THE EFFECTS OF TAI CHI ON BALANCE AND MOBILITY IN OLDER WOMEN WHO ARE AT VARIOUS RISK LEVELS FOR FALLS

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Abstract

Physical activity has been accepted as instrumental in the maintenance of functional ability and quality of life across the lifespan. Despite the benefits of exercise, Canada's Physical Activity Guide to Healthy Active Living (1999) reports that 60% of older adults are inactive. One of the outcomes of this inactivity is functional decline and consequent increased risk for falls. Falling is one of the most common causes of injury and subsequent death in older adults. Although the relationship between falls and functional decline is complex, several publications espouse that these risk factors can be modified through exercise (Galindo-Ciocon, Ciocon, & Galindo, 1995; Lord, Ward, Williams, & Strudwick, 1995). The purpose of the present study was to examine the effects of Tai Chi on biomechanical and functional measures of balance and gait in older adults who are at risk for falls. The participants in the study were 34 women with a mean age of 64 years, ranging in age from 55 to 85, who completed a 10 week program of 8 forms of Tai Chi. All participants were assessed on forceplate measures of postural sway and measures of balance, gait, handgrip strength and falls, prior to and following the intervention period. Tinetti's Performance Oriented Mobility Assessment (POMA) was used to provide functional measures of balance and gait. Postural sway variables that were examined included antero-posterior (AP) sway, area of sway, and path length and were measured during quiet standing with eyes open and eyes closed as well as during a dynamic balance space task. Following intervention, completion of a social validation questionnaire provided a medium for expression of participant experiences. Since 18 of the participants were novices with respect to Tai Chi and 16 had 34.44 hours of experience, the analyses were conducted by comparing the effect of the intervention on the two groups. Results of the MANOVA in quiet standing, eyes open indicated main effects for group

($F(3, 30) = 4.75$, $p < .05$, ES = .32) and time ($F(3, 30) = 16.80$, $p < .05$, ES = .63). Separate ANOVAs indicated that novices increased on all measures and the experienced increased both AP sway and area of sway. Similar results were seen in quiet standing, eyes closed, with main effects for group ($F(3, 30) = 3.14$, $p < .05$, ES = .24) and time ($F(3, 30) = 18.83$, $p < .05$, ES = .65). Again, the novices increased on all measures and the experienced increased both AP sway and area of sway. In balance space, there was a main effect for time ($F(3, 30) = 96.64$, $p < .05$, ES = .85) and separate ANOVAs indicated that AP sway, area of sway, and path length all increased for both novice and experienced. A significant change in right grip strength of 1.81 kg or 7% was also documented ($t(32) = 3.20$, $p < .05$). The number of fallers changed from 8 before the study to 2 during the study. The POMA was insensitive to risks in balance or gait in either group. All of the participants who completed the questionnaire reported improved functional status, such as balance, strength, flexibility, energy and mental state. Increased postural stability or balance is usually associated with decreased sway (Shih, 1997). The opposite was true in this study. Wolf et al. (1997) suggest that an increased tolerance for sway, particularly in dynamic tasks, may decrease fear of falling and improve responses to sudden loss of balance. The changes in sway cannot be attributed to the intervention without a control group for comparison. However, the magnitude of the changes in sway strongly suggest that Tai Chi is the cause. Further investigation employing a randomized controlled trial would provide evidence for this conclusion.

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Introduction

As life expectancy continues to increase, the population of older adults in Canada continues to flourish. According to McPherson (1998), the number of individuals over age 65 doubled from 6% in the early 1960's, to 12% by 1996. Furthermore, life expectancy at birth has increased from approximately 60 years for both men and women at the beginning of the 20th century to approximately 81 years for women and 75 years for men by the end of the century. With this inherent increase in life expectancy, there is a growing concern for the maintenance of independence and quality of life among older adults.

There is no doubt that some of the physical limitations the elderly sustain, such as genetic or hormonal dysfunction, are directly related to the aging process, however some of the *age-related* decline may be directly attributed to adverse lifestyle factors (Allison & Keller, 1997). Physical activity has been accepted as instrumental in the maintenance of functional ability and quality of life across the lifespan. According to *Canada's Physical Activity Guide to Healthy Active Living* (1999), the benefits of physical activity are numerous and include: improved physical and psychological health, improved quality of life, increased energy, improved posture and balance, improved self-esteem, weight maintenance, increased bone and muscle strength and, reduced stress and increased relaxation. Despite these benefits, it is estimated that as many as 60% of older adults are inactive (*Canada's Physical Activity Guide to Healthy Active Living*, 1999). And consequently, one of the most crucial problems is that inactivity is directly related to mobility decline and mobility decline is associated with increased risk for falls in older adults.

According to Tideiksaar (1997), up to 25% of community dwelling adults, aged 65-74, and one third or more aged 75 and older, fall annually. Increasing age leads to more frequent falls and thus more injuries and possibly even death. In Ontario this trend prevails. A more current report from the Canadian Institute for Health Information (CIHI) released in January 1999, states that of the 68, 222 injury admissions to Ontario's acute care hospitals, in 1996/1997, 58% were as a result of falls. On a regional scale, consider the trend in Northwestern Ontario. According to the 1998 Ontario Trauma Registry, injury admissions due to falls for people over 65 years increased from 588 in 1992/1993 to 613 in 1996/1997 in Northwestern Ontario. Because complications due to falls have such serious implications for the older adult, researchers have studied the risk factors for predicting falls and fall related injuries extensively.

Falling, an unexpected event in which the person comes to rest on the ground or another lower level, may occur for a variety of reasons (Tideiksaar, 1997). These reasons or factors may be categorized as either intrinsic or extrinsic (Shumway-Cook, Baldwin, Polissar, & Gruber, 1997) however, the literature continues to emphasize the relevance of intrinsic factors as important attributes to fall risk. The intrinsic risk factors that have been identified are numerous and include but are not exclusive to the following: mobility impairments in gait and balance (Shumway-Cook et al., 1997; Studenski et al., 1994; Tinetti, 1994), a decline in musculoskeletal function (Studenski et al., 1994; Tinetti, Baker, et al., 1994; Tinetti, Inouye, Gill, & Doucette, 1995), postural hypotension and number and type of medications (Tinetti, Baker, et al., 1994), fear of falling (Tinetti, Richman, & Powell, 1990), a history of falls (Studenski et al., 1994) and acute changes in health status (Kuehn & Sendelweck, 1995).

An important assumption central to the falls literature is that a decline in balance control, often attributed to aging alone, is a result of a complex interaction of intrinsic and extrinsic factors that are directly related to falling (Shupert & Horak, 1999; Vandervoort, Hill, Sandrin, & Vyse, 1990). Among the identified risk factors, difficulties in mobility, such as gait and balance, are very important in increasing the probability for falls. Although the relationship between falls and functional decline is complex, several publications espouse that these risk factors can be modified through exercise (Galindo-Ciocon et al., 1995; Lord, Ward, Williams, & Strudwick, 1995).

The Role of Exercise in Falls Prevention

While the advantages are many, it is generally accepted that exercise provides a lifetime of benefits that not only include the maintenance of functional health and mobility, but may also involve psychological and social benefits for the older adult. As Lord et al. (1995) state, exercise, as a proposed intervention, has become increasingly attractive because it can be an inexpensive form of falls prevention that is noninvasive and when implemented properly, may carry few risks.

Upon reviewing the literature, the modification of risk factors has traditionally involved: medication and environmental review and adjustments (Tinetti, McAvay, & Claus, 1996); gait training (Galindo-Ciocon et al., 1995; Tinetti et al., 1996); balance training (Tinetti et al., 1996; Wolf et al., 1996), strength training (Fiatarone et al., 1993; Sauvage et al., 1992) and aerobic exercise (Sauvage et al., 1992). Furthermore, the concept of impairments in balance, posture and locomotion as important indicators of fall risk has inspired the evolution of falls prevention programs designed to modify these factors (Lord et al., 1995; Means, Rodell, O'Sullivan, & Cranford, 1996; Sauvage et al., 1992; Wolf, Barnhart, Ellison, & Coogler, 1997). The assumption here is that if falls occur at least in part due to physical deficits in strength, gait and balance then exercise interventions targeted to improve these factors may in turn prevent falls or fall-related injuries in the older adult.

While this form of exercise may be non-traditional to some, it has been theorized that Tai Chi may reduce falls or fall risk as it incorporates important components of balance, strength, coordination, spatio-temporal awareness, and weight transference while continuously challenging the base of support (Skelton & Dinan, 1999). Consequently, there is growing interest in Tai Chi as an effective intervention for the prevention of falls. Tai Chi is considered moderate exercise with an exercise intensity of approximately 55% maximal oxygen uptake (Lai, Lan, Wong, & Teng, 1995; Lan, Lai, Chen, & Wong, 1998). Accordingly, this moderate form of exercise may be effective for the older adult who has decreased mobility, because it emphasizes slow and controlled movements of the upper and lower body.

Statement of the Problem

The purpose of this study was to examine the effects of Tai Chi on biomechanical and functional measures of balance and gait; strength; and falls in older women who were at risk for falls. The biomechanical measures assessed postural sway and included antero-posterior sway, area of sway and path length.

A social validation measure was also implemented upon completion of the study, to evaluate and reflect the impact that the intervention had on each participant.

It was posited that after 20 hours of Tai Chi, there would be a decrease in measures of postural sway during quiet standing and an increase in the balance space task. It was also hypothesized that there would be an improvement on functional measures of balance and gait, and an increase in strength after the Tai Chi intervention.

<u>Definitions</u>

Centre of Pressure (COP) - COP has been defined as the point location of the vertical ground reaction force vector. It represents a weighted average of all the pressures over the surface of the area in contact with the ground (Winter, 1995, p.4).

Centre of Mass (COM)- a point equivalent to the total body mass in the global reference system and is the weighed average of the COM of each body segment in 3D space. The vertical projection of the COM on the ground is considered the centre of gravity (COG) (Winter, 1995).

Quiet Standing- an orientation of the body in which stabilizing, corrective movements are made to counteract all equal and opposing forces acting on the body in its attempt to maintain an upright posture (Holbein & Chaffin, 1997; Usui, Maekawa, & Hirasawa, 1995).

Postural Sway- continuous, corrective body movements resulting from the body's effort to control posture and body position. Sway is evaluated by measuring COP excursions which reflect shifts in the forces applied by the body in its attempt to maintain upright (Thapa et al., 1994).

Antero-posterior Sway (AP)- displacement of the COP defined by postural sway in the antero-posterior direction (Prieto, Mykelbust, Goffmann, Lovett, & Mykelbust, 1996).

Area of Sway (AS)- a function of path length, that defines the shape and size of the area of the COP excursions, measured in inches squared (in^2) (Thapa et al.).

Path Length (PL)- a measure of body sway which reflects the total amount of displacement of the COP, measured in inches (in) (Jeong, 1994).

Balance Space- maximum voluntary excursions of the COM and COP within the base of support. It is defined by the range of movement in the antero-posterior (AP) and mediolateral (ML) directions where an individual preserves stance and does not take a step (Blaszczyk, Lowe, &

Hansen, 1994).

At Risk for Falls- In this study the identified risk factors associated with falling included being age 55 and older; being female; as well as factors that may cause functional impairment resulting in poor balance and gait difficulties (Gallagher, 1995).

Tai Chi (TC)- an ancient form of Chinese exercise rooted in Chinese medicine and philosophy in which slow deliberate body movements emphasize a symbiosis of the mind and a stable body environment. The movements of Tai Chi which personify the opposing forces of Yin (inactivity) and Yang (activity), are based on shifting the body's weight to create a state of physical and mental equilibrium through continuous changes in posture and breathing. These movements are coordinated with breathing patterns so that exhalation (Yang) moves the body forward or up and inhalation (Yin) moves the body down or back (Kessenich, 1998).

Tinetti's Performance Oriented Mobility Assessment (POMA)- a tool designed to evoke position changes and gait maneuvers used during daily activities. It is therefore used to identify impairments in balance and gait in elderly individuals who may be at risk for falling (Tinetti, 1986).

Review of Literature

The Impact of Population Aging

Although life is full of uncertainties, one certainty still prevails: aging is inescapable. At conception we begin the aging process and we continue to age throughout the life course. The 20th century has seen an extraordinary increase of older adults in the population. This phenomenon, known as population aging, is responsible for an increase in the number and proportion of the population over 65 years of age (McPherson, 1998). In 1996, more than 3.5 million Canadians were in this age group and it was predicted that this number would rise to 4 million by 2001. Of these 4 million, approximately 500,000 are over age 85 (McPherson).

Aging has been described by Medina (1996) as an internal clock, wound to zero at birth, which continues to tick away throughout life's entirety. This concept is so concrete that the terms 'lifespan' and 'life expectancy' have been used to shape the confines of longevity. Lifespan, the maximum time a person *could* live under appropriate conditions, is perceived by Medina to be 120-126 years. Most persons could survive a maximum of 126 years provided they were void of disease or accidents (McPherson, 1998). Life expectancy is the average number of years a person is projected to live beyond any given age and answers the question, given the current cultural, environmental, sociodemographic, and lifestyle factors, how long can a person expect to live?

How does one explain the Nation's longevity? Some may attribute Canada's population aging to religious or cultural ideologies while others may turn to genetic or hereditary factors for an explanation. McPherson (1998) explains that this amplified shift in the number and proportion of older adults has occurred not only because birth rates have declined but also because health status has improved. Life expectancy is projected to increase from approximately 81 years for women and 75 years for men at the end of the 20th century to approximately 84 years for women and 78.5 years for men by 2016 (McPherson). With this inherent increase in life expectancy, there is a growing concern that the later years of life will be saturated with disease and disability. One of the most common sources of disability for people 85 years and older, is falling.

<u>The Inevitability of Falling</u>

Falls are among the most serious problems concerning the health and well-being of Canada's aging population. The statistics are frightening. A report released by the Canadian Institute for Health Information (CIHI) (1999) shows that injury admissions due to falls in 1996/1997 accounted for:

- 452, 582 hospital days (72% of all hospital days due to injury)
- an average length of stay (LOS) of 11 days in Ontario compared to the LOS for all injury admissions of 9 days
- 2031 injury deaths (80% of in hospital deaths due to injury)
- 86% of all injury admissions for people 65 years of age and older
- a higher percentage of females than males (71% of females, 29% of males over age 65)

Falls affect Canada's aging population whether persons reside at home or in long-term care facilities (Schulman & Acquaviva, 1987). Because complications due to falls have such serious implications for the older adult, researchers who have studied the risk factors for predicting falls and fall related injuries extensively have concluded that the reasons for falling are multifaceted. They may be intrinsic, involving those factors related to the individual or extrinsic which includes factors external to the individual or associated with the environment (Shumway-Cook, Baldwin, Polissar, & Gruber, 1997). In a 1996 review, Myers, Young, and Langlois summarized the works of 52 studies in the fall prevention domain. Of the studies examined, those factors that were identified as significant risk factors for falls in the elderly included: demographic characteristics such as advanced age and being a Caucasian female; psychological factors such as cognitive impairments; behavioural factors such as fear of falling; social factors which included living conditions and social networks; environmental hazards such as slippery surfaces; medication type and medication overuse including benzodiazapenes and sedatives; a general decline in health as well as a history of falls; medical conditions such as postural hypotension, stroke, and dementia; sensory impairments; musculoskeletal and neuromuscular decline; low physical activity level; and gait, balance and overall mobility deficits. Tinetti, Doucette, Claus, and Marottoli (1995) contend that falling most often results not from a single cause but from an accumulated effect of several risk factors. Consequently, the probability of experiencing a fall increases with the number of risk factors present.

Of the identified factors, researchers have demonstrated that a decline in balance, mobility and strength, greatly increase the likelihood for falls in older adults (Spirduso, 1995; Tinetti & Speechley, 1989; Woollacott & Shumway-Cook, 1990). As people age, physiologic adaptive ability may decline, making environmental challenges more difficult. While a younger individual might slip yet avoid a fall, functional decline may affect balance and mobility, making compensatory reactions more difficult in the older adult (Tideiksaar, 1997). Falls may have such profound effects on the older adult that even one fall, may precipitate the onset of a spectrum of morbidities. In order to promote functional independence and quality of life in the later years of life, it is important for falls research to examine why people fall and upon identifying these factors, develop fall prevention strategies by modifying known risk factors.

In the implementation of falls prevention strategies, it is important to: identify those who are at risk for falls or those who have fallen; identify those known risk factors that are associated with falling; determine the appropriate outcome measure(s) to be assessed; and determine the appropriate intervention which targets known risk factors (Tinetti, 1994).

Issues Surrounding Falls Research Design

There has been a multitude of interventions designed for falls management from general exercise to individualized programs to group-oriented programs such as Tai Chi. Falls prevention strategies addressing single and multiple risk factors have been implemented. Some studies have focussed on improving such risk factors as strength, gait and balance with the assumption that targeting these risk factors, may reduce the risk or occurrence of falls in elderly individuals who have a predisposition to falling. While research emphasizes that adherence to a regular exercise program has a multitude of benefits for the older adult, previous intervention strategies have had conflicting results. Skelton and Dinan (1999) suggest that for a falls management program to be successful, it must be of: a) appropriate intensity, b) ample frequency and duration and c) it must also target the risk factors that participants exhibit.

Exercise intensity, duration, and frequency. Some of the existing clinical trials have been unsuccessful because they lacked the exercise intensity, duration and frequency to effect physiological change. The work of Means et al. (1996) is an example of this point. When the effect of a low intensity exercise program on balance, mobility and fall reduction in the elderly was evaluated, researchers found that the 6-week program was lacking sufficient duration to affect functional performance in elderly fallers. In addition, some interventions that have demonstrated improved balance, mobility, and reduced fall risk, have neglected to define the amount of exercise needed to achieve these results (Shumway-Cook, Gruber, Baldwin, & Liao, 1997).

Adherence and appropriateness. Piotrowski Brown (1999) contends that for interventions to be successful, they must not only consider the appropriateness for each individual but they must also be motivating so that compliance and performance may be optimized. In a clinical intervention designed to improve balance, mobility and the incidence of risks for falling, participants were classified into: a control group of fallers, a fully adherent exercise group, and a partially adherent exercise group (Shumway-Cook, Gruber, et al., 1997). All individuals were assessed to identify any functional impairments. Assessment results were utilized to design an individualized, multidimensional, exercise program addressing the functional impairments of each participant. Both exercise groups showed improvements on all measures of balance and mobility. Furthermore, these groups showed a reduction in the risk for falls with the fully adherent group displaying the greatest reduction. The researchers contend that adherence to an appropriately prescribed exercise program improves balance and mobility in community-dwelling older adults with a history of falls.

Specificity. Skelton and Dinan (1999) contend that specificity of training is a fundamental indicator of exercise response in falls management exercise programs. Furthermore, when exercise mimics functional movements then improvements may be seen in the functional tasks being measured. Consider the works of Sauvage and colleagues (1992). The researchers believed that an exercise program involving both strengthening and aerobic exercise would play a critical role in improving balance and gait in frail elderly nursing home residents. The rationale was that because lower extremity muscle weakness has been correlated with falls, and both muscle strength and VO_2 max have been correlated with gait velocity then a high intensity exercise program of weight training and aerobic exercise might improve strength, exercise capacity, gait and balance in these participants. Following 12 weeks of intervention, the high intensity exercise program had a significant effect on functional mobility, strength, muscular endurance and specific gait measures.

Lord et al. (1995) also showed the importance of specificity in a study that assessed the influence of exercise on muscle strength, reaction time, body sway, and falls. Participants were 197 women, aged 60 and older, who took part in an earlier falls study. A history identifying medical conditions, stability, medication use, activity level, and falls was provided from this initial, prospective study. In Lord's study, these women were matched on these health and lifestyle measures and then assigned to either an exercise or control group. At the end of the 12 month intervention, 75 exercisers who had adhered to the program, were then compared to the 94 controls who were available for retest and had completed the falls follow-up component. Those who exercised demonstrated improvements in sensorimotor predictors of balance related to strength, reaction time, and body sway, however, there was no significant difference among the proportion of fallers between the exercise and control groups. That is of the 75 exercisers, 34.7% had fallen during the study year while 35.1% of the controls had fallen in the study year as well. When analysing the reason for falls however, a significantly greater percentage of people in the control group fell due to balance related factors than in the experimental group. Those who exercised also experienced less falls within their homes, and less accidental falls in comparison to those in the control group.

In terms of appropriateness of interventions, Tinetti et al. (1994) argue that since the etiology of falls is multifactorial in nature then, falls prevention strategies should address multiple risk factors. In an attempt to address the complexity of falls, a collaborative study called Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) which assessed a variety of exercises of differing degrees of intensity, duration and frequency, behavioural and medication adjustments, as well as functional activity, education and nutritional components, was implemented. In a meta-analysis of the (FICSIT) trials, researchers evaluated the efficacy of the interventions and concluded that of all the clinical trials, those which incorporated a balance component, particularly Tai Chi, delayed the onset of first falls (Province et al., 1995).

One critical component of research design is the importance of large numbers of participants in order to show statistical change (Piotrowksi Brown, 1999). However, it remains to be determined whether, statistical significance is more important than clinical significance in falls research.

