

Differences in Balance Related Measures Among Older Adults Participating in Tai Chi, Structured Exercise, or No Exercise

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ABSTRACT

Purpose: This study compared balance-related measures for elderly individuals participating in Tai Chi, structured exercise classes, or no exercise program. **Methods:** We conducted a cross-sectional study of 94 healthy, older adults (>60 years) categorized according to their current participation in Tai Chi (n = 24), a structured exercise program (n = 29), or no exercise (n = 41). A battery of functional, balance-related measures was administered on one occasion. The measures included the Activities-specific Balance Confidence Scale (ABC scale), Timed-up and Go (TUG), 30 Second Chair Stand, and a Multidirectional Reach Test (MDRT). The data were analyzed using multiple one-way analyses of variance procedures (ANOVAs) and Tukey's HSD post-hoc analysis. **Results:** The Tai Chi and exercise groups performed significantly better than the no exercise group on the ABC Scale ($p < .01$) and Chair Stand ($p < .01$); the Tai Chi group performed significantly better than the no exercise group on the TUG ($p = .001$). The Tai Chi group performed significantly better than the no exercise and exercise groups on the forward ($p < .01$), backward ($p < .001$), and left ($p < .001$) components of the MDRT. The exercise group performed significantly better than the no exercise group on the forward ($p < .01$) reach. **Conclusion:** Both Tai Chi and structured exercise groups demonstrated greater balance and confidence than the no exercise group of well-elderly persons, while the Tai Chi group performed significantly better than both groups for reaching in 3 directions, indicating greater limits of stability.

Key Words: aging, balance, exercise, measurement

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INTRODUCTION

Health care professionals and researchers are exploring many methods that can be used to improve balance and decrease the risk of falling for older adults. This emphasis has emerged in light of the estimate that one-third of elderly people over the age of 65 and one-half of elderly people over the age of 80 fall each year.^{1,2} As our population ages, it is essential to determine the most effective means to improve balance and prevent falls. Over the past several years, many structured exercise programs have been developed to meet the needs of older adults.

In a review of controlled clinical trials, Gardner and colleagues³ concluded that exercise is effective in lowering fall risk in selected groups. Successful programs have reduced falls or fall risks through strength,^{4,5} balance,^{6,7} and endurance training,⁸ or Tai Chi exercise.⁹ Programs also have decreased fear of falling and improved overall health and wellness.^{7,9,10} A few programs that included resistive exercise led to associated improvement in balance scores.⁶⁻⁸ However, more trials are required to determine the exercise type, frequency, duration, and intensity that are most effective in improving balance and lowering fall risk in different groups of older adults.

With all of the exercise options available, one of the current trends gaining popularity for older adults is Tai Chi. Tai Chi, an ancient Chinese martial art, is an inexpensive approach to exercise that does not require any equipment and can be easily implemented in a variety of settings with older adults. Tai Chi's positive impact on balance is theorized to be the result of the use of slow movements that require the coordination of the entire body.¹¹ In a recent article, Wolf and colleagues¹² identified several elements of Tai Chi that contribute to improving balance skills. These elements include continuous slow movements, a slow increase in the amount of movement done by each area of the body, a gradual increase in the amount of flexion at the knees, the development of a straight and extended posture, and emphasis on rotation in the body. Tai Chi also emphasizes shifting body weight from limb to limb and using diagonal arm movements.¹⁰ Several investigators have found Tai Chi to be successful in improving balance,¹³⁻¹⁵ decreasing fear of falling,^{16,17} improving health status,¹⁷ maintaining strength/balance gains,¹⁸ or reducing fall risk.¹⁹

Across the wide array of exercise programs studied, balance training has emerged as an essential element for fall prevention. Based on a meta-analysis of the 7 FICSIT exercise trials, balance training may be judged more effective in lowering fall risk than other exercise components.²⁰ With its emphasis on postural control, Tai Chi would appear to be a superior method for balance training. However, direct comparisons of exercises used to improve balance are not well researched. Most studies compared one exercise group with a

control group, rather than with an alternative exercise group. Therefore, it remains unclear as to which type of exercise is most effective for improving balance among older adults. Furthermore, it is difficult to compare existing programs since most authors used very different instrumentation to gather outcome data.

