobility functional limitations increase with age (Lee &
Kim, 1997) and have been linked to increased risk and fear of falls in elders (Spellbring
& Ryan, 1997), and related to balance and postural control impairments. These
impairments have been associated with decreased muscle strength (Brill et al., 1999;
Buchner, 1997) that is especially burdensome to elders with OA of the lower extremities
resulting in pain and joint instability. Mobility functional limitations in older adults have
also been identified as predictors of disability (Strawbridge, Cohen, Shema, & Kaplan,
1996), independence, and functional capacity in terms of I/ADL (Podsiadlo &
Richardson, 1991).

Disability

Activities of daily living and instrumental activities of daily living. Activities of
daily living (ADL) are self-care activities or functions that people routinely perform
every day, while instrumental activities of daily living (IADL) are routine tasks that
people perform to maintain self in the home (Katz et al., 1963). Those who are not able to
perform daily tasks (I/ADL) that support independence will likely become disabled. The ability to perform I/ADL is closely linked with physical performance. Recent evidence suggests that physical performance competency including gait and mobility is a prerequisite to an individual’s ability to carry out ADL (Strawbridge et al., 1996) and IADL (Judge et al., 1996).

Decline in I/ADL (disability) in elders with OA has been linked to greater impairment such as pain, anxiety (Creamer et al., 2000), depression (Penninx, et al., 1999), and is associated with functional limitations including gait (Judge et al., 1996) and mobility (Strawbridge et al., 1996).

*Life tasks.* Life tasks are role-related activities that involve a variety of social areas beyond the conventional assessment of disability (I/ADL). Life tasks consist of two dimensions of disability (frequency of performance and limitation in performance of life tasks), with two domains each: (1) personal and social roles and (2) instrumental and management roles (Jette et al., 2002). Unlike I/ADL, life tasks encompass a wide variety of socially defined activities that are expected of a person within a typical environment (Jette et al., 2002, p. M209). The use of life tasks to assess disability was first described with the recent development of the disability component of the Late Life Function and Disability Instrument that uses Nagi’s model as a framework, and has yet to be tested in elders with OA.

*Exercise*

Exercise is planned, structured physical activity (Jones & Jones, 1997), and is classified as aerobic or anaerobic, depending on the underlying physiological demand of the activity. Aerobic exercise requires oxygen to produce energy by means of cellular
oxidation (Krebs cycle) in the mitochondria, while anaerobic exercise does not require oxygen and relies on glycolitic metabolism in the cytosol for its energy source (Brooks et al., 2000). Exercise of more than one-minute duration requires oxygen, and, therefore, aerobic metabolism, and utilizes slow-twitch skeletal muscle fibers. However, a short burst of exercise, such as a fast sprint, of less than one minute duration, can be sustained by anaerobic metabolism using fast-twitch skeletal muscle fibers (Brooks et al., 2000). Skeletal muscle fiber types (fast and slow-twitch) reflect the characteristic metabolic activity within the sarcomere.

Types of exercise include aerobic, muscle strength training, and flexibility or range of motion (ROM) (McArdle, Katch, & Katch, 1996). Aerobic exercise improves cardiovascular, respiratory and musculoskeletal function (Lam, 1999; Tratora & Grabowski, 1993), decreases blood pressure, improves mood, increases high-density lipoproteins, and inhibits osteoporosis (Tratora & Grabowski, 1993). Muscle strength-training increases the strength of muscles, tendons, and ligaments, promotes joint stability (McArdle et al., 1996; Schnitzer, 1993), and improves circulation to the joint and surrounding tissues (Lam, 1999). Range of motion exercise increases joint flexibility by gently stretching and strengthening the adjoining soft tissue of the joint (Dexter, 1992; Lam, 1999).

Exercise is low, moderate, or high intensity, and refers to the degree of burden placed on an individual’s system (McArdle et al., 1996). Although a variety of measures are available to assess exercise intensity, heart rate (HR) is used extensively because it is efficient and has a predicable relationship with maximum oxygen consumption (VO$_{2\text{max}}$) (McArdle et al., 1996). An increased HR to about 70 percent of maximum HR improves
aerobic capacity and is associated with moderate intensity exercise, and is equivalent to a score of 13 or 14 (somewhat hard) on the Borg rating scale of perceived exertion.

Exercise and Older Adults with OA

Customized exercise programs of flexibility, strength and endurance training reduce pain and do not exacerbate pain associated with OA in elders (O’Grady, Fletcher, & Oritz, 2000). Isokinetic quadriceps exercises (3 times per week over 8 weeks) were found to significantly decrease pain in older adults with knee OA when compared to a series of four education sessions. Similar results were shown with the addition of agility and perturbation training to a 6-week program of lower extremity stretching, strength, and endurance exercise (Fitzgerald, Childs, Ridge, & Irrgang, 2002), and after a hospital outpatient group exercise program was modified to include a home follow-up program (Fransen et al., 1997). Others found pain reduction with both home-based traditional and home-based functional exercise programs following elective knee arthroplasty, yet no statistically significant difference was demonstrated between the two groups (Frost, Lamb, & Robertson, 2002).

A community-based aquatic program decreased depression (Belza, Topolski, Kinne, Patrick, & Ramsey, 2002). Those in an aerobic exercise program had significantly less depression but similar effect was not observed in elders who participated in resistance exercise (Penninx et al., 2002). Yet, both aerobic and muscle strengthening exercise significantly reduced disability and pain in this latter study.

Anxiety in older adults with OA decreased using exercise intervention in an Arthritis Self-Management Program (Barlow, Turner, & Wright, 2000) and in a 12-week program comparing aerobic walking, aerobic aquatic and non-aerobic (range of motion)
exercise (Minor, Hewett, Webel, Anderson, & Kay, 1989). Another study of water aerobic exercise participants had significantly less anxiety compared to rheumatic clinic patients who did not exercise (Meyer & Hawly, 1994).

Balance has been assessed most often in elders with OA using clinical and laboratory tests with matched controls (Hinman et al., 2002) or a single cohort (Messier et al., 2002). However, a recent study demonstrated significant improvement in static postural ability in both exercise intervention groups (aerobic walking and strength training) compared to health education (Messier, Royer, Craven, O’Toole, Burns, & Ettinger, 2000).

Traditional physiotherapy treatments (Borjesson et al., 1996), ROM and progressive strength training (Fisher, White, Yack, Smolinski, & Pendergast, 1997) did not significantly improve gait in participants with knee OA. Yet, others found significant improvement in gait in patients with knee OA who attended a hospital outpatient group exercise program that was revised to include supplemental home care (Fransen et al., 1997), and ten weeks of either high- or low intensity exercise group using stationary cycling as an exercise alternative (Mangione et al., 1999).

Gait was improved in hip replacement patients using a customized exercise program (Wang, Gilbey, & Ackland, 2002) and treadmill training (Hesse et al., 1999), and in knee replacement patients with an in-hospital exercise program (Erler, et al., 2000). In vivo measurements of acetabular pressures in one elder with hip OA demonstrated that walking exercise generated lower pressures compared to isometric hip and standing exercise, and gait or stationary cycling (Tackson, Krebs, & Harris, 1997).
Others found that exercise combined with diet in obese elders with knee OA improved loading rate and maximum braking force during gait (Messier, Loeser et al., 2000).

Significant improvement in mobility was demonstrated using a home-based (exercise) rehabilitation program after arthritic knee arthroplasty (Frost et al., 2002), and eight weeks (3 times per week) of muscle strength-training for elders with knee OA (Schilke et al., 1996). Yet, no significant improvement in (joint) mobility and function was shown in older adults with hip and knee OA involved in a program with six weeks of physical therapy and health education (Hopman-Rock & Westoff, 2000).

Long term improvement of physical function with exercise was shown using the Stanford Health Assessment Questionnaire, and normal and fast gait speed with electric foot switch walkway (Fransen et al., 1997). However, similar effects were not demonstrated by others using the 6 minute walk, pain and stiffness subscales of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) (Deyle et al., 2000), and knee extension and flexion, muscle strength, function, pain, walking speed, and frequency of palpable joint effusion and crepitus (Rogind et al., 1998).

Muscle strength-training was found to be more economical than aerobic exercise at improving physical function (self-reported disability score, 6-minute walk, stair climbing, lifting and carrying task, car task, pain frequency and intensity on ambulation and transfer). Although the cost per participant for resistance training was less than education and more than aerobic training, the incremental savings for each incremental effect was greater for resistance training (Sevick et al., 2000).

Exercise improved disability in elders with OA using ADL as a measure of disability (Ettinger et al., 1997; Meisser, Royer et al., 2000; Miller et al., 2000; Penninx
Adler et al., 2001) or functional decline (Fitzgerald et al., 2002; Penninx et al., 2002; Wang, van Belle et al., 2002), and also reduced the mediating effect of functional limitations on ADL in elders (Miller et al., 2000). Others demonstrated improvement in IADL using aerobic and muscle strengthening exercise (Miller et al., 2000; Wang, van Belle et al., 2002).

In comparison, these findings of exercise and elders with OA on impairment, functional limitations, and disability are similar to, and yet different than those found in older adults in a review of 31 studies from 1995 to 2000 by Keysor and Jette (2001). Like the studies of exercise and elders with OA, exercise was found to improve impairment (97%) and functional limitations (81%) in older adults. However, unlike the studies of exercise and elders with OA, Keysor and Jette (2001) found that only five studies (15%) demonstrated improvement in disability. These authors concluded that the current outcome measures used to test disability lacked sensitivity, and therefore developed an alternative measure of disability (LLFDI) based on Nagi’s model of disability (Jette et al., 2002, p. M209).

Tai Chi

Tai Chi combines physical movement with meditation (Schaller, 1996). Tai Chi has its roots in eastern tradition based on the concept of balancing chi (bioelectricity) flow, yet Tai Chi has been tested in the west and around the world for its effectiveness as a muscle strengthening, aerobic (endurance) exercise, and flexibility exercise (Jwing-Ming, 1991, pp. 64-67).

Tai Chi has been found to improve muscle strength of knee extender and flexor muscles (Lan et al., 1998) through slow, repetitive, and alternating movement of the legs
with knees slightly flexed, shifting the weight from one leg to another in a sequence of postures that, at times, require a single leg stance. In addition, the movement of the feet requires placement on the ground using a slow “pumping action” of heel-to-toe (or toes to heel) that strengthen the lower extremities.

Tai Chi has been demonstrated to be a low (Fontana et al., 2000) to moderate (Lan et al., 1996) intensity aerobic exercise that consists of slow and continuous movement of the body in an upright posture in coordination with breath, while keeping the mind alert yet relaxed. Mental health benefits have been compared to those obtained using moderate aerobic exercise (Jin, 1989) and are likely related to modification of the stress response.

*Proposed Mechanisms for Selected Variables*

In summary, pain is reduced using Tai Chi because joints are strengthened and more stable, yet relaxed, and better nourished (Lam, 1999). Anxiety and depression are improved because of less pain related to joint stability and a relaxation response as demonstrated by increased cortisol levels (Jin, 1989, 1992) and possibly endorphin secretion (moderate aerobic effect) (Lan et al., 1996). Also decreased risk and fear of falling (Province et al., 1995; Taggart, 2001) is likely linked with joint stability and better postural control that contribute to the mental health benefits. Balance improves (Schaller, 1996; Taggart, 2001; Tse & Bailey, 1992) because of increased joint stability and postural control associated with slow, purposeful exercise, body alignment, lower center of gravity (Liao, 1990; Olson, 1992), and attention to foot placement. Muscle strength is increased (Hong, Li, & Robinson, 2000; Lan et al., 1998) because of slow, repetitive and alternating movement of the legs, shifting the weight from one leg to another in a
sequence. At times, these movements require a single leg stance while maintaining a balanced, upright body position (Liao, 1990; Olson, 1992). Better structural support of the joints is related to less pain and a reduction in anxiety and depression.

Gait improvement using Tai Chi is related to better balance, and decreased pain and mental impairment. In addition, gait improvement is dependent on the manner in which people perform the slow, coordinated movements of breath and body while being mindfully alert (Liao, 1990; Olson, 1992). Despite decreased gait velocity and increased walking stance (Kirsteins et al., 1991), gait is perhaps more functional and less risky for elders. Whereas, mobility improvement is likely associated with more effective gait (Roberts, 1999) and increased body awareness. Extra attention is paid to posture and movement, in particular, of the placement of the feet and position of the head. The head is held upright with the eyes open while moving the body with intention in the direction of the movement (Liao, 1990; Olson, 1992).

Moreover, activities of daily living, instrumental activities of daily living, and life tasks are likely improved using Tai Chi because of less impairment and functional limitations. These changes may contribute to the prevention of a disability outcome (Brandt & Pope, 1997; Jette et al., 2002).

Tai Chi and Impairment

Tai Chi was found safe for patients with rheumatoid arthritis because tests that included joint pain showed no significant exacerbation compared to controls (Kirsteins et al., 1991), and also improved balance in the well elderly but had no effect on pain (Schaller, 1996). Yet, others found significant decrease in pain in seniors with chronic pain (Adler et al., 2000) and no significant effects for pain or balance (Hartman et al.,
These studies were experimental in design, yet used small samples and a variety of different measures to assess the pain. The measures included self-report with palpation of joints (Kirsteins et al., 1991), pain intensity number scale (PINS) (Adler et al., 2000), and pain subscale of AIMS (Hartman et al., 2000) and the SF-36 (Schaller, 1996). The use of different measures to test pain may have contributed to the inconsistent findings. Hence, only the pilot study (Adler et al., 2000) showed significant pain reduction in one measure of pain.

The pilot study of 16 elders with OA with joint pain (Adler et al., 2000) found significantly greater decrease in pain (0-10 pain intensity scale) in the Tai Chi group than in the control group. Pre and posttest analgesic use were comparable, and no significant group differences in post minus pretest difference scores were found in health (Rand-36 health survey) or pain (Short-Form McGill Pain Questionnaire, and pain subscale of Rand-36). The floor effect in measures of pain reduced the power of the statistical tests and limited the amount of change in pain attributable to Tai Chi.

Since 2000, only one study assessed the effect of Tai Chi intervention on arthritis pain. Song and colleagues (2003) found significantly less reported joint pain with the WOMAC pain subscale, and stiffness in a 12-week Tai Chi experimental study of 33 elderly women. It is noted that there was 41% attrition in this study (Tai Chi = 43%, Control = 39%). Significant improvement was also found in balance, abdominal strength, and perceived physical functioning despite the evident attrition threat to the internal validity of the study and its findings.

Evidence of Tai Chi use to reduce psychological impairment is limited. Tai Chi has been shown to decrease depression and anxiety in healthy adults (Jin, 1989, 1992)
using the Profile of Mood States (POMS) and State-Trait Anxiety Inventory (STAI), respectively. Yet, others have demonstrated significant effects of Tai Chi on anxiety in elders with chronic illness assessed by the Arthritis Impact Measurement Scales (AIMS) (Hartman et al., 2000) but not on depression (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996) using the POMS and mood subscales of the SF-36 Health Survey, Rand-36 Health Survey, and the AIMS, respectively. Perhaps the inconsistent findings are related to differences in sample size ($n = 16-96$), health conditions and age. Only two studies (Jin, 1989, 1992) reported samples greater than 60, yet these studies were not randomized and included Tai Chi practitioners.

Tai Chi was shown to increase balance (Schaller, 1996; Taggart, 2001; Tse & Bailey, 1992) and strength among older adults (Hong, et al., 2000; Jacobson et al., 1997), and to reduce the risk of falls (Province et al., 1995; Taggart, 2001). However, elders with lower extremity OA using Tai Chi did not demonstrate significant improvement in balance measured by a single test of one-leg standing balance (Hartman et al., 2000) that may have contributed to the results of the findings.

Tai Chi and Functional Limitations

Little research has been done to assess the effects of Tai Chi on gait and mobility; the focus has been on its effectiveness of improving balance impairment in elders. Tai Chi significantly reduced the amount of time to walk 50 feet in the experimental group in a study designed to assess the safety of 10-weeks of Tai Chi for patients with rheumatoid arthritis (Kirsteins et al., 1991), while Taggart (2001) found significant improvement in self-reported gait with a three month Tai Chi program for older women. Others found no significant improvement in gait or mobility using quantitative measures in a 12-week
study of Tai Chi and elders with lower extremity OA (Hartman et al., 2000). Perhaps the type of measure used to assess gait and mobility accounts for the differences in findings.

