Reduction in Fear of Falling Through Intense Tai Chi Exercise Training in Older, Transitionally Frail Adults

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OBJECTIVES: To determine whether an intense tai chi exercise program could reduce fear of falling better than a wellness education (WE) program in older adults who had fallen previously and meet criteria for transitioning to frailty.

DESIGN: Cluster-randomized, controlled trial of 48 weeks' duration.

SETTING: Ten matched pairs of congregate living facilities in the greater Atlanta area.

PARTICIPANTS: Sample of 291 women and 20 men, aged 70 to 97.

MEASUREMENTS: Activity-related fear of falling using the Activities-Specific Balance Confidence Scale (ABC) and the Fall Efficacy Scale at baseline and every 4 months for 1 year. Demographics, time to first fall and all subsequent falls, functional measures, Centers for Epidemiologic Studies Depression Scale, medication use, level of physical activity, comorbidities, and adherence to interventions.

RESULTS: Mean ABC was similar in both cohort groups at the time of randomization but became significantly higher (decreased fear) in the tai chi cohort at 8 months (57.9 vs 49.0, $P<.001$) and at study end (59.2 vs 47.9, $P<.001$). After adjusting for covariates, the mean ABC after 12 months of intervention was significantly greater in the tai chi group than in the WE group, with the differences increasing with time (mean difference at 12 months = 9.5 points, 95% confidence interval = 4.8–14.2, $P<.001$).

CONCLUSION: Tai chi led to a significantly greater reduction in fear of falling than a WE program in transitionally frail older adults. The mean percentage change in ABC scores widened between tai chi and WE participants over the trial period. Tai chi should be considered in any program designed to reduce falling and fear of falling in transitionally frail older adults. **J Am Geriatr Soc 53:1168–1178, 2005.**

Key words: fear of falling; exercise; balance; aging; tai chi

Fear of falling ranks as the top fear of community-dwelling older persons.[1] The wide range of prevalence estimates for fear of falling (29–77%) may be due to differences between samples in age, sex, activity level, history of falls, measures of fear, and other comorbidities.[2–7] Individuals who have fear of falling are at greater risk of falling, and those who have fallen are at greater risk of developing fear of falling.[6] An escalating cycle of fear and falling or falling and fear can lead to decreased physical activity, decreased functional ability, and decreased quality of life.[2–10] This escalating cycle can, thus, adversely affect efforts to socialize and engage in activities that would lessen the risk of falling and other serious health conditions. Effective interventions to lessen fear of falling could therefore have significant consequences for individuals, their families, and healthcare delivery systems. Understanding fear of falling alone, without consideration of other chronic conditions and depressive symptoms, may not be sufficient to guide intervention activities.[10]

Few studies have evaluated interventions to reduce fear of falling. Recently, one[11] showed that seniors involved in a physical activity program or an education program had a decrease in fear of falling from their baseline measures of fear. Another study of 434 persons aged 60 and older showed that fear of falling could be reduced using a cognitive-behavioral program but only if the results were restricted to participants compliant with the program rather than all randomized participants.[12] Part of the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) trial[13] showed that a multifactorial intervention could reduce fear of falling in those who, on average, had minimal fear of falling at baseline. Also as part of FICSIT, it

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was found that, in robust older persons, a 16-week tai chi intervention resulted in a statistically significantly greater reduction in fear of falling than in an exercise control group.[14]

Recently, it was shown that a 48-week tai chi intervention for transitionally frail older adults can lead to a reduction in falls (primary outcome) after a 3-month latency period in learning the basic tai chi exercise forms.[15] Tai chi training may improve strength and flexibility,[16,17] balance,[18] blood pressure,[19] cardiorespiratory function,[20] and self-esteem[21] in older adults.

The prevalence of fear of falling and its association with several baseline demographic, functional, and behavioral characteristics in older transitionally frail older adults was previously reported.[22] Given the apparent effects of tai chi on balance, strength, and self-esteem and reduction in falls, the aim of this analysis was to determine the extent to which tai chi affects fear of falling, a secondary outcome of the 48-week single-blinded cluster-randomized controlled intervention trial in transitionally frail older adults.

METHODS

Facilities

Forty-nine independent living facilities in the greater Atlanta metropolitan area were considered, and 43 were visited.[23] From this list of 49, the study was conducted in 20 congregate living facilities between September 1997 and August 2001. The two primary reasons for why an independent living facility was excluded were evidence of poor staff support for implementing the study or too small a pool of participants, usually fewer than 75 potential candidates.[23] The target recruitment goal was to enroll at least 15 participants from each facility. Twelve facilities had more than 15 participants (maximum of 19), and all participants were allowed to enroll. Facilities were recruited in pairs by whether they were Housing and Urban Development (HUD) (n = 14) or private (n = 6) sites and then randomized to the tai chi or WE intervention group. A total capacity of 4,032 older adults could reside in the 20 congregate living facilities; the number per facility ranged from 98 to 349. Evaluators were blinded to intervention allocation, instructors were blinded to outcome measures, and participants were instructed not to disclose the intervention they received. The Emory University human investigation committee and the Centers for Disease Control and Prevention institutional review board approved this study. Written informed consent was obtained from all participants before their enrollment.