The Role of Exercise in Falls Prevention

It is evident that physical fitness plays a crucial role throughout the lifecourse as it is necessary to meet the demands imposed by every day tasks of daily living such as reaching, walking, bending and lifting. Consequently, the concept of exercise-based intervention to reduce falling has attracted many researchers in the falls prevention domain.

The consequences of the physiologic processes that accompany aging parallel those that accompany inactivity (Allison & Keller, 1997). Allison and Keller report that changes in musculoskeletal morphology and function have been attributed to the aging process and that similar structural and functional changes have been found when muscles have atrophied due to disuse. The relationship between impairments in musculoskeletal function and physical activity is quite interesting in that musculoskeletal decline may result in reduced physical activity in the elderly. Conversely, a decreased level of activity may result in functional impairments.

Muscle weakness and risk of falling. It is widely accepted that muscle weakness has been associated with increased risk for falls in the older adult. Several studies have examined the relationship between handgrip strength and risk of falls (Blake et al., 1989; Nevitt, Cummings, Kidd, & Black, 1989; Wickham, Cooper, Margetts, & Barker, 1989). This measure is easy to administer and has been correlated with total body strength (Tornvall, 1963). In a community survey of 1042 people aged 65 and older, 356 respondents reported one or more falls in the previous year (Blake et al.). Blake et al. found handgrip strength to be the most important factor in discriminating between fallers and non-fallers followed by reported giddiness, arthritis and reported foot problems. Nevitt et al., studied falls over 1 year in 325 adults over the age of 60. All participants had fallen at least once in the previous year. A weak grip strength (< 19 kg) was associated with being 1.4 times more likely to fall at least twice. Lastly, Wickham et al. surveyed 983 older adults. Of those surveyed, 305 had fallen. Those who experienced one or more falls had reduced grip strength in comparison to those who had not fallen and were 1.5 to 2.3 times more likely to fall because of this reduced strength.

Falls prevention strategies: Focus on strength and balance. The relationship between physical activity level and falls in the elderly is certainly complex. The aging individual not only undergoes the physiologic processes of aging but may also experience the physiologic effects of lowered activity levels. While we cannot turn back the hands of the biological clock, some intrinsic physical factors attributed to falls may be ameliorated through exercise.

Wolfson et al. (1996) contend that strength plays a very important role in gait, balance and, the occurrence of falls. Several researchers report that although a decline in muscle mass and strength occurs with age in sedentary individuals, this phenomenon occurs to a lesser degree in active individuals (Fiatarone et al., 1993). The effects of exercise on strength have been evaluated in various ways in the literature. Sauvage et al. (1992) found older adults had significantly increased right and left quadriceps strength and subsequent improvement in mobility as a result of a 12-week exercise intervention. Lord et al. (1995) measured hip flexion strength and found that those who participated in the 12-month exercise program had significant gains in strength. Similarly, O'Brien Cousins (1999) found a significant increase in right grip strength of 1.8 kg or 8% and a significant increase in left grip strength of 2 kg or 9%, in the elderly after a 4-week strength training program was implemented. It is encouraging that such a change could be effected so quickly.

There have been a multitude of exercise interventions designed to increase muscle strength and improve gait and balance for falls prevention. One proposed intervention which has been shown to improve both balance and strength is Tai Chi. In a 1997 study by Kutner, Barnhart, Wolf, McNeely, and Xu, participants reported that the benefits of Tai Chi included 'better coordination and balance, increased alertness, confidence, relaxation, better mental outlook, and a sense of achievement' (p. P245). This ancient martial art involves no physical contact and consists of repetitive movements targeted to enhance agility, strength, balance and postural control (Ross, Bohannon, Davis, & Gurchiek, 1999). According to the empirical evidence of Wolf et al. (1996) Tai Chi incorporates progressive rotational movements of the body while gradually decreasing the base of support thus, continually challenging the balance system. During this form of exercise, body segments are extended yet relaxed, the mind is calm while facilitating the concentration of body position, and body movements are slow and smooth while emphasizing soft, flowing, continuous motion (Schaller, 1996; Wolf et al., 1996; Wolf, Kutner, Green, & McNeely, 1993). Following is a summary of some of the current body of research on the use of Tai Chi.

Wolfson et al. (1996) examined the effects of a 3-month balance and strength training program immediately followed by a 6-month period of Tai Chi maintenance, on balance and strength. Balance training was implemented in two ways. Non-platform training was performed while standing and while sitting on a therapeutic ball. Platform training required participants to move their COP, which was represented by a cursor on a computer monitor, to targets on the screen. This was accomplished by leaning while the feet remained in contact with the ground. Strength training involved sandbag/body weight resistive exercises as well as the use of resistive machines. Both balance training tasks, incorporated the manipulation of: 1) vision, 2) base of support (BOS), 3) support surface, 4) perturbations (speed) and 5) limits of sway (maximal leaning in all directions). Gait training involved walking on foam or a narrow beam while visual conditions and direction, were manipulated.

There were significant decreases in loss of balance as determined by the Sensory Organization Test (SOT) on a force platform. There were also significant improvements in single stance time, functional base of support (a reflection of limits of sway), and summed isokinetic strength of the hip, knee and, ankle joints, after the 3-month intervention. Significant improvements in strength, functional base of support, loss of balance and, single stance time were also maintained after the 6-month period of Tai Chi maintenance.

Tai Chi based interventions have shown mixed results throughout the literature. As aforementioned, the Atlanta FICSIT site compared Tai Chi to computerized centre of mass feedback for balance training (Wolf et al., 1996). In this 1996 study, Wolf et al. examined the effects of Tai Chi and computerized balance training on strength, flexibility, cardiovascular endurance, body composition, instrumental activities of daily living, and psychosocial well-being. Participants were divided into one of three groups: Tai Chi (TC), balance training (BT) and/or education exercise-control (ED). For all groups, weekly sessions lasted for approximately 1 hour and all interventions were 15 weeks in duration.

The Tai Chi intervention consisted of 10 forms which emphasized gradual reduction of the base of support, increased trunk rotation and, varying arm movements. Balance training required participants to stand on two movable platforms that were connected to a computer. By leaning, the participant moved the cursor, reflected as the centre of mass, to various targets on the screen. Vision and perturbations of the support surface were manipulated. The goal of the task was to "progressively increase sway to the limits of postural stability" (p. 491).

The results showed that for the TC participants: left hand grip strength was less likely to decline over the 15 weeks; there was a greater reduction in systolic blood pressure and, in terms of psychosocial well-being, there was a reduced fear of falling and improved intrusiveness in the TC group. Interestingly, the TC group experienced a reduction in the distance travelled during the 12-minute walk. Throughout the 15 week intervention, the TC group had less falls, and in addition to delaying the onset of first falls, the rate of falls in TC exercisers was reduced by 47.5%.

In attempts to further advance their existing research, Wolf et al. (1997) examined whether Tai Chi and balance training would affect the ability to minimize postural sway in older adults. This study was an extension of the 1996 study by Wolf and colleagues. All participants completed a fear of falling questionnaire before and after the intervention. Recall that the TC, BT, and ED groups were tested on measures of sway by standing on two forceplates. The forceplates measured COP in the x and y axes and provided a reflection of antero-posterior and mediolateral displacement. The larger the values of the COP measures, the greater the displacement, pressure or sway. In this study, the results indicated that Tai Chi was associated with increased postural sway in the antero-posterior direction however, fear of falling was significantly reduced in the TC group in comparison to the other participants.

In a follow-up assessment to Wolf's 1996 /1997 studies, psychosocial well-being measures were evaluated and participants were asked about their perceived benefits of participation in the interventions (Kutner et al., 1997). Participants in both the Tai Chi and balance training groups reported increased confidence in balance and movement, however, only those who participated in Tai Chi reported that their daily activities and their overall life had been affected. Furthermore, many of these individuals changed their current physical activity regime to incorporate ongoing Tai Chi exercise.

Similar to the study by Wolf et al. (1997), Shih (1997) examined the effects of Tai Chi on postural sway. Wolf looked at antero-posterior and mediolateral sway however, Shih examined average velocity of sway in the anterior and posterior directions. For the static task, participants in Shih's study were required to remain as still as possible on a forceplate. During the dynamic task, participants were required to lean, at the ankle joint, from their anterior limit to their posterior limit as fast as possible. Shih found reduced average velocity of sway in the anterior and posterior direction following a 16-week Tai Chi intervention, and concluded that this was indicative of increased postural stability.

In a 1995 study, Lai et al. examined the effects of Tai Chi Chuan (TCC) on the maintenance of cardiorespiratory function in community dwelling older adults. There were 84 participants, with a mean age of 64 years. The TCC group had been practising Yang style TCC for approximately 7 years and continued to practise TCC five times per week for approximately 1 hour for the duration of this study. All participants were tested on measures of cardiorespiratory function and then tested again on these same measures two years later. The results indicated that during TCC, heart rate was approximately 55% of the maximal heart rate reserve. Also, TCC practitioners had significantly less of a reduction in oxygen uptake (VO_2 max) than the sedentary control group. The authors concluded that TCC is a low velocity, low impact form of exercise that may delay the decline of cardiorespiratory function in older adults.

Lan et al. (1998) studied the effects of a 12-month Tai Chi intervention on the health and fitness of older adults. There were 38 community-dwelling older adults aged 58-70 in this study. As in the previous study, the TCC group practised 108 forms approximately 5x/week for 1 hour per session. Heart rate intensity was calculated as the percentage of maximal heart rate reserve. The exercise intensity during TCC was 52-63% of the heart rate range. The TCC group showed significant increases in VO_2 max, flexibility, strength of the knee extensor and flexor where as the control group showed no change in these measures. To illustrate, the increase in knee extensor strength ranged between 18% and 20% for those in the TCC group with no significant change in the control group. This study suggests that a 12-month TCC intervention can improve cardiorespiratory function, muscle strength and flexibility in older adults.

More recently, Lan, Lai, Chen, and Wong (2000) studied the effects of TCC on strength and endurance in the elderly. Forty-one community-dwelling individuals, approximately 61 years of age, were involved in a TCC intervention. The TCC program ran daily for 6 months and each training session was 1 hour long. The researchers found that concentric and eccentric knee extensor strength as well as knee extensor endurance increased by the conclusion of the study. The results of this pilot study suggest that TCC may be effective in improving muscular strength and endurance of the knee extensors in older adults.

Tai Chi has been shown to have potential benefits in producing positive biological and psychological responses. The slow and controlled movements demanded by the various forms of Tai Chi, result in heightened kinesthetic sense and may in turn result in increased confidence as the balance system is continuously challenged (Kutner et al., 1997; Chen & Snyder, 1999). In summary, the literature suggests that Tai Chi practice may be beneficial in lowering blood pressure and reducing sway velocity, as well as increasing strength, cardiorespiratory function, flexibility, stability and, balance. Tai Chi may also reduce the risk for falls as well as fear of falling, in older adults. Lastly, Kutner et al. suggest that when psychological as well as physical control is perceived to be enhanced, resulting in a general sense of improvement in overall well-being, an individual's motivation to continue exercising may also increase.

The Assessment of Postural Control

Human postural control plays a crucial role in all aspects of goal directed activities whether the goal is simple, as in sitting or standing, or more complex, as in walking. While performing such tasks, opposing internal and external forces threaten the balance system while the body sways continuously, battling to control balance. Consequently, the body is challenged to remain in a state of equilibrium despite any imposed constraints on postural control. Westcott, Lowes, and Richardson (1997) describe this ability, to maintain or control the body's position over its base of support, whether the base is stationary or moving, as postural stability.

Therefore, balancing is the process by which postural stability is maintained (Westcott et al., 1997, p.630). Spirduso (1995) describes posture as the orientation of many body parts, relative to each other, at a given time. The control of posture during standing or sitting is defined as static balance (Spirduso). Dynamic balance refers to the ability to maintain postural control by activating internal and external cues in response to postural perturbations (Spirduso).

When there is an insult to the balance control system, the central nervous system (CNS) must determine the direction and magnitude of the perturbation and choose the appropriate response. In order to maintain a state of equilibrium, the response must be detected and then executed in ample time to prevent a fall (Shupert & Horak,1999). Researchers have described the balance control system as an integration of several body systems: sensory, motor, and cognitive (Skelton & Dinan, 1999; Woollacott & Shumway-Cook, 1996). To illustrate, Shupert and Horak explain that in some older adults, a deficit in sensory function which reduces the ability to detect a fall, results in delayed postural responses. For others, an impairment of the CNS may result in the inability to access the appropriate postural responses to varying stimuli. Conversely, there are those who function well at the level of the CNS yet still experience degenerative muscle strength thereby reducing postural control.

A biomechanical measure of balance. Considering the complex nature of postural control, in the implementation of a falls prevention program, quantitative measurement of balance and mobility are important factors in identifying older adults who are at risk for falls.

While sway is a normal phenomenon that occurs in all humans, the literature has shown that sway increases with increasing age (Baloh et al., 1994). "Postural sway is the corrective body movement resulting from the control of body position" (Thapa, Gideon, Brockman, Fought,

& Ray, 1996, p. M240). Consequently, increased sway is a reflection of insufficient control of body movements or poorer balance (Thapa et al.).

Traditionally, postural sway has been measured using a force platform. The force platform evaluates the centre of pressure (COP) excursions which reflect the shifts in the forces applied on the platform by the body in its effort to maintain equilibrium (Thapa et al., 1996). Although commonly measured during quiet stance, the literature has addressed the dynamic nature of postural control by evaluating the COP excursions at the border of stability limits (Blaszczyk, Hansen, & Lowe, 1993). Blaszczyk et al. compared the sway characteristics of 11 elderly and 11 young individuals during maximum voluntary excursions of the centre of gravity while leaning forward, backward, left and right. The researchers found that the COP excursion and the amount of sway produced at the borders of stability discriminated the elderly from the young. For example, maximum backward lean was significantly less in the elderly when compared to that of the young. The researchers concluded that there was a greater decline in balance control in the elderly due to impairment of perception of postural stability borders. In boys aged 6-13, Przysucha (2000) also found that the balance space task discriminated between good and poor balancers. Consistent with the findings of Blaszczyk et al., those considered to have better balance, were able to explore their balance space further than poorer balancers, in this age group. Przysucha concluded that for more skilled balancers, higher balance space scores corresponded with lower scores in quiet standing. In contrast, for less skilled balancers, lower balance space scores corresponded with higher scores in the quiet standing task.

What measures of sway best discriminate the young from the older adult? Studies have assessed path length, sway area and sway velocity and antero-posterior sway as valid reflections of COP excursions. Thapa et al. (1996) claim that the rationale for using an area measure of sway is that it is a reflection of the portion of the base of support utilized during quiet stance. In addition, measuring area describes the size and shape of the ground covered by the COP as well as the proportion of the base of support used during sway (Jeong, 1994). Sway area is a function of path length in that postural sway reflects the contour of sway area enclosed by the perimeter of sway path. Furthermore, to capture the dynamic nature of postural control, it has been argued that velocity of sway is not only a better indicator of the effort required to maintain balance under dynamic conditions but sway velocity also distinguishes young from older adults better than amplitude measures of sway (Baloh et al., 1994).

A clinical measure of balance and gait. According to Bruininks (1978) a good assessment tool is one which provides objective measurement of function for screening; can evaluate baseline status; can monitor changes over time and thus determine the effectiveness of the intervention; is reliable and valid; is safe, inexpensive and requires minimum time and is easy to administer; and lastly, provides a means of predicting and documenting outcomes for the individuals under study. Poor balance, gait disorders, difficulty rising from a chair and other functional impairments are among the various factors that increase the risk for falls in older adults. Consequently, accurate measurement of physical function is paramount in the identification of physical limitations in the elderly population.

Thapa et al. (1996) explain that the Tinetti Performance-Oriented Mobility Assessment (POMA) provides a mobility assessment that has been commonly used because the test has been correlated with falls in community-dwelling elderly, and it has good test-retest reliability. The POMA was developed in 1986 by Dr. Mary Tinetti to help identify individuals who are at risk for falls. It has been divided into two parts: a gait assessment and a balance assessment. When designing the POMA, Tinetti's (1986) goal was to develop an instrument which required little equipment and minimal experience to master so that the tool could be used clinically without a need for intensive training or a special setting.

The assessment can also be used as a clinical means of identifying: mobility difficulties that may be encountered during daily activities; the potential reasons for identified difficulties; other problems that may be associated with functional performance such as falling; potential medical and rehabilitative interventions that may improve mobility; and potential environmental adjustments that may need to be implemented. As seen in Appendix A, the balance and gait tests which comprise the POMA, measure position changes and gait maneuvers that are designed to reflect activities of daily living (Tinetti, 1986). There are nine items in the balance subscale and eight for the gait portion. Maximum scores are 16 on the balance and 12 on the gait subscales. Thus with all items combined, the maximum mobility score is 28. It has been reported that a gait score of less than nine and a balance score of less than 10 are independent predictors for recurrent falling ($p < .05$ and $p < .0001$, respectively) (Galindo-Ciocon et al., 1995). Furthermore, the POMA has been shown to be highly predictive of falls in that an aggregate score below 19 is indicative of high risk for falls while a score of 19 to 24 suggests that there is a chance for falls but not a high risk (Tinetti, Speechly, & Ginter, 1988). Tinetti has reported both interrater and test-retest reliability of .95 for the aggregate mobility score. In addition, the POMA has been described as a simple, portable and inexpensive measure of balance and gait that can be administered in its entirety in approximately 15 minutes.

As previously mentioned, the objective of this study was to evaluate the effect of a 20 hour Tai Chi intervention on measures of balance and mobility in older woman at risk for falls. The measures that were used included: a) antero-posterior sway, area of sway and path length sway, b) functional measures of balance and gait using Tinetti's POMA, c) strength, d) falls, and lastly e) subjective well-being as reported on a social validation questionnaire. Since Tai Chi has been found to improve function, particularly balance and strength in older adults, it was hypothesized that participants would experience decreases in sway in quiet stance, increases in balance space and improvements in functional measures of balance, gait and strength with a subsequent reduction in falls.

Method

Participants and Design

The participants in the study were 34 community-dwelling older women who reside in Thunder Bay, Ontario. They ranged in age from 55 to 85 years (mean age = 64.5 years) and were considered to be at risk for falls. Risk for falls was determined by: gender (female); age (being 55 and older); a history of falls; a change in activities in response to fear of falling; chronic conditions; number of medications (> 2.75 prescription medications); a score on the POMA of less than10 (balance) and less than nine (gait) (see Figure 1)

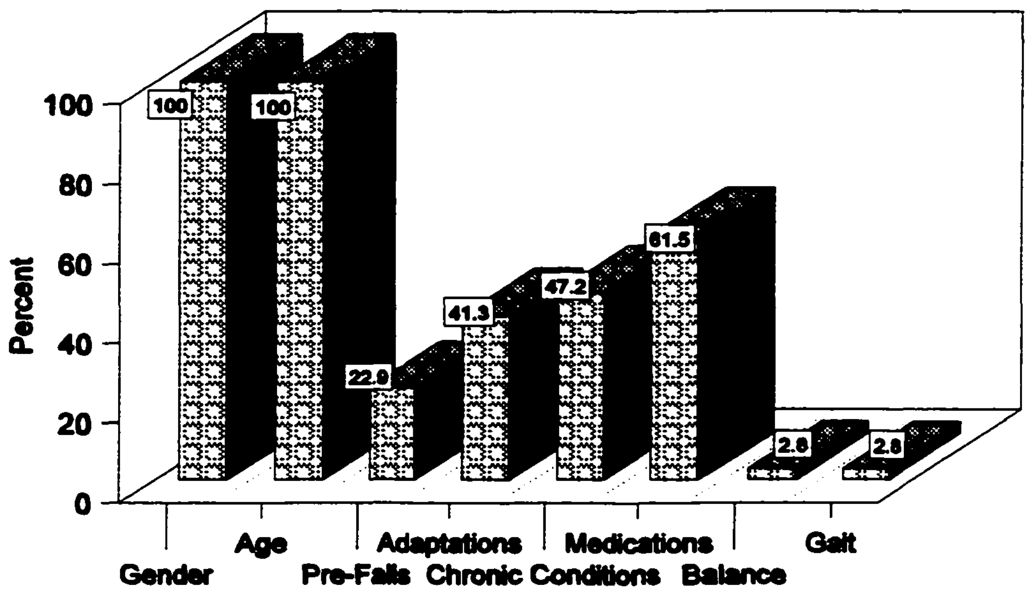

Figure 1. Assessed risks for falls in 34 community-dwelling older adults.

Participants were recruited for the study in two ways: 17 women concerned about falling who were residents of a local (seniors') apartment, were approached by a public health nurse involved in falls prevention in the city of Thunder Bay. The researcher met with these women and a written explanation of the study was provided along with a consent form (see Appendix B).

The second strategy involved recruiting people registered for Tai Chi at a local senior's centre. Seniors registered for Tai Chi during the winter 2001 session, were contacted by mail and were provided a written explanation of the study, along with a consent form (see Appendix B).

An information session was held for all interested individuals. At this time, further explanation of the study was provided by the researcher. The functional and clinical balance and gait tasks were demonstrated and an explanation of the method of recording falls that might occur during the intervention, was given. To identify the proportion of fallers in the population under study, a falls history was obtained from all participants (see Appendix C).