*Tai Chi and Disability*

Randomized participants of 15 weeks of Tai Chi ($n = 130$) reported improvement in activities of daily living (ADL) at a four month follow-up interview that was tested using a single-item question, “Has participation in the program affected your activities of daily living in any way?” (Kutner et al., 1997). One meta-analysis showed that Tai Chi exercise demonstrated strong association between physical performance (gait velocity, balance function, grip strength, and chair rise time) and independence of IADL (Judge et al., 1996). Yet, another randomized study of Tai Chi ($n = 94$) found significant improvement in daily activities of sedentary older adults ranging from walking and lifting to running measured by the physical function subscale of the SF-20 (Li et al., 2001). The Tai Chi group improved 65% in daily activities (physical function) after completing a one-hour, twice a week, 6-month Tai Chi program while the wait-list control group improved 22%.

In summary, OA, also known as degenerative joint disease, is the leading cause of disability in elderly Americans and primarily effects the weight bearing joints of the lower extremities in older adults, including the knee and hip. Millions of elders with OA suffer pain, depression, anxiety, balance, and muscle strength impairment, and functional limitations such as gait and mobility that often result in disability or the inability to perform ADL, IADL, and life tasks. Exercise is recommended to reduce impairments, maintain function, and prevent disability. Tai Chi is an alternative form of exercise that has the potential to ameliorate functional limitations and disability because
of its aerobic, strengthening and ROM components. However, little research has been
done on the effects of Tai Chi on elders with chronic OA and results have been
inconclusive.

Despite favorable effects of Tai Chi on OA pain (Adler et al., 2000; Song et al.,
2003), these results have not been found in other studies (Hartman et al., 2000; Schaller,
1996). Although Tai Chi has been shown to decrease depression (Jin, 1989, 1992), others
found no effect (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996). Evidence
suggests that Tai Chi reduces anxiety (Hartman et al., 2000; Jin, 1989, 1992). Tai Chi has
also been shown to improve balance in older adults but not in elders with OA (Hartman et
al., 2000) and to improve muscle strength (Lan et al., 1998). The effects of Tai Chi on
gait in elders with OA were not significant (Hartman et al., 2000) and the effects on
mobility have been inconsistent (Hartman et al., 2000; Taggart, 2001).

Significant improvement in ADL with Tai Chi was found in elders with OA
(Kutner et al., 1997), but not among elders without OA (Li et al, 2001). In addition, a
meta-analysis suggested that Tai Chi improved IADL in older adults (Judge et al., 1996).

Therefore, the purpose of this study was to determine the effects of 10 weeks of
Tai Chi on impairment (pain, anxiety, depressive symptoms, balance, muscle strength),
functional limitations (gait, mobility), and disability (IADL, life tasks) of older adults
with arthritis pain. Unlike other studies, Nagi’s model provides this study with a
framework that allows the variables of interest to be tested for direct effects of Tai Chi.
Chapter III

Methods

Using a modified version of Nagi’s model of disability (Brandt & Pope, 1997) and an experimental design, a convenience sample of older adults with arthritic pain were randomly assigned to either a nonphysical recreational activity (Bingo), or a 10-week Tai Chi class. Impairment, functional limitations, disability were measured before the first and after the last exercise (Tai Chi) class and the Bingo sessions (control), and pain (impairment) was assessed weekly.

Sample

A convenience sample of 14 community-dwelling men and women 60 years and older with chronic pain related to osteoarthritis (OA) was recruited and randomly assigned to either a control \((n = 6)\) or experimental group \((n = 8)\) in August, 2005. The age criteria were lowered to 60 years from 65 years to enhance participant recruitment. OA is the leading cause of disability in older adults, and approximately 50% of people with OA pain are 65 years and older (CDCP, 1994). The percentage of women, men, and minorities in the sample was 93 \((n = 12)\), 7 \((n = 1)\), and 14 \((n = 2)\), respectively.

A sample size of 80 was proposed using \(\alpha = .05\) (one-tailed) with a power of .8 and an estimated large effect size of \(d = .7\) for ANOVA with two groups (Lipsey, 1990), and included 10 additional participants in each group to allow for 25% attrition. The proposed sample size was estimated from calculated effect sizes for pain and balance from other studies (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996; Song, 2003). The actual sample size was 14 participants and the analysis plan was adjusted accordingly.
Included were participants who had no Tai Chi practice during the previous three months and no activity limitations prescribed by a health practitioner. Participants were asked to rate their OA pain of the hip and/or knee during the past 24 hours using a pain intensity scale 0 (no pain) to 100 (most pain imaginable) and identify the activity that gave them pain. Included were those who reported OA knee and/or hip pain during the previous 24 hours; those with no pain were not included.

Included were people > 60 years who were ambulatory without the aid of an assistive device (except for distance), those who reported difficulty getting up from a chair, were able to speak and read English, had hip and/or knee pain and a physician confirmed diagnosis of OA of the hip and/or knee (yes, no) via facsimile; and those with no memory or concentration problem requiring medication, and no hearing deficit or regular Tai Chi practice. Excluded were those with fibromyalgia and recent history of myocardial infarction, stroke, or uncontrolled diabetes; activity limitations by the person’s physician; orthostatic hypotension, history of recent fall, and Meniere’s disease; those who were taking steroid analgesics or participating in an exercise program; and those with a mini mental score that showed impaired mental status (3 or more missed items out of 10 points) (McDowell & Newell, 1996, pp. 308-311).

**Experimental Intervention**

Participants in the experimental group began a program consisting of a one-hour class each week for 10 weeks, which was a reasonable and acceptable amount of time for elders to learn to use Tai Chi (Adler et al., 2000; Schaller, 1996). Since the effects of Tai Chi have been demonstrated in programs of 10 weeks (Schaller, 1996) and in pilot work, the intervention lasted 10 weeks. To determine adequate amount of the intervention, the investigator monitored weekly attendance and participants were expected to attend at
least 8 Tai Chi classes. The dose of 8 of 10 weeks of Tai Chi was based on the investigator’s experience in working with elders and Tai Chi in the community.

Tai Chi is a gentle exercise of low intensity and is appropriate for persons with impairments and functional limitations (Fontana et al., 2000) often found in elders with arthritis. Tai Chi is based on the Tao (Yin/Yang) philosophy of opposites and is a way to transform (change) the energy condition of the body to promote health. Tai Chi is considered a “mind-body” exercise (external environments factor) that involves physical movement with meditation (National Center for Complementary and Alternative Medicine, 2006; Schaller, 1996). Tai Chi begins with the shifting the mental focus to the abdomen (dantien) and breathing slowly through the nose. The head is positioned as if suspended from a thread, and the feet are firmly established with the ground as if rooted to the earth. As breathing continues, the pelvis (center of gravity) shifts downward, posture improves, muscles relax, and joints become more “open” as the top part of the body becomes lighter and the lower part becomes heavier. Then the slow, circular movements of Tai Chi are initiated, performed with a gentle heel-strike (cat walk) while shifting the weight in the legs in coordination with the arm movements and guided by the rate and depth of the breath. Participants were encouraged to use their imagination to visualize the different Tai Chi movements, many of which are patterned from animals in nature.

The traditional Wu-style form of Tai Chi was used because the upright stance and compact movements are more suitable to beginning senior practitioners. However, only the first part or “first circle” that consists of 16 movements was used because seniors can easily accomplish the movements within 10 weeks. The movements of the first part of the
form are also less complicated and easier to execute, compared to the other two sections. The first part of the form is generally practiced for health purposes rather than self-defense (T. Huang, personal communication, December 4, 1999). Participants were encouraged to move slowly using gentle steps and abdominal breathing, and use their legs as a foundation to move “bottom to top” before executing the hand/arm movements to decrease the risk of falling.

The same new movements were introduced to Tai Chi participants at each location weekly and were repeated during each class by the instructor, to reinforce learning the movements without overwhelming the participants with learning too many at a time. Prior to engaging in Tai Chi, the instructor guided the participants through warm-up exercises known as the Eight Movements for Health and Tai Chi Warm-up. A short break was planned about halfway through the class, to allow for a gradual transition from warm-up exercise to the form movements. In the nine years that the investigator has been teaching Tai Chi, no untoward reactions have been found even with physically compromised individuals such as those with multiple sclerosis. However, the investigator monitored participants for over exertion (extreme fatigue, light-headedness and shortness of breath). If this had occurred, the participants would have been instructed to stop exercising and rest in a chair until these symptoms abate. Although none of the participants complained of overexertion, on any given week, some participants would voluntarily sit down and rest or require additional attention to modify a particular movement to accommodate their body condition.

Ten weekly, one-hour classes took place in a comfortable, well-lit room in two community adult education centers that were easily accessible to participants without
having to use stairs. Music was not used during the class because it has been shown to be an effective intervention for pain and may have confounded the effect of the Tai Chi intervention (Good et al., 2001). Participants were encouraged to wear comfortable clothes and shoes with adequate support. Shoes with high-heels or no shoes were not permitted.

Participants were encouraged to practice daily at home, with the support of a class handout and videotape created by the investigator to facilitate learning. The handout was composed of the Eight Movements for Health, Tai Chi Warm-up and First Circle that complemented and reinforced the audiovisual demonstration of the same content for the learner. The instructor recommended, in keeping with the philosophy of Tai Chi education, that participants practice the movements they were taught and not worry about remembering or practicing all of them. With time and repetition, subjects were able to do more movements. Participants were requested to practice at least 3 times per week for 15 minutes. Participants reported weekly whether or not they practiced the movements. Refreshments were provided by the investigator each week.

Control Group

Participants in the control group met weekly with the investigator at two community adult education sites for a one-hour, 10-week non-physical recreational activity. Bingo is a popular non-physical recreational activity among many elders in the community. It is a social group activity of elder peers similar to the experimental group without the physical exercise of Tai Chi. Participants generally remain seated for the duration of the Bingo activity.

Bingo took place in the activity room of the facility where participants received
Bingo cards. The Bingo cards were cardboard with sliding plastic covers over each number so that “chips” are not necessary. Each board (card) had twenty-five numbers (5 x 5) in large print. A prize of $5 cash was awarded weekly to one player randomly selected from the pool of Bingo players to support participation and minimize the attrition threat to internal validity. In addition, participants had the opportunity to win prizes, and refreshments were available weekly. Bingo was conducted by the investigator who randomly selected individually numbered ping-pong balls from a wire basket, and than secured each selection to a “master” Bingo board and announced the number to participants. The numbers on the card of the bingo winner were checked with those on the “master” board for confirmation. A short break was planned about halfway through the Bingo activity session after five games were played.

Control groups were conducted at the same community centers as the Tai Chi classes but at different times of the day. The investigator monitored weekly attendance and participants were expected to attend at least 8 Bingo activity sessions. All those who completed the study received a $5 cash, certificate of participation, and the opportunity to attend a Tai Chi class free of charge. Refreshments were provided by the investigator each week.

Measures

The instruments chosen for the measurement of impairment, functional limitation, and disability are standard instruments that have been widely tested, and utilized in the research of older adults, except for the Late-Life Function and Disability Instrument (Late-Life FDI). The Late-Life FDI is a recently developed instrument of function and disability conceptually based on Nagi’s model of disability. Therefore, considering the
model and scope of this study, it was important to include the Late-Life FDI as one of the instruments.

Demographic information was reported by participants at screening, and again at pretest for any changes using Appendix B, and included age, pain score, gender, race, work status, marital status, type of residence, reported joint/s, and joint/s replaced. Participants reported the height and weight at posttest (pounds), and whether their weight had changed more than five pounds since the start of the study (yes, no).

The investigator and two experienced research assistants obtained data from participants using questionnaires. Although inter-rater reliability was not established, the investigator gave the same instructions to the research assistants on how to obtain data using the data collection forms and response cards. Pre and posttest data were obtained from participants by the same research personnel. The investigator was trained to collect data using the performance measures and was the only data collector of these tests.

Tai Chi. Tai Chi was measured using weekly class attendance, and reported practice during the previous week before the start of each class. Participants reported their practice as number of days each week and number of minutes each day during the previous week. Weekly report data collection forms were distributed and collected each week before class by the investigator. To minimize missing data, the investigator gave a follow-up call to those who missed class.

Bingo (non-physical activity). Bingo was measured using weekly activity attendance. Participants who missed a Bingo session received a follow-up telephone contact to encourage attendance and minimize missing data.
Impairment

Pain. Pain was measured by the pain subscale of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) that includes five visual analog scales with anchors at 0 (no pain) and 100 (extreme pain) at pretest (week 0), posttest (week 11), and weekly (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988). Items include walking on a flat surface, going up or down stairs, sleeping, sitting or lying down, and standing. Participants were asked to “think about the pain you felt in your hip and/or knee caused by your arthritis in the previous 24 hours, and mark your answers on each 100 mm line with an “x.” Each line (0–100 mm visual analogue scale) was measured using a standard ruler and the number of millimeters for each line was recorded as an item score. The five scores were summed to equal a single score for the pain subscale (0–500 mm). Test-retest reliability for the pain subscale (five VAS scales) was $r = .64$ and the internal consistency was $\alpha = .73$ to .81, while the construct validity was $r = .43$ and $r = .51$ using the Lequesne physical and pain indices, respectively, and $r = .47$ using the Doyle tenderness index (Bellamy et al.). In addition, a verbal measure of pain intensity from 0 (no pain) to 100 (worst possible pain) was used to screen potential participants by telephone contact during the months of July to September, 2005.

Anxiety. Anxiety was measured by the state subscale of the State Trait Anxiety Inventory (STAI) (Speilberger, 1983). State anxiety is a temporary emotional condition (Grimm, 1997). There were 20 items such as “I feel calm” and “I feel secure.” Participants were asked to describe how they felt at the present time, using a 4-point scale, from 1 (not at all) to 4 (very much so) for 20 items; ten (positive) items were reverse-scored (1, 2, 5, 8, 10, 11, 15, 16, 19, 20). Scores could range from 20 to 80 and
higher scores indicate greater anxiety (Norcross & Hagopian, 1990). Test-retest reliability for the state subscale was $r = .16$ to $.62$ for a normative sample of college and high school students that reflects the anticipated effect of “situational factors” at testing (Spielberger, p. 31). Internal consistency (alpha coefficient median) was $\alpha = .93$ for a normative sample of working adults, college and high school students, and military recruits, and .90 for working adults ages 50 to 69 (Spielberger). Construct validity was demonstrated by higher stress in college students compared with military recruits after testing and training respectively, and concurrent validity was established using the Cornell Medical Index ($r = .70$) with neuropsychiatric patients and Jackson’s Personality Research Form ($r = .61-.65$) with college students seeking counseling (Spielberger).

**Depressive symptoms.** Depressive symptoms were measured by the Center of Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977). The CES-D is a 20-item self-report scale measuring six major symptom areas, including depressed mood, guilt/worthlessness, helplessness/hopelessness, psychomotor retardation, loss of appetite, and sleep disturbance (Pasacreta, 1997). Participants describe the frequency of a particular feeling or behavior during the past week, using a 4-point scale, from 0 (*rarely or none of the time; less than 1 day*) to 3 (*most or all of the time; 5 to 7 days*), except for 4 (positive) items (4, 8, 12, 16) that were reverse-scored (Pasacreta, 1997, p. 358). Total scores can range from 0 to 60, from no depressive symptoms to severe depressive symptoms, respectively. A score greater than 16 points was the cut-point used to define elevated depressive symptoms because it was associated with a depressive syndrome (Mossey, Knott, & Craik, 1990; Pasacreta, p. 350). Participants with CESD > 16 were counseled to follow-up with their HCP. Internal consistency was $\alpha = .85$ for the general
population and .90 for the patient sample, and test-retest reliability was \( r = .45 \) to .70 for the general population (Radloff). Criterion validity compared to a nurse clinician rating scale was \( r = .56 \), and compared to the Hamilton Clinician’s Rating Scale and the Raskin Rating Scale was \( r = .44 \) to .54 (at hospital admission), but correlations were higher after 4 weeks of treatment (\( r = .69 \) to .75) (Radloff). The correlation of the CES-D with five measures (scales) of depressive symptoms including the Lubin, Bradburn Negative Affect, Bradburn Balance, Langner, and Cantril Ladder was \( r = .55 \) to .74 for psychiatric inpatients and \( r = .43 \) to .61 for the general population sample (Radloff).