Study Participants

Details regarding the design and methodology of this trial have been reported elsewhere.[23] Briefly, inclusion criteria were age 70 and older, ambulatory (with or without assistive device), no severe or unstable medical conditions, absence of severe psychological conditions, no significant cognitive impairment (Mini-Mental State Examination (MMSE) score $\geq$24), history of one or more falls in the previous year, and transitioning to frailty (based upon Speechley and Tinetti's classification[24] of older adults into vigorous, transitional, and frail categories). Staff and administrators at the 20 facilities identified 2,288 of the 4,032 residents as being aged 70 and older, ambulatory, and cognitively competent. Forty-eight percent (n = 1,095) of these identified residents attended a recruitment event held at each facility. After each recruitment presentation, everyone (n = 688) who had signed interest sheets at the event was called. Working from a supplementary facility list, 696 additional potential participants were contacted via cold calls, yielding a total of 1,384 persons contacted after recruitment events. The main reasons for not scheduling persons for screening were an absence of falls within the previous 12 months (n = 359), self-report of poor health (n = 152), noninterest (n = 146), reluctance to commit to the time required for study participation (n = 116), reluctance to being randomized (n = 32), not being aged 70 and older (n = 32), too busy (n = 30), and other (n = 81). Of the remaining 436 persons who scheduled a screening appointment, 82 withdrew or canceled before the appointment, leaving 354 who were screened for participation.

Interventions

Tai chi consists of slow, rhythmic movements that emphasize trunk rotation, weight shifting, coordination, and a gradual narrowing of lower extremity stance. Six of the 24 simplified tai chi forms that best exemplified these movements and could be combined into a final product (2 continuous minutes of unassisted tai chi exercise) were used.[25,26] All tai chi exercise was standardized by having the two instructors practice with one another until their execution of the movement forms to be taught in each class were identical. One instructor was a tai chi grand master, and the other was his student, who had studied with him for more than 5 years. Participants progressed from often being dependent on assistive devices for upright support to performing 2 continuous minutes of tai chi without support. Intense tai chi was defined as two sessions per week at increasing durations starting at 60 minutes contact time and progressing to 90 minutes over the course of 48 weeks. The actual work time, exclusive of warm up and cool down, progressed from about 10 minutes to 50 minutes over the course of the 48 weeks.

The wellness education (WE) program was given at participating facilities for an hour each week and consisted of instruction about falls prevention; exercise and balance; diet and nutrition; pharmacological management; legal issues relevant to health; changes in body function; and mental health issues, such as stress, depression, and life changes. Interactive handout materials were provided, but there was no formal instruction in exercise. The total time for individual attention from instructor to participants in each group was comparable.

Measurement of Fear of Falling

The Falls Efficacy Scale (FES)[27] and the Activities-Specific Balance Confidence Scale (ABC)[28] are the two most frequently used surrogate measures for fear of falling in older persons. The reliability and validity of ABC and FES have been previously reported.[27–29] The FES and the ABC were measured at baseline and at 4-month intervals for 12 months.

Falls Efficacy Scale

The FES is based on the operational definition of fear as "low perceived self-confidence at avoiding falls during essential, relatively nonhazardous activities." A modified FES version used in the FICSIT trials was used here.[30] Briefly, participants were asked how concerned they were about the possibility of falling while performing 10 different activities on a four-category scale from 1 (not at all concerned) to 4 (very concerned). If participants indicated that they did not perform or were unable to perform the activity, they were encouraged to respond hypothetically. The FES emphasizes mainly indoor, home-based activities.

Activities-Specific Balance Confidence Scale

The ABC assesses the confidence with which one can engage in a wide range of activities of daily living, including those performed outside the home. For 16 specific activities, the participants were asked how confident they were in not losing their balance or becoming unsteady. Answers were rated on a 0% (no confidence) to 100% (complete confidence) scale. The ABC represents a wider activity range than the FES.

Additional Measurements and Definitions

Trained evaluators collected demographic, medical, functional, and behavioral data at baseline and every 4 months for each study participant. Interrater reliability of the evaluation team was maintained at a kappa of 0.98 or greater. For this analysis, demographic variables and selected measures were included based on their proven reliability and validity or their known association with falling or fear of falling.[1–10,29–31] Depression was assessed using the Center for Epidemiological Studies Depression Scale (CES-D).[31] This test for depression consists of 20 items measuring four domains of depressive symptoms, including depressive affect, positive affect, somatic symptoms, and interpersonal relationships. Scores of 16 or greater are indicative of depression. Gait speed was assessed using time to complete a 10-m walk;[32] the median value for all study participants was 0.97 m/s. Activity level at baseline was defined as active if participants reported exercising for at least 1 hour per week before study enrollment; otherwise they were considered sedentary. Other measures included the distance one could reach the arm forward at 90° shoulder flexion without moving the feet (functional reach test),[33] use of sedatives (narcotics, benzodiazepines, antidepressants, or phenothiazines), and number of fall events. Fall events were defined as events in which the participant unintentionally came to rest on an object (e.g., person, table, chest of drawers) that prevented center of mass from exceeding the base of support or came to rest on the floor or a lower object because the center of mass exceeded the base of support.[15] Details on the methodology to ascertain falls have been described previously.[15,23]

Dropouts

Dropouts were defined as noncompliance or absences by any participant who missed more than 8 consecutive weeks of the intervention. Beyond this interval, learning tai chi movement forms or WE materials already covered by the respective classes would have impeded the progress of those classes. Every effort was made to secure quarterly data from all randomized participants.