After providing the researcher with informed consent, a Par-Q and Par Med-X was completed for all who were interested in participation in the study (see Appendix D). These physical activity-specific checklists provided medical and physical activity histories which determined whether there were any limitations that would preclude participation in the study. As this study involved a pretest/posttest design, all participants were assessed on functional measures of balance and gait, clinical measures of postural sway, measures of strength and experience in Tai Chi, before the 20-hour intervention period. Of the 49 interested individuals, 15 dropped out of the study after the initial assessments. For the purpose of this paper, 34 individuals were reported on in the analyses.

After these preliminary evaluations, the intervention period commenced and participants began a Tai Chi program at their respective senior's facility. Throughout the 20-session intervention period, all participants were given a series of 2-week calendars, on which to record any falls that occurred (see Appendix E). Each participant returned the calendar to the Tai Chi class at the conclusion of each 2-week period. If a participant failed to do so, she was then contacted by phone in order to identify any falls. If a fall was reported, the researcher conducted a phone inquiry to record details about the fall (see Appendix E, Part B).

During the 2 weeks immediately following the intervention period, participants were assessed again on balance, gait, postural sway and strength. At the post-assessment, participants completed a social validation questionnaire, which provided an opportunity for them to express feelings about their exercise regime (see Appendix F). This questionnaire was developed by the researcher with the assistance of a qualitative researcher. Throughout the process of formulating the questions, the qualitative researcher critiqued the questionnaire. The questionnaire was then revised by the researcher to minimize the imposition of bias in the questions. A combination of closed- and open-response questions were developed in order to allow a range of possible responses from the participants. This format allowed participants to choose either negative, positive or undecided responses to questions and also provided an opportunity to elaborate on any given response (Henerson, Lyons Morris, & Taylor Fitz-Gibbon, 1987).

<u>Procedures</u>

<u>Measures and instrumentation.</u> All participants were offered transportation, to and from Lakehead University. All clinical and functional measures of balance and gait as well as measures of strength were taken in the Multipurpose Lab at Lakehead University's School of Kinesiology.

Tinetti's Performance-Oriented Mobility Assessment (POMA) was used to assess balance and gait (see Appendix A). This assessment required a hard, straight-backed, armless chair, an obstacle-free area providing a straight path of at least 10 ft, a measuring tape, masking tape, pencil and scoring sheets (see Appendix A). All participants were videotaped for both the balance and gait portions of the POMA using a Mitsubishi Camera Controller (Camera 1), Model S 8493 which translated the data to a Toshiba VHS VCR, Model M-441C, for recording. At the conclusion of the study, the videotaped performances were evaluated according to Tinetti's scoring procedures (see Appendix A).

For the POMA, participants were asked to wear, what they considered to be, comfortable shoes. The balance assessment was administered first and began with the participant seated in a chair. During this assessment, the examiner first observed sitting balance. The participant was asked to stand while the examiner observed the number of attempts required and any assistance, such as the use of hands or the use of an assistive device. Balance was then observed during the first 3-5 seconds of standing and again once the individual stabilized. The observer noted a) whether an assistive device was needed and b) whether the feet were more than 4" apart once the participant was standing. While the individual stabilized, the use of an assistive device was noted and foot position was evaluated at this time. From this same position, balance was assessed with eyes closed. The participant was then asked to turn 360° while the researcher evaluated unsteadiness and continuity of steps. Lastly, the individual was asked to sit down in the chair while fluidity of movement and spatial-orientation were observed.

When assessing gait, each participant was asked to walk at her "usual pace", a distance of 24 feet. During this assessment, any usual walking aids were used. The researcher videotaped the participant from front, side and back views. The observer assessed one component of gait at a time starting with gait initiation. Here, the observer looked for any hesitancy during the first few steps. Step height and step length were observed bilaterally. The researcher looked for shuffling or inability to clear the floor and a lack of symmetry from step to step. When step continuity was evaluated the examiner looked for symmetry in stride. Path deviation, trunk stability and walking stance were examined from behind. For path deviation, one foot was observed over several strides in relation to a line on the floor. Foot excursions from side to side or in one direction were noted. Marked trunk sway, combined with slumped or stooped posture and outstretched arms in an effort to maintain stability, were observed. During walking stance, the observer noted the distance between the heels while walking.

Although Tinetti's POMA normally incorporates a sternal nudge as part of the protocol, this task was eliminated from the study because of concerns that the participants might be uncomfortable with it. Thus, only eight items from the balance subscale were used in the assessment. As detailed in Appendix A, the researcher scored the performance on each item of the POMA from a minimum of 0 to a maximum of 2, and the balance and gait scores were tallied separately. Thus the higher the score, the better the performance. A score of less than10 and less than nine on the balance and gait subscales respectively, are seen as independent predictors of recurrent falling (Galindo-Ciocon et al., 1995).

To ensure accuracy of assessment, the researcher was instructed on proper assessment techniques by a physiotherapist. Interobserver reliability of the videotape analysis was calculated to ensure accuracy of scoring. The research assistant was trained by observing videotaped pilot data of two individuals several times within a 60 minute session. Within this session, Tinetti's scoring definitions were used and the researcher and assistant conferred with each other to reach an agreement on each item being evaluated. The assistant and researcher independently scored the performances of two individuals. If the researcher and assistant were not at 80% agreement on the scores of the individuals' performance, the discrepancies were discussed and the process was repeated. Through random selection, a sample of 26% of participants was chosen for reliability testing. All 34 participants were given an identification (ID) code for pre and post POMA data. The 68 POMA ID codes were written on separate pieces of paper and put in two separate boxes: one for pre data and one for post data. Through random selection, a sample of 18 performances (nine pre and nine post) were chosen from each box for reliability testing. Similarly, this sample of 18 was randomly selected and the order of selection was recorded.

Once the training was successfully completed, the research assistant independently assessed the sample of 18 performances, in the order selected. Interobserver reliability was calculated using the following formula:

Interobserver Agreement = A/ (A+D) x 100, where A = agreements, D = disagreements (Thomas & Nelson, 1996). Interobserver agreement was 97%.

An Advanced Mechanical Technology, Inc. (AMTI) force plate was used to assess postural sway. The force platform was connected to an IBM compatible pentium 166 MHz personal computer. BioSoft-Beta version 1.0 software was used to translate and record the vertical force and antero-posterior (AP) and mediolateral (ML) moments of force, applied to the force plate. Measures of postural sway were taken during quiet upright stance and in a balance space task and included: antero-posterior (AP) sway, area of sway (AS), and path length (PL). All measures were taken at a sampling frequency of 100 Hz, for 20 seconds.

During the pre-test phase, height and foot size were measured. Each participant stood barefoot on a plain sheet of paper as each foot was traced. Weight was automatically calculated when each participant stood on the forceplate. These height and weight measures were used to calculate Body Mass Index (BMI) (Powers & Howley, 1997).

All platform measures were performed barefoot. During quiet stance the participant was asked to stand with arms across the chest, remain as still as possible on the platform, and look straight ahead at a spot located on a board 10 feet away. During the balance space task, participants were asked to lean forward, backward, right and left, as far as possible while keeping the trunk erect, knees and hips extended and without lifting toes or heels, for the 20-second duration. As in quiet stance, the data were projected on the computer screen and the related software computed measures of AP sway, area of sway and path length for each participant. Overall group means for AP sway, AS, and PL were calculated based on the individual means so as to compare means across the Tai Chi groups. Three readings of 20 seconds were taken for each stance and the mean of the three trials was used in the analysis. Measurements of quiet standing were obtained under both eyes closed and eyes open conditions however the balance space task was implemented with eyes open only.

Strength was evaluated in terms of grip strength since grip strength has been found to reflect total body strength (Simpson, 1993). Grip strength was assessed using a handgrip dynamometer which was individually adjusted for the size of each participant's hand. Each participant stood holding the dynamometer comfortably by her side and squeezed, while slightly abducting the arm, so the hand being tested moved approximately 20 cm from the side of the body. Two measures were taken and the mean was used. If the difference between trials was greater than 2 kg, the test was continued until a consistent performance resulted.

The intervention. All participants practised the International 8 forms of Tai Chi Chuan, Yang Style (often described as Tai Chi in Western culture) (Schaller, 1996), over the course of the intervention period (see Appendix G). A certified Tai Chi Master instructed the Tai Chi groups for two 1-hour sessions per week. During the 20 sessions, participants learned ½ to1 form a week until all forms were implemented. Each session began with a Tai Chi warm-up lasting 15-30 minutes. The warm-up included breathing, stretching and muscular endurance techniques that were eventually incorporated into the Tai Chi sessions. During each session, movements were taught in a slow and controlled manner emphasizing, breathing control, concentration, clarity of mind and soft, flowing continuity of motion. As shown in Appendix G, Tai Chi exercises consisted of varying and occasionally repetitive, non-strenuous movements. All 8 forms involved synchronous hand and leg movements. These movements resulted in deliberate foot placements and ultimately a pose which eventually lead into the next form. All participants were encouraged to practice at home, and although this practice was not monitored, attendance was recorded during each Tai Chi class.

Data analysis

All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize the following: age, gender, height, weight, BMI, foot length and width, attendance, assessed risk factors, falls and experience in Tai Chi. Since 18 of the participants were novices with respect to Tai Chi and 16 had between 16 and 60 hours of experience, the analyses were conducted by comparing the effect of the intervention on the two groups. The novice and experienced groups did not differ substantially on age, weight, height, foot size, intervention hours (program attendance), assessed risks or falls (see Table 1). Pearson correlations were used to determine the relationships among gait and balance scores on the POMA, strength, and measures of postural sway. These measures included antero-posterior sway (AP), area of sway (AS), and path length (PL). Two-way (time × group) factorial MANOVAs were conducted on the three measures of postural sway during eyes open and eyes closed conditions of quiet standing and in the balance space task. For each condition, main effects for group and time as well as the multivariate interaction effect between group and time were computed. Significant multivariate effects were further examined through subsequent ANOVAs.

Independent samples t tests were used to analyze between group differences on strength and POMA scores. Subsequent dependent samples t tests were computed to compare the effect of the intervention on strength and POMA scores.

In order to establish the meaningfulness of the statistical results, effect size was calculated and reported. Thomas and Nelson (1996) explain that while Omega squared (ω^2) can be used to estimate the degree of association (or percent variance accounted for) between the independent and dependent variables, effect size is also used to estimate the meaningfulness of group differences or the meaningfulness of treatments. However unlike Omega squared, estimates of effect size place the differences between the means in standardized units. For this analysis, effect size was calculated for the multivariate and univariate effects using Wilks's Lambda (Λ) such that effect size (ES) = $1 - \Lambda$ (Diekhoff, 1992; Cohen, 1988). Effect size for t tests was calculated using the *d* index, such that ES = $2\,t / \sqrt{df}$, where *t* is the numerical t test result (Cohen).

Results

Participant Characteristics

Descriptive characteristics of the participants are reported in Table 1. Although, novices

Table 1

Participant Characteristics

Characteristics	Novice Group n=18		Experienced Group n=16	
	Mean	SD	Mean	SD
Pre-Study Tai Chi Experience (hrs)	.39*	1.15	34.44*	15.71
Anthropometric Measures				
Age in years	64.83	9.67	64.00	6.66
Weight (lb)	174.41	26.81	157.26	30.23
Height (ft)	5.14	0.32	5.31	0.2
BMI (wt/ht^2)	32.58*	6.58	27.21*	4.59
Foot Length (cm)				
Right	24.18	1.08	24.45	.80
Left	23.98	1.17	24.54	.96
Foot Width (cm)				
Right	9.21	.42	9.34	.44
Left	9.12	.46	9.25	.50
Assessed Risks				
Pre-Study Falls	0.33	0.77	0.13	0.34
Medications	3.06	3.75	2.44	2.33
Adapted Activities	0.59	0.80	0.50	0.63
Chronic Conditions	4.81	2.46	3.75	1.65
Total Assessed Risks	3.94	1.55	3.63	1.36
Intervention Hours	17.22	2.26	18.25	1.61

*$p < .05$

tended to be smaller in height and foot size, weigh more, have more pre-study falls, more chronic conditions and take more prescription medications on a daily basis than those in the experienced group, none of these perceived differences were statistically significant. On the other hand, novice and experienced groups did differ on their experience in Tai Chi ($t(15.14) = 8.65$, $p < .05$). Novices also had a significantly larger BMI than the experienced group ($t(32) = -2.73$, $p < .05$).

Performances on Measures of Postural Sway

In the quiet standing (eyes open and closed) task and in the balance space task, postural sway was measured for antero-posterior sway, area of sway and, path length. Results of the pre tests indicated that across both tasks, novices tended to score lower on all three measures of sway in comparison to the experienced group. Although this was the dominant trend upon post assessment as well, novices did score higher than the experienced group on area of sway in eyes open and for antero-posterior sway and area of sway in the eyes closed condition (see Table 2).

In quiet standing (eyes open and closed), the novices increased all measures of sway with time. The experienced group however, increased antero-posterior sway and area of sway, yet decreased path length, with time. All participants increased measures of antero-posterior sway, area of sway and, path length with time, in the balance space task. When comparing the two visual conditions, all participants had higher scores for all measures of sway, in the eyes closed condition.

Table 2

Means and Standard Deviations for Antero-posterior Sway (AP), Area of Sway and, Path Length in Quiet Standing (Eyes Open and Closed) and Balance Space

Groups	AP PRE	AP POST	Area PRE	Area POST	Path Length PRE	Path Length POST
EYES OPEN						
Novice[a]						
Mean	.51	.67	.20	.72	7.39	9.15
(SD)	(.12)	(.15)	(.10)	(.40)	(1.99)	(2.24)
Experienced[b]						
Mean	.53	.68	.21	.65	10.42	9.74
(SD)	(.15)	(.22)	(.18)	(.66)	(2.91)	(2.16)
Total						
Mean	.52	.67	.21	.68	8.81	9.43
(SD)	(.14)	(.18)	(.14)	(.53)	(2.87)	(2.19)
EYES CLOSED						
Novice[a]						
Mean	.63	.87	.24	.96	9.13	11.48
(SD)	(.19)	(.23)	(.12)	(.88)	(3.16)	(4.03)
Experienced[b]						
Mean	.69	.82	.32	.87	12.59	12.31
(SD)	(.32)	(.32)	(.33)	(1.02)	(3.83)	(3.64)
Total[c]						
Mean	.66	.84	.28	.92	10.76	11.87
(SD)	(.26)	(.30)	(.94)	(.24)	(3.86)	(3.81)
BALANCE SPACE						
Novice[a]						
Mean	2.70	3.36	9.08	50.91	23.00	29.90
(SD)	(.93)	(.97)	(6.89)	(27.32)	(7.98)	(8.52)
Experienced[b]						
Mean	3.25	4.11	11.92	77.82	26.71	35.75
(SD)	(.71)	(.76)	(4.65)	(31.39)	(4.50)	(7.58)
Total[c]						
Mean	2.95	3.71	10.42	63.57	24.74	32.65
(SD)	(.86)	(.94)	(6.03)	(31.91)	(6.74)	(8.50)

Note. All values represent mean scores in inches. [a]$n = 18$. [b]$n = 16$. [c]$N = 34$.

Relationships Among Sway, Strength, Balance, Gait and, Age

Pearson correlations, identifying the relationships among measures of postural sway, strength, and balance and gait on the POMA and age, can be found in Appendix H. The correlation coefficients indicate the strength of the relationships and have been evaluated using the following scale: poor = 0.0 - .19; weak = .20 - .49; moderate = .50 - .79; strong = .80 - 1.0 (Hyllegard, Mood, & Morrow, 1996).

Sway. The measures of sway included in the analyses were antero-posterior sway, area of sway, and path length. One of the most interesting findings is that area of sway was significantly correlated with antero-posterior sway and also with path length, across all tasks, before and after intervention. A more detailed explanation of the relationships in the eyes open, eyes closed, and balance space task, follows.

In the pre intervention eyes open condition, there was a strong correlation between antero-posterior sway and area of sway ($r = .82$, $p <. 01$). Although there was no significant correlation between antero-posterior sway and path length pre intervention, there was a significant but weak relationship between area of sway and path length ($r = .35$, $p < .05$).

In the pre intervention eyes closed condition, there was also a strong correlation between antero-posterior sway and area of sway ($r = .91$, $p < .01$) whereas there was a moderate correlation between antero-posterior sway and path length ($r = .63$, $p < .01$) and between area of sway and path length ($r = .63$, $p < .01$).

Similarly, in the balance space task, there was a strong correlation between antero-posterior sway and area of sway ($r = .91$, $p < .01$); a significant but moderate correlation between antero-posterior sway and path length ($r = .78$, $p < .01$); and a significant moderate correlation between area of sway and path length ($r = .77$, $p < .01$).

None of the measures of postural sway were correlated with age.

Strength. In the pre and post intervention, eyes open task, there was no significant correlation between strength and each of the following: antero-posterior sway, area of sway, and path length.

In the pre intervention eyes closed condition, strength was not correlated with antero-posterior sway and area of sway however, there was a weak, negative correlation between strength and path length, on post intervention scores only ($r = -.35$, $p < .05$).

In the pre intervention balance space condition, strength was correlated with all variables. That is, strength was moderately correlated with antero-posterior sway ($r = .70$, $p < .01$), area of sway ($r = .72$, $p < .01$), and path length ($r = .53$, $p < .01$). In the post intervention balance space condition, strength was moderately correlated with antero-posterior sway ($r = .64$, $p < .01$) and area of sway ($r = .55$, $p < .01$) but uncorrelated with path length.

Lastly, as was expected, there was an inverse relationship between grip strength and age. Results showed a weak, negative correlation between right grip strength and age ($r = -.48$, $p < .01$).

Balance and gait scores on the POMA. Although there was a moderate correlation between balance and gait measures of the POMA, in the pre intervention scores ($r = .69$, $p < .01$), post intervention balance and gait scores were not correlated. While a strong negative relationship between the POMA and postural sway may have been expected, POMA scores were not correlated with measures of sway. Only the post intervention balance scores of the POMA were significantly, but weakly, correlated with strength ($r = .38$, $p < .05$). Lastly, there was a negative relationship between age and pre intervention balance scores ($r = -.42$, $p < .05$) and between age and post gait scores on the POMA ($r = -.40$, $p < .05$).

Changes in Measures of Postural Sway, Strength, and the POMA

In the eyes open, eyes closed, and balance space tasks, two-way (Time x Group) MANOVAs were performed on the following measures of postural sway: antero-posterior sway, area of sway, and path length.

Quiet standing (eyes open). In the eyes open condition, there was a significant main effect for time ($F(3, 30) = 16.80$, $p < .01$, ES = .63) and a significant main effect for group ($F(3, 30) = 4.75$, $p < .01$, ES = .32). As a result of these multivariate main effects, subsequent univariate effects for group and time were examined. A 2 x 2 (Time x Group) factorial ANOVA was performed for each of the three measures of sway (see Appendix I). Results of the ANOVAs indicated significant main effects for time for antero-posterior sway ($F(1, 32) = 42.62$, $p < .05$, ES = .57) (see Figure 2) and area of sway ($F(1, 32) = 38.72$, $p < .05$, ES = .55). For path length, a significant main effect for group was found ($F(1, 32) = 7.92$, $p < .01$, ES = .20). Results of t tests indicated that both the novices and the experienced group increased antero-posterior sway ($t(33) = -6.65$, $p < .05$, ES = 2.31) and area of sway ($t(33) = -6.33$, $p < .05$, ES = 2.21). However, only the novices increased path length ($t(26.06) = 3.51$ $p < .05$, ES = 1.38).