**Balance.** Balance was measured by the balance subscale of the Tinetti Mobility Assessment Instrument (Tinetti, 1986). This 13-item measure is an observational method that includes the original 8-items tested on institutionalized patients and the additional 5-items developed to assess community-dwellers in a subsequent study (Tinetti). In this study, balance was measured using 6 items of the 13-item balance subscale of the Tinetti Mobility Assessment Instrument; it was decided that these 6 test items were safe and appropriate for the population tested. General aspects of balance were measured: sitting, arising from chair, immediate standing, standing, sitting down, and turning. Performance of each item was scored using a 3-point scale, including 0 (*abnormal*), 1 (*adaptive*), and 2 (*normal*). The score was the sum of the ratings, with the higher score indicating better balance. Interrater reliability was more than \( r = .90 \) (institutionalized elders) and \( r = .85 \) (community-dwelling elders), and content validity was established by adapting previous works of experts (Tinetti, p. 123). Concurrent validity was demonstrated in a study of 41% of 458 arthritic elders (\( n = 138 \)) using two balance maneuvers and associated abnormal neuro-muscular clinical findings (Tinetti & Ginter, 1988, p. 1192).
Muscle strength. Muscle strength of the lower extremity of participants’ dominant side was measured by hand-held dynamometry. Participants were seated in a chair and instructed to move the extremity using maximum effort while the device is held in place for a count of three by the investigator during hip flexion (anterior quad muscles), knee flexion (hamstring) and extension (quadiceps), plantar flexion (peronei), dorsi flexion and foot inversion (tibialis anterior). Each of the five muscle groups were measured at least twice and then the mean score of the two was reported in kilograms of force capacity. A third score was obtained if the first two scores were not similar and the aberrant measure was removed from the calculation (intrarater reliability). A break in the examiner’s strength during the test was also recorded. Muscle strength scores were normalized by body weight (strength is divided by body weight in kg) (McArdle et al., 2001, pp. 505, 507).

Despite precautions that the examiner’s strength can influence reliability (Bohannon, 1999) and validity (Visser et al., 2003), dynamometry is an accepted method of testing muscle strength (Bohannon, 1999; Kilmer et al., 1997; Visser et al., 2003; Wang, Olson, & Protas, 2002). Test-retest (intraclass correlation coefficients) reliability was $r = .95$ to $.99$ in the first trial and $r = .97$ to 1.00 in the second trial in a study of 41 community-dwelling elders with a history of fall (Wang, Olson, & Protas, 2002). Intrarater and interrater reliability was $r = .82$ to $.96$ and $r = .72$ to $.97$, respectively, in a study of ambulatory outpatients with neuropathic weakness of the lower leg (Kilmer et al., 1997). Concurrent validity was $r = .78$ to .98 in 19 patients with lower motor neuron syndrome comparing maximal voluntary isometric contraction and hand-held dynamometry (Visser et al., 2003).
**Functional Limitations**

*Mobility.* Mobility was measured by the Get-Up and Go test (Podsiadlo & Richardson, 1991) and the advanced lower extremity subscale of the Function Component of the LLFDI (Haley et al., 2002). During the Get-Up and Go test subjects are timed using a stopwatch, in seconds, as they rise from a straight-back chair, walk 10 feet, turn around, and return to the chair, and sit down (Podsiadlo & Richardson). Results of the timed scores are determined using three functional mobility categories, including < 20 seconds (*independent mobility*), 20 to 29 seconds (*interdependent mobility*), and ≥ 30 seconds (*dependent mobility*). Intraclass correlation coefficient for intra- and inter-rater reliability was $r = .98$ and .99, respectively, and internal consistency was high with Cronbach alpha ($\alpha = .96$). Validity of the measure was established by correlating the results with the Berg Balance Scale ($r = .81$), gait speed ($r = .61$) and Barthel Index of ADL ($r = .78$). Reliability and validity was assessed using a sample of elders who attended a geriatric day hospital with a mean age of 79.5 years (Podsiadlo & Richardson).

The Function Component of the LLFDI is a 32-item, self-report measure that assesses upper extremity, basic lower extremity, and advanced lower extremity function, and is conceptually based on Nagi’s model (Haley et al., 2002). These items were chosen from 54 physical functioning items that were pilot tested and subsequently loaded into a three factor model using factor analysis. Participants report the degree of difficulty they have performing physical activities using a 5-point scale, from 1 (*cannot do*) to 5 (*none*). Test-retest (intraclass correlation) reliability was $r = .91$ to .98, and validity was established by obtaining the expected mean difference scores of known functional limitation groups (none to slight, moderate to slight, and severe to moderate) using
published data of the physical function subscale of the SF-36. All mean difference scores were significant except for the basic lower and upper extremity function categories in the slight to none group (Haley et al., 2002).

The advanced lower extremity function subscale of the Function Component of the LLFDI used in this study consists of 11 self-reported items (functional activities) that include walk several blocks, walk one mile, get up from floor, one flight outside, three flights inside, carry while climb stairs, run to catch bus, walk brisk mile, slippery surface, hike several miles, and run half mile. Participants report the degree of difficulty they have performing physical activities using a 5-point scale, from 1 (cannot do), 2 (quite a lot), 3 (some), 4 (a little), and 5 (none). Total scores can range from 11 to 55, from more functional limitation to less functional limitation.

_Gait._ Gait was measured by the gait subscale of the Tinetti Mobility Assessment Instrument (Tinetti, 1986). This 9-item measure is an observational method that focuses on general aspects of gait such as stride length, symmetry of movement and others (Tinetti). Observational analysis of gait requires the data collector to identify many components of the gait cycle and motions of body parts. Performance of each gait component is scored using a 2-point scale, from 0 (abnormal) to 1 (normal). The score is the sum of the ratings, with the higher score indicating a more normal gait. Interrater reliability was over $r = .90$ (institutionalized elders) and $r = .85$ (community-dwelling elders), and content validity was established by adapting previous works of experts (Tinetti, p. 123). Concurrent validity was demonstrated in a study in which 41% of the sample was arthritic elders, using two gait maneuvers and associated abnormal neuromuscular clinical findings (Tinetti & Ginter, 1988, p. 1192).
Disability

Instrumental activities of daily living. Instrumental activities of daily living (IADL) were measured using the Instrumental ADL (self-care capacity) subscale of the Older Americans Resource Survey (OARS) (Lawton et al., 1982). The OARS is a 7-item self-report measure of the amount of independence in doing daily routine tasks that people perform such as handling finances, using the phone, taking medications, using public transportation, shopping, preparing meals and doing housework (Lawton et al.) Participants respond to the questionnaire using a 3-point scale, from 1 (without help), (need some help) to 3 (unable to perform task). Scores range from 7 to 21. Higher scores indicate more disability. The interrater (intraclass correlation coefficient) reliability ranged from $r = .66$ (physical health) to $r = .87$ (self-care capacity), and content validity was established by experts, such as physical therapists, in the case of the development of the self-care OARS subscale. Criterion validity was $r = .60$ to .89, using the level of agreement between OARS and (1) an economic scale, (2) mental health assessments by geropsychiatrists, (3) physical health ratings by physicians using the Karnofsky scale, and (4) self care capacity assessments by physical therapists during home visits (Fillenbaum & Smyer, 1981).

Life tasks. Life tasks were measured by the Disability Component of the LLFDI that is conceptually based on Nagi’s model (Jette et al., 2002). The Disability Component of the Late-Life FDI is a 16-item, self-report measure of two dimensions of disability (frequency of performance and limitation in performance of life tasks) with two domains each: personal, social, instrumental, and management roles (Jette et al.). Participants report how often they perform daily tasks using a 5-point scale, from 1 (never) to 5 (very
often), and to what extent they feel limited in performing daily tasks using a 5-point scale, from 1 (completely) to 5 (not at all). Two distinct summary scores are obtained each ranging from 5 to 25. Lower scores indicate more disability. Test-retest (intraclass correlation coefficient) reliability was $r = .68$ to .82, and validity was established by obtaining the expected mean difference scores of known functional limitation groups of community dwelling older adults $\geq 60$ years of age (none to slight, moderate to slight, and severe to moderate). Mean difference scores of the three groups were significant except for the frequency (personal role) dimension in the severe to moderate and slight to none groups, and the limitation (management role) dimension in all three groups (Jette et al., 2002).

Control Variable

Analgesic medication. Analgesic medication was measured during the past week, and in the previous 24 hours. Analgesics used in the past week were ranked as 0 (none), 1 (OTC), 2 (prescribed), and 3 (both). Scores were summed to create a mean that reflects the strength of the analgesic agent. Analgesics used during the previous 24 hours was limited to PRN rescue medication; responses were categorized as 0 (no), 1 (yes). Daily routine medications were not considered PRN rescue medication. Participants were requested not to take PRN rescue medication 24 hours before weekly testing. Nutritional supplements and topical remedies were reported for possible use in a secondary analysis.

Procedure

Institutional Review Board (IRB) approval was obtained from Case Western Reserve University to conduct the study at local Cleveland senior community facilities. During the months of January to May 2005, attempts to start the study at 3 different
facilities were unsuccessful because (1) there was not enough interest, and (2) those interested did not meet criteria. With the consent of the dissertation committee, revisions in the protocol were submitted to and approved by the IRB, in an attempt to recruit more people for the study at other locations in the Cleveland area. During the months of July to September 2005, 24 more facilities were contacted, yet only 2 were viable options to conduct the study. In September 2005, the study started at one eastside and one westside location with 14 participants total, and 7 participants at each site (Tai Chi = 4, Bingo = 3). Participants were given a choice of two study locations to encourage recruitment and promote retention.

Recruitment activities were extensive. A flier and/or email with the information that was posted on study website (www.stopstudy.com) and website address was sent to physicians, nurses, senior-related organizations in the community, and those interested in the study. The website provided information about the study and how to contact the investigator. A contact person in each facility advertised the study in newsletters and posted the flier, and scheduled meetings with the investigator to answer questions and encourage recruitment of participants for the study. Of the 24 facilities contacted during the months of July to September 2005, information meetings with a total of 275 potential participants were conducted at 18 facilities. In addition, local newspapers and church bulletins, fliers in libraries, markets, and talking with people in a shopping mall, were used to promote the study in the community.

Telephone and email contacts in response to these recruitment activities were recorded consecutively. Follow-up telephone calls were made by the investigator to screen participants for eligibility using an interview guide (see Appendix B). The
diagnosis of OA was confirmed by the physician of potential participants via facsimile that was sent from and returned to the residence of the investigator.

Participants did not need physician approval because participants were recruited from a population of healthy older adults. However, people who were told by their physician to refrain from exercise or had activity limitations were not included in the study. Information obtained during the screening process included medical and surgical problems and current medications should this background be needed if problems arose. Those with cognitive difficulties requiring medical attention, or a score \( \geq 3 \) missed items (of 10 points) on the Mental Status Questionnaire (McDowell & Newell, 1996, pp. 308-311) at screening were also excluded from the study. All participants were asked to confirm inclusion and exclusion data obtained during the screening process on the day of enrollment (see Appendix B). The investigator observed for any change in memory or concentration that would interfere with following instructions and exercising safely.

Verbal agreement to participate to either group was obtained by the investigator by telephone and randomization was done using permuted blocks to balance the groups on depression medication usage and size (Conlon & Anderson, 1990). The blocks were prepared by another researcher and placed in opaque envelopes. The investigator randomly assigned the list of participants to groups at each study location and mailed them the group assignment, date and time that their group would meet, and copy of the consent form. Afterwards, the investigator followed-up with a telephone call to each participant to answer questions before enrollment.

All participants signed a written informed consent form on the day of enrollment before pretest data were collected and one week before the 10 weekly, 1-hour classes and
Bingo sessions started. The Tai Chi and Bingo participants met on the same day at their respective community location, but did not meet at the same time. Separate times were used to diminish demoralization of the control group so groups could be tested and led by the investigator.

The investigator or research assistant provided assistance to each participant by reading questionnaires aloud in a private place so that answers were confidential. These questionnaires included: (1) impairment (pain subscale of WOMAC, state subscale of the STAI, CES-D), (2) functional limitations (advanced lower extremity subscale of the Function Component of the LLFDI), and (3) disability measures (OARS, Disability Component of the LLFDI). With the same consideration, the investigator also instructed each participant in the performance measures that tested impairment (balance subscale of Tinetti Mobility Assessment Instrument, lower extremity dynamometry) and functional limitations (Get-Up and Go test, gait subscale of Tinetti Mobility Assessment Instrument). Estimated time to complete the measures was approximately 60 minutes.

Participants who obtained a score > 16 on the CES-D (Mossey, Knott, & Craik, 1990) were informed of their score and the meaning of the score by the investigator in a private, confidential conversation. The investigator counseled these participants to see their physician for a follow-up appointment; there were 6 participants at pretest (Tai Chi = 1, Bingo = 5) and 7 at posttest (Tai Chi = 3, Bingo = 4).

All participants reported weekly pain (WOMAC pain subscale), analgesic usage, change in exercise prescription and health condition, and the Tai Chi group reported weekly practice. This information was recorded by participants using the weekly assessment form at each Tai Chi class and Bingo session. The investigator collected the
form weekly to assure completeness of the report and provide an opportunity for questions. The investigator made telephone calls to obtain data from those who missed a class, using the same weekly assessment form to record the report. The investigator assisted participants who had difficulty converting their verbal response to 0 to 100 pain score for each of the pain scale items at telephone follow-up. Participants who knew that they would be missing a class were given the weekly assessment form to complete and return at the next class or Bingo session.

The Tai Chi group was instructed not to share the handout and the audiovisual materials, discuss or demonstrate exercise movements with the control group to avoid potential contamination of the group. However, none of the participants admitted to knowing or coming in contact with another person in the other group.

Tai Chi group participants were encouraged to take part in the class according to their own comfort level, and not to force themselves beyond their own exercise tolerance. Those who become fatigued were told that they could stop at that time and return to participating in the class when rested. A cell phone was available to the investigator in the room where participants were exercising, as an emergency precaution. It was planned that any emergent or non-emergent accident or injury sustained during Tai Chi class or Bingo would be reported to the contact person the participant identified. However, no accidents or injuries occurred during the study.

Pretest measures (week 0) were repeated at posttest (week 11) one week after the completion of the Tai Chi class and Bingo sessions. Posttest data were obtained by the same investigator or research assistant who measured the pretest, and under similar conditions. Upon completion of the study, all participants received a certificate of
participation and $5 cash, and the Bingo participants (n = 6) were offered 10, 1-hour weekly Tai Chi classes free of charge. Five of the Bingo participants (83%) decided to attend the free Tai Chi classes that started in February 2006.

Data Management

The investigator was responsible for data management, coding, entry, verification, cleaning, transformations, storage and retrieval of data collected during the study. All forms were reviewed for completeness at pretest, post-test, and weekly at each group session. The investigator contacted participants by telephone to obtain missing data when necessary. A record of all decisions made during the data management process was maintained by the investigator (Roberts, Anthony, & Madigan, 1997).

Paper and pencil (hardcopy) forms were used to obtain and record data. Data were entered into a database by hand twice and checked for accuracy. This data set was stored in SPSS 11.0 file for future analysis. All data files were copied and stored (as back-up) onto compact discs. Permission was obtained to use the instruments that were protected by copyright including the WOMAC, STAI, and LLFDI.