Statistical Analyses

Sample size and power considerations for the primary outcome, number of falls, have been described previously.[15,23] The primary analyses of the data were performed according to patients' original treatment assignment (intent-to-treat principle) and the inclusion of all data from all patients randomized in the final analysis. Baseline measurements of tai chi and WE participants were compared using a permutation test in which the unit of randomization is the independent living facility pair.[34] Baseline characteristics of completers and noncompleters for each intervention were compared with a one-sample t test on the difference, in which the unit of analysis was the facility.

Repeated-measures analyses using mixed linear models were performed for ABC and FES. These analyses included participant-level characteristics and congregate living facilities variation or clustering. Participants were clustered or nested within living facilities, with living facility pairs as a random effect and the participant as the experimental unit. A priori, selected demographic characteristics (age, sex, ethnicity) and risk factors for fear of falling (activity level at baseline, depression, gait speed, functional reach, use of sedatives, number of falls) were included as covariates, based upon previous literature.[1–10,35] For each covariate-adjusted analysis in Table 2, a saturated model was fit that included the main effects, the two-way interaction effects, and the three-way interaction. For example, for activity level at baseline, the two-way statistical interaction included intervention by time, intervention by activity level, and activity level by time, and the three-way interaction included intervention by activity level by time. Repeated-measures analyses of ABC and FES scores and percentage change from baseline were performed using a means model using SAS Proc Mixed (version 8, SAS Institute, Inc., Cary, NC), providing separate estimates of the means by time on study and intervention group. A compound-symmetry form in the repeated measurements was assumed for each outcome, and robust estimates of the standard errors of parameters were used to perform statistical tests and construct 95% confidence intervals (CIs).[36,37] Variance components included the cluster and the between- and within-participant components. The model-based means are unbiased with unbalanced and missing data, so long as the missing data are noninformative (missing at random). Sensitivity analyses for missing data, including those for participants who completed follow-up only, last observation carried forward, baseline observation carried forward, and multiple imputation (implemented using SAS Proc MI), showed similar results to repeated measures analyses, which suggest that the missing data were noninformative. Statistical tests were two-sided. A Bonferroni adjustment ($P < .01$) was used for the comparison of tai chi versus WE made at each of the four time points.

RESULTS

From December 1997 to September 1999, 311 persons were enrolled in this trial. A recruitment and randomization flow chart is shown in Figure 1. Twenty-four participants

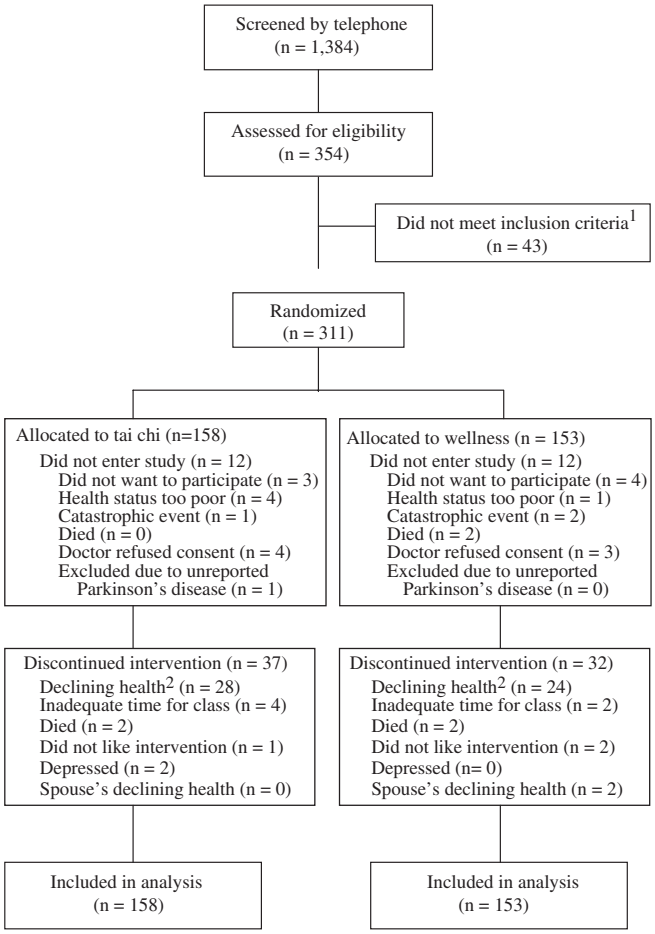

Figure 1. Progress through the stages of the tai chi (TC) and Wellness Education (WE) study, including flow of participants, withdrawals, and inclusion in analyses. Not meeting inclusion criteria: too frail (n = 7), chose to stop screening procedure (n = 7), progressive neurological disease (n = 6), too robust (n = 5), unstable coronary status (n = 5), Mini-Mental State Examination score <24 (n = 4), orthopedic problems (n = 3), emotionally unstable/early dementia (n = 2), recent cerebrovascular accident (n = 2), untreated abdominal aneurysm (n = 1), and severely compromised vision (n = 2).[1] Declining health reasons: injuries/fractures (n = 4, TC; n = 5, WE), deteriorating vision (n = 3, TC), cardiac (n = 3, TC; n = 3, WE), musculoskeletal/neurological impairment (n = 10, TC; n = 4, WE), loss of independence (n = 1, TC; n = 6, WE), stroke (n = 1, TC; n = 2, WE), cancer (n = 1, TC; n = 2, WE), diabetes mellitus (n = 1, TC; n = 1, WE), diverticulitis (n = 1, TC), major surgery (n = 1, TC), asthma (n = 1, TC), hospitalized at time of postintervention interview (participant later died) (n = 1, TC), and prolonged illness (n = 1, WE).[2]