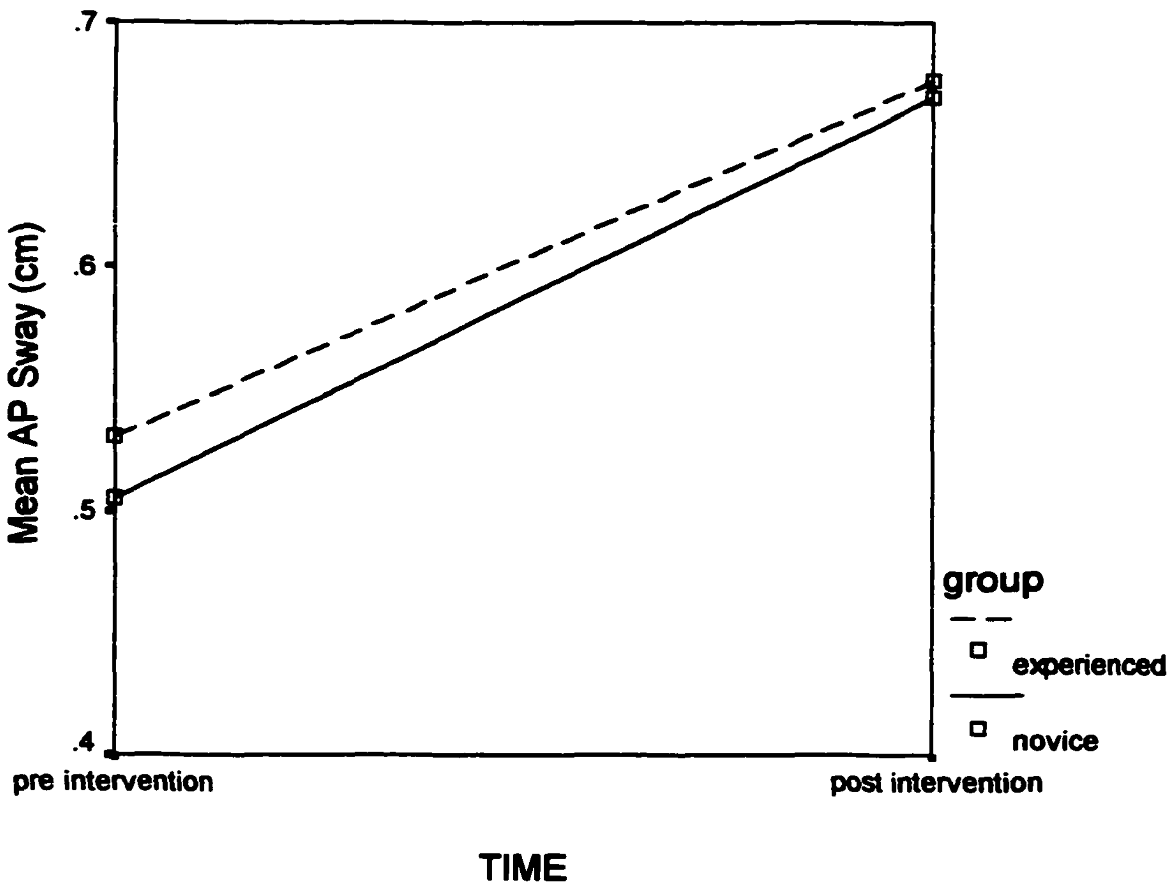

Figure 2. Change in average AP sway (eyes open) after 20 hours of Tai Chi.

Quiet standing (eyes closed). In the eyes closed condition, the 2 x 2 (Time x Group) MANOVA indicated main effects for time, ($F(3, 30) = 18.83$, $p < .05$, ES = .65) and group ($F(3, 30) = 3.14$, $p < .05$, ES = .24). As seen in Appendix I, subsequent ANOVAs indicated that there was a significant main effect for time for antero-posterior sway ($F(1, 32) = 51.52$, $p < .05$, ES = .65) and area of sway ($F(1, 32) = 21.61$, $p < .05$, ES = .40) (see Figure 3). The results of t tests revealed that both the novice and experienced groups increased antero-posterior sway ($t(33) = -6.92$, $p < .05$, ES = 2.41) and area of sway ($t(33) = -4.74$, $p < .05$, ES = 1.65).

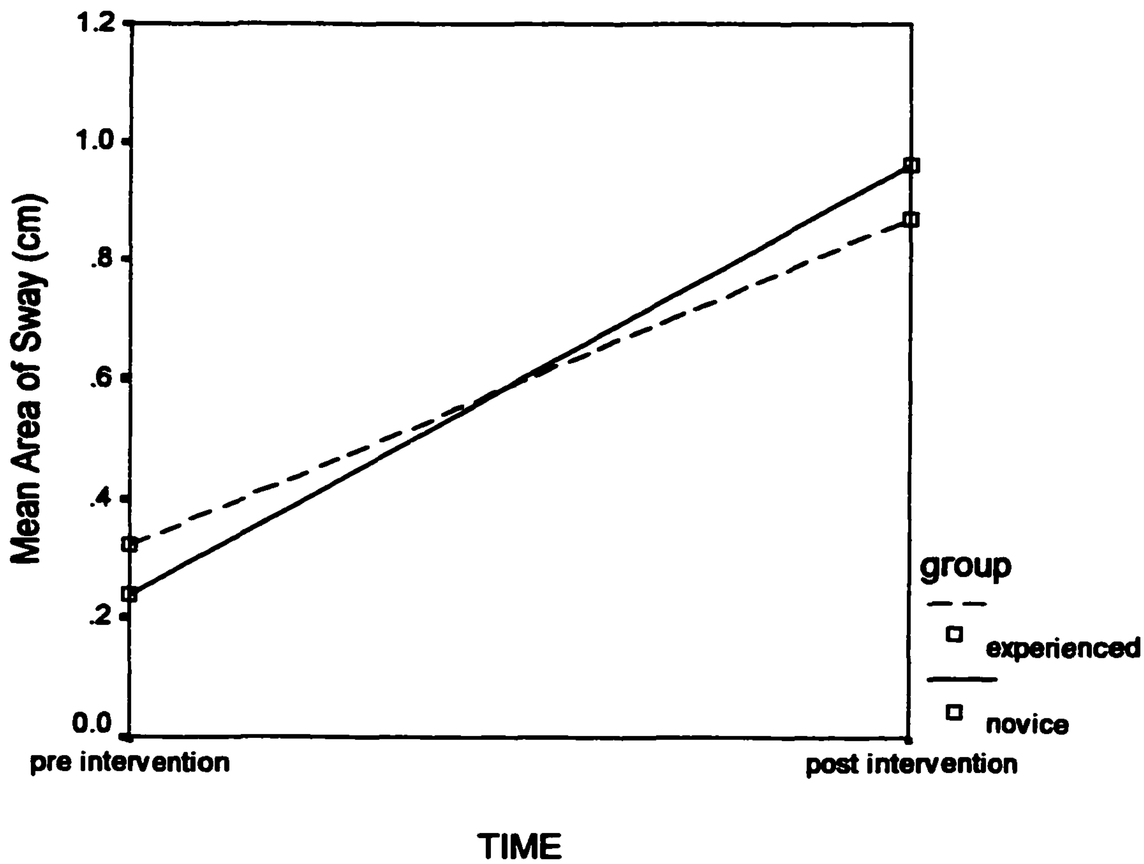

Figure 3. Change in average area of sway (eyes closed) after 20 hours of Tai Chi.

Balance space. In the balance space task, the MANOVA revealed a significant main effect for time ($F(3, 30) = 55.32$, $p < .05$, ES = .85). Subsequent ANOVAs indicated significant main effects for time for antero-posterior sway ($F(1, 32) = 96.64$, $p < .05$, ES = .75), area of sway ($F(1, 32) = 152.16$, $p < .05$, ES = .83), and path length ($F(1, 32) = 69.37$, $p < .05$, ES = .68) (see Appendix I). Calculated t tests revealed, novice and experienced groups increased antero-posterior sway ($t(33) = -9.66$, $p < 05$, ES = 3.66), area of sway ($t(33) = -11.13$, $p < .05$, ES = 3.88), and path length ($t(33) = -8.25$, $p < .05$, ES = 2.87) (see Figure 4).

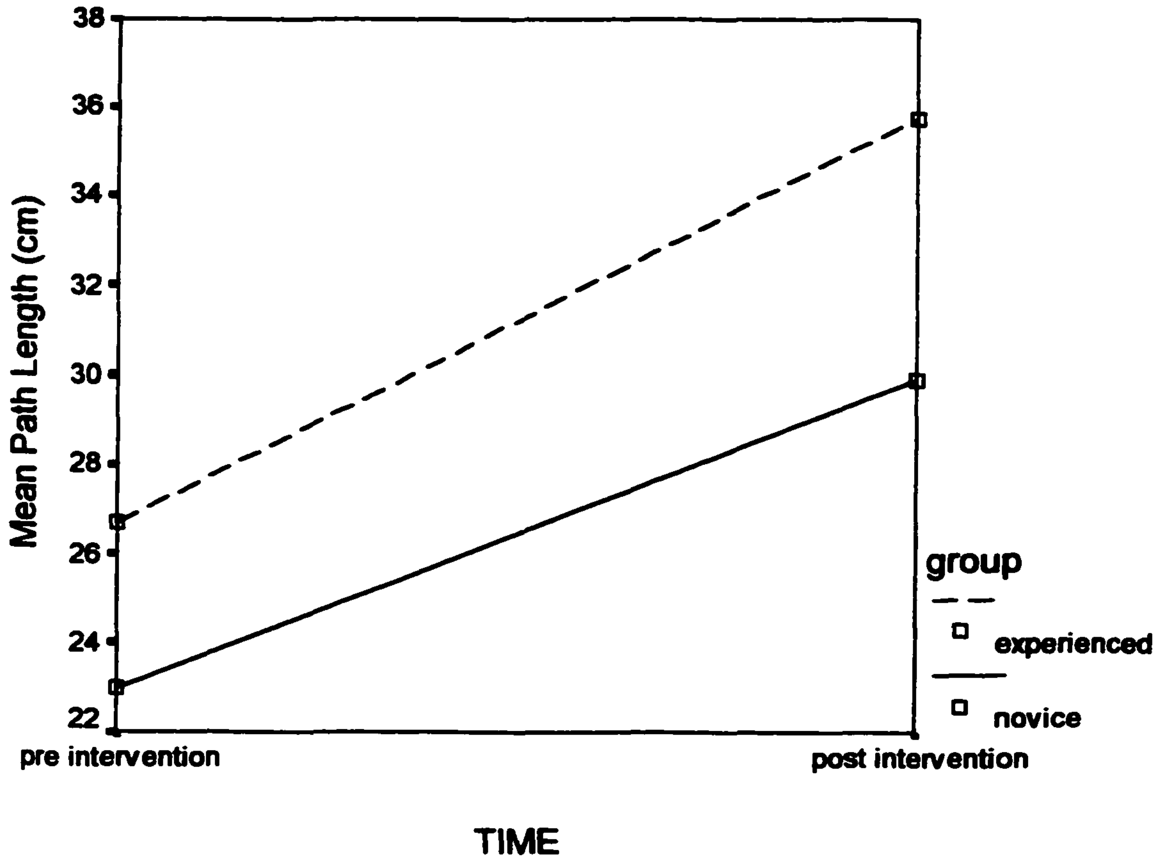

Figure 4. Change in average path length (balance space) after 20 hours of Tai Chi.

Exploratory Analysis

Although it is not customary to report on interactions that are not expressed in the MANOVA, this exploratory analysis serves to provide further insight into the factors that contributed to the multivariate main effects for both conditions of quiet standing. In the eyes open condition, the univariate analysis revealed a significant time x group interaction for path length ($F(1, 32) = 6.51$, $p < .05$, ES = .17).

In the eyes closed condition, there was a significant time x group interaction for antero-posterior sway ($F(1, 32) = 4.98$, $p < .05$, ES = .14) and a significant time x group interaction for path length ($F(1, 32) = 5.37$, $p < .05$, ES = .14). The results of t tests indicated that novices increased antero-posterior sway from pre intervention to post intervention ($t(17) = -7.21$, $p < .05$, ES = 3.50). The experienced group also increased antero-posterior sway from pre to post intervention ($t(15) = -3.23$, $p < .05$, ES = 1.67). The groups were not significantly different from each other on either pre or post scores, for antero-posterior sway. Lastly, only the novices increased path length ($t(32) = 2.89$, $p < .05$, ES = 1.02) at the conclusion of the study.

In terms of the balance space task, the MANOVA indicated that balance space increased with time for all participants. In order to determine the limits of stability, functional base of support (FBOS) was determined and is defined as the proportion of the antero-posterior displacement of the centre of pressure during maximal antero-posterior leaning (King, Judge, & Wolfson, 1994). FBOS was calculated as antero-posterior sway divided by foot length (Lord et al., 1995). All participants increased FBOS from pre intervention (M= .31, SD = .09) to post intervention (M = .39, SD = .10) ($t(33) = -9.64$, $p < .05$, ES = 3.36). However, the pre test results showed that FBOS for the novices was significantly smaller (M = .28 or 28%, SD = .10) than the experienced group (M = .34 or 34%, SD = .08) ($t(32) = 2.06$, $p < .05$, ES = .73). Similarly, post tests results showed that Novice's FBOS was significantly smaller (M = .35 or 35%, SD = .10) than those in the experienced group (M = .44 or 44%, SD = .08) ($t(32) = 2.64$, $p < .05$, ES = .93).

Strength and the POMA. Right hand grip strength significantly increased by 1.81 kg or 7%, from pre intervention (M = 25.02, SD = 5.91) to post intervention (M = 26.60, SD = 6.29) ($t(32) = 3.20$, $p < .05$). There was a comparable increase in left hand grip strength of 1.69 kg or 6% from pre intervention (M = 24.26, SD = 5.62) to post intervention (M = 25.69, SD = 6.36) ($t(32) = 3.27$, $p < .05$) (see Figure 5).

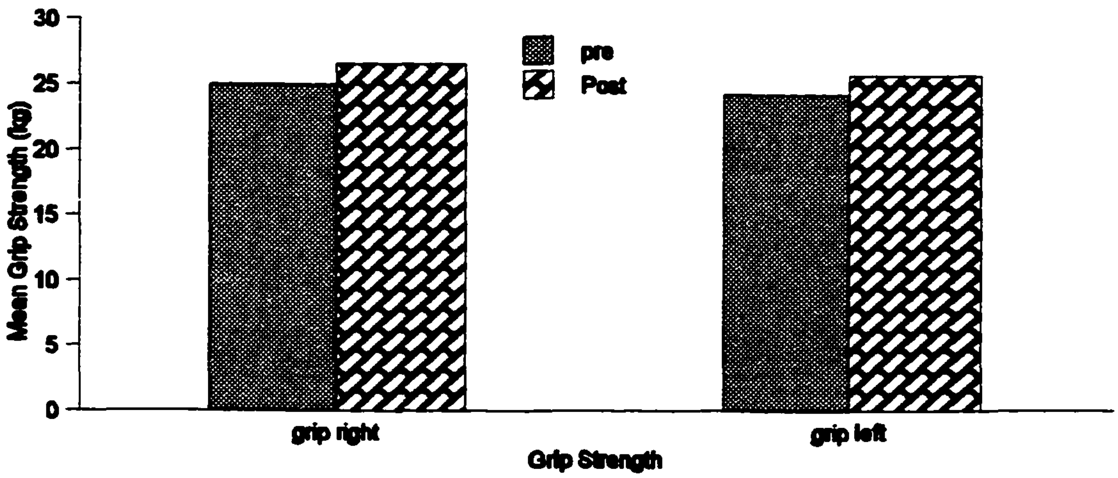

Figure 5. A comparison of right and left grip strength pre and post intervention.

In terms of the POMA however, no significant changes in scores were found on balance from pre intervention (M= 12.47, SD = 1.42) to post intervention (M = 12.61, SD = 1.12). Similarly, there were no significant changes in gait from pre intervention (M = 11.71, SD = .76) to post intervention (M= 11.76, SD = .75).

Social validation questionnaire. A questionnaire was administered which captured the experiences of the participants as a result of their involvement in Tai Chi. Thirty of the thirty-four participants completed the questionnaire. All participants felt their lives had changed as a result of participating in Tai Chi and all said they would participate should Tai Chi be offered again. Responses revealed three themes. Participants perceived they experienced physical, psychological and social benefits as a result of participation in the Tai Chi program. In terms of physical benefits, participants reported improvements in balance, strength and flexibility. One woman said "my legs and arms are stronger". Another woman who felt her life had changed since she had been involved in Tai Chi said she felt she had "better balance" and was "more flexible"while another said, [Tai Chi] "helps me to relax and still obtain some benefit with muscular development". One woman said, "I have better balance as I can now climb ladders". Another reported that her "bowling games have improved" since she's been involved in this Tai Chi program. There were also perceived psychological benefits as a result of being involved in the program. Participants said, "I have a more positive feeling about myself and what I do"; "I feel more cheerful"; "it made me use my head as well as my body"; "...the forms along with the mental stimulation...it will become a way of life for me". Participants expressed perceived social changes as well. One participant said she "enjoyed the group and friendships made". Another woman said she "enjoyed the comraderie...and the encouragement received from fellow participants and instructors".

Falls. In the 3-month falls history, participant reports revealed that six novices and two people in the experienced group, fell before the study began. All 8 individuals reported no serious injuries as a result of these falls. Although the differences were not significant, during the study, the number of people who fell was reduced by 75% from eight pre intervention to two, post intervention. In addition, the number of falls decreased by 50%, from eight pre intervention to four, at the conclusion of the study. Of the two people who fell during the study, one fall was on ice in the novice group and there were three falls on ice by one person, in the experienced group. Both of these people reported no injuries with these falls.

Discussion

It is absolutely impossible to stand completely motionless. Whether a person is standing quietly or moving, the body sways ceaselessly in an effort to maintain the body's position over the base of support (BOS) so as to prevent a fall (Spirduso, 1995). The present study evaluated postural sway during quiet stance and during a dynamic balance space task. It was postulated that: 1) there would be a decrease in postural sway in quiet standing and 2) an increase in balance space, as a result of the Tai Chi program. The results of this study partially supported these hypotheses. While a decrease in sway was expected in quiet stance, the opposite was true. In quiet stance, eyes open and closed, novices increased antero-posterior sway, area of sway and path length and the experienced group increased antero-posterior and area of sway only. In the balance space task, both the novice and experienced groups increased all measures of sway as hypothesized.

Quiet Stance

According to Slobounov, Slobounova, and Newell (1997) the responses produced in quiet stance are based on reflexive actions that afford the individual flexibility and adaptability whereas imposed constraints during quiet stance limit the flexibility and adaptability of the postural control system. The nature of Tai Chi involves slow, gradual body movements while progressively diminishing the BOS. Thus, in the present study, the fact that sway increased in quiet stance is not surprising in this flexible, adaptable system.

Sway has been found to discriminate the young from the old such that during quiet stance, older individuals exhibit larger sway amplitudes than their younger counterparts (Blaszczyk et al., 1993; Ekdahl, Britt Jarnlo, & Ingmar Andersson, 1989). In contrast to the findings of the present study, some researchers suggest that exercise can reduce postural sway in older adults (Shih, 1997; Perrin, Gauchard, Perrot, & Jeandel, 1998). According to these researchers, good postural control is characterised by a small sway path and by a small area covered by the centre of pressure. However, consistent with our findings, Wolf et al. (1997) also found increased sway in quiet stance, after a Tai Chi intervention.

As Wolf and colleagues (1997) suggest, the increase in sway during quiet stance could be a reflection of confidence in mobility. If we consider the results of the social validation questionnaire, in general, participants enjoyed Tai Chi and reported improved functional status as a result of Tai Chi. As Spirduso (1995) and Wolf et al. contend, before the intervention, participants may have been less confident and consequently more rigid as evidenced by the lower values in sway in the pretest versus posttest results. Since a more rigid body shows little body motion it could be argued that as a result of the intervention, participants became more relaxed as reflected by increased sway at the conclusion of the program.

Balance Space

In this study, the dynamic task of balance involved body leaning, a condition that occurs during the transition from stance to gait (Schieppati, Hugon, Grasso, Nardone, & Galante, 1994). It was hypothesized that measures of sway would change, as indicated by an increase in balance space, after the 20-hour Tai Chi intervention. While traditionally, particularly in quiet standing tasks, an improvement in sway may be characterized by a decrease in sway values, sway increased for both the novice and experienced groups, after the Tai Chi intervention. It is important to consider the nature of the balance space task as well as the nature of Tai Chi when interpreting these results.

The nature of Tai Chi is such that it encourages increased body movement through coordinated movements of the hands and legs while the legs shift weight and change direction. In terms of balance space, the goal of the task is to lean as far as possible in the extreme postures without losing balance (i.e. taking a step or falling down). It was postulated that after a Tai Chi intervention which promotes greater total body displacement, participants should be able to lean farther. As hypothesized, there was a definite increase in antero-posterior displacement of the centre of pressure in the novice and experienced groups (see Appendix J). This increase in displacement was accompanied by an increase in antero-posterior sway. Blaszczyk et al. (1993) also found that increased antero-posterior displacement corresponded with an increase in sway. While increased sway often distinguishes the young from the elderly, Blaszczyk et al. found that both the young and the elderly who further displaced their centre of gravity within the base of support also significantly increased antero-posterior sway during a similar leaning task.

Some researchers maintain that an older adult's centre of pressure does not approach the limits of stability as closely as that of a younger individual's (Blaszczyk et al., 1993; Spirduso, 1995). In Blaszczyk's 1993 study, maximum excursion, expressed as a percentage of size of the base of support during maximal leaning, was significantly less for the elderly. Schieppati (1994) also examined limits of stability during maximal lean and found that maximal antero-posterior displacement of the centre of pressure was 60% of foot length for young individuals, whereas, maximal antero-posterior displacement was 40% of foot length for older adults. These results suggest that in an attempt to maintain equilibrium, the elderly are forced to utilize a postural control system that has been degraded because of a decline in the perception of the borders of stability and a decline in postural control.

How are the limits of stability determined? In order to establish the functional limits of stability, functional base of support (FBOS) can be calculated. According to King et al., (1994) FBOS is defined as the proportion of the antero-posterior displacement of the centre of pressure during maximal forward and backward lean and is calculated as antero-posterior displacement divided by foot length.

In this study, all participants increased FBOS with time from 31% pre intervention to 39% post intervention. The large effect size, ES = 3.36, indicates that the FBOS is more than three standard deviations larger than the pre test results. It may be suggested that during dynamic balance, increased sway in older adults may not necessarily be indicative of a loss of postural control. In inclined postures, sway area may increase in all directions as a result of purposeful, small movements issued to maintain balance despite the changes in gravity (Schieppati et al., (1994). In this study, increased sway may have been tolerated as the older adult further displaced the centre of pressure toward the limits of stability. The results of the present study address the concept of an increase in sway as "the expression of deliberate action aimed at reaching further displacement" in the leaning postures as opposed to an indication of a decline in postural control (Schieppati et al., 1994, p.286).