Although it had been planned that regression would be used to estimate (impute) missing values identified as having a random pattern to avoid mean substitution of missing data (Tabachnick & Fidell, 2001, pp. 59-63), this was not done due to the small sample size. The only missing data was on one item of the WOMAC pain subscale: pain when using stairs, measured each week in reference to the previous 24 hours. It was decided that missing data would be replaced with the mean of two scores before and two scores after the missing data, except for one participant. In this case, the mean of two scores before and one after, and one score before and two after were used. Analysis was
not repeated with and without missing data using only complete cases for comparison (Tabachnick & Fidell, 2001, p. 65) because of the sample size.

Outliers were assessed using descriptive statistics (histograms, box plot, and probability plots). Variance was tested using the Hartley’s test for homogeneity ($F_{\text{max}}$). Variables with skewed distributions were not transformed due to the small sample size. Data were calculated using intention to treat analysis (ITT). None of the participants crossed-over to another group.

During the study, response variables of pain and balance were monitored by the advisor of the investigator who performed the function of a data monitoring committee (DMC) to assess early benefits or potential harmful effects. There were no study related harmful effects. In anticipation of a spring cohort, interim analysis was conducted by the advisor of the investigator after the fall cohort completed the study ($n = 14$).

**Data Analysis**

The participants and variables were described using measures of central tendency and dispersion appropriate to the level of measurement by group. Posttest to pretest difference scores (slopes) were calculated for each variable by group and displayed in Table 9 and in individual graphs (see Figures 3-20). Although parametric statistics (analysis of variance) had been planned for the proposed sample of 80, in the sample ($N = 14$), the number of dependent variables for analysis was reduced and nonparametric statistics were used for two dependent variables (pain and muscle strength). Assumptions for normal distribution and homogeneity of variance (Hartley’s $F_{\text{max}}$ test) were examined for each dependent variable. The assumptions were not met for comparing slopes of the focus variables: pain and muscle strength with $t$-tests. Therefore, nonparametric statistics
were used. Results were presented in terms of the research questions guiding the study. Research Question 1 was the only one analyzed due to the small sample size and failure to meet assumptions. The alpha used for significance was .05.

Research Question 1. Do seniors using Tai Chi in a 10-week exercise program have less impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (mobility, gait), and disability (IADL, life tasks) than those who do not use Tai Chi?

Mann-Whitney U was used to assess the difference in slopes (posttest minus pretest difference scores) between groups on two of nine variables (pain and muscle strength), because of the risk of type I error related to small sample size. The remaining variables were analyzed using descriptive statistics that included slopes and trends.

Research Question 2. Do the effects of Tai Chi on pain hold when controlled for analgesic medication usage?

The investigator did not analyze this research question because of the small sample size and violations of the assumptions of parametric tests that precluded the use of tests to control for analgesic medications, either in the past week or the past 24 hours.

Research Question 3. Do the effects of Tai Chi on anxiety and depression hold while controlling for posttest pain?

Anxiety and depression were not variables of interest in the revised statistical plan due to small sample size and increasing risk of type I error with repeated testing.

Human Subjects

A convenience sample of 14 community-dwelling elders with lower extremity joint pain due to osteoarthritis was recruited and randomly assigned to either a Bingo-
control \((n = 6)\) or Tai Chi-experimental group \((n = 8)\). The sample size was determined using available older adults who were interested in the study and met inclusion criteria.

The investigator promoted the study by actively networking with community resources to recruit participants. Potential participants contacted the investigator in response to advertisements by telephone or in person at information meetings. Potential participants were interviewed over the telephone (see Appendixes A and B) and oral consent was obtained; a copy of the unsigned consent form was mailed to participants (see Appendix C). Signed informed consent was obtained at enrollment prior to data collection. Participants were interviewed at pretest and posttest about impairments, functional limitations, and disability, and tested on performance measures (muscle strength, gait, and mobility), and pain (impairment) was reported weekly by both groups.

Risks of participation were minimal; as in all physical exercise there was a small risk of falling. Risks were minimized by (1) excluding participants at risk of falls, (2) supervising the exercise classes, (3) instructing participants to not perform movements beyond their comfort level and to stop exercising if tired and return to class when rested, and (4) modifying movements to make them suitable and easier to practice. Potential participants were told that they may directly benefit from the study by a reduction of chronic pain and improved function. However, those assigned to the group that will not attend Tai Chi classes may benefit from knowing that their participation in this study was a contribution to society. There was no direct compensation in this study.

Participants were also informed that (1) if they were physically injured during the study, the investigator and/or Case Western Reserve University would not provide or pay
for any medical care, (2) they would not be penalized in any way for deciding to withdraw from the study for any reason, and (3) participation was voluntary.

In summary, this chapter described the method used in the experimental study of community-dwelling elders with OA joint pain of the lower extremities, randomly assigned to either a control group that attended a nonphysical recreational activity (Bingo), or a 10-week Tai Chi group. Impairment, functional limitations, disability and pain were assessed before the first and after the last exercise (Tai Chi) class and the non-physical activity Bingo (control), and pain (impairment) was tested weekly.
Chapter IV

Results

Using a modified version of Nagi’s model of disability (Brandt & Pope, 1997) and an experimental design, a convenience sample of community-dwelling elders with arthritic pain was randomly assigned to either a control group that attended a 10-week nonphysical recreational activity (Bingo), or a 10-week Tai Chi group. Impairment, functional limitations, disability were assessed before the first and after the last exercise (Tai Chi) class and the non-physical Bingo activity (control). Pain (impairment) was also assessed weekly before the Tai Chi class or Bingo session.

Sample

Twenty-three older adults were recruited to participate in the study at two suburban locations that included one site on the eastside and another on the westside of Cleveland in fall 2005. One person (4%) decided later not to participate because of a family emergency. Twenty-two participants were randomized into the Tai Chi group ($n = 11$) or the Bingo group ($n = 11$) and were notified by mail of the results, after which 7 (32%) decided not to enroll because: they did not want to be in the Bingo group ($n = 2$), could not commit to 12 weeks ($n = 2$), or had a family emergency ($n = 3$). One person (5%) withdrew from the study after enrollment but before the start of the intervention because of a personal family emergency.

Verbal agreement to participate in either group was obtained by the investigator by telephone and randomization was done, using permuted blocks to balance the groups on depression medication use and size (Conlon & Anderson, 1990). The blocks were prepared by another researcher to conceal the assignment as the investigator made the
assignments. The other researcher placed a paper saying “TC” or “Control” in opaque envelopes that were arranged according to the blocking scheme in two stacks. One was labeled “depression med” and one labeled “no depression med.” Using the envelopes, the investigator randomly assigned each participant on her list at each study location to either the Tai Chi group or the Bingo group. Thus there was masked allocation to groups. The investigator mailed the group assignment and the date and time that their groups would meet to each participant. Tai Chi participants were scheduled in the morning and Bingo group participants were scheduled in the afternoon on the same day at the respective community location. Separate times were used to diminish demoralization of the control group and so both groups could be tested and led by the investigator. Signed informed consent was obtained at the first meeting.

The sample consisted of 14 older adults aged 61 to 85 years ($M = 71.6$, $SD = 6.8$) with pain scores on a pain intensity number scale (0–100) ranging from 10 to 80 ($M = 48.6$, $SD = 20.3$) at the time of screening. The mean height and weight of participants at the start of the study is shown in Table 1. The total mean body mass index (BMI) at the onset of the study was high and suggests that participants were obese (BMI of 30 or greater) (National Institutes of Health, 2006). However the BMI category for group means was different: Tai Chi = overweight (BMI of 25-29.9); Control = obese. The results for body weight and BMI should be interpreted with caution because the variance of the groups was significantly different. Moreover, all participants reported $\leq 5$ pound change in weight from pretest, except for one Bingo participant who lost 24 pounds during the course of the 10 week study. As shown in Table 1 and 2, there were no significant differences in the demographic characteristics between groups at pretest. All
14 (100%) participants completed the study. None of the participants reported any change in their activity prescription from the physician during the study.

Table 1

Demographic Characteristics by Sample and Group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n = 14)</th>
<th>Control (n = 6)</th>
<th>Experimental (n = 8)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Age</td>
<td>71.6</td>
<td>6.8</td>
<td>72.8</td>
<td>5.4</td>
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<tr>
<td>Weight (kg)</td>
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<td>19.0</td>
<td>82.0</td>
<td>25.1</td>
</tr>
<tr>
<td>Body Mass Index (kg/m²)</td>
<td>30.5</td>
<td>6.4</td>
<td>33.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>159.3</td>
<td>6.6</td>
<td>156.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Pain Score (0-100) a</td>
<td>48.6</td>
<td>20.3</td>
<td>43.3</td>
<td>17.5</td>
</tr>
<tr>
<td>Hip</td>
<td>52.0</td>
<td>13.0</td>
<td>50.0</td>
<td>14.1</td>
</tr>
<tr>
<td>Knee and hip</td>
<td>54.0</td>
<td>28.8</td>
<td>36.7</td>
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</tr>
<tr>
<td>Knee</td>
<td>37.5</td>
<td>15.0</td>
<td>50.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. None of the t values were significant. * Significant Levene’s test for variance.

A shown in Table 2, most of the participants were white (n = 12, 86%) female (n = 13, 93%), retired (n = 12, 86%), and married (n = 6, 43%) or widowed (n = 5, 36%) and living in their own home (n = 10, 71%). One participant was male (7%) and one participant was never married (7%).

At the onset of the study, participants reported OA pain in hip (n = 5, 36%), knee and hip (n = 5, 36%), and knee (n = 4, 29%). The total mean pain score in the previous 24 hours at screening by OA joints suggested less reported pain for those with arthritic knees (see Table 1). However, the mean pain score in the previous 24 hours by joint and group showed that those with hip pain reported similar pain levels in the two groups. Those with both knee and hip pain in the Tai Chi group had higher pain scores than those in the control group, while among those with knee pain, scores were higher in the control
group. Of the 14 participants, nine (64%) had not undergone joint replacement surgery, and five (36%) reported joint replacement: hip = 3 (22%), unilateral knee = 1 (7%) and bilateral knee = 1 (7%).

Table 2

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n = 14)</th>
<th>Control (n = 6)</th>
<th>Experimental (n = 8)</th>
<th>( \chi^2 )</th>
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<tr>
<td></td>
<td>f</td>
<td>(%)</td>
<td>f</td>
<td>(%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
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<td></td>
</tr>
<tr>
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<td>13</td>
<td>(93)</td>
<td>6</td>
<td>(100)</td>
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<td>0</td>
<td>(0)</td>
</tr>
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<td>Race</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>White</td>
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<td>(86)</td>
<td>6</td>
<td>(100)</td>
</tr>
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<td>(0)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Retired</td>
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<td>(86)</td>
<td>5</td>
<td>(83)</td>
</tr>
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<td>Employed</td>
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<td>1</td>
<td>(17)</td>
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<tr>
<td>Marital status</td>
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<td></td>
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<tr>
<td>Married</td>
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<td>(43)</td>
<td>2</td>
<td>(33)</td>
</tr>
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<td>Widowed</td>
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<td>(36)</td>
<td>3</td>
<td>(50)</td>
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<td>(17)</td>
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<td>0</td>
<td>(0)</td>
</tr>
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<td>Residence</td>
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<td></td>
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</tr>
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<td>House</td>
<td>10</td>
<td>(71)</td>
<td>5</td>
<td>(83)</td>
</tr>
<tr>
<td>Condominium</td>
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<td>1</td>
<td>(17)</td>
</tr>
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<td>(0)</td>
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<tr>
<td>Reported joint/s</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hip</td>
<td>5</td>
<td>(36)</td>
<td>2</td>
<td>(33)</td>
</tr>
<tr>
<td>Knee and hip</td>
<td>5</td>
<td>(36)</td>
<td>3</td>
<td>(50)</td>
</tr>
<tr>
<td>Knee</td>
<td>4</td>
<td>(29)</td>
<td>1</td>
<td>(17)</td>
</tr>
<tr>
<td>Joint/s replaced</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9</td>
<td>(64)</td>
<td>4</td>
<td>(67)</td>
</tr>
<tr>
<td>Hip</td>
<td>3</td>
<td>(22)</td>
<td>1</td>
<td>(17)</td>
</tr>
<tr>
<td>Knee</td>
<td>1</td>
<td>(7)</td>
<td>0</td>
<td>(0)</td>
</tr>
<tr>
<td>Knees</td>
<td>1</td>
<td>(7)</td>
<td>1</td>
<td>(17)</td>
</tr>
</tbody>
</table>

Note. None of the chi-square values were significant.
The diagnosis of OA of the knee and/or hip was confirmed (yes, no) via facsimile by the primary care physician, rheumatologist, or surgeon (see Table 3). In addition, participants reported 25 different health conditions during the screening process. The most frequently reported health conditions included hypertension ($n = 9, 64\%$), hypercholesterolemia ($n = 8, 57\%$), depression ($n = 3, 21\%$), and diabetes ($n = 2, 14\%$). Some of the reported conditions were not easily identified as a diagnostic category and were included in Table 3 as “Other.” In addition, one participant of the Tai Chi group used a cane for distance walking but did not use the cane for testing. Two participants reported taking depression medication (Tai Chi = 1; Bingo = 1), and one was diagnosed with depression but refused to take antidepressant medication.

Before each Tai Chi class or Bingo session, participants reported any change in their health condition during the previous week (see Figure 2). A total of 12 changes in health conditions were reported during the study. These included infection of the upper respiratory system (25\%) and gums following oral surgery (8\%); imbalance problem related to ankle laxity (8\%) and resulting in a fall (8\%); upper gastrointestinal discomfort (17\%); injury due to knee contusion with a grocery cart (8\%) and hamstring strain while mopping a floor (8\%); asthma (8\%); and paroxysmal atrial tachycardia (8\%). The number of participants who reported a change in health condition each week remained stable over 12 weeks and was comparable by group (Tai Chi = 8, Bingo = 7) (see Figure 2).

**Independent Variable**

Each of the two Tai Chi groups at the eastside and eastside locations had four participants ($n = 8, 57\%$), while each of the Bingo groups had three participants ($n = 6, 43\%$). Weekly attendance of both groups was recorded by the investigator. Attendance
Table 3

*Health Conditions by Sample and Group*

<table>
<thead>
<tr>
<th>Health condition</th>
<th>Total $(n = 14)$</th>
<th>Control $(n = 6)$</th>
<th>Experimental $(n = 8)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$f$ $(%)$</td>
<td>$f$ $(%)$</td>
<td>$f$ $(%)$</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>14 (100)$\textsuperscript{a}</td>
<td>6 (100)$\textsuperscript{a}</td>
<td>8 (100)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>9 (64)</td>
<td>5 (83)</td>
<td>4 (50)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>8 (57)</td>
<td>3 (50)</td>
<td>5 (63)</td>
</tr>
<tr>
<td>Depression</td>
<td>3 (21)</td>
<td>2 (33)</td>
<td>1 (13)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2 (14)</td>
<td>1 (17)</td>
<td>1 (13)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1 (7)</td>
<td>0 (0)</td>
<td>1 (13)</td>
</tr>
<tr>
<td>Osteoporosis</td>
<td>1 (7)$\textsuperscript{b}$</td>
<td>1 (17)$\textsuperscript{b}$</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Macular degeneration</td>
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<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Glaucoma</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Asthma</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Spondylosis</td>
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<td>1 (13)</td>
</tr>
<tr>
<td>Bursitis</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Restless legs syndrome</td>
<td>1 (7)</td>
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<td>Atrial fibrillation</td>
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<td>1 (17)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Heart murmur</td>
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<td>0 (0)</td>
<td>1 (13)</td>
</tr>
<tr>
<td>Carpal tunnel</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
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<tr>
<td>Other$\textsuperscript{c}$</td>
<td>7 (50)</td>
<td>3 (50)</td>
<td>4 (50)</td>
</tr>
</tbody>
</table>

$\textsuperscript{a}$ One doctor reported hip and lumbar spine OA. $\textsuperscript{b}$ No report of spinal fracture. $\textsuperscript{c}$ Includes ocular sloughing, hypotestosteronism, past ear surgery for benign tumor, infection after recent oral surgery, vertigo controlled with medication, low vision due to past stroke.