The purpose of this study was to compare balance-related measures among older adults who currently participate in Tai Chi, structured exercise programs, or no exercise. We hypothesized that individuals involved with Tai Chi would demonstrate superior postural control and balance confidence compared to others who participate in other exercise or no exercise. Similarly, it was expected that participants of structured exercise programs would exhibit better balance and confidence compared with those that do not participate in such programs.

METHODS

Subjects

A cross-sectional study was conducted with a convenience sample of 94 older adults (15 males, 79 females, mean age=75.2 ± 7.5 years, range = 60 to 96) who were recruited from area senior centers, YMCAs, and Tai Chi Chuan classes in Northeastern Pennsylvania over a 6-week period. To be eligible for inclusion in this study, individuals had to be over the age of 60 and able to ambulate independently with or without an assistive device. In addition, a person was excluded if he/she had any known neurological, musculoskeletal, or cardiopulmonary complication that might interfere with safe participation.

The 94 individuals included in this study came from a pool of 158 people recruited. Sixty-four exclusions were made on the basis of the criteria stated above, difficulty completing or understanding the necessary paperwork, and time constraints. Subjects were categorized in 1 of 3 groups based on their current participation in Tai Chi, structured exercise programs, or no exercise program. Prevalence data for self-reported chronic medical conditions is reported in Table 1 and demographic data for each group are presented in Table 2. Each subject volunteered to participate in this study and signed an informed consent form prior to data collection. Confidentiality was maintained by the utilization of data coding. This study was approved by the Institutional Review Board (IRB) of the University of Scranton to ensure protection of human subjects.

The Tai Chi group consisted of 4 males and 20 females with a mean age of 70.3 ± 6.8 (range = 60 to 82) years. It was composed of individuals participating in an organized class taught by a trained instructor, one or more times per week, for more than one year (mean length of participation = 5.6 years). The classes included training in 108 forms according to the Yang school of thought and 74 forms from Tai Chi Chen. A review of 9 scientific studies published in both Chinese and English by Li et al²¹ indicated that Tai Chi can be classified as moderate intensity exercise, requiring energy expenditure of approximately 3 to 5 metabolic equivalent tasks.²²

The structured exercise group consisted of 29 females with a mean age of 73.9 ± 6.7 (range = 62 to 85) years. It was composed of individuals participating in YMCA-sponsored pro-

Table 1. Self-Reported Prevalence of Chronic Medical Conditions for Older Adults According to Group

History	No Exercise (n = 41)		Exercise (n = 29)		Tai Chi (n = 24)	
	Number	%	Number	%	Number	%
Number of chronic conditions:						
None	7	17.0	13	44.8	9	37.5
One	20	48.8	9	31.0	9	37.5
Two	8	19.5	5	17.2	1	14.2
Three	1	2.4	2	6.9	2	8.3
Four	5	12.2	0	0.0	2	8.3
More than four	0	0.0	0	0.0	1	4.2

grams one or more times per week for more than one year. Classes were led by YMCA certified instructors and consisted of one or more of the following: strengthening, flexibility, aerobics, and aquatic exercise. These classes were considered moderate intensity as defined by nonvigorous activities requiring energy expenditure of approximately 4 to 6 METs,²² analogous to the Tai Chi group's activity level. The no exercise group (11 males, 30 females) had a mean age of 79.0 ± 6.6 (range = 62 to 96) years and consisted of individuals that did not participate in any regular or structured exercise programs, including walking.