Exercise and Strength: Focus on Balance

As hypothesized, after 20 hours of Tai Chi, there was a significant increase in strength. These findings are very important particularly because aging is often associated with decrements in muscle strength (Sauvage et al., 1993; Vandervoort et al., 1990). Vandervoort et al., explain that slow and/or weak muscles as a consequence of the aging process, may not detect a stimulus which threatens balance and may also lack the reactive ability to prevent a loss of balance.

Similar to our findings, Lan et al. (1998) demonstrated that those who practised Tai Chi improved strength. In terms of physical function, strength, particularly lower extremity strength, is essential in the maintenance of upright standing posture and dynamic balance tasks such as walking or climbing stairs. Since Tai Chi involves continuous coordination of lower and upper extremities, and has been associated with improvements in strength and balance, this increase in strength is not surprising. In the balance space task, strength was found to be correlated with antero-posterior sway and area of sway, post intervention. Recall that FBOS is a function of antero-posterior sway and that the balance space task is a reflection of FBOS. The balance space task requires greater activation of postural muscles to counteract the momentum of gravity employed in the task, than is required in quiet stance (Schieppati et al., 1994). It is suggested that the increased strength may have contributed to improvements in balance space by allowing further displacement of the centre of gravity near the boundaries of the base of support, while still maintaining balance. However, further studies should examine the effect of Tai Chi on lower extremity strength using an appropriate control group.

Is the observed increase in strength due to a learning effect, muscle hypertrophy or a recruitment of more motor units? It seems unlikely that muscle hypertrophy would have resulted in a significant increase in strength in such a short period of time. On the other hand, although some learning may have occurred, another plausible explanation could be that increased muscle recruitment may have occurred. In future studies such physiological changes could be evaluated through muscle biopsies.

Exercise and Functional Measures of Balance and Gait

Although it was hypothesized that Tai Chi would improve functional measures of balance and gait, the POMA only identified one individual as being at risk for falls. This same participant was identified as being at risk for falls on the post assessment of the POMA. As a result, it was not possible to assess any improvement nor any decline in mobility with this assessment tool, post intervention.

One of the issues surrounding assessment tools such as the POMA, is the sensitivity of the tool to detect specific impairments. The findings suggest that the POMA is insensitive to balance or gait impairments in this population of community-dwelling older women. Harada et al. (1995) tested the ability of four clinical assessment methods (the Berg Balance Scale, balance scale of the POMA, gait speed and Tinetti Falls Efficacy Scale) to screen for balance and mobility impairments in 53 older adults (mean age = 83.3 years) who resided in a resident care facility. Eighty-seven percent of participants were female. Half of the participants used an assistive device and there was an average of 2.2 diagnoses per participant (characterized as cardiovascular, neurologic, psychiatric, musculoskeletal and, endocrine).

While the POMA has been found to be an independent predictor of risk for falls in older adults, Harada et al. (1995) also found the POMA to be less sensitive at identifying mobility impairments in comparison to other measures such as the Berg Balance Scale. Perhaps the POMA may be more sensitive to a population with more obvious balance and gait problems than in the present study and in the study by Harada and colleagues. However, in agreement with Harada et al., the weakness in detecting physical impairment seems to be due to a lack of detail in the grading scale of the POMA.

In the present study both clinical and biomechanical assessments of postural control were implemented. Lack of portability of the biomechanical forceplate has limited its use outside of the laboratory promoting the use of clinical measures in assessing balance and gait (Thapa et al., 1994). Some researchers have compared clinical assessments of balance and gait, with platform measures of postural sway to establish whether both measures are testing the same aspects of postural control. Thapa et al. found little or no correlation between Tinetti's balance subscale of the POMA and platform measures of postural sway.

In this study, balance and gait scores of the POMA were only moderately correlated with each other before the intervention but uncorrelated post intervention. Similar to Thapa's (1994) findings, there was no correlation between the POMA and measures of postural sway. Perhaps this emphasizes that a) the two subscales of the POMA measure different aspects of mobility: balance and gait and b) the POMA and biomechanical measures of postural sway are independent predictors of fall risk and may indeed evaluate different aspects of postural control (Thapa et al., 1994).

<u>Exercise and Subjective Well-being</u>

While significant improvements in postural sway and strength were found, how do these findings relate to the daily lives of these individuals? Participants volunteered comments on functional improvements throughout the duration of the Tai Chi program. In addition, when asked "how do you feel your life has changed since you've been in the program?", questionnaire responses were all positive. Some questionnaire responses revealed that participants felt stronger; felt their balance improved; and also that they had more energy as a result of the Tai Chi intervention. One woman said, "I have better balance as I can now climb ladders". Another woman explained that her "bowling games have improved".

All participants said that they would participate should Tai Chi be offered again. One woman said, "I enjoyed it thoroughly. The forms along with the mental stimulation...it will become a way of life for me". This finding is important in that aging is associated with muscle atrophy which can lead to functional decline, falls and even death in the older adult. Our findings support the multitude of studies which demonstrate that exercise can improve muscular strength and thus ward off the effects of functional decline. The testimonials suggest that participants enjoyed this exercise form. Also, it is clear that participants perceived that Tai Chi has positive benefits and important implications for their everyday lives. Similar to those who participated in the study by Wolf et al. (1996), it could be said that in this study heightened motivation to exercise resulted from the positive physical and psychological effects participants experienced as a result of participation in the Tai Chi program (Kutner et al., 1997). Furthermore, the perceived improvements in functional ability during their involvement with the Tai Chi program allowed participants to recognise the value of the effectiveness of any chosen physical activity on physical function.

Falls

As hypothesized, the number of falls decreased by 50%, from eight pre intervention to four at the conclusion of the study. The number of people who fell also decreased from eight to two, by 75%. Of the two people who fell during the study, one fall was on ice in the novice group and there were three falls on ice by one person, in the experienced group. Both of these people reported no injuries with these falls. While none of these findings were statistically significant, there is great functional relevance in that one of the most serious risks for falls is falling itself (Tinetti, 1994).

One of the issues surrounding research design is the importance of sample size in detecting statistically significant differences (Sutlive & Ulrich, 1998). An exploratory analysis revealed that if 24 people had fallen before the study, and 12 people had fallen at the conclusion of the study, there would have been a statistically significant (50%) reduction in the number of falls ($p < .05$). Sutlive and Ulrich suggest that relying solely on the fact that the t tests failed to reach significance at the .05 level, may possibly be an example of a Type 2 Error (failing to detect a difference when one actually exists). It is important to consider the variables being studied and the population under study when interpreting the meaningfulness of statistical results.

We know that falls can produce devastating functional limitations and possibly even death (CIHI, 1999; Tideiksarr, 1997). Fortunately, not enough people had fallen in this study to reach statistical significance. However, the reduction in the number of fallers and in the number of falls in this population, is functionally significant in that this decrease in falls also reduced the risk for falls in this population. Furthermore, the gain in muscle strength as demonstrated in this study, may have translated into important gains in functional capacity contributing to a reduction in falls in older adults.

Lastly, although extrinsic factors such as environmental hazards, were not assessed in this study, identifying that people fell due to an icy surface is important in targeting and eliminating risks for future falls.

Summary and Implications

A belief of researchers in the fall prevention domain is that if falls occur in part due to physical deficits in balance, strength, and flexibility, it may be possible to prevent falls by improving these factors. Tai Chi as a falls prevention strategy was found to improve functional status in this population of community-dwelling older women. While it was determined that postural sway, strength, subjective well-being and falls were improved after 20 hours of Tai Chi, the implications of these findings must be examined further.

It has been said that for a falls prevention program to be successful, it must be of ample intensity, frequency, and duration. Additionally, the exercise program must be appropriate in that the study must intervene on risk factors that the participants exhibit. Lastly, participants must adhere to the exercise intervention in order for the intervention to be effective (Skelton & Dinan, 1999).

Tai Chi: Intensity, Frequency and Duration

In terms of program intensity, Tai Chi is considered a moderate form of exercise as its intensity does not exceed 55% of maximal oxygen intake (Lai et al., 1995). Furthermore, Tai Chi has gained interest in the falls prevention domain particularly because it involves slow and smooth movements which are executed with low velocity and low impact. What is most encouraging is that although the exercise intensity might not exceed 55% of maximum oxygen intake during Tai Chi practice, in addition to the present study, several studies have illustrated that Tai Chi can improve physical function. With respect to frequency and duration, participants partook in 20 hours of Tai Chi practice in 10 weeks, as part of this intervention. Wolf's (1997) study suggests that the present study may have been of short duration and frequency, particularly because in

China, Tai Chi is practised daily and is introduced into the lives of Tai Chi practitioners earlier than the individuals involved in the present study. However, after 20 hours of Tai Chi, there was a definite effect on sway, strength and falls. It is therefore concluded that this intervention was of sufficient intensity, frequency and duration to affect some of the change that occurred after the 10-week program.

Appropriateness of Tai Chi

The effectiveness of an exercise regime is also determined by whether the program is appropriately prescribed for the participants. In other words, a falls prevention intervention must not only be of appropriate intensity for the participant but it must also address the risks that participants may have. In this study, all participants were considered to be at risk for falls as they exhibited attributes that have been associated with a decline in balance and, consequently, falls in the older adult. Since the elderly often experience this functional decline, Tai Chi seems an appropriate intervention, particularly because it has been found to improve balance and strength in elderly practitioners.

In terms of appropriateness of a task, consider the results of the balance space task. In this task, participants were required to lean as far as possible antero-posteriorly and mediolaterally. While executing the 8 forms of Tai Chi, participants were also required to lean in these directions. Participants were able to lean farther, at the conclusion of the study in comparison to the pre test results. Since the Tai Chi movements mimicked the movement demands of the balance space task, improvements in this task are not surprising. Additionally, the increase in strength and the perceived improvements in functional status, may have also contributed to the participants' ability to lean farther in antero-posterior and mediolateral directions at the conclusion of the study. This increased movement capacity was also accompanied by increased sway. The researcher believes that increased sway in older adults may not necessarily be indicative of a loss of postural control. This effect may be because Tai Chi allowed people to move more freely while maintaining control of the centre of gravity 1) within the BOS and also 2) while stressing the limits of stability. Participants were able to control balance while meeting the demands of the task at the conclusion of the intervention. The findings suggest that increased sway, when accompanied by an increase in strength may reduce a person's risk for falls as it prepares the mover to respond in a controlled manner to fluctuations which could normally cause a loss of balance.

Adherence to Tai Chi

Adherence to an exercise program is of paramount importance if the program is to be effective. Questionnaire results indicated that participants enjoyed Tai Chi as an exercise form. Participants expressed social benefits and perceived improvements in physical and psychological function, as a result of Tai Chi. These perceived benefits may have motivated participants to continue to attend as many classes as possible. In this study, the novice group attended 86% of the Tai Chi classes and the experienced group attended 92% of the classes. Both groups adhered well to the program. Furthermore, participants reported that they would participate should Tai Chi be offered again.

Exploratory Analysis

In this study it was of great interest to answer the question, "What effect does Tai Chi have on balance and mobility in older women?". The results revealed definite effects on sway, strength and falls, with time. To illustrate this point, effect size was calculated to evaluate the meaningfulness of the statistical results. Reporting effect size provides information about the magnitude of the treatment effects or the strength of the relationships between variables (Sutlive & Ulrich, 1998). The effect size was large for quiet standing (eyes open: ES = 63%; eyes closed: ES = 65%) and even greater for balance space (ES = 85%), further emphasizing the fact that there were meaningful changes in sway with time.

Unfortunately, this study was subjected to experimental mortality in that several participants in the control group dropped out of the study. Consequently, for the analyses, intact groups were selected based on their experience in Tai Chi. Since group assignment was not randomized, an additional threat to the design of the experiment is that groups may have been susceptible to selection bias. However, as reported in Table 1, the novice and experienced groups did not differ significantly on any characteristics other than Tai Chi experience and BMI. This suggests that selection bias does not seem to be a major threat to internal validity in this study.

Although it is not customary to report on interactions that may be suppressed at the level of the MANOVA, yet are present in the ANOVA, an exploratory analysis of univariate effects, associated $\underline{t}$ tests and effect size, was completed to further identify the factors that may have contributed to the results of this study. In terms of effect size, Cohen's (1988) general guidelines for interpreting the amount of explained variance in the dependent variable that is accounted for by the independent variable for ANOVA is as follows: a small ES accounts for 1%; medium accounts for 6%; and a large effect explains 15% (or more) of the variance. For $\underline{t}$ tests, the *d* index is used to reflect effect size. Using the *d* index, an effect size of .20 to .50 is small, .50 to .80 is medium, and greater than .80 is considered a large effect (Cohen).

Recall that in the quiet standing task (eyes open and closed) there were multivariate main effects for time and group. In the eyes open condition, the computed ES for the change over time was 63%. The ES for the difference between the novice and experienced groups was 32%. While these are large effects, these main effects were examined further to determine which measures of sway changed over time and to determine where the group differences lay.

In the eyes open condition, the effect size results for the change in antero-posterior sway and area of sway with time and for the time x group interaction for path length, are all indicative of a large effect. Further analyses revealed that all participants increased antero-posterior sway and area of sway at the conclusion of the study. In terms of path length, the novices increased from pre test (M = 7.39, SD = 1.99) to posttest (M = 9.15, SD = 2.24) however, the experienced group had no significant change in path length from pre intervention (M= 10.42, SD = 2.90) to post intervention (M = 9.74, SD = 2.16). The effect size results indicate that there were large differences (more than two standard deviations) between pre and post scores on antero-posterior sway and area of sway. Also, since novices significantly increased path length and the experienced group decreased path length with time, it is plausible that the large effect size (ES = 17%) for the significant time x group interaction and the large effect size for the difference between the novice and experienced groups for path length, may be attributed, in part, to Tai Chi and not simply the effect of time alone.

In the eyes closed condition, the effect size for the multivariate main effects indicated the overall change with time was 65% and the difference between the novice and experienced groups was 24 %. The ANOVAs, revealed that antero-posterior sway and area of sway significantly increased with time. Further analyses revealed that all participants increased antero-posterior sway and area of sway. The large effect size for path length (ES = 1.02) indicated that more than one standard deviation separates the novices from the experienced group. Although there was no significant difference between the groups pre and post intervention, novices had greater changes in antero-posterior sway from pre intervention (M = .63, SD = .19) to post intervention (M = .87, SD = .28) in comparison to the experienced group (pre intervention, M = .69, SD = .32; post intervention, M = .82, SD = .32). The effect size results indicate that the change in antero-posterior sway for novices was more than twice that of the experienced group. Lastly, the significant time x group interactions for antero-posterior sway and path length both revealed a large effect size (ES = .14) further emphasizing a definite change in antero-posterior sway and path length over time.

In the balance space task, the multivariate main effect for time revealed that the change over time was 85%. The univariate analyses indicated that antero-posterior sway, area of sway and path length, changed significantly, with time. Further, all participants increased antero-posterior sway, area of sway, and path length. Again, the effect sizes results are large and indicate that there was a definite change in all sway measures in the balance space task, at the conclusion of the study.

In relation to balance space, functional base of support (FBOS) also increased with time, for all participants. Daily activities such as reaching, bending and walking often force the COM near or even outside of the boundaries of the BOS. In everyday activities such as these, the balance system is challenged to provide an appropriate response, to these movements, which restores and optimizes equilibrium to prevent a fall (King et al., 1994). Ideally, to restore balance, the location of the COP, which results from body forces acting on the support surface, must remain within the base of support. Researchers have identified that, antero-posterior FBOS decreases by as much as 35-40% in late adulthood; an attribute of physical decline that is associated with the aging process (Blaszczyk et al., 1994). Although a reduction in the perception of the functional stability boundary, as often seen in the elderly, may limit physical responses to dynamic balance (King et al., Blaszczyk et al., 1993 & 1994), the results of this study indicate that balance space and FBOS can be improved. The results showed that the FBOS increased significantly from 31% pre intervention to 39% post intervention (ES = 3.36) and the change in balance space with time was 85%. The increase in FBOS and balance space (ES = 85%) seem to be too large an increase to occur by the natural passing of time alone, thus it seems logical that some of this change over time may be attributed to the Tai Chi intervention.

Recall that for all participants, strength increased significantly, as well. Perhaps this increased strength allowed increases in sway to be tolerated while participants continued to explore the limits of stability further and further throughout the duration of the study.

What other plausible explanations are there for the observed changes in sway over time? Some of the change may be explained by fitness levels. Anecdotal testimonials revealed that the novice group was less active than the experienced group. This was further evidenced by the group differences in Tai Chi experience; the novices had .39 hours of Tai Chi experience and the experienced group had 34.44 hours of Tai Chi experience prior to the start of the study. Furthermore, anthropometric measures revealed that novices tended to be shorter and weigh more than those in the experienced group. According to obesity guidelines, novices demonstrated a BMI that is associated with obesity whereas the experienced group showed excess body fat

(Powers & Howley, 1997). This result further emphasizes the notion that the novices were less fit than those in the experienced group.

How can fitness levels affect the results? In the eyes open and eyes closed conditions, novices increased on all three measures of sway: antero-posterior sway, area of sway and path length. Yet, the experienced group increased on antero-posterior and area measures of sway only. Powers and Howley (1997) explain that fitness level has a definite influence on an individual's response to training. In general, the amount of improvement after a training program is greater in those participants who are less conditioned at the beginning of the exercise program. Thus, in the present study, it could be argued that since the novices had less experience in Tai Chi, and were less fit, in comparison to the experienced group, then the training effect was more pronounced in novices as evidenced by the greater increase in sway measures.

The additional experience with Tai Chi as a result of involvement with the study may have also contributed to the large effects on measures of sway with time. By the conclusion of the study the exposure to Tai Chi was increased by at least 17.41 hours for each group. Interestingly, the experienced group decreased path length in the quiet standing task (eyes open and eyes closed). The experienced group also had a greater FBOS in comparison to the novices. The pre test results showed that FBOS, for the novices, was significantly smaller ($M = .28$, $SD = .10$) than the experienced group ($M = .34$, $SD = .08$). Similarly, post tests results showed that novice's FBOS was significantly smaller ($M = .35$, $SD = .10$) than those in the experienced group ($M = .44$, $SD = .08$). While both groups improved FBOS by the conclusion of the study, the experienced group had an FBOS that was 6% greater than the novices pre intervention and almost 10 % greater than the novices, post intervention. The difference between the groups may suggest that having more experience in Tai Chi, (perhaps accompanied by an increase in strength) may contribute to an increase in FBOS and a subsequent decrease in path length in quiet standing thus illustrating increased postural control.

It may also be argued that some of the change over time was due to a practice effect. In other words, since the participants were pretested and posttested on postural sway using the same protocol and instrumentation, then there may have been a practice or learning effect from trial to trial or from pre assessment to post assessment. Because of the nature of the instrumentation it is difficult to see how this could be true, particularly in the quiet standing task. The quiet standing task required participants to stand as still as possible for each trial. After 10-weeks of Tai Chi, participants were asked to perform the same test. Not only were the participants blind to the results of the pretest but they also had no way of manipulating the readings of COP that were registered in the computer after each trial. In other words, they could not have "stepped lighter" on the forceplate nor could they have tried to change their sway in order to exert less force because the nature of the quiet standing task demands involuntary, reflexive reactions of the COP.

In the balance space task, there may have been some familiarity with the test in that some participants did remember the protocol however, the grouped means revealed that there were differences from pre to post intervention for all participants, on all measures of sway with the largest changes demonstrated in area of sway and path length, post intervention (see Table 2, p. 37). Also, when analysing the results of the ANOVA, there were large main effects for time for all three sway measures. These univariate results and associated effect sizes are much too large to be attributed to practice/learning alone.

In summary, this exploratory analysis emphasizes that the observed changes are much too large to be attributed to time, selection bias, previous experience in Tai Chi, and practice/learning alone. The results of this study suggest that increased sway, particularly in quiet standing, and increases in balance space may be a response that is attributed, in part, to the Tai Chi intervention. However, despite the magnitude of the changes recorded, confirmation of the effect of Tai Chi can only be made with the presence of a control group. Further research studies should therefore involve a randomized controlled trial of Tai Chi where the researcher is blind to group assignment. Lastly, recall that participants reported perceived improvements in flexibility. Future controlled studies should examine the effect of Tai Chi on flexibility, to validate this finding.