*Figure 2.* Reported change in health condition during the previous week by group and sample over 12 weeks.
for the 10 weeks ranged from 7 to 10 weeks (Tai Chi) and 4 to 10 weeks (Bingo). A total of 24 (17%) weekly sessions were missed during the study (Tai Chi = 12, Bingo = 12).

Thirty-six percent (n = 5) of the participants attended all 10 weeks of either Tai Chi class (n = 2) or Bingo (n = 3). Fourteen percent (n = 2) missed one week (Tai Chi = 1, Bingo = 1), while 29% (Tai Chi = 4) missed 2 weeks and 7% (Tai Chi = 1) missed 3 weeks. One Bingo player (7%) missed 5 weeks and another (7%) missed 6 weeks. There was no significant group difference in total number of weeks attended (see Table 4). All Tai Chi participants missed no more than 2 classes, except for one participant who missed 3 classes which was one more than the proposed dose for the study.

Participants reported that they could not attend because of family issues including vacation (13%), plans (8%), problem (8%), or situation (8%); involvement with city elections (29%); death of a family or friend (8%); need to support friend or neighbor (8%); doctor’s appointment (4%); fatigue (4%), illness (4%); and lack of transportation (4%). Those who missed a Tai Chi class or Bingo session were contacted by the investigator to obtain missing data. All participants attended pretest and posttest evaluations.

Home practice was advised (at least 3 times per week for 15 minutes) and participants recorded the number of days and the length of time (min) that they practiced since the previous class, using the weekly assessment form. If a participant missed a class, the investigator telephoned them to obtain this information. Tai Chi participants reported home practice of a 10-week mean of 442.8 minutes (SD = 143.6) and a weekly mean of 44.3 minutes (SD = 14.4), which is close to the 15 minutes, 3 times per week that was requested in this study. The 10-week median was 442.50 minutes and similar
to the 10-week mean for home practice by the Tai Chi group.

Table 4

Attendance of Participants by Sample and Group

<table>
<thead>
<tr>
<th>Number of Sessions</th>
<th>Total (n = 14)</th>
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<th>Experimental (n = 8)</th>
<th>χ²</th>
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<tbody>
<tr>
<td></td>
<td>f (%)</td>
<td>f (%)</td>
<td>f (%)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5 (36)</td>
<td>3 (50)</td>
<td>2 (25)</td>
<td>7.1</td>
</tr>
<tr>
<td>9</td>
<td>14 (2)</td>
<td>1 (17)</td>
<td>1 (13)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4 (29)</td>
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</tr>
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<td>- -</td>
<td>- -</td>
<td>- -</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>0 (0)</td>
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</tr>
<tr>
<td>4</td>
<td>1 (7)</td>
<td>1 (17)</td>
<td>2 (25)</td>
<td></td>
</tr>
</tbody>
</table>

Note. The chi-square value was not significant for total number of sessions attended by group.

Dependent Variables

The study was designed to test impairment (pain, anxiety, depression, balance, muscle strength), functional limitation (gait, mobility), and disability (IADL, life tasks) as dependent variables (see Table 5). However, before analyzing the data the number of dependent variables was reduced from 9 to 2, because of the small sample size and the increased risk of type I error with repeated statistical testing. The two variables of primary interest in this study were pain and muscle strength. These variables were chosen for two reasons (1) little research on the effects of Tai Chi on pain and muscle strength has been done in this population, (2) pain and muscle strength are impairment variables in the model that could potentially impact the threshold effect of impairment on functional limitations (gait, mobility) and subsequently influence a disability outcome (IADL, life tasks).

As shown in Table 5, nine dependent variables were tested with one measure. These included pain, anxiety, depression, balance, muscle strength, gait, mobility, IADL,
and life tasks (frequency of activities and limitations in activity). Mobility and life tasks

Table 5

Dependent Variables by Sample and Group

<table>
<thead>
<tr>
<th>Variable</th>
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<th></th>
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<th></th>
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<th></th>
<th>Experimental $\ (n = 8)$</th>
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<tbody>
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Note. $F_{max}$ = Hartley’s test of variance homogeneity; IADL = Instrumental Activities of Daily Living; LLFDI = Late-life Function and Disability Instrument; Pretest = week 0; Posttest = week 11. * $p < .05$
were each tested using two measures. Six measures were questionnaires: anxiety, depression, mobility, IADL, life tasks. Pain was measured with five visual analogue scales. The remainder were performance measures using examiner observation (balance, gait), a timed test (gait), and dynamometry (muscle strength). The research assistant or investigator administered all tests except for the performance measures. These were assessed only by the investigator who was trained in their use.

Skewness was within acceptable limits (≤2.0) for all variables except for pretest mobility using the Get Up & Go test (2.9), and for pretest (2.9) and posttest (2.6) IADL, posttest anxiety (2.5), and posttest depression (2.4) (see Tables 5 and 8), and for one component of the muscle strength score (pretest anterior tibialis = 2.9) (see Table 7). In all cases, the skew was to the right (+) indicating a long tail on the right that was likely related to an outlier in the Tai Chi group (mobility on the Get-up & Go test, IADL, anterior tibialis muscle strength) and Bingo group (anxiety, depression), and/or low scores in Tai Chi and Bingo groups on the test (IADL, anterior tibialis muscle strength).

Hartley’s test of variance homogeneity ($F_{\text{max}}$) showed that for posttest pain, posttest anxiety, posttest depression, pre and posttest mobility (Get-Up & Go), and pretest IADL, the two groups had significantly different variance (Table 5). As shown in Table 8, one component of muscle strength (anterior tibialis) also had significantly different variance at pretest. Figures 3, and 6-20 display the mean pre and posttest scores shown in Tables 5 and 8 for the dependent variables in graphs by groups.

The dependent variables of interest were pain and muscle strength. Pain scores on the WOMAC were not skewed > 2.0, yet posttest pain did not have equal variance. The histogram showed that pain scores for the sample decreased compared to pretest, except
for one score in the Bingo group that was higher (408 mm) that contributed to the unequal variance. One muscle strength component (pretest anterior tibialis) was skewed > 2.0, yet the overall muscle strength pretest had equal variance (see Table 8). Most pretest anterior tibialis scores were low except for one outlier in the Tai Chi group that was much higher in comparison. Yet on posttest, the anterior tibialis distribution showed a more normal appearance with scores suggesting an increase in strength. Perhaps with a larger sample, the effect of a single score would not have created such a dramatic change in the results.

Parametric tests require that assumptions be met before data analysis. The assumptions for the *t*-tests included random assignment, normal distribution, and equal variance. In this study, the assumption for random assignment was met in the design. Pretest and posttest pain and the muscle strength composite scores met the assumption for normal distribution, yet posttest pain and one component of the muscle strength composite score (anterior tibialis at pretest) did not meet the assumption for equal variance. Therefore, statistical analysis for pain and muscle strength slopes, posttest minus pretest scores, was accomplished by using the nonparametric Mann-Whitney *U* test since it was agreed that the assumptions for parametric testing were violated given the small sample size.

**Pain.** Pain was measured using the 5-item WOMAC pain scale (0-500) (see Figure 3). Participants reported their pain during the past 24 hours using 5 visual analogue scales (mm) with the same anchors 0 (*no pain*) and 100 (*extreme pain*) for each item. Both groups showed a reduction in pain in knee and/or hip from pretest at week 0 to posttest at week 11 (Tai Chi slope = - 47.9 mm, Bingo slope = - 24 mm), yet the Tai Chi
group demonstrated a greater reduction (see Table 5). The mean Bingo pretest score ($M = 164.5\ mm$, $SD = 74.2$) was similar to pretest means in a study of older adults with hip or knee OA after NSAID washout (Bellamy, Buchanan, Goldsmith, Campbell, & Stitt, 1988), while the mean Tai Chi pretest score ($M = 137.9\ mm$, $SD = 69.9$) was comparably lower. Data were not skewed. However, Hartley’s test of variance homogeneity ($F_{\text{max}}$) indicated that the variance of posttest pain scores were significantly different between groups, with the Bingo group having greater variance ($SD = 143$) than the Tai Chi group ($SD = 59$). As needed (PRN) rescue medication during the previous 24 hours was used by 5 (Tai Chi = 3, Bingo = 2) participants at pretest and 2 (Tai Chi = 1, Bingo = 1) at posttest, suggesting that the groups were similar in the number who needed rescue analgesics.

![Figure 3](image)

Figure 3. Mean pre and posttest pain scores by group with slopes (Tai Chi = - 47.9, Bingo = - 24). A Mann-Whitney $U$ test indicated that posttest minus pretest subscale difference scores on a 0 to 500 mm scale were not significantly different, $U = 22$, $p = .43$ (one-tailed).

Each of the 5 items in the WOMAC pain subscale is shown in Table 6. The Tai group demonstrated a decline. Both groups showed improvement in item 1 (walking) and
item 3 (at night in bed); the Tai Chi group demonstrated more pain reduction in item 1 but less in item 3. The Tai Chi group showed only a small decrease in item 4 (sitting-lying), while the Bingo group demonstrated an unexpected decrease in comparison.

Skewness was within acceptable limits (2.0) except for posttest stairs (2.2) and at night in bed (2.2). The $F_{\text{max}}$ was significant for posttest stairs and standing.

Table 6

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Note. $F_{\text{max}}$ = Hartley’s test of variance homogeneity; Subscale items were measured in millimeters (mm).

* $p < .05$

As shown in Table 7, pain was also measured weekly over 12 weeks using the 5-item WOMAC pain subscale for OA pain of the knee and/or hip during the previous 24 hours. Replacement of missing data was done prior to the initial descriptive analysis, and
involved only item 2 (stairs) of the pain subscale for one participant (7%) at weeks 2, 4, 5, 6, 8, and 9, and for 2 participants (14%) at week 3. Missing data were replaced with the mean of two scores before and two scores after the missing data, except for one participant. In this case, the mean of two scores before and one after, and one score before and two after were used.

Table 7

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<td>-</td>
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Note. $F_{\text{max}} =$ Hartley’s test of variance homogeneity.
* $p < .05$

Figure 4 is a graph of the weekly mean WOMAC subscale pain scores for the previous 24 hours of both groups over 12 weeks. Pain scores were collected at pretest (week 0) and posttest (week 11), and weekly before each Tai Chi class or Bingo session. Data were collected at week 1 prior to the first class or Bingo session. When the scores were standardized to a 0-100 scale, the mean of the control group over 2 weeks (before
Tai Chi) was $M = 22.8, SD = 14.1$ and the mean of the Tai Chi group was $M = 30.5, SD = 30.5$. A downward trend was seen for the Tai Chi group over the 12 weeks except for an unusual increase at 8 weeks. Skewness was within acceptable limits (2.0) for each of the 12 weeks, and $F_{\text{max}}$ was significantly different only at week 11 for posttest pain (see Table 7).

![Graph showing mean pain scores for Tai Chi and Bingo groups across 12 weeks.]

*Figure 4. Mean WOMAC pain scores (0-500) across 12 weeks for groups (range = 0 to 408).*

Figure 5 includes 5 graphs with each of the five mean pain subscale item scores (0-100) across 12 weeks by item and group. Scores on item 2 (pain up and down stairs) was consistently showed less pain after week 2. There was an increase in pain at week 8 in items 3 (pain at night in bed) and 4 (pain while standing-lying), and also a little in items 1 (pain while walking) and 2 (pain up and down stairs). Tai Chi resulted in a consistent decrease pain in the final 3 weeks for all items and also in week 4 to 7 on some items (1, 3, and 5). All but one item (stairs) showed an increase at week 2 that was measured before the first Tai Chi class or Bingo session. However, most items (80%)
indicated a noticeable decrease in the Tai Chi group compared to Bingo at posttest (week 11), except for one that showed a slight decrease (walking).

Figure 5. Mean WOMAC pain subscale item scores (0-100) across 12 weeks by item (1 to 5) and group.

Item 1 Walking (range = pretest, 2-70; posttest, 0-70)

Item 2 Stairs (range = pretest, 6-62; posttest, 0-87)

Item 3 At Night in Bed (range = pretest, 4-80; posttest, 0-83)
Anxiety. Anxiety was measured using the 20-item State Anxiety Inventory (see Figure 6). Participants described how they felt at the present time (20-80 points) using a 4-point scale from 1 (not at all) to 4 (very much so) for each item. Tai Chi group participants showed a decrease in anxiety, while the Bingo group showed an increase in anxiety at posttest (see Table 5). Posttest data were skewed, and $F_{\text{max}}$ showed that the group variances were significantly different at posttest, and not at pretest. None of the participants reported taking anti-anxiety medication at screening or during the 12 weeks of the study.
Figure 6. Mean pre and posttest anxiety scores by group with slopes (Tai Chi = -2.4, Bingo = 5.5).

Depressive symptoms. Depressive symptoms were measured using the 20-item Center of Epidemiologic Studies Depression Scale (0-60) (see Figure 7). Participants rated the frequency of a particular feeling or behavior during the past week using a 4-point scale from 0 (rarely or none of the time; less than 1 day) to 3 (most or all of the time; 5-7 days) for each item. The groups were different at pretest with the Bingo group having more depressive symptoms (see Table 5). Both groups showed a small improvement in depressive symptoms, with slightly more improvement in the Tai Chi group. Data were skewed at posttest, and $F_{\text{max}}$ at posttest indicated that group variances were significantly different with greater variance in the control group.

The total mean pre and posttest depressive symptoms scores for the sample were less than 16 points (see Table 5 and Figure 7). A score greater than 16 points was the cut-point used to define elevated depressive symptoms (Mossey, Knott, & Craik, 1990). Two (14%) participants (Tai Chi = 1, Bingo = 1) at pretest scored greater than 16 and one (7%) Bingo participant at posttest scored greater than 16. Those with a score of greater than 16 were contacted by the investigator to consider follow-up with their physician. At
the onset of the study, two participants (14%) reported taking antidepressant medication (Tai Chi = 1, Bingo = 1), which was balanced during random assignment; both participants scored less than 16 at pretest. Another Bingo participant reported that she had been diagnosed with depression before the onset of the study but refused to take medication because of allergies; this participant scored greater than 16 at pretest. At posttest, one Bingo participant who was diagnosed with depression but not on medication scored > 16.

**Balance.** Balance was measured using 6 items of the 13-item balance subscale of the Tinetti Mobility Assessment Instrument (see Figure 8). It was decided that these 6 test items were safe and appropriate for population tested. Participants were observed by the investigator and given a score (0–12) using a 3-point scale for each item from 0 (abnormal), 1 (adaptive), to 2 (normal) for each item. Both groups demonstrated an improvement in balance, yet the Tai Chi group showed slightly more improvement at posttest in comparison to the Bingo group (see Table 5). Data were not skewed and $F_{\text{max}}$ was not significant.

![Figure 7. Mean pre and posttest depressive symptom scores by group with slopes (Tai Chi = -0.6, Bingo = -0.5).](image)
Figure 8. Mean pre and posttest balance scores by group with slopes (Tai Chi = .6, Bingo = .3).

Muscle strength. Muscle strength of the dominant lower limb was measured using a hand-held dynamometer (see Figure 9). Participants were measured while seated in a chair and the device was held in place for the count of 3 during knee extension and flexion, dorsi flexion and foot inversion (anterior tibialis), plantar and hip flexion. Muscle strength was reported in kilograms of force velocity that was normalized by dividing the measurement by the participant’s weight in kilograms. One participant was measured using her nondominant leg because of joint discomfort at pretest; the same limb was assessed at posttest. There was no break in the investigator’s strength during measurement so it was unlikely that the examiner’s muscle strength influenced the reliability and validity of muscle testing.

Composite scores were calculated by summing the score for each of the 5 muscle groups at pre and posttest. Both groups demonstrated an improvement in composite muscle strength, yet the Tai Chi group showed a slightly greater improvement in comparison (see Table 5). Muscle strength composite scores were not skewed at pre and posttest and $F_{max}$ was not significant.
Figure 9. Mean pre and posttest composite muscle strength (MS) scores by group with slopes (Tai Chi = .07, Bingo = .04). A Mann-Whitney $U$ test indicated that post-pretest difference scores were not significantly different, $U = 19, p = .29$ (one-tailed).