randomized to tai chi (n = 12) and WE (n = 12) withdrew immediately after randomization because they were no longer interested (n = 7), perceived their health to be too poor (n = 5), were denied physician approval to participate (n = 7), experienced catastrophic health events (n = 3), or died (n = 2). One additional participant was later excluded because of a previously undetected diagnosis of Parkinson's disease.

The mean ABC and FES score at baseline was similar between the tai chi and the WE groups (Table 1). Most other baseline characteristics of the tai chi and WE groups were also similar, except that persons in the tai chi group had better functional reach ($P = .05$) than those in the WE group. The 24 persons who dropped out after randomized assignment had similar baseline characteristics to those in their respective treatment groups. Of the remaining 286 participants, 69 (24%) did not complete the intervention: 37 in the tai chi group and 32 in the WE group ($P = .58$).

The baseline characteristics of the 217 persons who completed the entire 48-week trial were compared with those of the 94 persons (50 in the tai chi group and 44 in the WE group) who did not complete the entire trial (Table 1). Overall, completers and noncompleters were similar in age, sex, race, education, presence of depression, activity level, gait speed, impairment in gait/balance, presence of lower extremity disability, use of sedatives, body mass index, and fear of falling according to the ABC and FES. Noncompleters had less functional reach than did completers ($P < .001$). Tai chi noncompleters were more likely than tai chi completers to have slower gait speed ($P = .02$), more impairment in gait/balance ($P = .04$), and worse functional reach ($P < .001$), and WE noncompleters were more likely than WE completers to have worse functional reach ($P = .05$).

ABC in the two study cohorts changed in significantly different ways during the intervention trial ($P < .001$, test for interaction between intervention group and time) (Table 2, Figure 2A,C). Mean ABC was similar in both cohort groups at the time of randomization but became significantly higher (better) in the tai chi cohort at 8 months (57.9 vs 49.0, $P < .001$) and at 12 months (59.2 vs 47.9, $P < .001$). Mean differences at 8 months and 12 months were 8.9 points (95% CI = 3.8–13.9) and 11.3 points (95% CI = 6.3–16.4), respectively. Mean FES became significantly lower (better) in the tai chi cohort at 8 months (18.4 vs 20.5, $P = .01$) and at 12 months (17.6 vs 21.2, $P < .001$). All subsequent analyses reported herein use the ABC only.

The pattern of change in ABC means over time by treatment group was consistently different for one level of a covariate than for the other level for baseline activity level, baseline depression, baseline functional reach, use of sedatives, and number of falls during the study period (Table 2). For each level of these covariates, the tai chi group had a statistically significantly greater mean ABC over time than the WE; this difference between the tai chi and WE groups was greatest at 12 months. However, for race and gait speed, an intervention effect was seen for Caucasians but not African Americans.

All of the variables listed in Table 2 were included in a multivariable model. After adjusting for each covariate, the mean ABC after 12 months was significantly greater in the tai chi group than in the WE group, with increasing differences over time (Table 3, Figure 2B). The mean difference after 12 months of intervention was 9.5 points higher in the tai chi group than the WE group (95% CI = 4.8–14.2). The percentage change in ABC from baseline increased over the 12 months in the tai chi group (mean percentage increase = 13.4%, 95% CI = 6.4–20.4), but, in the WE group, the percentage change in ABC was less than baseline at 12 months (mean percentage decrease = 4.2%) (Figure 2D).

Adherence to the tai chi exercise and to the WE program was assessed by maintaining weekly attendance records and calculating the percentage of total sessions

Table 1. Baseline Characteristics of the Study Completers Versus Noncompleters for the Two Intervention Groups