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APPENDIX A

THE PERFORMANCE-ORIENTED MOBILITY ASSESSMENT (POMA)

Tinetti Performance-Oriented Mobility Assessment (POMA)

Balance Tests

1. Sitting balance

	Leans/slides in chair	=0_____
	Steady, safe	=1_____

2. Arises

	Unable without help	=0_____
	Able, uses arms to help	=1_____
	Able, without arms	=2_____

3. Attempts to arise

	Unable without help	=0_____
	Able, but more than one attempt	=1_____
	Able to arise, one attempt	=2_____

4. Immediate standing balance (first 5 seconds)

	Unsteady (swaggers, moves feet, trunk sway)	=0_____
	Steady but uses support (i.e.cane)	=1_____
	Steady without support	=2_____

5. Standing balance

	Unsteady	=0_____
	Steady but wide stance (medial heels more than 4" apart and uses cane/other support)	=1_____
	Narrow stance without support	=2_____

6. Eyes closed (feet together as close as possible)

	Unsteady	=0_____
	Steady	=1_____

The POMA - Balance Tests cont'd

7.	Turning 360°		
		Discontinuous steps	=0_____
		Continuous	=1_____
		Unsteady (grabs, staggers)	=0_____
		Steady	=1_____
8.	Sitting down		
		Unsafe (misjudged distance, falls into chair)	=0_____
		Uses arms or not a smooth motion	=1_____
		Safe, smooth motion	=2_____

Balance Score:_____

Tinetti Performance-Oriented Mobility Assessment (POMA)

Gait Tests

1. Initiation of gait (immediately after being told to "go")

Any hesitancy or multiple attempts to start	=0_____
No hesitancy	=1_____

2. Step length

Right swing foot:	
does not pass left stance foot with step	=0_____
passes left stance foot	=1_____
Left swing foot:	
does not pass rt stance foot with step	=0_____
passes rt stance foot	=1_____

3. Step height

Right foot does not clear floor completely with step	=0
Right foot completely clears floor	=1_____
Left foot does not clear floor completely with step	=0_____
Left foot completely clears floor	=1_____

4. Step symmetry

Right and left step length not equal	=0_____
Right and left step length appear equal	=1_____

5. Step continuity

Stopping or discontinuity between steps	=0
Steps appear continuous	=1_____

6. Path (estimated 12" square, observe excursion of one of the participant's foot covering a distance of 10 feet)

Marked deviation	=0_____
Mild/moderate deviation or uses walking aid	=1_____
Straight without walking aid	=2_____

7. Trunk

Marked sway/uses walking aid	=0_____
No sway, but flexion of knees or back/spreads arms out while walking	=1_____
No sway, no flexion, no use of arms, no use of walking aid	=2_____

8. Walking stance

Heels apart	=0_____
Heels almost touching while walking	=1_____

Gait Score:_____

Balance + Gait Score:_____

APPENDIX B

COVER LETTER

CONSENT FORM

Cover Letter

Dear participant:
Too often, people think that "falls are just something that happens when you get older and there is nothing you can do about it", but that is not entirely true. Research shows that there are some risk factors that are linked to falls that can be reduced through exercise. Since poor balance is linked to falls, Dr. Jane Taylor and I, Dale Allen, are studying the effects of Tai Chi on balance and walking in seniors.

In order to get an understanding of your falls history, you will be asked to provide a record of any falls that you have had within the past 3 months. In order to test your walking and balance, you will be asked to complete a series of tasks at Lakehead University's School of Kinesiology (C.J. Sanders Fieldhouse). Please understand that transportation will be provided for you to and from the university.

For the first task you will be asked to keep as still as possible for 20 seconds while the second task will involve you leaning forward, backward, left and right. Other tasks involve you getting up from a chair, standing still, turning around and then sitting down in the chair. For the final task, you will be videotaped walking 10 feet, turning around and then walking back to the starting position. It will take about 30 minutes to complete all tasks.

After you have completed the balance and walking tests, you will begin your Tai Chi program for 10 weeks. You will be asked to record any falls that may occur during these weeks, on postcards that will be given to you. All postcards will already have a return address as well as pre-paid postage stamps so you may mail a postcard on a weekly basis, at no cost to you.

While you may withdraw from the study at any time, it is better for you if you are able to go to as many of the exercise sessions as possible. Please understand that if you have any difficulties during the exercise sessions, you may stop exercising at any time. After 10 weeks of Tai Chi, your walking and balance will be tested again. You will also be asked to complete a questionnaire about the experiences you had in the Tai Chi program. You will be asked to continue to record your falls for 1 month after the end of the program. We would like your permission to contact you after this one month period, to see how you are feeling.

All information that you provide will be coded and your name will not appear in any reporting of the results. Please understand that all information will be securely stored at Lakehead University's School of Kinesiology for seven years. However, the results of this study will be made available to you at your request upon completion of the project.

If you have any questions, please feel free to contact Dr. Jane Taylor or Dale Allen at 343 8752.

Sincerely,

Consent Form

My signature on this form indicates that I, ______________________ will participate in a study by Dale Allen on identifying the effects of Tai Chi on balance and walking in seniors.

I have received an explanation about the nature of the study and its purpose. I understand the following:

1. I am a volunteer and can withdraw from the study at any time.
2. I will attend as many exercise sessions as possible.
3. I may stop exercising at any time if I have any difficulties.
4. There is no more risk of physical or psychological harm than would be involved in physical activities done at my own pace.
5. I will be tested by Dale Allen, on balance and walking, and I will be videotaped while walking.
6. Transportation will be provided for me to and from the university.
7. I will provide a report of any falls that have occurred within the past three (3) months, as well as during and after my exercise program.
8. All information collected during the study will be coded and my name will not be released in the report at any time.
9. The information that I provide will be confidential and will be stored for seven years at Lakehead University's School of Kinesiology.
10. I will receive a summary of the project, upon request, following the completion of the project.

Please return this form as soon as possible.

____

Signature of Participant Date

____

Phone number of participant

APPENDIX C

FALLS HISTORY

Falls History

Name:________________ Date:________________

How many times have you fallen in the past 3 months?_____

	1	2	3	4	5	6
Did you hurt yourself?						
After the fall did you have trouble:						
Dressing						
Bathing						
Walking						
Climbing stairs						
Cleaning						
Preparing meals						
Lifting						

APPENDIX D

PAR-Q

PAR MED-X

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 1994)

PAR - Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
☐	☐	2.	Do you feel pain in your chest when you do physical activity?
☐	☐	3.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5.	Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6.	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7.	Do you know of <u>any other reason</u> why you should not do physical activity?

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to <u>all</u> PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

<u>Informed Use of the PAR-Q</u>: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to copy the PAR-Q but only if you use the entire form

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

NAME ____________________

SIGNATURE ____________________ DATE ____________________

SIGNATURE OF PARENT ____________________ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Supported by: Health Canada Santé Canada

Physical Activity Readiness
Medical Examination
(revised 1995)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP-Professional Fitness and Lifestyle Consultant). To assist in this, the following instructions are provided:

PAGE 1: • Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGES 2 & 3: • A checklist of medical conditions requiring special consideration and management.

PAGE 4: • Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.

• Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION:

NAME ____________________

ADDRESS ____________________

____

TELEPHONE ____________________

BIRTHDATE ____________ GENDER ________

MEDICAL No. ____________________

B PAR-Q: *Please indicate the PAR-Q questions to which you answered YES*

- ☐ Q 1 Heart condition
- ☐ Q 2 Chest pain during activity
- ☐ Q 3 Chest pain at rest
- ☐ Q 4 Loss of balance, dizziness
- ☐ Q 5 Bone or joint problem
- ☐ Q 6 Blood pressure or heart drugs
- ☐ Q 7 Other reason: ____________

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:

Check all that apply

- ☐ Less than 30 minutes of moderate physical activity most days of the week.
- ☐ Currently smoker (tobacco smoking 1 or more times per week).
- ☐ High blood pressure reported by physician after repeated measurements.
- ☐ High cholesterol level reported by physician.
- ☐ Excessive accumulation of fat around waist.
- ☐ Family history of heart disease.

Please note: Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

____

____

____

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

☐ Cardiovascular ☐ Respiratory ☐ Other
☐ Musculoskeletal ☐ Abdominal

Tests required:

☐ ECG ☐ Exercise Test ☐ X-Ray
☐ Blood ☐ Urinalysis ☐ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommend:

- ☐ No physical activity
- ☐ Only a medically-supervised exercise program until further medical clearance
- ☐ Progressive physical activity
  - ☐ with avoidance of: ____________
  - ☐ with inclusion of: ____________
  - ☐ with Physical Therapy: ____________
- ☐ Unrestricted physical activity — start slowly and build up gradually

Further Information:
☐ Attached
☐ To be forwarded
☐ Available on request

Physical Activity Readiness
Medical Examination
(revised 1995)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

Following is a checklist of medical conditions for which a degree of precaution and/or special advice should be considered for those who answered "YES" to one or more questions on the PAR-Q, and people over the age of 69. Conditions are grouped by system. Three categories of precautions are provided. Comments under Advice are general, since details and alternatives require clinical judgement in each individual instance.

	Absolute Contraindications	Relative Contraindications	Special Prescriptive Conditions	ADVICE
	Permanent restriction or temporary restriction until condition is treated, stable, and/or past acute phase.	Highly variable. Value of exercise testing and/or program may exceed risk. Activity may be restricted. Desirable to maximize control of condition. Direct or indirect medical supervision of exercise program may be desirable.	Individualized prescriptive advice generally appropriate: • limitations imposed; and/or • special exercises prescribed. May require medical monitoring and/or initial supervision in exercise program.	
Cardiovascular	❑ aortic aneurysm (dissecting) ❑ aortic stenosis (severe) ❑ congestive heart failure ❑ crescendo angina ❑ myocardial infarction (acute) ❑ myocarditis (active or recent) ❑ pulmonary or systemic embolism—acute ❑ thrombophlebitis ❑ ventricular tachycardia and other dangerous dysrhythmias (e.g., multi-focal ventricular activity)	❑ aortic stenosis (moderate) ❑ subaortic stenosis (severe) ❑ marked cardiac enlargement ❑ supraventricular dysrhythmias (uncontrolled or high rate) ❑ ventricular ectopic activity (repetitive or frequent) ❑ ventricular aneurysm ❑ hypertension—untreated or uncontrolled severe (systemic or pulmonary) ❑ hypertrophic cardiomyopathy ❑ compensated congestive heart failure	❑ aortic (or pulmonary) stenosis—mild angina pectoris and other manifestations of coronary insufficiency (e.g., post-acute infarct) ❑ cyanotic heart disease ❑ shunts (intermittent or fixed) ❑ conduction disturbances • complete AV block • left BBB • Wolff-Parkinson-White syndrome ❑ dysrhythmias—controlled ❑ fixed rate pacemakers	• clinical exercise test may be warranted in selected cases, for specific determination of functional capacity and limitations and precautions (if any). • slow progression of exercise to levels based on test performance and individual tolerance. • consider individual need for initial conditioning program under medical supervision (indirect or direct).
			❑ intermittent claudication	progressive exercise to tolerance
			❑ hypertension: systolic 160-180; diastolic 105+	progressive exercise; care with medications (serum electrolytes; post-exercise syncope; etc.)
Infections	❑ acute infectious disease (regardless of etiology)	❑ subacute/chronic/recurrent infectious diseases (e.g., malaria, others)	❑ chronic infections ❑ HIV	variable as to condition
Metabolic		❑ uncontrolled metabolic disorders (diabetes mellitus, thyrotoxicosis, myxedema)	❑ renal, hepatic & other metabolic insufficiency	variable as to status
			❑ obesity ❑ single kidney	dietary moderation, and initial light exercises with slow progression (walking, swimming, cycling)
Pregnancy		❑ complicated pregnancy (e.g., toxemia, hemorrhage, incompetent cervix, etc.)	❑ advanced pregnancy (late 3rd trimester)	refer to the "PARmed-X for PREGNANCY"

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. J. Clin. Epidemiol. 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy. In: A. Quinney, L. Gauvin, T. Wall (eds.), Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health. Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Can. J. Spt. Sci. 17:4 338-345.

The PAR-Q and PARmed-X were developed by the British Columbia Ministry of Health. They have been revised by an Expert Advisory Committee assembled by the Canadian Society for Exercise Physiology and the Fitness Program, Health Canada (1995).

Disponible en français sous le titre «Évaluation médicale de l'aptitude à l'activité physique (X-AAP)».

Physical Activity Readiness
Medical Examination
(revised 1995)

	Special Prescriptive Conditions	ADVICE
Lung	☐ chronic pulmonary disorders	special relaxation and breathing exercises
	☐ obstructive lung disease ☐ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	☐ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	☐ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	☐ arthritis—acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	☐ arthritis—subacute	progressive increase of active exercise therapy
	☐ arthritis—chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	☐ orthopaedic	highly variable and individualized
	☐ hernia	minimize straining and isometrics; stregthen abdominal muscles
CNS	☐ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountainclimbing, etc.)
	☐ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness; retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	☐ anemia—severe (< 10 Gm/dl) ☐ electrolyte disturbances	control preferred; exercise as tolerated
Medications	☐ antianginal ☐ antiarrhythmic ☐ antihypertensive ☐ anticonvulsant ☐ beta-blockers ☐ digitalis preparations ☐ diuretics ☐ ganglionic blockers ☐ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	☐ post-exercise syncope	moderate program
	☐ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	☐ temporary minor illness	postpone until recovered
	☐ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights.

**Refer to special publications for elaboration as required*

The following companion forms are available by contacting the Canadian Society for Exercise Physiology (address below):

The Physical Activity Readiness Questionnaire (PAR-Q) - a questionnaire for people aged 15-69 to complete before becoming much more physically active.

The Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY) - to be used by physicians with pregnant patients who wish to become more physically active.

To order multiple printed copies of the PARmed-X and/or any of the companion forms (for a nominal charge), please contact the:

Canadian Society for Exercise Physiology
185 Somerset St. West, Suite 202
Ottawa, Ontario CANADA K2P 0J2
Tel. (613) 234-3755 FAX: (613) 234-3565

Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

Physical Activity Readiness
Medical Examination
(revised 1995)

Physical Activity & Lifestyle Advice

We know that being physically active provides benefits for all of us. Physical Inactivity is recognized by the Heart and Stroke Foundation of Canada as one of the four modifiable primary risk factors for coronary heart disease (along with high blood pressure, high blood cholesterol, and smoking). Physical activity has also been shown to reduce the incidence of hypertension, colon cancer, maturity onset diabetes mellitus, and osteoporosis. It can also reduce stress and anxiety, relieve depression, and improve self-esteem.

People are physically active for many reasons — play, work, competition, health, creativity, enjoying the outdoors, being with friends. There are also as many ways of being active as there are reasons. What we choose to do depends on our own abilities and desires. No matter what the reason or type of activity, physical activity can improve our well-being and quality of life. Well-being can also be enhanced by integrating physical activity with enjoyable healthy eating and positive self and body image. Together, all three equal VITALITY. So take a fresh approach to living. Check out the VITALITY tips below!

Active Living:

- make meaningful and satisfying physical activities a valued and integral part of daily living
- accumulate 30 minutes or more of moderate physical activity most days of the week
- choose from an endless range of opportunities to be active according to your own abilities and desires:
  - take the stairs instead of an elevator
  - get off the bus early and walk home
  - join friends in a sport activity
  - take the dog for a walk with the family
  - follow a fitness program

Healthy Eating:

- follow Canada's Food Guide to Healthy Eating
- enjoy a variety of foods
- emphasize cereals, breads, other grain products, vegetables and fruit
- choose lower-fat dairy products, leaner meats and foods prepared with little or no fat
- achieve and maintain a healthy body weight by enjoying regular physical activity and healthy eating
- limit salt, alcohol and caffeine
- don't give up foods you enjoy — aim for moderation and variety

Positive Self and Body Image:

- accept who you are and how you look
- remember, a healthy weight range is one that is realistic for your own body make-up (body fat levels should neither be too high nor too low)
- try a new challenge
- compliment yourself
- reflect positively on your abilities
- laugh a lot

Enjoy eating well, being active and feeling good about yourself. That's VITALITY

Physical Activity Readiness Conveyance/Referral Form

Based upon a current review of the health status of ________________________, I recommend:

- ☐ No physical activity
- ☐ Only a medically-supervised exercise program until further medical clearance
- ☐ Progressive physical activity
  - ☐ with avoidance of: ____________________
  - ☐ with inclusion of: ____________________
  - ☐ with Physical Therapy: ____________________
- ☐ Unrestricted physical activity — start slowly and build up gradually

Further Information:
- ☐ Attached
- ☐ To be forwarded
- ☐ Available on request

________________________ M.D.

________________________ 19 ____
(date)

Physician/clinic stamp:

APPENDIX E

FALLS CALENDAR

FALLS FOLLOW-UP

FALLS STUDY

I.D. #: ____________ Card #: ______________

Two weeks

beginning: ____

ending: ____

SUN	MON	TUES	WED	THUR	FRI	SAT

Falls Follow-up

The following questions pertain to the details of the most recent fall.

1. Where did you fall? (i.e. on the stairs, in the bedroom)
2. What time of day did you fall?
3. What were you doing when you fell?
4. What type of footwear were you wearing when you fell?
5. What do you think caused you to fall?

APPENDIX F

SOCIAL VALIDATION QUESTIONNAIRE

Tai Chi Questionnaire

Please read the following questions and provide the response which best explains your opinion about the exercise program. Your honest opinions, positive or negative are greatly appreciated.

1. How do you feel that your life has changed since you have been in this program?

1	2	3	4	5
Gotten worse		Not at all		A great deal

Please explain why you feel that way:

____
____
____
____

2. If this program were to be offered again would you choose to participate?

Yes______ No______ Undecided______

Please explain why you feel that way:

____
____
____
____

3. Would you recommend this program to a friend?
Yes______ No______ Undecided_____

Please explain why you feel that way:

____
____
____
____

4. Do you feel that the instruction was geared at your ability level?
Yes______ No_____ Undecided_____

Please explain why you feel that way:

____
____
____
____

5. How did you feel about the length of the program?

1	2	3
Too long	Just right	Too short

Please explain why you feel that way:

____
____
____
____

6. How did you feel about the length of each exercise session?

1	2	3
Too long	Just right	Too short

Please explain why you feel that way:

____

____

____

____

7. In general, were you satisfied with the program?
Yes______ No_____ Undecided_____

Please explain why you feel that way:

____

____

____

____

8. Do you have any other comments about your participation in the Tai Chi program?

____

____

____

____

____

____

____

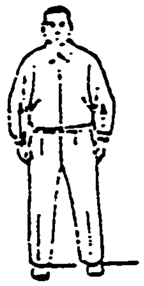
____

____

APPENDIX G

TAI CHI: INTERNATIONAL 8 FORMS

Commencing Form



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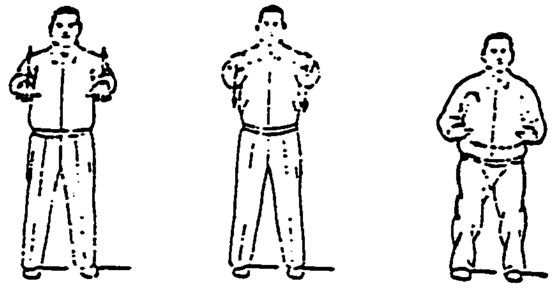


2 3 4

Note: In the illustrations, the paths of the movements to be executed are indicated by arrows drawn in solid lines for the right hand and left foot, and dotted lines for the left hand and right foot.

1) Stand upright with feet shoulder-width apart, toes pointing forward, arms hanging naturally at sides. Look straight ahead (Fig 1).

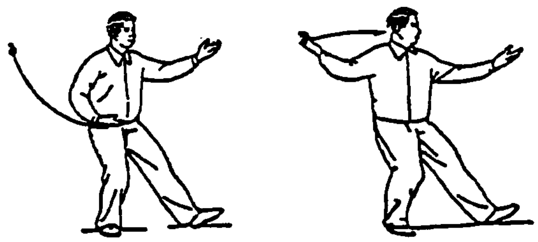
Points to remember: Hold head and neck erect, with chin drawn slightly inward. Do not protrude chest or draw abdomen in.

2) Raise arms slowly forward to shoulder level, palms down (Figs 2-3).

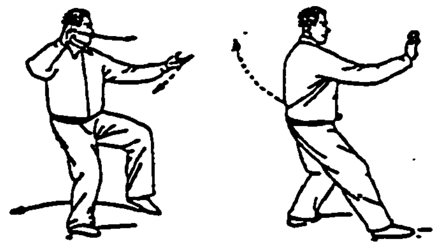
3) Bend knees as you press palms down gently, with elbows dropping towards knees. Look straight ahead (Fig 4).

Points to remember: Keep torso erect and hold shoulders and elbows down. Fingers are slightly curved. Body weight is equally distributed between legs. While bending knees, keep waist relaxed and buttocks slightly pulled in. The lowering of arms should be coordinated with the bending of knees.

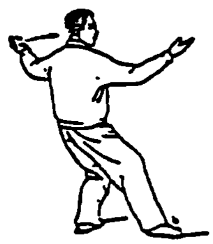
1. Curve Arms



1) Turn torso slightly to the right, moving right hand down in a curve past abdomen and then upward to shoulder level, palm up and arm slightly bent. Turn left palm up and place toes of left foot on floor. Eyes first look to the right as body turns in that direction, and then turn to look at left hand.