The five muscle strength component scores are shown in Table 8. The Tai Chi group showed improvement in components 5 (hip flexion) and 2 (knee flexion), while the Bingo group demonstrated a decline and no change, respectively. Both groups showed a small increase in component 1 (knee extension), and a slight decrease in component 4 (plantar flexion). One (anterior tibialis) showed an unexpected direction with a slight increase in the control group and a decrease in the Tai Chi group. Skewness was within acceptable limits (2.0) except for pretest anterior tibialis (2.28). Likewise, $F_{\text{max}}$ was only significant for pretest anterior tibialis indicating more variance in the Tai Chi group.

Figures 10 to 14 display the mean pretest and posttest scores for the muscle strength by groups. There were no missing data.

*Knee extension.* Both groups showed improvement in muscle strength with knee extension at posttest, yet the Bingo group showed more improvement in comparison (see Figure 10 and Table 8). Data were not skewed and $F_{\text{max}}$ was not significant.
Table 8

Muscle Strength Components by Sample and Group

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<td>SD</td>
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<td>.04</td>
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<td>Posttest</td>
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<td>.16</td>
<td>.04</td>
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Note. F<sub>max</sub> = Hartley’s test of variance homogeneity; all values were normalized by kg body weight (strength [kg of force capacity] divided by body weight in kg).
* p < .05

Figure 10. Mean pre and posttest muscle strength for knee extension (KE) scores by group with slopes (Tai Chi = .01, Bingo = .04).
Knee flexion. The Tai Chi group showed improvement in muscle strength with knee flexion at posttest, while the Bingo group remained the same (see Figure 16 and Table 11). Data were not skewed and $F_{\text{max}}$ was not significant.

![Figure 11. Mean pre and posttest muscle strength for knee flexion (KF) scores by group with slopes (Tai Chi = .03, Bingo = 0).](image)

Anterior tibialis. Both groups showed similar improvement in anterior tibialis muscle strength at posttest (see Figure 12 and Table 8). Data were skewed (2.28) at pretest and not at posttest. However, $F_{\text{max}}$ was not significant.

![Figure 12. Mean pre and posttest anterior tibialis (AT) muscle strength scores by group with slopes (Tai Chi = .01, Bingo = .01).](image)
**Plantar flexion.** Both groups showed a decrease in mean muscle strength with plantar flexion at posttest from pretest (see Figure 13 and Table 8). Data were not skewed and $F_{\text{max}}$ was not significant.

![Graph showing mean PF (kg) for Tai Chi and Bingo groups](image)

**Figure 13.** Mean pre and posttest muscle strength for plantar flexion (PF) scores by group with slopes (Tai Chi = -.02, Bingo = -.01).

**Hip flexion.** The Tai Chi group showed improvement in muscle strength with hip flexion, while the Bingo group showed a decline in hip flexion (see Figure 14 and Table 8). Data were not skewed and $F_{\text{max}}$ was not significant.

![Graph showing mean HF (kg) for Tai Chi and Bingo groups](image)

**Figure 14.** Mean pre and posttest muscle strength for hip flexion (HF) score by group with slopes (Tai Chi = .03, Bingo = -.01).
Mobility.

Mobility was measured using two instruments: the 11-item advanced lower extremity subscale of the LLFDI-function component (see Figure 15) and the Get-Up & Go test (Figure 16). With the advanced lower extremity subscale of the LLFDI, participants reported the degree of difficulty (11-55 points) they have in performing physical activities using a 5-point scale from 1 (cannot do) to 5 (none). With the Get-Up and Go test, participants were timed using a stopwatch (seconds) as they rose from a chair, walked 10 feet, turned around, and returned to the chair and sat back down. The score was determined using 3 functional categories including < 20 seconds (independent mobility), 20-29 seconds (interdependent mobility), and ≥ 30 seconds (dependent mobility). The Tai Chi group showed improvement in the advanced lower extremity mobility (1.5 points) and the Get-Up & Go test (4.4 seconds), while the Bingo group showed a decline in advanced lower extremity with no change in the Get-Up & Go mobility test (see Table 5). Data were skewed for only the Get-Up & Go pretest, and $F_{\text{max}}$ was significant for both pre and posttest.

![Figure 15](image.png)

**Figure 15.** Mean pre and posttest mobility scores by group: Advanced Lower Extremity (ALE) subscale of the LLFDI with slopes (Tai Chi = 1.5, Bingo = -0.5). An increase in mean points at posttest indicates improvement.
Figure 16. Mean pre and posttest mobility scores by group: Get-Up & Go test with slopes (Tai Chi = -4.4, Bingo = -0.1). A decrease in mean seconds at posttest indicates improvement.

Gait. Gait was measured using the 9-item gait subscale of the Tinetti Mobility Assessment Instrument (see Figure 17). Participants were observed by the investigator and given a score (0-9) using a 2-point scale from 0 (abnormal) to 1 (normal) for each item. The Tai Chi group showed a 0.4 point improvement in gait, while the Bingo group showed a decrease in gait (see Table 5). Data were not skewed and $F_{\text{max}}$ was not significant.

Figure 17. Mean pre and posttest gait scores by group with slopes (Tai Chi = 0.4, Bingo = -0.3).
**IADL.** Instrumental activities of daily living were measured using the 7-item IADL (self-care capacity) subscale in the Older Americans Resource Survey (see Figure 18). Participants described the activities (7-21 points) using a 3-point scale from 1 (*without help*), 2 (*need some help*) to 3 (*unable to perform task*) for each item. Mean scores were low for each group indicating that they were quite independent in IADL. No change was demonstrated in either the Tai Chi or Bingo group (see Table 5). Pre and posttest scores were skewed and $F_{max}$ was significant for pretest only.

*Figure 18.* Mean pre and posttest IADL scores by group with slopes (Tai Chi = 0, Bingo = 0).

**Life tasks.** Life tasks were measured using the 16-item LLFDI-disability component that tests performance frequency (PF) (see Figure 19) and performance limitations (PL) (see Figure 20). Participants described (a) how often they perform daily tasks using a 5-point scale from 1 (*never*) to 5 (*often*), and (b) to what extent they feel limited in performing daily tasks using a 5-point scale from 1 (*completely*) to 5 (*not at all*). Two distinct summary scores were obtained, each ranging from 5 to 25. Both groups showed a small improvement in performance frequency. Both groups showed greater
improvement in performance limitations, yet the Tai Chi group demonstrated 4.9 points improvement in comparison to 2.3 points for the Bingo group (see Table 5). Data were not skewed and $F_{\text{max}}$ was not significant.

**Potentially Confounding Variable**

Correlation of analgesic usage with pain of $r \geq .30$ would indicate that pain was confounded by analgesic usage (Cook & Campbell, 1979). If this was the case, analgesic usage would need to be controlled in the analysis of the effects of Tai Chi on pain if...
inferential statistics were used. Because the assumptions for parametric tests were not met, nonparametric tests were used for analysis. Analgesic usage was accounted for descriptively.

Analgesic medication use was measured each week in 2 ways: (1) during the past week, and (2) in the previous 24 hours (yes, no). Analgesics used in the past week were ranked in terms of their probable strength of action: 0 (*none*), 1 (*OTC*), 2 (*prescribed*), 3 (*both*). Scores were summed to create a mean that reflects the estimated strength of the class of analgesic agent that participants were taking (see Figure 21). Participants were also requested not to take PRN medications 24 hours before each Tai Chi class or Bingo activity if possible, and to report each week whether or not they used PRN medication during this time. Analgesic medication used during the previous 24 hours was limited to the use of PRN rescue medication and responses were categorized as 0 (*no*), 1 (*yes*) (see Figure 22). The PRN rescue medications in the previous 24 hrs included OTC or prescribed analgesics, depending on the case. All but two of the PRN rescue medications (Darvocet and Day Pro) were OTC analgesics. Daily routine medications were not considered PRN rescue analgesics.

Figure 21 shows that both the Tai Chi and Bingo groups had inconsistent trends of analgesic usage during the previous week across 12 weeks, yet the Tai Chi group was more inconsistent in comparison. These finding are likely related to the use of PRN prescription medications by two participants in the Tai Chi group; none of the control participants used prescription analgesics. However, at pretest (week 0), the Tai Chi group reported greater analgesic usage than the Bingo group, while, at posttest (week 11), the opposite was demonstrated.
Analgesic usage as a potential confounder of pain in the last 24 hours was tested in 3 ways. First, to determine whether there were group differences in analgesic use, $\chi^2$ was used. Second, to determine whether pain in the previous 24 hours was related to analgesic use in the previous week, Pearson’s correlation of 12-week mean pain scores during the previous 24 hours (0-500), with the 12-week mean analgesic usage scores (0-3) during the past week was used. Third, to determine whether pain in the past 24 hours (0–500) was related to use of rescue medication categorized as 0 (no), 1 (yes) in the past 24 hours, 12 weekly Spearman’s correlations were used.

In the first analysis, analgesic medication usage during the previous week was recorded each week and categorized (above) and therefore, the range was 0 to 3. Weekly analgesic usage was averaged over the 12 weeks. The mean analgesic usage was .71 points ($SD = .71$), while the 12-week mean analgesic usage for the Tai Chi and Bingo groups was .68 ($SD = .71$) and .73 ($SD = .79$), respectively. The groups did not differ on analgesic usage during the previous week, $\chi^2 (6, N = 14) = 4.5, p = .61.$
Analgesic rescue medication usage of “as needed” (PRN) medication during the previous 24 hours was recorded each week and categorized as 0 (no), 1 (yes). Chi-square ($\chi^2$) for group differences in analgesic rescue medication each week was not significant; p-values ranged from .20 to .87. Figure 22 shows only the number of participants who reported using PRN rescue medication during the last 24 hours each week for 12 weeks; those who did not use rescue medication are not shown.

**Figure 22.** Weekly PRN analgesic usage during the previous 24 hours across 12 weeks by sample ($n = 14$) and group (Tai Chi = 8, Bingo = 6).

In the second analysis of analgesic usage, Pearson’s correlation between the total mean weekly analgesic usage scores ($M = .71$, $SD = .71$) and total mean pain scores during the previous 24 hours each week ($M = 134.7$, $SD = 75.6$) was not significant, $r = -.10$, $p = .74$). These data support the conclusion that analgesic usage in the past week and pain in the past 24 hours were not related.

In the third analysis (see Figure 23), for the whole sample, Spearman’s correlation of weekly PRN analgesic usage during the previous 24 hours and weekly pain score for the past 24 hours was $r_s < .30$, except for the pretest at week 0 ($r_s = .54$) and week 8 ($r_s = \ldots$)
**Figure 23.** Correlation of weekly PRN rescue analgesic usage [0 (No), 1 (Yes)] and weekly WOMAC pain score (0-500) across 12 weeks by sample ($n = 14$).

The correlation for week 1 ($r_s = .24$) showed that PRN analgesic usage was not related to pain scores for that week. Week 1 data collection for these variables occurred just before the start of the first Tai Chi class and Bingo activity. Thus week 0 and 1 both preceded treatments. In addition, one participant from the Tai Chi group at week 7, 8, and 9 took a PRN medication for a hamstring strain that occurred at work while mopping floor, but was not taking this medication for OA pain. This event likely influenced the

**Figure 24.** Correlation of weekly PRN rescue analgesic usage [0 (No), 1 (Yes)] and weekly WOMAC pain score for the previous 24 hours (0-500) across 12 weeks by group (Tai Chi = 8, Bingo = 6).
results for week 8 ($r_s = .31$). Based on these results, any influence of analgesic usage on pain scores was minor. However, examination of each group suggests otherwise (see Figure 24). In the majority of the time points after Tai Chi began (60%), the Tai Chi group showed high positive correlations ($r_s \geq .30$) for 24 hour analgesics and pain compared to 20% in the control group, who had high negative correlation ($r_s \geq -.30$).

**Analysis**

The following are the proposed research questions and the analysis actually performed in the sample that was smaller than expected.

**Research Question 1.** Do seniors using Tai Chi in a 10-week exercise program have less impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (mobility, gait), and disability (IADL, life tasks) than those who do not use Tai Chi?

The investigator was unable to perform the proposed analysis because of the small sample size and increased risk of type I error with repeated testing of multiple variables. To this end, the focus of the analysis was reduced before analysis from nine variables to the two impairment variables of pain and muscle strength. The remaining variables were analyzed using descriptive statistics and examined for trends.

In addition, the assumptions for parametric testing for pain and muscle strength were not met, and this was likely related to the sample size. Therefore, a nonparametric test, a one-tailed Mann-Whitney $U$, was used with posttest minus pretest difference scores to assess the effect of Tai Chi on the variables of interest: pain and muscle strength. A Mann-Whitney $U$ test indicated that WOMAC pain subscale difference scores were not significantly different between the Tai Chi group and the control group, $U = 22,$
Similarly, composite muscle strength difference scores were not significantly different between groups, \( U = 19, p = .29 \).

**Research Question 2.** Do the effects of Tai Chi on pain hold while controlling for analgesic medication usage?

The investigator did not analyze this research question because of the small sample size and violations of the assumptions of parametric tests that precluded the use of tests to control for analgesic medications, either in the past week or the past 24 hours. Pain medication over the past week was not a confounding variable for the outcome of pain over the past 24 hours. However, rescue medications were associated with greater pain in the Tai Chi group but not the control group.

**Research Question 3.** Do the effects of Tai Chi on anxiety and depression hold while controlling for posttest pain?

Anxiety and depression were not variables of interest in the revised statistical plan due to small sample size and increasing risk of type I error with repeated testing. Anxiety was promising as it did decrease in the Tai Chi group and increase in the control group.

In summary, this chapter presents the results of an experimental study of community-dwelling older adults with OA randomly assigned to either 10 weekly, one-hour Tai Chi classes or Bingo sessions (control). Impairment, functional limitations, and disability were assessed before the first and after the last Tai Chi class and Bingo session, and pain (impairment) was assessed weekly before the Tai Chi class or Bingo session. Only two of the nine variables (pain, muscle strength) were tested because of risk of type I error related to small sample size. The remaining variables were analyzed using descriptive statistics (slopes = the difference between the last time point and time point 1).
(see Table 9). Difference scores for pain and muscle strength were not significantly
different between the two groups.

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<td>-0.1</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Gait</td>
<td>0.4</td>
<td>-0.3</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>IADL</td>
<td>0</td>
<td>0</td>
<td>s</td>
<td>-</td>
</tr>
<tr>
<td>Life tasks</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>LLFDI-PF</td>
<td>0.4</td>
<td>0.2</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>LLFDI-PL</td>
<td>4.9</td>
<td>2.3</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note.* Slope = posttest – pretest difference score; improvement is defined as slopes that were
greater in the Tai Chi group than the control group; (+) = improvement which should be
interpreted with caution; (s) = slopes were the same for both groups or no change in the Tai Chi
group; (o) = slopes that were worse for the Tai Chi group; ns = not statistically significant; (-) =
statistical significance not tested.

*p < .05

Eight of the nine dependent variables (89%) showed some improvement in the Tai
Chi group: five impairment (pain, balance, anxiety, depressive symptoms, composite
muscle strength), two functional limitations (mobility, gait), and one disability (life
tasks). One variable (IADL) showed no change in the Tai Chi group. In addition of the
five muscle strength component variables (40%) showed some improvement (plantar and hip flexion), while one variable showed slopes that were the same (knee flexion), and two others (knee extension, anterior tibialis) were worse in the Tai Chi group. Overall, any influence of analgesic usage on pain scores by sample was minor, yet when examined by group positive correlates were noticeably greater in the Tai Chi group. However, due to the retrospective and 24 hour measure of both analgesic use and pain scores, the relationship was not clear. Analgesic medication was not ruled out as a confounder of pain in the sample.
Chapter V

Discussion

This chapter consists of a summary of the study followed by a discussion of the findings and conclusions. Limitations of the study and recommendations for further research and practice are also presented.