Characteristic	Tai Chi			Wellness Education		
	Completers (n = 108)	Noncompleters (n = 50)	*P*-value	Completers (n = 109)	Noncompleters (n = 44)	*P*-value
Sex, n (%)						
Male	5 (5)	5 (10)	.35	7 (6)	3 (7)	.61
Female	103 (95)	45 (90)		102 (94)	41 (93)	
Race, n (%)						
Caucasian	86 (80)	40 (80)	.80	92 (84)	32 (73)	.29
Non-Caucasian*	22 (20)	10 (20)		17 (16)	12 (27)	
Education, n (%)						
<12 years	20 (19)	11 (22)	.16	24 (22)	11 (25)	.63
≥12+years	88 (81)	39 (78)		85 (78)	33 (75)	
Depression, n (%)†						
Absent	86 (80)	34 (68)	.19	84 (77)	29 (66)	.22
Present	22 (20)	16 (32)		25 (23)	15 (34)	
Activity level, n (%)						
Sedentary	41 (38)	23 (46)	.55	45 (41)	26 (59)	.22
Active	67 (62)	27 (54)		64 (59)	18 (41)	
Gait speed, n (%)						
<0.97 m/s	48 (44)	28 (56)	.02	63 (58)	26 (59)	.82
≥0.97 m/s	60 (56)	22 (44)		46 (42)	18 (41)	
Impairment gait/balance, n (%)						
Impaired	96 (89)	50 (100)	.04	102 (94)	42 (95)	.92
Normal	12 (11)	0 (0)		7 (6)	2 (5)	
Lower extremity disability, n (%)‡						
Absent	41 (38)	19 (38)	.62	42 (39)	18 (41)	.92
Present	67 (62)	31 (62)		67 (61)	26 (59)	
Functional reach, n (%)						
<10 inches	21 (19)§	23 (46)§	.0002	42 (39)§	25 (57)§	.05
≥10 inches	87 (81)§	27 (54)§		67 (61)§	19 (43)§	
Use of sedatives, n (%)‖						
Yes	25 (23)	14 (29)	.29	26 (24)	12 (27)	.58
No	83 (77)	6 (71)		83 (76)	32 (73)	
Age, mean ± SD	80.4 ± 3.1	82.6 ± 3.7	.12	80.5 ± 3.2	80.9 ± 2.8	.78
Body mass index, kg/m^2, mean ± SD	26.9 ± 2.5	28.1 ± 3.6	.16	26.5 ± 2.2	27.3 ± 2.5	.12
Fear of falling						
Activities-specific Balance and Confidence Scale, mean ± SD¶	53.5 ± 9.2	49.9 ± 12.2	.41	52.1 ± 6.0	47.1 ± 12.8	.20
Falls Efficacy Scale, mean ± SD#	19.9 ± 2.2	20.4 ± 2.6	.63	19.9 ± 1.5	21.2 ± 4.9	.39

* Fifty-five African-American and six other.
† Using Center for Epidemiologic Studies Depression Scale; a score of ≥16 indicates presence of depression.
‡ Gross lower extremity motor impairment; disability and impairment based upon reference 24 definitions.
§ All participants combined in the tai chi group had better functional reach than those in the wellness education group ($P = .05$).
‖ Narcotics, benzodiazepines, antidepressants, or phenothiazines.
¶ Confidence in percentage not to lose balance.
# 10 = not at all concerned about falling; 40 = very concerned about falling.
SD = standard deviation.

attended. The average attendance ± standard deviation in the tai chi group was 76 ± 19% (range 6–100%), whereas the average attendance for the WE group was 81 ± 17% (range 10–100%). No adverse events occurred during the tai chi or WE intervention. One participant sustained an ankle abrasion during the medical evaluation.

DISCUSSION

The results from this study show that a 48-week tai chi intervention for transitionally frail older persons led to a significant reduction in fear of falling. Older persons in the tai chi group had a continued improvement in average fear of falling at each subsequent time period. The difference in effect with the WE group increased over each time interval and was greatest at 12 months. Fear of falling was lower in tai chi than in WE participants, regardless of activity level, presence or absence of depression, use of sedatives, or functional reach at baseline or the number of falls during the study. The effect of tai chi on reducing fear of falling remained even after adjusting for covariates.

Table 2. ABC Scores according to Intervention (Tai Chi Training or Wellness Education Program) and Time on Study by Covariates

	Baseline		4-month		8-month		12-month		Covariate	Intervention	Intervention by Time
Covariate	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE	*P*-value		
Intervention									—	.001*	<.001*
Tai chi	153	53.0 ± 1.90	127	56.6 ± 1.99	115	57.9 ± 2.02	108	59.2 ± 2.05			
Wellness	158	50.1 ± 1.92	130	52.1 ± 1.98	116	49.0 ± 2.03	109	47.9 ± 2.05			
P-value: tai chi vs wellness		.22		.07		<.001*		<.001*			
Activity level at baseline									.003*	.001*	<.001*
Sedentary											
Tai chi	64	51.8 ± 2.78	50	53.3 ± 2.95	45	56.2 ± 3.02	41	56.1 ± 3.08			
Wellness	71	45.1 ± 2.64	59	48.2 ± 2.76	54	44.3 ± 2.80	45	43.0 ± 2.92			
P-value: tai chi vs wellness		.06		.18		.002*		.001*			
Active											
Tai chi	94	53.7 ± 2.38	77	58.8 ± 2.49	70	59.1 ± 2.53	67	61.2 ± 2.55			
Wellness	82	54.5 ± 2.51	71	55.5 ± 2.58	62	53.2 ± 2.65	64	52.0 ± 2.64			
P-value: tai chi vs wellness		.80		.31		.08		.006*			
Depression at baseline									<.001*	.002*	.002*
Absent											
Tai chi	120	52.4 ± 1.95	106	58.0 ± 2.01	95	60.1 ± 2.05	92	59.6 ± 2.06			
Wellness	113	52.0 ± 1.98	93	53.5 ± 2.07	80	51.4 ± 2.13	82	50.3 ± 2.12			
P-value: tai chi vs wellness		.86		.08		.001*		<.001*			
Present											
Tai chi	38	54.7 ± 2.79	21	49.2 ± 3.38	20	48.4 ± 3.36	16	57.6 ± 3.69			
Wellness	40	44.5 ± 2.72	37	48.7 ± 2.72	36	43.6 ± 2.71	27	40.6 ± 2.98			
P-value: tai chi vs wellness		.006*		.91		.24		<.001*			
Functional reach at baseline									<.001*	.004*	<.001*
<10 inches											
Tai chi	44	48.5 ± 2.67	26	54.3 ± 3.12	29	55.2 ± 2.90	27	52.8 ± 2.97			
Wellness	67	48.6 ± 2.28	47	51.2 ± 2.51	41	46.6 ± 2.59	46	42.8 ± 2.49			
P-value: tai chi vs wellness		.97		.42		.02		<.001*			
≥10 inches											
Tai chi	114	54.7 ± 1.98	101	57.5 ± 2.03	86	59.3 ± 2.11	81	61.8 ± 2.14			
Wellness	86	51.3 ± 2.12	83	52.7 ± 2.13	75	50.4 ± 2.18	63	51.8 ± 2.28			
P-value: tai chi vs wellness		.20		.07		.001*		<.001*			
Race and gait speed at baseline									<.001*	.05	.12
White, <0.97m/s											
Tai chi	55	51.9 ± 2.39	38	54.0 ± 2.70	31	55.5 ± 2.86	33	57.1 ± 2.77			
Wellness	69	46.6 ± 2.25	55	46.5 ± 2.40	43	41.2 ± 2.60	45	40.3 ± 2.51			
P-value: tai chi vs wellness		.09		.03		<.001*		<.001*			
African-American, <0.97m/s											
Tai chi	21	42.6 ± 4.10	15	54.4 ± 4.50	14	46.2 ± 4.63	13	46.8 ± 4.73			
Wellness	20	37.0 ± 4.19	15	47.8 ± 4.56	12	36.8 ± 4.92	8	38.2 ± 5.56			
P-value: tai chi vs wellness		.33		.29		.15		.23			