Instrumentation

The instruments used for data collection were chosen based on balance measures reported in the literature to be valid and reliable. Furthermore, consideration was given to the feasibility, cost effectiveness, and efficiency of administering the measures. The selected tests were the Multidirectional Reach Test (MDRT),²³ Timed-Up-and-Go (TUG),²⁴ 30 Second Chair-stand test,²⁵ and the Activities-specific Balance Confidence (ABC) Scale.²⁶ In addition, an intake form was used in which subjects reported information on social and medical history, age, gender, exercise history, and level of independence in ambulation. Pilot testing was completed on a different sample of older adults (n = 27) prior to data collection to become familiar with the above tests and establish reliability consistent with published values.²³⁻²⁷

Table 2. Comparison of Demographic Characteristics for Older Adults According to Group

Characteristics	No Exercise (n = 41)		Exercise (n = 29)		Tai Chi (n = 24)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	79.0	6.7	73.9	6.7	70.3	6.8
	Number	%	Number	%	Number	%
Gender:						
Male	11	26.8	0	0.0	4	16.7
Female	30	73.2	29	100.0	20	83.3
Ambulates:						
Independently	33	80.5	29	100.0	24	100.0
With a cane	8	19.5	0	0.0	0	0.0
Walks:						
Regularly*	0	0.0	13	44.9	15	62.5

* Regularly indicates at least one mile three times weekly.

The MDRT is a balance test in which subjects stood beside a yardstick taped horizontally to a wall at shoulder height, with feet comfortably apart. Subjects raised their dominant arm to 90° flexion and reached as far forward and backward as possible without taking a step. They were then asked to stand with their back to the yardstick, raise their arm to 90° abduction, and reach to the left and right as far as possible without taking a step. The distance reached (in inches) was determined using the difference between the starting and finishing points of the middle finger in relation to the yardstick. Subjects were allowed a practice trial before data was recorded. The reach was performed 3 times in each direction and the mean was used for data analysis. The MDRT, as described by Newton, is reliable (interrater ICC >.92) and valid, as correlated with the Berg Balance Test and TUG.²³

The TUG is a timed balance test in which subjects were seated in an armchair with feet flat on the floor. The subjects were asked to stand up, walk at their usual pace to a line on the floor 3 meters from the chair, turn around, and return to sitting in the chair. A practice trial was allowed for familiarization with the task. The mean of 3 trials was used for data analysis. The TUG is reported as reliable (interrater ICC = .99, test-retest ICC = .98) and valid, as correlated with the Berg Balance Test, gait speed, and Barthel Index.²⁷

The 30 Second Chair Stand is a functional strength test²⁵ that requires coordinated control of the body's center of mass in order to maintain dynamic balance as the base of support is transitioned from 3-point (ie, sitting) to 2-point (ie, standing) support.²⁸ Subjects were seated in a chair positioned against a wall for stability. The subjects were asked to fold their arms across their chest and place their feet shoulder width apart, just behind their knees, and in a slight stagger stance. On the command 'go,' subjects stood upright in a stable standing posture and then sat back down as many times as possible within 30 seconds. The subjects were allowed a practice trial and then the test was performed for one, 30-second trial. The examiner counted only full-stands. The 30 Second Chair Stand is reported as reliable (test-retest ICC = .84 for men/.92 for women) and valid, as correlated with maximum weight-adjusted leg press performance.²⁵

The ABC Scale is a written test that describes 16 activities in which subjects indicated their level of confidence for performing each item by placing a vertical mark on a visual analogue scale of 10 centimeters, anchored with 0% and 100% at each end. The distance of the mark from 0 was measured and converted to a percentage. A mean of the percentage score for all 16 questions was used in data analysis. The ABC scale is reported as reliable (test-retest ICC = .92) and valid, as correlated with the Physical Self-Efficacy Scale and Falls Efficacy Scale.²⁶

Procedures

After a brief introduction describing the procedure, instruments, and purpose of the study, subjects were asked to complete the medical intake form that was then reviewed by the primary investigators to ensure the safety of participants prior to assessment. Subjects then completed the ABC Scale before commencing with the TUG, MDRT, and 30 Second Chair Stand. Subjects performed the physical assessments in

a random sequence so that the confluence of an order effect could be eliminated. Research assistants guarded for safety during testing and the primary investigators were responsible for data collection.