Using a modified version of Nagi’s disability model, the purpose of this study was to assess the effects of Tai Chi on improving impairment (pain, anxiety, depression, balance, muscle strength), functional limitations (mobility, gait), and disability (IADL, life tasks) in elders with osteoarthritis of the lower extremities. The sample consisted of 14 older adults (men = 1, women = 13), aged 60 years and older, randomly assigned to either an experimental (Tai Chi, n = 8) or control (Bingo, n = 6) group. Both groups attended 10 weekly, one-hour sessions that were conducted by the investigator. Participants in the Tai Chi group were expected to practice at least 3 times each week for 15 minutes using the videotape and handouts.

At pre- and posttest, measures were collected for impairment, functional limitations, and disability. One measure of pain (WOMAC pain subscale) was measured weekly. Self-report measures were used to assess (1) impairment: pain (WOMAC pain subscale), anxiety (state subscale of STAI), depressive symptoms (CES-D), (2) functional limitations: mobility (advanced lower extremity subscale of Function Component of Late-Life FDI (FC-LLFDI), and (3) disability: IADL (OARS, lower extremity subscale of FC-LLFDI), and life tasks (Disability Component of LLFDI). In addition, performance measures were used to evaluate other (1) impairment variables including balance (balance subscale of Tinetti), muscle strength (dynamometer) and (2) functional
limitations variables including mobility (Get-Up and Go), and gait (gait subscale of Tinetti). Class attendance, analgesic use, change in health condition, and practice done at home were reported weekly before each Tai Chi class and Bingo session.

Variables of Interest: Pain and Muscle Strength

The nonsignificant findings for pain and muscle strength were consistent with three previous studies of Tai Chi for pain that found no significant improvement in pain (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996) and one study that found no effect for muscle strength (Song et al., 2003). However, nonsignificant differences were not consistent with findings for pain on another instrument in the pilot (Adler et al.) and in Song’s study. In addition, the nonsignificant findings for muscle strength were not consistent with five Tai Chi studies of muscle strength that showed significant improvement (Choi et al., 2005; Christou et al., 2003; Jacobson et al., 1997; Lan et al., 2000; Wu et al., 2002).

Tai Chi and Pain

Tai Chi did not affect pain in the present study. This is consistent with two pain measures in the pilot and two other studies that also found Tai Chi did not influence pain (Hartman et al., 2000; Schaller, 1996). There are a number of plausible explanations for this finding that are key to this discussion. First, the sample size of the present study was small and the study lacked the statistical power to detect a significant change in pain. Second, analgesic usage in the Tai Chi group may have been a confounder of pain in this study, but could not be controlled for using retrospective measures and a nonparametric analysis.

However, several other explanations also need to be considered. First, although
participants practiced with the videotape three times a week, it may be unrealistic to expect Tai Chi to reduce pain associated with OA in 10 weekly sessions of Tai Chi without daily practice. In support of this contention, participants continued to use rescue analgesics prior to class, despite requests to the contrary for study purposes, suggesting that pain exceeded their ability to manage without the analgesics. Yet, it also might suggest that participants with long-standing OA pain found it difficult to change their behavior pattern of taking analgesics in advance of increased activity “just in case.”

Another explanation for the lack of effect on pain is that the movement of the joints when doing the Tai Chi movements reduced the natural guarding that people with OA use in daily activities (Theodosakis & Buff, 2004, pp. 142-143). In other words, the participants were moving their arthritic joints in ways that they had not moved them for some time. Thus, the lack of significant decrease compared to controls may be that the pain associated with unaccustomed movement. Additionally, the 12-week time frame for data collection may not have been sufficient for the pain associated with new and different joint movements to subside.

The results from the present study are consistent with the results of three other studies (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996) that found Tai Chi did not reduce pain. There are some similarities between the present study and those that found nonsignificant results. Yet, in comparison, there are more differences between these studies than similarities.

The present study and the pilot treated analgesic usage as a potential confounder. However, the present study was the only one that tested the correlation between pain medication use and pain score during the previous 24 hours each week, Hartman et al.
Adler (2000) instructed elders to continue “routine care,” and Schaller (1996) did not provide information on analgesic usage in the study. The findings of the present study need to be interpreted with caution since the sample size was small and measures were obtained on a 24 hour retrospective time frame. Further, a nonparametric test was performed on pain that did not have the capability to control for confounders such as pain medication.

A small sample size was common for the all the three other studies with nonsignificant results on pain outcome (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996). Sample sizes for two groups ranged from 14 (present study) to 43 (Hartman et al) and participants were American and older adults. The sample in Schaller’s study consisted of older adults but their OA status was unknown because it was not an inclusion criteria and medical conditions of the participants were not described in the article. Like the present study, these other studies compared two groups (experimental and control). However, two studies were randomized (Adler et al., Hartman et al.) and one was not (Schaller). The investigators of all three recommended further study using a larger sample, and to consider the findings with caution.

There also were other methodological differences between the present study and the studies that had similar findings on pain outcome. The present study measured pain using the WOMAC pain subscale. Other studies found nonsignificant results using the McGill Pain Questionnaire and the Rand 36-Item Health Survey pain subscale (pilot), the SF-36 pain subscale (Schaller, 1996) that is similar to the Rand Survey, and the AIMS pain subscale (Hartman et al., 2000) designed for people with arthritis. The Tai Chi style that was used in these studies included Wu style (pilot and present study), short-form Yang style (Hartman et al.), and a “westernized” form known as Tai Chi Chih (Schaller).
Two studies conducted weekly, 10 week sessions, and one study (Hartman et al.) conducted two sessions weekly for 12 weeks.

None of these studies used a videotape for home practice, except for the present study. All the Tai Chi participants were expected to practice at home, yet studies varied in terms of the amount of practice. Participants in the pilot were requested to practice “a little each day,” while those in the present study and Schaller (1996) were expected to practice at least three times each week for 15 minutes. Hartman et al. (2000) on the other hand, requested participants to practice 15 minutes daily. Schaller reported that 80% of participants practiced outside of class on the average of 3 to 4 times per week, while Hartman et al. did not report the results of practice after class. In the present study, participants reported practicing a mean of 44.3 minutes ($SD = 14.4$) weekly, suggesting adherence to the research protocol. Thus, the request for participants to practice at least three times a week rather than daily may have influenced the results; especially since beginning level students are usually taught to practice a little each day and not a specific amount of time. Participants may have not gained as much as they could because Tai Chi practice was a requirement for the study based on Western understanding of exercise that exercise is needed at least three times a week to get an effect, or observe improvement.

In contrast, two other researchers have found Tai Chi to reduce pain (Adler et al., 2000; Song et al., 2003). There are differences between the present study and those that found significant results. The sample size and composition of the present study ($n = 14$) and the pilot ($n = 16$) were different than Song et al. ($n = 43$); participants were American (present study and pilot) and South Korean elders (Song et al.). Dissimilar to the present study and pilot, Song et al. recruited patients from a single site: one university
arthritis outpatient medical clinic. In the present study and pilot, the intervention consisted of 10 weekly, 1-hour classes of Wu style Tai Chi, while Song et al. tested a 12 week program of Sun style Tai Chi that met three times weekly for two weeks and then weekly thereafter. Furthermore, Song et al. used a videotape with music as an adjunct to the exercise in class, and the present study and pilot did not. Finally, unlike the pilot and present study, it was not clear as to when analgesic usage data were obtained in the study by Song et al.

Overall, the findings of the present study for pain were consistent with three previous studies for pain that found no significant improvement in pain (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996). Findings were inconsistent with two that did find improvement (Adler et al.; Song et al., 2003). Thus, the pool of studies testing Tai Chi for pain is extremely limited, the findings are mixed and the methods are comparatively diverse, limiting the ability to draw strong conclusions.

Tai Chi and Muscle Strength

Tai Chi did not affect muscle strength in the present study. This was consistent with one other study (Song et al., 2003) that found Tai Chi to not affect muscle strength. There are several plausible explanations that are key to this discussion. First, the sample size was small in the present study, and it lacked the statistical power to detect a significant change in muscle strength. Both studies included only elders with OA. Yet, in a later study of Tai Chi with older adults, Song, and the other researchers studied elders in “residential care facilities” at risk for falls and found that lower leg muscle strength improved significantly (Choi et al., 2005). It is likely that the modified inclusion criteria contributed to the outcome of the latter study because the focus was not on elders with
OA pain; this change in the study design was a noticeable difference from Song’s earlier study. Hence, the inclusion of only elders with OA is a viable explanation for the results.

Despite similar results for muscle strength, there are differences between the present study and that of Song et al., 2003. The present study measured dominant lower extremity muscle strength with using a composite score of five hand-held dynamometry measures on five muscle groups at pretest and posttest. However, unlike the present study, Song et al. used isokinetic dynamometry of knee flexion (degrees/seconds) at pretest and posttest to test only knee flexion muscle strength. Although Song et al. used a greater dose (12 weeks), and a different form of Tai Chi (Sun) compared to the present study (Wu), muscle strength did not improve.

In contrast, other researchers have found Tai Chi to improve muscle strength (Choi et al., 2005; Christou et al., 2003; Jacobson et al., 1997; Lan et al., 2006; Wu et al., 2002). Sample sizes for two groups was small and ranged from 24 (Jacobson et al.) to 59 (Choi et al.). The differences between the present study and the studies where Tai Chi was found to improve muscle strength are several. First, there were differences in the health conditions of the samples. While the present study only included older adults with OA of the lower extremity, the other studies included healthy adults (Jacobson et al.), elders (Choi et al.; Christou et al.), or elders with few chronic problems (Lan et al., Wu et al.). Second, the present study analyzed a composite score of the muscle strength of five muscle groups, rather than a specific muscle group. All five of the studies showed significant muscle strength in knee extensor muscles; one study (Choi et al.) also showed significant knee and ankle flexion, and ankle extension. Third, the present study was the only one to use Wu style Tai Chi. Other styles included Yang 108 (Jacobson et al.; Lan et
al.), Sun (Choi et al.), Chen (Christou et al.), and one did not describe a style used in the experiment (Wu et al.). In addition, Tai Chi classes ranged from one to three weekly classes, and practice after class ranged from no practice to daily practice. Hence, contrary to what one would expect, the outcome was not likely influenced by the amount of time that participants’ practiced after class.

Overall, muscle strength increased in five studies and not in Song et al. (2003), because, like the present study, Song’s study tested only older adults with OA and arthritic joint pain. To support this contention, the same intervention that was used by Song in another study (Choi et al., 2005) of Korean elders at risk for fall demonstrated a significant improvement in muscle strength. It was unclear in the description of this study if the same muscle testing procedure was used in these two studies. Therefore, the favorable results in the Choi’s study were likely related to the change in sample criteria, yet may have been influenced by a different muscle testing procedure.

Analgesic Usage

The studies of Tai Chi on pain were not consistent with this study in terms of assessing weekly analgesic usage as potential confounder of pain with the exception of the pilot study. In addition, only the current study assessed analgesic usage during the previous 24 hours before testing for pain. Hartman et al. (2000) measured pain and analgesic usage at pretest and instructed the Tai Chi and control groups to continue “routine care.” The control group was contacted by telephone every two weeks to discuss “changes in symptoms, treatment, and daily activities” and was expected to maintain usual physical activity and routine care. At pretest, the Tai Chi group reported less pain, more analgesic medication, and less activity in the past six months compared to controls.
Song et al. (2003) also requested participants to maintain routine arthritis treatment, and reported that “most subjects were taking medications that remained unchanged during the study period.” Yet it was unclear as to when this data was obtained. In addition, values for analgesic usage were not reported. Finally, Schaller (1996) did not provide any information on analgesic usage by participants in the description of the study.

In conclusion, the findings of the present study advance knowledge by developing methods to test an exercise alternative for elders with OA pain of the lower extremities and functional deficits that has been recommended but has limited evidence to support this claim. Nurses are in a position of recommending exercise to their older patients and need to have evidence to support their recommendations; this is one exercise alternative that has the potential of preventing a disability outcome.

**Descriptive Trends**

The number of variables to be analyzed for group differences was decreased from nine to two because of the small sample size and the risk of type I error with multiple analyses. All variables were analyzed using descriptive statistics and trends. In this study, a participant can show improvement, no change, or decline in status comparing the Tai Chi group in relation to control group using a slope or difference score (last time point minus and time point 1) (see Table 9, p. 95).

Eight of the nine dependent variables (89%) showed some degree of improvement in composite scores for the Tai Chi group, including five impairment (pain, balance, anxiety, depressive symptoms, composite muscle strength), two functional limitations (mobility, gait), and one disability (life tasks) (see Table 10). One variable (IADL) showed no change in the Tai Chi group. In addition, two of the five muscle strength
component variables (40%) showed some improvement (plantar and hip flexion) in the Tai Chi group, one component showed slopes that were the same for both groups (knee flexion), and two others (knee extension, anterior tibialis) showed slopes that declined in the Tai Chi group.

Overall, then, the Tai Chi group had more improvement than decline in most of these measures of impairment, functional limitations, and disability. Therefore, these findings suggest that further study is warranted.

Descriptive Findings in Relation to Literature

Trends for each of the seven variables that were not tested for significance are described and compared to results found in the literature. Part of the challenge is that the research results in this area of research are equivocal and thus it is hard to draw conclusions about the findings from the present study compared with past research.

The trend for anxiety showed improvement and was consistent with three studies (Hartman et al., 2000; Jin 1989, 1992) that found significant improvement in the Tai Chi group compared to controls. In this study, the Tai Chi group showed improvement, while the Bingo group showed an increase in anxiety. None of the participants reported taking anti-anxiety medication, during the 12 weeks.

Research on the effects of Tai Chi on depression is equivocal. Three studies (Adler et al., 2000; Hartman et al., 2000; Schaller, 1996) found no significant effects for Tai Chi on depression while two studies that found decreased depression in the Tai Chi group compared to controls (Jin, 1989, 1992). In the present study, there was a small improvement in both groups, with slightly more improvement in the Tai Chi group. A score of 16 was the cut-point for depressive symptoms that was substantiated. However,
current standards suggest that a score of 16 is sensitive, but has low specificity. Instead, Cheng and Chan (2005) recommend using a score of 22 or 23 as a cut-point because the higher score demonstrated high sensitivity and specificity (p. 468).

The trend for balance showed some improvement in the Tai Chi group and was consistent with three studies (Schaller, 1996; Taggart, 2001; Tse & Bailey, 1992), yet inconsistent with one study (Hartman et al., 2000) that found no significant results. In the present study, the balance scores for participants were high at pretest which would make it difficult to attain further improvement. Both groups did improve, but similarly. Furthermore, the outcome may have been influenced by the decision to reduce the number of items in the original Tinetti balance subscale from 13 to only six. A Cronbach’s alpha test was performed to establish internal consistency of the six items, but was influenced by the limited sample size, and possibly the reduced number of items.

The trend for gait showed improvement in the Tai Chi group and was consistent with one study (Taggart, 2001), and inconsistent with another (Hartman et al., 2000) that found no significant change. Likewise, the trend for mobility showed improvement and was inconsistent with the one other study that measured mobility (Hartman et al.). However, the trend for IADL and life tasks could not be compared because this was the first study to test the effect of Tai Chi on these variables. Because gait and mobility are significant contributors to life tasks, according to the model, improvement in gait and mobility would be expected to be associated with improvement in life tasks, which indeed appeared to be the case in the present study. Hence, these results were similar to Nagi’s model, and suggested that at least two impairment variable, most likely (plantar
and hip flexion) muscle strength and pain, influenced the threshold of gait and mobility (functional limitations), that, likewise, influenced life tasks (disability outcome).