(Continued)

Table 2. (contd.)

	Baseline		4-month		8-month		12-month		Covariate	Intervention	Intervention by Time
Covariate	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE	n	Mean ± SE	*P*-value		
White/other, ≥0.97m/s											
Tai chi	71	57.9 ± 2.24	64	59.7 ± 2.26	61	63.2 ± 2.30	53	64.9 ± 2.38			
Wellness	56	59.7 ± 2.42	54	58.8 ± 2.42	54	57.4 ± 2.40	47	56.0 ± 2.50			
P-value: tai chi vs wellness		.57		.77		0.06		.006*			
African-American, ≥0.97m/s											
Tai chi	11	47.7 ± 5.16	10	52.8 ± 5.17	9	52.9 ± 5.41	9	54.8 ± 5.41			
Wellness	8	47.8 ± 5.89	6	57.6 ± 6.34	7	54.4 ± 5.88	9	58.0 ± 5.36			
P-value: tai chi vs wellness		.99		.55		.86		.67			
Use of sedatives									.21	.01*	.01*
No											
Tai chi	119	52.2 ± 2.10	97	56.0 ± 2.21	89	58.3 ± 2.24	83	58.2 ± 2.27			
Wellness	115	49.1 ± 2.14	99	51.9 ± 2.21	90	47.7 ± 2.25	83	46.4 ± 2.29			
P-value: tai chi vs wellness		.24		.15		<.001*		<.001*			
Yes											
Tai chi	39	55.2 ± 3.40	30	58.5 ± 3.61	26	56.5 ± 3.74	25	62.2 ± 3.77			
Wellness	38	52.3 ± 3.54	31	52.6 ± 3.68	26	53.6 ± 3.84	26	52.5 ± 3.84			
P-value: tai chi vs wellness		.67		.24		.58		.06			
Number of falls while on study†									.91	.002*	<.001*
0											
Tai chi	76	53.0 ± 2.49	62	57.6 ± 2.63	56	58.2 ± 2.69	52	59.1 ± 2.73			
Wellness	55	50.6 ± 2.89	50	51.7 ± 2.96	43	50.2 ± 3.06	41	50.2 ± 3.09			
P-value: tai chi vs wellness		.53		.12		.04		.03			
1											
Tai chi	35	50.3 ± 3.60	32	56.4 ± 3.67	29	59.9 ± 3.74	29	63.0 ± 3.74			
Wellness	42	48.6 ± 3.30	39	52.6 ± 3.33	36	50.6 ± 3.40	34	48.1 ± 3.44			
P-value: tai chi vs wellness		.73		.41		.06		.003*			
≥2											
Tai chi	34	56.6 ± 3.64	33	55.7 ± 3.67	30	56.3 ± 3.75	27	56.1 ± 3.83			
Wellness	44	51.8 ± 3.21	41	52.6 ± 3.29	37	46.8 ± 3.34	34	45.4 ± 3.40			
P-value: tai chi vs wellness		.30		.51		.05		.03			

* Statistically significant.
† Twenty-five participants (13 tai chi and 12 wellness) did not provide any data on this variable.
SE = standard error.