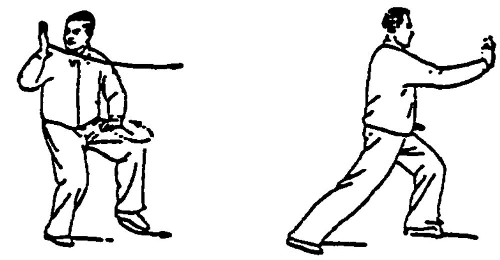
2) Bend right arm and draw hand past right ear before pushing it out with palm facing forward while left hand moves to waist side, palm up. At the same time, raise left foot slightly and take a curved step backward, placing down toes first and then the whole foot slowly on floor with toes turned outward. Turn body slightly to the left and shift weight onto left leg for a right empty stance, with right foot pivoting on toes until it points directly ahead. Look at right hand.



3) Turn torso slightly to the left, carrying left hand sideways up to shoulder level, palm up, while right palm is turned up. Eyes first look to the left as body turns in that direction and then turn to look at right hand.

2. Brush Knee (left then right)

1) Turn torso slightly to the left (8 o'clock) as right hand moves down while left hand moves up. Then turn torso to the right (11 o'clock) as right hand circles past abdomen and up to ear level with arm slightly bent and palm facing obliquely upward, while left hand moves in an upward-rightward-downward curve to the front of right part of chest, palm facing obliquely downward. Look at right hand.

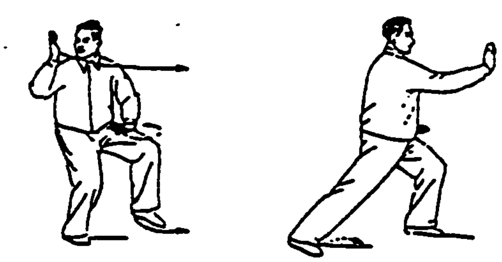


2) Turn torso to the left (9 o'clock) as left foot takes a step in that direction for a left bow stance. At the same time, right hand draws leftward past right ear and, following body turn, pushes forward at nose level with palm facing forward, while left hand circles around left knee to stop beside left hip, palm down. Look at fingers of right hand.

3) Sit back slowly with right knee bent, shifting weight onto right leg. Raise toes of left foot and turn them a bit outward before placing whole foot on floor. Then bend left leg slowly and turn body slightly to the left, shifting weight onto left leg. Bring right foot forward to the side of left foot, toes on floor. At the same time, turn left palm up and with elbow slightly bent, move left hand sideways and up to shoulder level while right hand, following body turn, moves in an upward-leftward-downward curve to the front of left part of chest, palm facing obliquely downward. Look at left hand.

4) Repeat movements in 2), reversing "right" and "left".

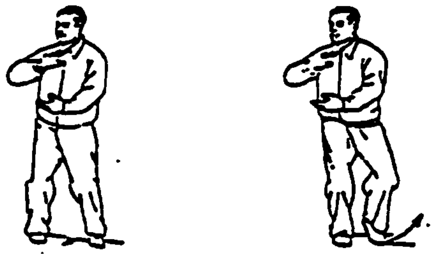
5) Repeat movements in 3), reversing "right" and "left".



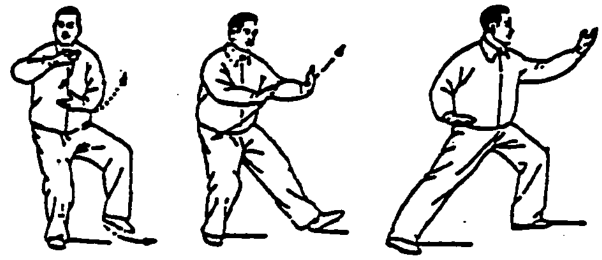
Repeat movements in 2)

Points to remember: Keep torso erect and waist relaxed and hold shoulders and elbow down while pushing palm forward. Movements of palm should be coordinated with those of waist and legs. Keep a transverse distance of 30 cm between heels in bow stance. Face 9 o'clock in final position.

3. Horse's Mane (left then right)

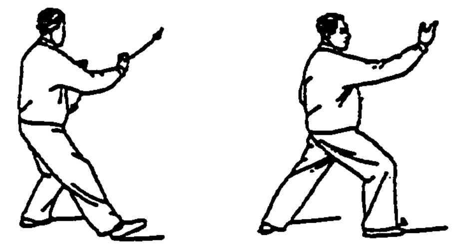


1) With torso turning slightly to the right (1 o'clock) and weight shifted onto right leg, raise right hand until forearm lies horizontally in front of right part of chest, while left hand moves in a downward curve until it comes under right hand, palms facing each other as if holding a ball (henceforth referred to as "hold-ball gesture"). Move left foot to the side of right foot, toes on floor. Look at right hand.

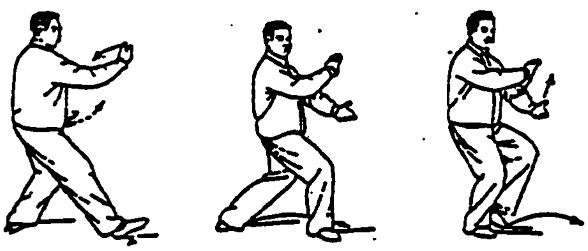


2) Turn body to the left (10 o'clock) as left foot takes a step towards 8-9 o'clock, bending knee and shifting weight onto left leg, while right leg straightens with whole foot on floor for a left "bow stance." As you turn body raise left hand to eye level with palm facing obliquely up and elbow slightly bent, and lower right hand to the side of right hip with palm facing down and fingers pointing forward. Look at left hand.

3) "Sit back": slowly — move torso backward as if ready to take a seat — and shift weight onto right leg, raising toes of left foot slightly and turning them outward before placing whole foot on floor. Then bend left leg and turn body to the left, shifting weight onto left leg and making a hold-ball gesture in front of left part of chest, left hand on top. Then move right foot to the side of left foot, toes on floor. Look at left hand

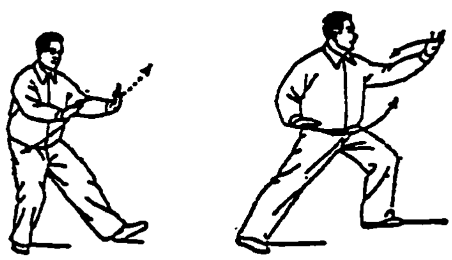


4) Take a right bow stance by moving right foot a step towards 9 o'clock, straightening left leg with whole foot on floor and bending right leg at knee. At the same time, with body turning slightly to the right, gradually raise right hand to eye level with palm facing obliquely upward and elbow slightly bent, and press left hand down to the side of left hip, palm down. Look at right hand.



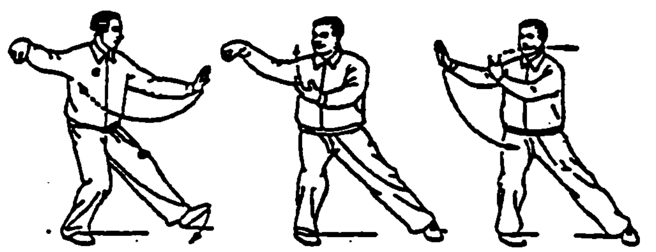
5) Repeat movements in 3), reversing "right" and left".

6) Repeat movements in 4), reversing "right" and "left".

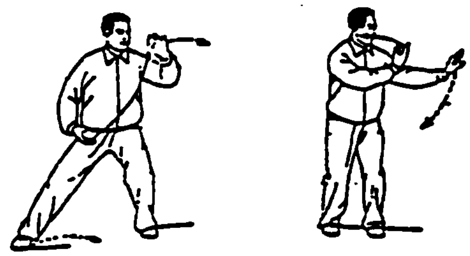


Points to remember: Hold torso erect and keep chest relaxed. Move arms in a curve without stretching them when you separate hands. Use waist as the axis in body turns. The movements in taking a bow stance and separating hands must be smooth and synchronized in tempo. When taking a bow stance, place front foot slowly in position, heel coming down first. The knee of front leg should not go beyond toes while rear leg should be straightened, forming an angle of 45 degrees with ground. There should be a transverse distance of 10-30 cm between heels. Face 9 o'clock in final position.

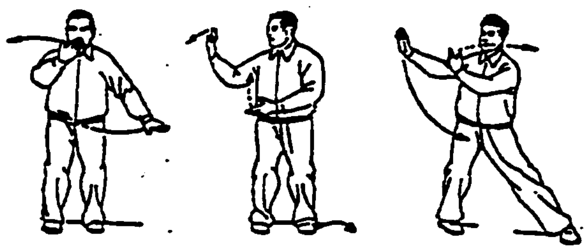
4. Wave Hands Like Clouds (left then right)



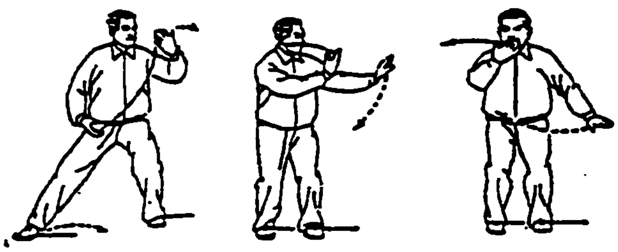
1) Shift weight onto right leg and turn body gradually to the right (1-2 o'clock), turning toes of left foot inward. At the same time, move left hand in a curve past abdomen to the front of right shoulder, palm turned obliquely inward, while right hand is opened, palm facing outward. Look at left hand.



2) Turn torso gradually to the left (10-11 o'clock), shifting weight onto left leg. At the same time, move left hand in a curve past face with palm turned slowly leftward, while right hand moves in a curve past abdomen up to the front of left shoulder with palm slowly turning obliquely inward. As right hand moves upward, bring right foot to the side of left foot so that they are parallel and 10-20 cm apart. Look at right hand.

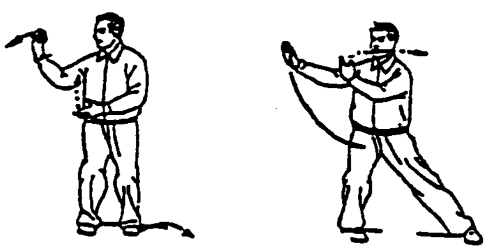


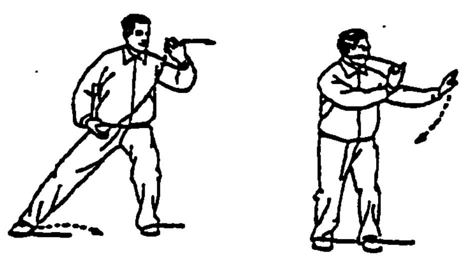
3) Turn torso gradually to the right (1-2 o'clock), shifting weight onto right leg. At the same time, move right hand continuously to right side past face, palm turned slowly outward, while left hand moves in a curve past abdomen up to shoulder level with palm turned slowly obliquely inward. As left hand moves upward, take a side step with left foot. Look at left hand.



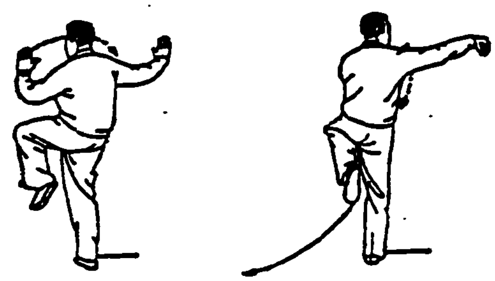
4) Repeat movements in 2), 3) and 2)

Points to remember: Use your lumbar spine as the axis for body turns. Keep waist and hips relaxed. Do not let your body rise and fall abruptly. Arm movements should be natural and circular and follow waist movements. Pace must be slow and even. Maintain a good balance when moving lower limbs. Eyes should follow the hand that is moving past face. Body in final position faces 10-11 o'clock.





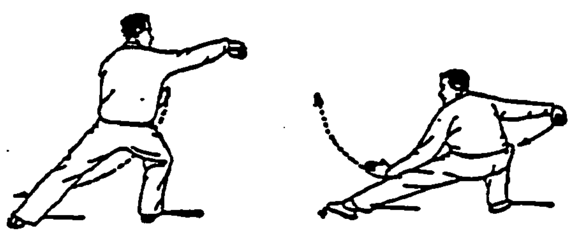
5. Stand Up On One Leg (left then right)



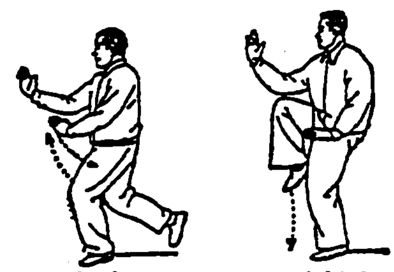
1) Pull back left foot and keep thigh level. Turn torso to the right (7 o'clock). Hook right hand as you turn up left palm and move it in a curve past facs to the front of right shoulder, turning it inward in the process. Look at right hand

2) Turn torso to the left (4 o'clock), and crouch down slowly on right leg, stretching left leg sideways towards 2-3 o'clock. Move left hand down and to the left along the inner side of left leg, turning palm outward. Look at left hand.

Points to remember: When crouching down, turn toes of right foot slightly outward and straighten left leg with toes turned slightly inward, both soles flat on floor. Keep toes of left foot in line with right heel. Do not lean torso too much forward.

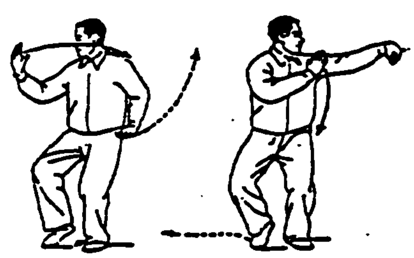


3) Turn toes of left foot outward and those of right foot inward: straighten right leg and bend left leg onto which weight is shifted. Turn torso slightly to the left (3 o'clock) as you rise up slowly in a forward movement. At the same time, move left arm continuously to the front, palm facing right, while right hand drops behind the back, still in the form of a hook, with bunched fingertips pointing backward. Look at left hand

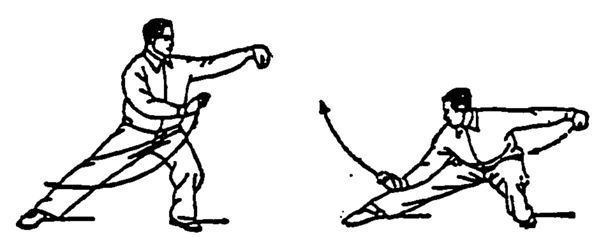


4) Raise right knee slowly as right hand opens into palm and swings to the front past outside of right leg, elbow bent just above right knee, fingers pointing up and plam facing left. Move left hand down to the side of left hip, palm down. Look at right hand (Figs 130–131).

Points to remember: Keep torso upright. Bend the supporting leg slightly. Toes of the raised leg should point naturally downward. Face 3 o'clock in final position.

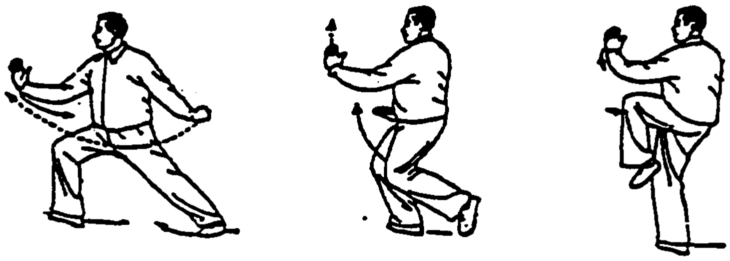


1) Put right foot down in front of left foot, toes on floor. Turn body to the left (12 o'clock), pivoting on toes of left foot. At the same time, raise left hand sideways to shoulder level and turn it into a hook while right hand, following body turn, moves in a curve to the front of left shoulder with fingers pointing up. Look at left hand

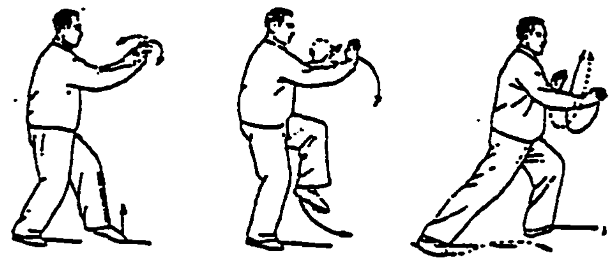


2) Repeat movements in 2)–4) under Form 16, reversing "right" and "left" and changing the clock directions of movements accordingly (Figs 134–138).

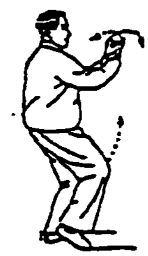
Points to remember: Raise right foot slightly before crouching down and stretching right leg sideways. Other points are the same as those for Form 16, except that "right" and "left" are reversed. Face 3 o'clock in final position.



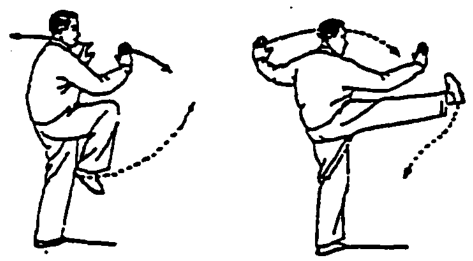
6. Kick Out Your Heel (right then left)



1) Turn torso slightly to the right (10 o'clock) and move left hand, palm up, to cross right hand at wrist as you pull left foot a bit backward, toes on floor. Then separate hands, moving both in a downward curve with palms turned obliquely downward. Meanwhile, raise left foot to take a step towards 8 o'clock for a left bow stance, toes turned slightly outward. Look straight ahead

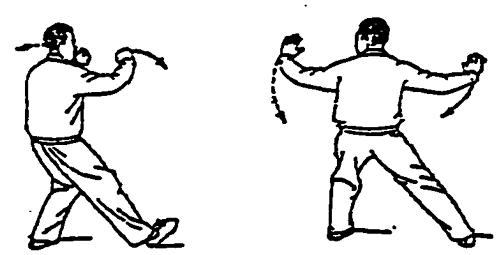


2) Continue to move hands in a downward-inward-upward curve until wrists cross in front of chest, with right hand in front and both palms turned inward. At the same time, draw right foot to the side of left foot, toes on floor. Look forward to the right

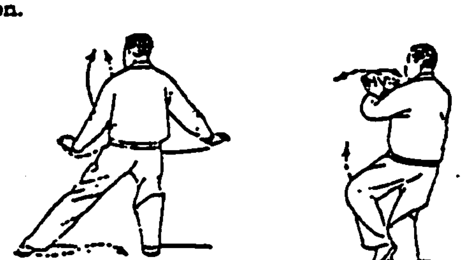


3) Separate hands, turning torso slightly to 8 o'clock and extending both arms sideways at shoulder level with elbows slightly bent and palms turned outward. At the same time, raise right knee and thrust foot gradually towards 10 o'clock. Look at right hand.

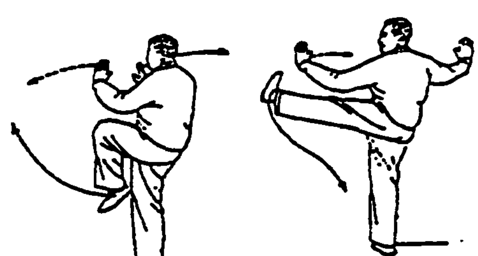
Points to remember: Keep your balance. Wrists are at shoulder level when hands are separated. When kicking right foot, left leg is slightly bent and the kicking force should be focussed on heel, with ankle dorsiflexed. The separation of hands should be coordinated with the kick. Right arm is parallel with right leg. Face 9 o'clock in final position.



1) Shift weight gradually onto left leg, turning body to the left (6 o'clock) with toes of right foot turned inward. Simultaneously, open both fists and separate hands in an upward curve, extending both arms sideways, palms facing forward. Look at left hand.



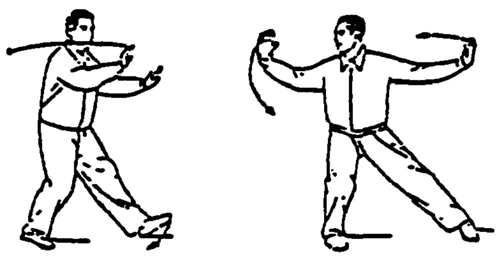
2) Shift weight onto right leg and draw left foot to the side of right foot, toes on floor. At the same time, move both hands in a downward-inward-upward curve until wrists cross in front of chest, with left hand in front and both palms facing inward. Look forward to the left.



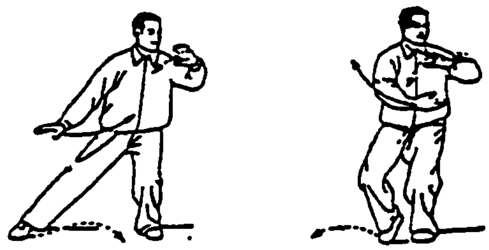
3) Separate hands, extending both arms sideways at shoulder level, elbows slightly bent and palms facing outward. Meanwhile, raise left knee and thrust foot gradually towards 4 o'clock. Look at left hand

Points to remember: The same as those for Form 13, except that "right" and "left" are reversed. Face 4 o'clock in final position.