**Pilot Studies**

The study was developed based on two pilot studies. The first tested the intervention in elders with chronic arthritis pain, and the second tested a videotape that was produced by the investigator with focus groups. The pilot study (Adler et al., 2000) was similar to this study in that the focus of the investigation was the effects of Tai Chi on older adults with arthritis pain using the same 10 week Tai Chi intervention, and testing before and after the 10 weeks and also weekly. Control participants in the pilot were offered a Tai Chi class free of charge upon completion of the study. Yet the methods of the dissertation study were different from the pilot in many ways. The dissertation included (1) use of videotape for home practice (Adler & Roberts, 2003), (2) confirmation of OA by physician, (3) minimum weekly practice, (4) more variables related in and a model, (5) different and a greater variety of measures, (6) a Bingo control group rather than no Tai Chi group, (7) an exercise cut-point for inclusion, (8) use of a research assistant, (9) two sites, and (10) participants were instructed to omit rescue analgesic 24 hours before class or Bingo session if possible. These changes were made to strengthen the design of the study and expand the work done with the pilot to assess more related variables within a framework of a disability model. It had been planned to include only persons with a pain score of at least 40 mm on a 100 mm scale, but because of recruitment challenges this requirement was relaxed to include people with OA pain of the hip and/or knee that was less than 40 mm. Even so at screening, mean pain was 49 of 100 points.
The pilot study tested the effects of 10 weekly, 1-hour Tai Chi classes on pain and health in 16 American elders with chronic arthritis pain (experimental = 8, control = 8). Significant pain reduction was found using the Pain Intensity Number Scale (0-10), yet, significant pain reduction was not found in two other measures of pain: the Short-form McGill Pain Questionnaire and the pain subscale of the Rand-Item 36 Health Survey. Findings for health were not significant using the Rand-Item 36 Health Survey. Tai Chi group PINS scores (0–10) were decreased from 3.25 (SD = 2.29) at pretest to 1.75 (SD = 1.39) at posttest, while those for the control group increased from .50 (SD = 1.41) to 1.50 (SD = 1.41). Pre and posttest analgesic use was comparable.

Limitations

The primary limitations of the study were the small sample size (n = 14) and lack of power to detect a difference that was significantly greater than chance. The pool of available participants decreased during the six years since the pilot study was conducted because of the variety exercise options that are now available to community-dwelling elders. These include Tai Chi, line and ballroom dancing, water aerobics, yoga, walking programs, low intensity chair exercise, and circuit training. Most people who decided to participate in the study were interested in the exercise and were not interested in a 50:50 chance of getting into a Bingo group; some felt that they were “too young” for Bingo. So the use of a Bingo group as the control did not enhance the appeal of the study. This investigator also found that she created her own competition for viable participants within the community by advertising and talking with people about the study. Specialized Tai Chi classes for seniors began to be available at multiple locations shortly after the initial recruitment effort. This investigator also found that personal accounts of a negative past
experience with Tai Chi, and preconceived notions about Tai Chi, such as its link with
the occult, also influenced some people’s interest in the study. Other limitations included:
(1) the currently accepted criteria for knee and hip OA were not faxed to physicians so
they could all use the same criteria, (2) rescue medication was not stopped by all
participants 24 hours before pain assessment, (3) interim telephone calls may be a
possible confounder, and (4) participants in the study may be different from the general
population of people with OA.

Implications for Theory

This study was designed using a modified version of Nagi’s model of disability
(see Figure 1) (Brandt & Pope, 1997). Disability is a potential outcome of the interaction
of environment (exercise) and person (impairments, functional limitations) that is
dependent upon a threshold effect of impairment and functional limitation on disability. It
was proposed in the current study that Tai Chi is an exercise intervention (therapeutic
modality) aimed at reducing impairment (pain, depression, anxiety, balance, muscle
strength), functional limitations (mobility, gait), and disability (IADL, life tasks).

However, the number of variables was reduced from nine to two impairment variables
(pain and muscle strength) that were selected for analysis in keeping with the model that
identifies impairment variables as those that drive the threshold effect to the right toward
disability.

Although differences between groups were not shown to be greater than chance, it
is possible that small positive changes in impairment variables (pain, muscle strength,
and balance) tended to be enough to positively change the threshold of functional
limitations. It is possible that one or more of the pain items in the subscale or muscle
Adler

strength components influenced the threshold effect on functional limitations. It is also possible that the amount of change in functional limitations (gait and mobility) was enough to positively change the threshold of disability on one measure (life tasks). However, the trends in this study cannot be interpreted as facts. These changes suggest that the use of this model holds promise for future research, but a larger sample would be needed before one could propose a conclusion beyond this one, because of the small sample and lack of power to differentiate these trends between groups.

Recommendations for Research

This study should be conducted again with the following changes (1) larger sample, (2) more than two sites, (3) use a no Tai Chi or patient education control group and not Bingo (4), collaborate with other health professionals at a large health care system with satellites in the community, (5) obtain grant support to fund additional resources, (6) collaborate with and obtain the endorsement of rheumatologists, (7) consider cluster or crossover design, or using one group with sedentary participants as their own controls, (8) obtain more data from participants on how to customize movements for different body conditions, (9) conduct study in a city with fewer resources for seniors, and (10) consider providing classes twice a week instead of weekly as recommended by at least one participant, (11) decrease the number of weeks from 10 to 8 weeks since the investigator has been able to do this with elder in community classes, and (12) examine co-morbidity.

In the future, given the results of the current study, this investigator would likely reduce the number of variables to one impairment (muscle strength), one functional limitations (mobility) and one disability variable (life tasks) if the sample size was
limited, so that the alpha would not be affected. By conducting the study in a city with fewer exercise resources, recruitment of participants may be enhanced, since many people did not meet criteria due to involvement with a variety of exercise programs that were not available at the time of the pilot. However, with a larger sample, more human resources would be needed including research assistants to perform testing, data entry and management, a consultant for statistical support, and perhaps collaboration with local community Tai Chi instructor. Regarding the issue of how to control for exercise in the control group, this may be managed by requesting participants to maintain the level of activity reported at screening throughout the study, and document adherence in a daily log.

Another way to recruit more participants for the study may be to collaborate with a health care system with satellite centers within the community. In this way, the investigator would have a larger pool of potential participants to recruit from. However, another way to possibly recruit people for the study may be to use cluster design by randomly selecting centers and offering the intervention or control activity to all those at each center. This may reduce the chance of demoralization among participants in control groups.

In addition, the interview guide that was used for the focus groups in the development of the videotape may be used to obtain more data from participants on how to customize movements for different body conditions. Perhaps more simply, several questions could be asked of participants at posttest using the handout with the movements given to participants in the study. Also Tai Chi classes conducted twice a week should be considered since at least two participants made this suggestion during the course of the
study. It would be important to ask questions after posttest to assess whether or not participants liked the intervention, what they thought was most helpful about it, and how difficult it was to find the time to practice at home.

**Three Future Studies.** One potential study would be to compare two interventions, Tai Chi and meditation, to a control to determine if either was beneficial for patients with osteoarthritis. This study would allow further examination of the effects of Tai Chi as a movement based intervention versus meditation as a non-movement based intervention. Variables of interest that were not included in the present study would include impairment variables: self-efficacy of pain management and fear of falling.

A second potential study would be to compare Tai Chi and sham-Tai Chi as the control to determine if mind-body exercise (Tai Chi) was beneficial compared to low intensity, low impact movement. The effect of the intervention would be measured by assessing bioelectric-meridian flow with an instrument used by clinical practitioners to locate and quantify acupuncture points. This study would likely be better explained using an energy model such as Rogers.

Finally, a third potential study would be to compare Tai Chi and a control group much like the present study. However, the control group would be assessed during an 8-week period using pre and posttest, and daily logs, and then crossover into an 8 week course of Tai Chi and serve as their own control. Participants would have weekly contact with a research assistant, and get a small stipend for each week they continue in the study.

**Implications for Practice**

In this study, no effects of Tai Chi on pain and muscle strength were found; the
sample size was not large enough. However, no attrition or adverse effects occurred and the Tai Chi classes were conducted successfully with older adults using adaptations appropriate for the wide variety of conditions they presented, in particular those with arthritic joint pain.

Since the intervention was safe with adaptation to elders, this investigator would recommend that nurses encourage healthy elders to consider taking a community class of Tai Chi as an alternative to traditional exercise. It is important to note that despite limited evidence to support the use of Tai Chi in elders with joint pain, the Arthritis Foundation has recommended its use, and has endorsed a Tai Chi videotape with little evidence-based research.

In conclusion, this chapter was a summary of the study with a discussion of the results and conclusions. In addition, limitations and strengths of the study were identified along with recommendations for nursing practice, and future research of Tai Chi and older adults with chronic conditions, in particular those with arthritic joint problems. This study will serve as a feasibility study future research with grant support of Tai Chi and older adults.
Appendix A

INTERVIEW GUIDE FOR SCREENING PARTICIPANTS

Hello, this Pat Adler, I am the nurse who is conducting the Tai Chi Study from Case Western Reserve University. Thank you for your interest in participating in my study. I have some questions to ask you that will determine whether or not you are eligible for the study. This will take about 20 minutes of your time. Your participation in this interview is completely voluntary. The information that you share with me will be confidential. Do you have time to talk now? *If YES, proceed to next paragraph. If NO, then set up another time that is convenient for potential participant to discuss the study.*

This study is about older adults with osteoarthritis pain of the knee or hip. Since there are many types of arthritis, I will need to contact your doctor to make sure that you have osteoarthritis. Would it be OK for me to contact your doctor by sending a facsimile (fax) to find out this information? *If YES, then obtain name and address (and phone number if possible) of primary care physician or rheumatologist and proceed with screening using Appendix B. If NO, thank the person for their interest in the study and wish him (or her) well and good-bye.*

*Meets Screening Criteria? NO*
Unfortunately for me, you are not a candidate for my study. *(Explain why)* I appreciate your interest in my study and wish you well. Take care and good-bye.

*Meets Screening Criteria? YES*
Congratulations, it looks like you are a candidate for the study. But I will still need to hear back from your doctor to make sure that you have osteoarthritis (OA). I will call you as soon as I hear back from your doctor. This usually takes a few days. Thank you again for your interest in my study!

*OA diagnosis? NO*
According to your doctor, you do not have osteoarthritis, so I will not be able to include you in my study. I appreciate your interest in my study and wish you well. Take care and good-bye.

*OA diagnosis? YES*
According to your doctor, you have osteoarthritis and I will be able to include you in the study. I will send you a copy of the consent form in the mail for your review. Please contact me with any questions that you have before our first meeting. Thank you again for your interest in my study!
Appendix B

SCREENING/DEMOGRAPHICS FORM

Date: ____________________     Interviewer Initials:  PA             ID#_______________

Referral Source:______________________ Choice of Location: ___________________

Note:  Information obtained at screening via PC will be verified at the time of enrollment
except for the mini mental exam.

Name________________________________________DOB _______Age_____ (age)

Address___________________________________  MS ____ (ms) Gender____ (gender)

Phone (h) ________________ (alternate) _______________Email__________________

Checklist (✓ = screening,  X = enrollment)  Candidate:  Yes_____ No_____

✓/  At least 60 years of age
✓/  Dx pain d/t OA of knee and/or hip (confirmed by MD - fax_______________)
✓/  No fibromyalgia
✓/  Pain score in the last 24 hours (see page 2)
✓/  No MI, stroke, angina, PVD, or uncontrolled DM within the last 6 months
✓/  No regular Tai Chi practice during the last 3 months
✓/  No activity limitation (from physician)
✓/  Ambulatory; no assistive device (except cane OK for distance)
✓/  Some difficulty getting out of a chair
✓/  No problem with memory or concentration requiring medical attention
✓/  Mini Mental (less than 3 errors of 10 points)
✓/  Living independently
✓/  No hearing deficit (OK with use of hearing aid)
✓/  Able to speak and read English
✓/  No difficulty with BP r/t change in position
✓/  Not taking medication for anxiety, and/or steroids (depression meds OK)
✓/  Not participating in a (community) exercise program (< 20-30 min, 3x/wk at
home; no weights)
✓/  Recent h/o injury due to falling within the last 3 months
✓/  Any pain medications (name, amount, and frequency/usage) No change; same
drugs

_____________________________________________________________________

IN CASE OF EMERGENCY   Contact Person__________________________________
Relationship__________________________________Phone______________________
Medical problems________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Past Surgery_________________________________________________________________
Current medications________________________________________________________________________
PAIN SCALE
Think about the pain you felt in your knees and/or hips due to your arthritis during the last 24 hours. (Please describe your pain on a scale of 0 (no pain) and 100 extreme pain).
What type of activities cause you pain?
SCORE: ___________ with medication           SCORE: __________ without medication

MINI MENTAL
The number of errors is scored and omissions are counted as errors. A score of 3 or more errors of 10 points indicates cognitive impairment.
SCORE: ___________
Appendix C

INFORMED CONSENT DOCUMENT

The Effects of Tai Chi on Pain and Function in Older Adults with Osteoarthritis

You are being asked to participate in a research study about the effects of Tai Chi on older adults with arthritis pain. Nurse researchers at Case Western Reserve University (CASE) are conducting this study. You were selected as a possible participant because your physician forwarded your name to the investigators, or you personally responded to our advertisement (postcard or website and/or flier). Please read this form and ask any questions that you may have before agreeing to be in the research.

Background Information

The purpose of this research is to determine whether Tai Chi will work in reducing pain and improving function in older adults with osteoarthritis. Tai Chi is a gentle form of exercise that has been used in China for many years to reduce chronic pain associated with aging. However, little research has been done in the West to investigate this claim. Patricia (Pat) Adler, PhD(c), RN is conducting this study as part of her research education at Frances Payne Bolton School of Nursing, CASE, where she is a PhD candidate.

Procedures

If you agree to be a participant in this research, you will be randomly assigned to either a Tai Chi exercise group or a Bingo activity group and we would ask you to do the following things:

- Attend 10 weekly one-hour group sessions of Tai Chi or Bingo, depending on your assignment, at a suburban community senior center. Practice at least 3 times each week for 15 minutes (Tai Chi only).
- Report your pain level, use of pain medication, change in exercise prescription, any change in health condition, and exercise practice (Tai Chi group only) every week during group sessions.
- Complete questionnaires and performance tests to evaluate pain and function one week before the first session and one week after the last session. These measures (tests) should take about 60 minutes.

Pat Adler will conduct the Tai Chi classes. She has been a nurse for almost 30 years and has taught Tai Chi to older adults such as you in the community for the past 6 years.

Risks and Benefits to Being in the Study

Risks of participation are minimal. As in all physical exercise, there is a small risk of falling. However, you will not be expected or encouraged to perform the movements beyond your own comfort level. If you become tired during class, you may stop at the time and return when you are rested. The traditional Tai Chi movements will be modified to make them suitable and easier to practice. If you are physically injured during the study the investigator and/or CASE will not provide or pay for any medical care.
Older adults who participate may directly benefit from the study by a reduction of chronic pain and improved function. Those assigned to the group that will not attend Tai Chi classes may benefit from knowing that their participation in this study is a contribution to society.

Compensation
There will be no compensation in this study. Tai Chi participants will receive a videotape for home practice and the Bingo group members will have an opportunity to win a grocery debit card or cash equivalent. All those who complete the study will receive a grocery debit card or cash equivalent and certificate of participation.

Confidentiality
The records of this research will be kept private. They will be kept in a locked file and any report we publish will not include any information that will make it possible to identify a participant. Access to research records will normally be limited to the researchers. However, the University’s Institutional Review Board (IRB) and other regulatory agencies, and sponsors and funding agencies may review the research records to ensure that the rights of human subjects are being adequately protected.

Voluntary Nature of the Study
Your participation is voluntary. If you choose not to participate, it will not affect your current or future relations with the University or with other cooperating institutions (senior centers). There is no penalty or loss of benefits for not participating or for discontinuing your participation.

You will be provided with any significant new findings that develop during the course of the research that may make you decide that you want to stop participating.

Contacts and Questions
The researchers conducting this study are Pat Adler, PhD (c), RN and Marion Good, PhD, RN, FAAN. You may ask any questions you have now. If you have any questions later, you may contact them at 216-221-6807 or 216-368-5975.

If you would like to talk to someone other than the researcher(s) about; (1) concerns regarding this study, (2) research participant rights, (3) research-related injuries, or (4) other human subjects issues, please contact Case Western Reserve University’s Institutional Review Board at (216) 368-6925 or write: Case Western Reserve University; Institutional Review Board; 10900 Euclid Ave.; Cleveland, OH 44106-7230.

You will be given a copy of this form for your records.

Statement of Consent
I have read the above information. I have received answers to the questions I have asked. I consent to participate in this research.

Print Name of Participant: ________________________________
Signature of Participant: ________________________________

Date: ____________

Signature of Person Obtaining Consent: ________________________

Date: ____________
References


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