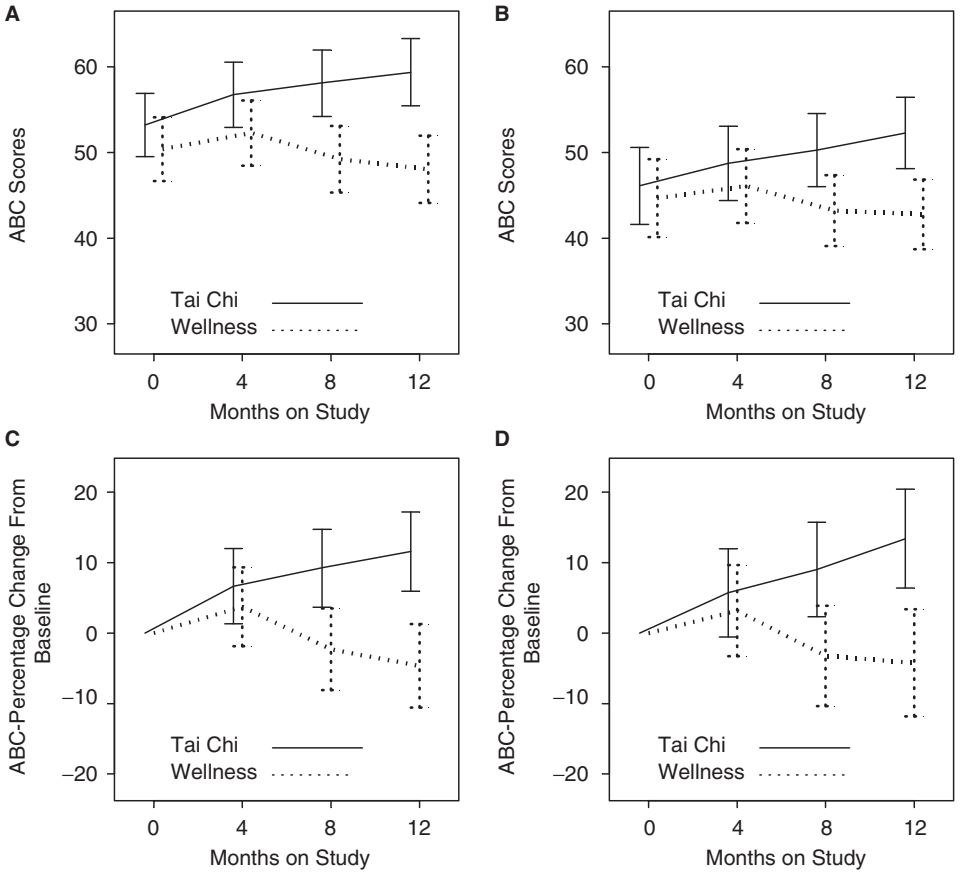

Figure 2. Longitudinal changes in activities-related fear of falling measured using the Activities Balance Confidence Scale (ABC) by intervention (tai chi exercise program or wellness education program). The vertical bars indicate the 95% confidence intervals for the mean. A: Mean ABC scores from univariate analysis (Table 2). B: Mean ABC scores from multivariable analysis (Table 3). C: Mean percentage change from baseline in ABC scores from univariate analysis. D: Mean percentage change from baseline in ABC scores from multivariable analysis.

The results also show that African Americans tended to have a greater fear of falling than Caucasians, regardless of baseline gait speed. Tai chi was no better at reducing fear of falling for African Americans than WE in those with a gait speed of 0.97 m/s or greater or in those with a gait speed less than 0.97 m/s. The reason for this lack of effect is unclear but may reflect differences in perceived safety in one's environment or small numbers of African Americans in the sample; therefore, these data should be interpreted cautiously. Little information exists about differences of and reasons for fear of falling in racial/ethnic groups other than Caucasian.[9,22]

When the data were reanalyzed using the FES, similar results to those derived using the ABC score were obtained. Because of the known strong correlation between these measures,[22,27,29] and the larger variety of environments in which to assess confidence in not falling using the ABC versus the FES, the ABC was chosen for reporting most of the final results. Although frequently used as surrogates for fear of falling, the FES and the ABC scales used in this study have some limitations. The FES is restricted to self-reports regarding fear of falling in the home only, whereas the ABC addresses confidence that one will not fall under a variety of circumstances but does not capture the behavior of fear. In this regard, the development of a behavioral scale that better engages the fear of falling in this transitional or intermediate frail group is warranted.[38]

Tai chi is a martial art, and its underlying philosophy was developed in China many centuries ago,[39,40] but its use in Western culture is relatively new. It teaches precise body movements while maintaining a tranquil, concentrated mind, and its performance relies more on image recollection than memorization of instruction.[41] Tai chi has postulated effects on balance, mental outlook, and stress that might directly affect fear of falling. A multivariable analysis of the data from FICSIT revealed that fear of falling was a predictor of subsequent falls.[14] Findings from that study also suggested that tai chi practice increased older participants' sense of well-being when performing other activities[14] and favorably affected older participants' activities of daily living.[42] Another study showed that women practicing an exercise program like tai chi experienced significant reductions in tension, depression, and anger, with an overall improvement in mood.[43] Also, experienced tai chi practitioners have lower levels of salivary cortisol concentration, suggesting reduced stress, a notion confirmed by participant reports of reduced tension and anxiety compared with sedentary control participants.[44] Other studies have shown that tai chi can reduce resting systolic blood pressure,[14,19,45] can reduce the rate of cardiorespiratory decline compared with age-matched sedentary controls,[46]