Data Analysis

Descriptive statistics were used to characterize the sample. Means were calculated for the 3 trials of the TUG and each direction of the MDRT. In addition, the mean of the 16 items contained in the ABC Scale was determined for each subject. Multiple one-way analysis of variance (ANOVA) procedures and Tukey's Honestly Significant Difference (HSD) post-hoc analyses were performed to determine the significant differences in balance measures across the 3 groups. The probability level was set at $p < .01$ to provide a more rigorous requirement to reach statistical significance when performing multiple hypothesis tests. Statistical Package for the Social Sciences (SPSS) computer software was used to make these computations.

RESULTS

Table 3 summarizes the data for the 3 groups on each of the 4 balance measures used in this study with normative data for comparison. The Tai Chi and exercise groups performed significantly better than the no exercise group on the 30 Second Chair Stand ($p=.001$ and $p<.01$, respectively), and the ABC Scale ($p<.001$ and $p=.001$, respectively). The Tai Chi group scored significantly better than the no exercise group on the TUG ($p=.001$). A statistically significant difference was not found between the exercise and Tai Chi groups on any of these measures.

The Tai Chi group scored significantly higher than both the exercise and no exercise groups on the forward ($p =.01$ and $p<.001$, respectively) and backward ($p =.001$ and $p<.001$, respectively) components of the MDRT. Additionally, the exercise group performed significantly better than the no exercise group on the forward reach ($p =.001$). The Tai Chi group

Table 3. Mean Scores (M) and Standard Deviations (SD) of Outcome Measures According to Group with Normative Data for Comparison

Outcome Measures	No Exercise (n = 41)		Exercise (n = 29)		Tai Chi (n = 29)		Normative Data	
	M	SD	M	SD	M	SD	M	SD
TUG (seconds)	13.3	7.7	9.5	1.9	8.0	1.8	15.6	7.0 ²³
30 Second Chair Stand (repetitions)	9.0	4.3	12.0	3.2	13.0	2.4	13.1	3.4 ²³
MDRT (inches)								
Forward Reach	7.6	2.9	9.9	2.9	12.1	1.8	8.9	3.4 ²³
Backward Reach	4.9	2.2	6.2	2.1	8.5	2.4	4.6	3.1 ²³
Right Reach	5.9	2.4	7.1	1.9	8.9	2.5	6.2	3.0 ²³
Left Reach	5.8	2.5	6.8	2.3	9.7	3.1	6.6	2.9 ²³
ABC Scale (%)	66.0	26.1	84.1	18.2	86.8	9.0	80.9	20.8 ²²

Note: A lower (ie, faster) TUG score indicates better balance; a higher chair stand score indicates greater strength; a higher (ie, further) MDRT score indicates better balance; ABC score of 100% indicates complete confidence with all 16 items on the scale.

showed statistically superior performance on both right and left reach components of the MDRT compared to that of the no exercise group ($p < .001$), and for the left reach component compared to the exercise group ($p < .001$), with the right direction approaching statistical significance ($p = .013$). There was no statistically significant difference between the exercise and no exercise groups on both the right and left components of the MDRT. Refer to Table 4 for ANOVA summary data.

DISCUSSION

The analyses of data for the 94 older adult subjects used in this study indicated that both Tai Chi and exercise participants demonstrated greater balance and confidence than the no exercise group. The classes from which the standard exercise subjects were recruited included activities focused on strength (including both closed-chain and open-chain movement of the lower extremities) and endurance, made use of both walking and marching exercises, and addressed flexibility in the form of gentle stretching and range of motion exercises. These elements are also key components of Tai Chi. The use of progressive knee flexion in standing, weight shifting, increased unilateral stance, and the use of slow and continuous concentric and eccentric contractions of muscles of the lower extremities promote increased strength, endurance, and flexibility. Based on our findings, any form of exercise that promotes increased strength, endurance, and flexibility of the lower extremities appears to improve the balance of older adults during dynamic functional activities such as rising from a chair and reaching for an object.