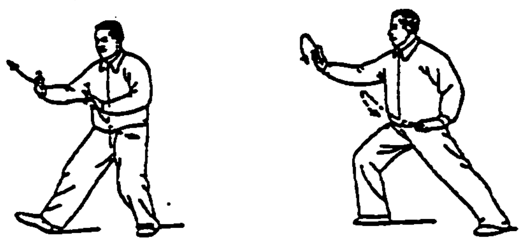
7. Grasp the Bird's Tail (right then left)



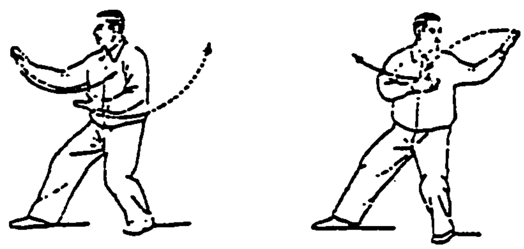
1) Sit back and turn torso to the right (12 o'clock), shifting weight onto right leg and turning toes of left foot inward. Move right hand in a horizontal curve to the right and then in a downward curve past abdomen for a hold-ball gesture in front of left part of chest, left hand on top.

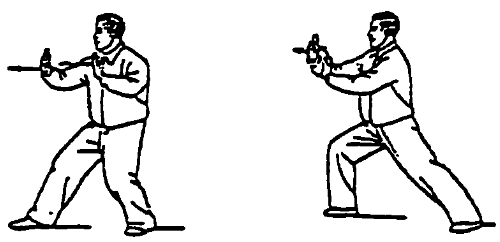


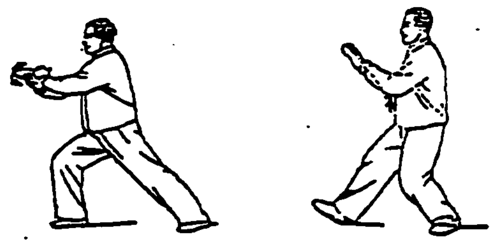
Meanwhile, shift weight onto left leg and place right foot beside left foot, toes on floor. Look at left hand.

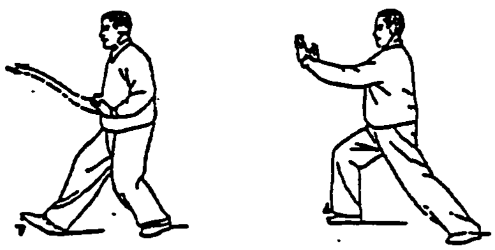


Face 3 o'clock in final position.



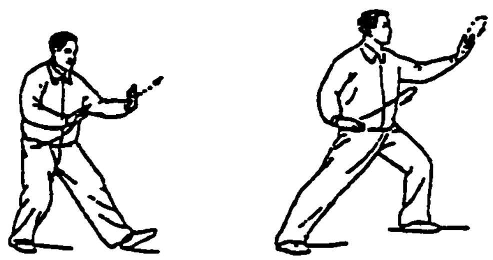






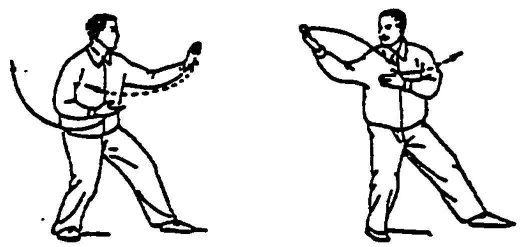
1) Turn torso slightly to the right (11-12 o'clock), carrying right hand sideways up to shoulder level, palm up, while left palm is turned downward. Look at left hand.

2) Turn body slightly to the right (12 o'clock) and make a hold-ball gesture in front of right part of chest, right hand on top. At the same time, shift weight onto right leg and draw left foot to the side of right foot, toes on floor. Look at right hand.



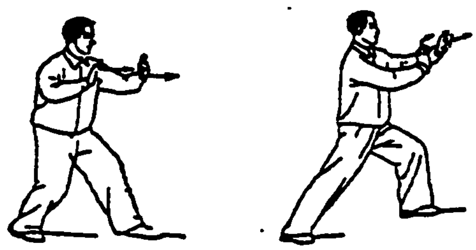
3) Turn body slightly to the left, taking a step forward with left foot towards 9 o'clock for a left bow stance. Meanwhile, push out left forearm and back of hand up to shoulder level as if to fend off a blow, while right hand drops slowly to the side of right hip, palm down. Look at left forearm.

Points to remember: Keep both arms rounded while pushing out one of them. The separation of hands, turning of waist and bending of leg should be coordinated.



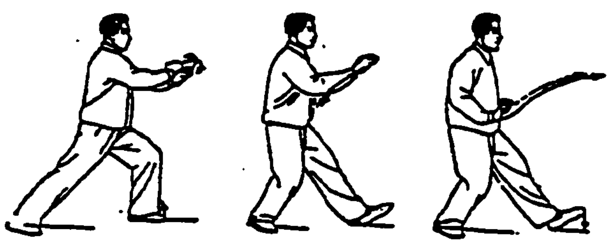
4) Turn torso slightly to the left (9 o'clock) while extending left hand forward, palm down. Bring up right hand until it is below left forearm, palm up. Then turn torso slightly to the right while pulling both hands down in a curve past abdomen — as if you were taking hold of an imaginary foe's elbow and wrist in order to pull back his hand and body — until right hand is extended sideways at shoulder level, palm up, and left forearm lies across chest, palm turned inward. At the same time, shift weight onto right leg. Look at right hand.

Points to remember: While pulling down hands, do not lean forward or protrude buttocks. Arms should follow the turning of waist and move in a circular path.



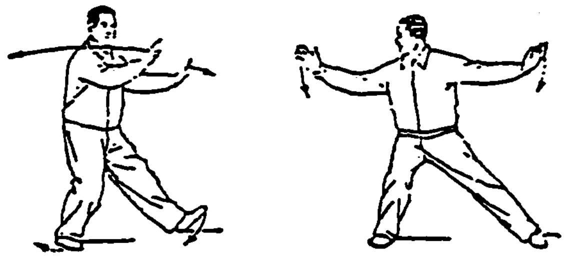
5) Turn torso slightly to the left as you bend right arm and place right hand inside left wrist; turn torso further to 9 o'clock as you press both hands slowly forward, palms facing each other and keeping a distance of about 5 cm between them and left arm remaining rounded. Meanwhile, shift weight slowly onto left leg for a left bow stance. Look at left wrist.

Points to remember: Keep torso erect when pressing hands forward. The movement of hands must be coordinated with the turning of waist and bending of front leg.

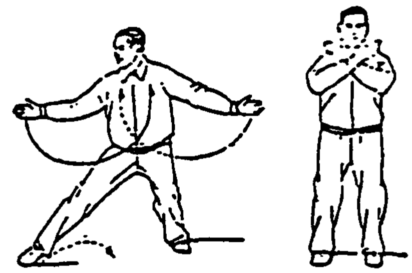


6) Turn both palms downward as right hand passes over left wrist and moves forward and then to the right until it is on the same level with left hand. Separate hands shoulder-width apart and draw them back to the front of abdomen, palms facing obliquely downward. At the same time, sit back and shift weight onto right leg which is slightly bent, raising toes of left foot. Look straight ahead.

8. Cross Hands



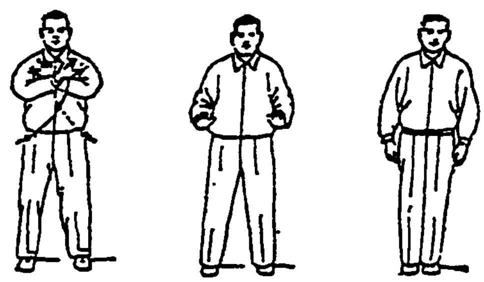
1) Bend right knee, sit back and shift weight onto right leg, which is bent at knee. Turn body to the right (1 o'clock) with toes of left foot turned inward. Following body turn move both hands sideways in a horizontal curve at shoulder level, palms facing forward and elbows slightly bent. Meanwhile, turn toes of right foot slightly outward and shift weight onto right leg. Look at right hand.



2) Shift weight slowly onto left leg with toes of right foot turned inward. Then bring right foot towards left foot so that they are parallel to each other and shoulder-width apart; straighten legs gradually. At the same time, move both hands down in a vertical curve to cross them at wrist first in front of abdomen and then in front of chest, left hand nearer to body and both palms facing inward. Look straight ahead.

Points to remember: Do not lean forward when separating or crossing hands. When taking the parallel stance, keep body and head erect with chin tucked slightly inward. Keep arms rounded in a comfortable position, with shoulders and elbows held down. Face 12 o'clock in final position.

Closing Form



Turn palms forward and downward while lowering both hands gradually to the side of hips. Look straight ahead.

Points to remember: Keep whole body relaxed and draw a deep breath (exhalation to be somewhat prolonged) when you lower hands. Bring left foot close to right foot after your breath is even. Walk about for complete recovery.

APPENDIX H

CORRELATION TABLES

Table 3

Pre Intervention Intercorrelations Among Measures of Sway, Strength, Balance, Gait and Age for Quiet Standing (Eyes Open)

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.82**	0.32	0.19	0.15	0.05	0.11	0.1
Area of Sway		----	.35*	0.15	0.18	-0.06	-0.07	0.1
Path Length			----	0.07	0.1	0.14	0.16	0.16
Right Grip Strength				----	.91**	0.14	0.16	-0.3
Left Grip Strength					—	0.18	0.25	-0.3
POMA Balance						----	.69**	-.42*
POMA Gait							----	-0.2
Age								----

Note. *p < .05.
**p < .001.

Table 4

Pre Intervention Intercorrelations Between Measures of Sway and Strength, Balance, Gait and Age for Quiet Standing (Eyes Closed)

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.91**	.63**	0.14	0.19	0.06	0.17	10
Area of Sway		----	.63**	0.07	0.15	-0.04	0.05	0.17
Path Length			----	-0.01	0.04	0.12	0.19	0.2

Note. *p < .001.

Table 5

Pre Intervention Intercorrelations Between Measures of Sway and Strength, Balance, Gait and Age for Balance Space

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.90**	.78**	.70**	.65**	0.21	0.15	-0.2
Area of Sway		----	.77**	.72**	.64**	0.27	0.19	-0.2
Path Length			----	.53*	.46*	0.12	-0.07	0

Note. *p < .05.
**p < .001.

Table 6

Post Intervention Intercorrelations Among Measures of Sway, Strength, Balance, Gait and Age for Quiet Standing (Eyes Open)

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.76**	.63**	0.04	0.01	-0.07	-0.12	0.18
Area of Sway		----	.68*	0.01	0.04	-0.27	-0.06	0.15
Path Length			----	-0.1	-0.12	-0.16	-0.11	0.09
Right Grip Strength				----	.85**	.38*	0.23	-.48**
Left Grip Strength					----	0.26	0.32	-.48**
POMA Balance						----	.69**	0
POMA Gait							----	-.40*
Age								----

Note. *$p < .05$.
**$p < .001$.

Table 7

Post Intervention Intercorrelations Between Measures of Sway and Strength, Balance, Gait and Age for Quiet Standing (Eyes Closed)

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.84**	.76**	0.03	0.08	-0.13	-0.01	0.1
Area of Sway		----	.76**	-0.11	0.03	-0.19	-0.02	0.1
Path Length			----	-.35*	-0.21	-0.21	-0.01	0.13

Note. *$p < .05$.
**$p < .001$.

Table 8

Post Intervention Intercorrelations Between Measures of Sway and Strength, Balance, Gait and Age for Balance Space

Measure	AP Sway	Area of Sway	Path Length	Right Grip Strength	Left Grip Strength	POMA Balance	POMA Gait	Age
AP Sway	—	.94**	.80**	.64**	.65**	.38*	-0.01	0
Area of Sway		----	.63**	0.07	0.15	-0.04	0.05	-0.1
Path Length			----	0.23	0.29	0.15	-0.24	0.19

Note. *$p < .05$.
**$p < .001$.

APPENDIX I

ANOVA TABLES

Table 9

Analysis of Variance for Quiet Standing (Eyes Open)

		F		
Factor	df	AP Sway	Area of Sway	Path Length
	Between	Subjects		
Group(G)	1	0.1	0.06	7.92**
(G) Within-group error	32	-0.04	-0.21	-7.01
	Within	Subjects		
Time (T)	1	42.62**	38.72**	1.28
Time x Group	1	0.13	0.31	6.51*
(T)Within-group error	32	-0.01	-0.1	-3.89

Note. Values enclosed in parentheses represent mean square errors.
*$p < .05$. **$p < .01$.

Table 10

Analysis of Variance for Quiet Standing (Eyes Closed)

		F		
Factor	df	AP Sway	Area of Sway	Path Length
	Between	Subjects		
Group(G)	1	0.01	0.01	3.62
(G) Within-group error	32	-0.15	-0.65	-21.6
	Within	Subjects		
Time (T)	1	51.52**	21.61**	3.33
Time x Group	1	4.98*	0.42	5.37*
(T)Within-group error	32	-0.01	-0.32	-5.45

Note. Values enclosed in parentheses represent mean square errors.
*$p < .05$. **$p < .01$.

Table 11

Analysis of Variance for Balance Space

		F		
Factor	df	AP Sway	Area of Sway	Path Length
	Between	Subjects		
Group(G)	1	5.30*	6.57*	4.15
(G) Within-group error	32	-1.36	-570.73	-93.27
	Within	Subjects		
Time (T)	1	96.64**	152.16**	69.37**
Time x Group	1	1.76	7.59**	1.25
(T)Within-group error	32	-0.1	-323.09	-15.52

Note. Values enclosed in parentheses represent mean square errors.
*$p < .05$. **$p < .01$.

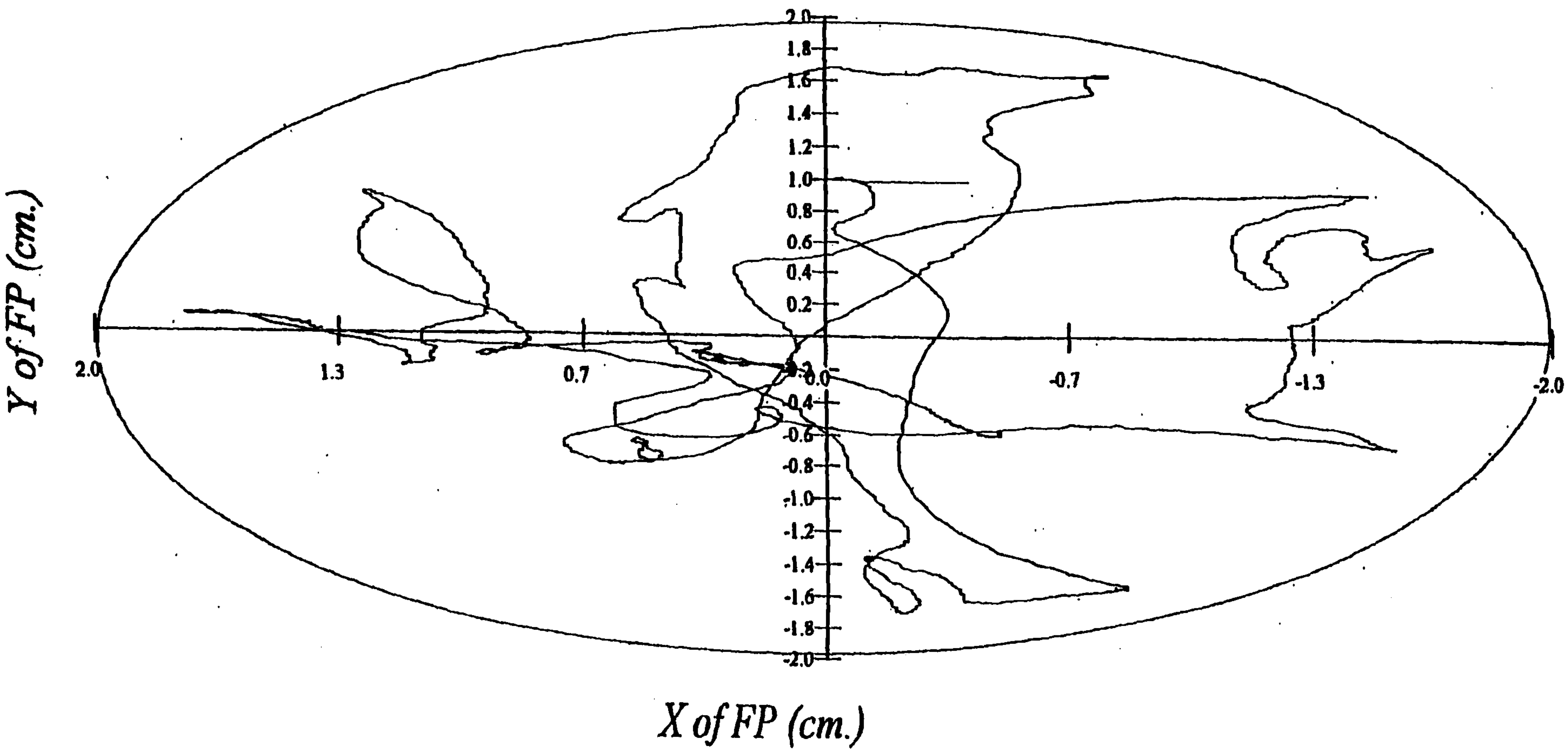
APPENDIX J

FORCEPLATE REPRESENTATIONS OF BALANCE SPACE

Balance Space Analysis

Name: Mrs. Tai Chi
Group: Novice,
Task: Balance Space, Pre Intervention

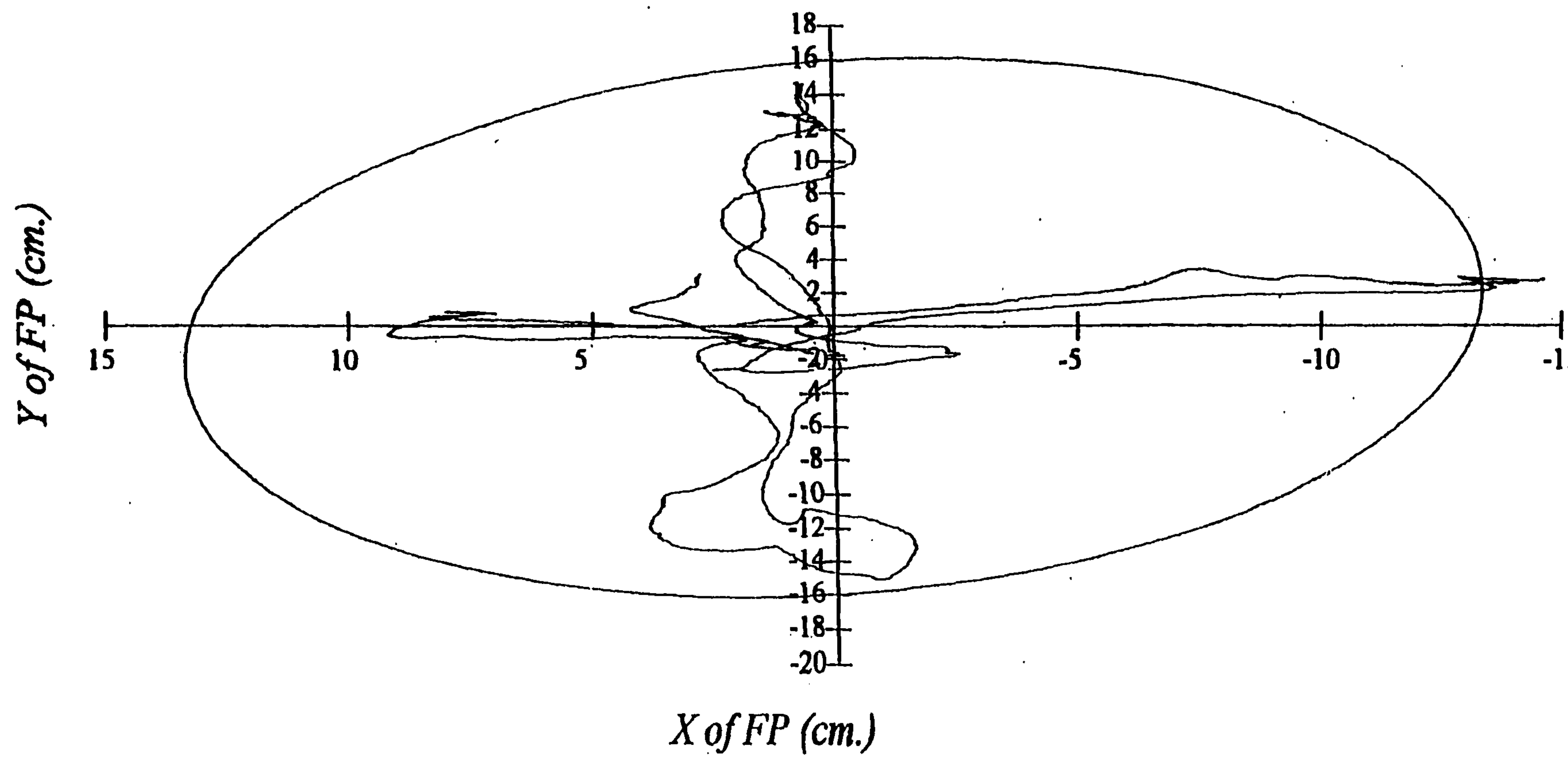
95% Ellipse



Balance Space Analysis

Name: Mrs. Tai Chi
Group: Novice
Task: Balance Space, Post Intervention

95% Ellipse



Balance Space Analysis

Name: Mrs. Tai Chi
Group: Novice
Task: Balance Space (Overlay of Pre and Post Intervention)

95% Ellipse