Table 3. Multivariable Analysis of Activities-Specific Balance and Confidence Scale (ABC): Adjusted Mean ABC at 12 Months After Baseline by Treatment Intervention Program, Depression, Functional Reach, Race, Gait Speed, and Number of Falls

Covariate	Mean ABC	95% Confidence Interval	*P*-value
Treatment intervention			.008
Tai chi	52.3	(48.1–56.5)	
Wellness	42.8	(38.7–46.8)	
Depression			<.001
Absent	49.8	(46.4–53.1)	
Present	43.8	(40.0–47.5)	
Functional reach			.006
<10 inches	45.2	(41.7–48.8)	
≥10 inches	48.3	(44.8–51.8)	
Race and gait speed			<.001
White/other <0.97 m/s	45.8	(42.4–49.2)	
African-American <0.97 m/s	39.6	(34.2–44.9)	
White/other ≥0.97 m/s	54.3	(50.9–57.6)	
African-American ≥0.97 m/s	47.4	(41.1–53.7)	
Number of falls*			.01
0	49.4	(46.6–52.3)	
1	50.4	(47.0–53.7)	
2	50.1	(45.7–54.6)	
3	41.7	(35.5–47.9)	
4	47.4	(40.1–54.6)	
5+	41.6	(35.5–47.8)	

Note: Reported means are least-squares means that adjust for other factors in the model. The multivariable model for ABC scores included, initially, the treatment intervention, baseline depression, baseline functional reach, baseline race and gait speed, use of sedatives, and number of falls as a time-dependent covariate. Use of sedatives was not statistically significant in the multivariable analysis, and the model was refit without "use of sedatives" for the final analysis. The treatment intervention means are the estimated ABC means after 12 months of follow-up, averaged over levels (categories) of the other factors. The estimated means for levels of the other covariates (e.g., depression) represent the ABC scores, averaged over levels of the other factors. Reported *P*-values are for comparing the means across categories of each variable, after adjusting for the other variables in the model.

* Time-dependent covariate. Participants were classified according to the number of falls at the time of each ABC measurement. As the number of falls increased over time, the mean ABC scores tended to decline.

can lead to a reduction in self-perceived stress scores and stress assessed by skin temperature measurements,[47] can produce greater enjoyment compared with the activities of a control group,[48] and can produce a feeling of self-efficacy to perform movements in a continuous and qualitatively pleasing way.[49] Findings from the latter study also suggested that there may be a relationship between self-efficacy in movement performance and adherence to the tai chi exercise program.[49]

Fear of falling is common in older persons and can lead to gait alteration, deconditioning, activity restriction, decreased social interaction, worsening perceived health status, and increasing risk of falling.[1–10,35] It was recently reported that older persons with fear of falling had greater declines in ability to perform activities of daily living than did those with no fear of falling over a 12-month period.[7] Persons who had not fallen but were fearful had a greater risk of admission to an aged care institution. Persons who have fear of falling alone may differ from persons who are afraid and restrict their activities.[10] The current study found that tai chi significantly increased confidence in preventing falls and reduced fear of falling in those who were sedentary or active at baseline. Moreover, fear of falling was lower in tai chi than in WE participants, independent of the number of falls sustained by the participants.

The result showing that nearly half of all participants were afraid of falling at baseline is consistent with a transitionally frail population because it lies between previous prevalence estimates from vigorous and frail groups.[1–7,10] That tai chi can reduce fear of falling in transitionally frail older persons is important because the transitional stage may be the last opportunity to have an effect on frailty.[22] It also builds on previous work that showed that tai chi can reduce fear of falling in robust older adults.[14]

This study has several limitations. First, the study sample was not large enough, nor was the original study designed to determine whether tai chi could alter changes in fear of falling immediately after a fall. Knowing whether tai chi had immediate effects in reducing fear of falling after a fall and how quickly after a fall tai chi should be begun would be important in designing a targeted intervention program. Nevertheless, all of the study participants had a history of one or more falls in the previous year. Second, data on fear of falling were not collected beyond the 48-week study period, so it is unknown whether the changes seen in this study will persist. In a previous Atlanta FICSIT trial, more than 35% (personal communication, SL Wolf, 2004) and up to nearly half[14] of the tai chi participants continued tai chi exercise after the study concluded, suggesting that the general sense of well-being can lead older adults to exercise more. Third, male participation was lower than expected. Anecdotal comments from spouses suggested that their male partners were too frail to participate or were too busily engaged in other activities.[15] Finally, 94

(30%) of the transitionally frail participants did not complete the 48-week trial. It is possible that the changes observed over time in the tai chi group were due to differential dropout of more frail individuals. The mixed model analysis was used to reduce this bias.[50] In addition, many transitional older people declined to participate in this study. Therefore, the study results may not generalize to the entire population of transitional older people or to those with lesser or greater degrees of physical frailty.

Tai chi is a safe exercise form for older adults willing and able to participate and fosters focused mental control over body movements. Given that tai chi can improve balance confidence, tai chi could be considered a therapeutic exercise to build falls confidence in the face of declining functional and cognitive abilities in older adults and to counteract fears about losing balance or falling. Tai chi should be considered in any program designed to reduce falling and fear of falling in transitionally frail older adults.

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