The results of the MDRT offered compelling evidence for choosing to implement a Tai Chi program over a typical exercise class to improve limits of stability as defined by reaching distance. The Tai Chi group performed significantly better than both the exercise and no exercise groups on nearly all components of the MDRT. Tai Chi's use of continuous concentric and especially eccentric contractions allowed this group to demonstrate greater limits of stability, as eccentric control of antagonists is necessary for the performance of this type of activity. Although the exercise group performed strengthening activities during their classes, less focus was placed upon use of eccentric strength, which may explain the difference between their performance and the Tai Chi group's performance. It appears that performing activities incorporating elements of weight-shifting and strengthening, especially eccentric training, improves the ability to safely move the center of gravity outside of one's base of support. Whether or not this type of balance translates to reduced incidence of falls is yet to be determined.

Both Tai Chi and structured exercise afforded greater confidence for participants during daily functional tasks as evidenced by their significantly higher scores over the sedentary group on the ABC Scale. These results demonstrated that both exercise conditions promoted affective as well as physical benefits. This is a critical area to consider since elderly individuals who are afraid of falling typically increase their risk of experiencing a fall.²⁹ This fear may result in a sequelae of decreased mobility that leads to physical deconditioning, decreased independence, and a lower quality of life.^{29,30}

Table 4. Results of Seven One-Way Analysis of Variance (ANOVA) Procedures Comparing Outcome Measures of Well Elderly Individuals in Three Groups

Outcome Measures	Sum of Squares	df	Mean Square	F*
Timed-up-and-Go	453.479	2	226.740	8.191
30 Second Chair Stand	255.751	2	127.875	9.990
Multidirectional Reach				
Forward	318.355	2	159.177	22.580
Backward	194.256	2	97.128	19.808
Right	138.133	2	69.066	3.027
Left	27.662	2	113.831	16.851
Activities-specific Balance Confidence Scale	87.408	2	43.704	10.367

* All F ratios are significant at $p < .001$

Tai Chi may be more desirable than other traditional means of improving balance as it provides a very low-impact alternative to other physical activities. Additionally, Tai Chi is a low-cost activity requiring no equipment that can be easily implemented as a community program in most geographic locations. Even sedentary older adults can be expected to benefit from starting a program based on research findings that exercise is beneficial for elderly persons, even if they have not exercised throughout their lives.³¹

Several limitations should be acknowledged. This study was done as a community balance screening and as a result, the number of subjects recruited on each day of data collection varied. Subjects were given more rest between assessments when large numbers of people were being tested because of the necessity to wait for the next available tester after completing the previous measure. Without a consistent rest period, it cannot be known if the effect of fatigue had any confounding affect on the results of this study. Due to time constraints, this study was done as a cross-sectional analysis. Therefore, random assignment was not used as volunteer subjects were simply categorized into groups, which limits group equivalence and the generalizability of findings. Future research involving a longitudinal design, incorporating random assignment, and including both pre- and post-measurements, could produce results with a higher level of evidence. Future research also should account for any differences in the incidence of falls accompanying Tai Chi (which appears capable of increasing the limits of stability) and other exercise (which may result in greater strengthening)

CONCLUSION

Well elderly individuals participating in Tai Chi or structured exercise programs demonstrated greater balance and confidence than well-elderly individuals who were sedentary. Multidirectional reach was significantly better among individuals participating in Tai Chi. Although any form of regular exercise may result in greater balance performance, Tai Chi is a feasible and effective method of low impact balance training that can be incorporated into a fall prevention program for older adults in many settings.

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