Research Report

Community-Based Tai Chi and Its Effect on Injurious Falls, Balance, Gait, and Fear of Falling in Older People

Background and Purpose. It is important to determine the effect of adherence to a tai chi program on falls and related functional outcomes in older people. This study examined the effect of a community-based tai chi program on injurious falls, balance, gait, and fear of falling among people aged 65 years and older in Taiwan. Subjects and Methods. In 6 rural villages in Taichung County, 1,200 subjects participated in the initial assessment. During a 1-year intervention period, all study villages were provided with education on fall prevention. Two villages had been provided tai chi exercise (n=472 participants or "tai chi villagers"), and 4 villages served as control villages (n=728 participants or "control villagers"). Injurious falls were ascertained by telephone interviews every 3 months over a 2-year study period; additionally, balance, gait, and fear of falling were assessed in 2 follow-up assessments. Results. Eighty-eight subjects, 83 from the tai chi villages and 5 from the control villages, participated and practiced in the tai chi program (the group labeled "tai chi practitioners"). After the tai chi program, injurious falls among the control villagers significantly declined by 44% (adjusted rate ratio [RR]=0.56; 95% confidence interval [CI]=0.36–0.92). Compared with the results for the control villagers, the decline was 31% greater (RR=0.69; 95% CI=0.30–1.56) among the tai chi villagers and 50% greater (RR=0.5; 95% CI=0.11–2.17) among the tai chi practitioners; the results did not reach statistical significance. Furthermore, compared with the scores for the control villagers, the scores for the tai chi practitioners increased by 1.8 points (95% CI=0.2–3.4) on the Tinetti Balance Scale and increased by 0.9 point (95% CI=0.1–1.8) on the Tinetti Gait Scale. No significant changes in the fear of falling were detected among the tai chi practitioners, tai chi villagers, and control villagers. Discussion and Conclusion. Tai chi can prevent a decline in functional balance and gait among older people. However, the reduction in injurious falls attained with tai chi did not reach statistical significance; the statistical inefficiency may have resulted partly from the large decline in injurious falls in control villagers. Finally, the unexpected effect of educational intervention on reducing injurious falls in different settings needs to be further examined. Lin MR, Hwang HF, Wang YW, et al. Community-based tai chi and its effect on injurious falls, balance, gait, and fear of falling in older people. *Phys Ther*. 2006;86:1189–1201.]

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Preventing falls is very important for older people and for society. Of community-dwelling older people, 30% to 50% fall at least once a year.[1–5] Furthermore, falls are the most common cause of injuries and hospital admissions among people aged 65 years and older,[6] accounting for 87% of all fractures, and are the second leading cause of spinal cord and brain injuries. Falls also lead to psychological trauma,[7–9] motor deficits, and loss of autonomy,[1,4,5,10,11] as well as enormous economic costs.[12,13]

Tai chi has only recently been recognized as a potentially effective exercise for fall prevention and other health outcomes among older people in Western societies,[14–17] even though this traditional Chinese exercise has been practiced for centuries for health promotion and self-defense in Asian countries.[18] Tai chi exercise was devised particularly to produce balanced movements between yin and yang in a slow, meditative, and relaxed way, with sequential graceful movements that emphasize the smooth integration of trunk rotation, weight shifting, and coordination and a gradual narrowing of the lower-extremity stance.[19] Its intensity is moderate and approximately equivalent to walking at a speed of 6 km/h.[20]

By improving cardiorespiratory function, spinal flexibility, muscle strength, and postural control among older people,[21–24] tai chi is believed to be one of the most promising exercises that older people can practice to reduce falls and related risk factors,[25] as well as providing an alternative or adjunct to Western-style exercise programs. Nevertheless, only one study has directly examined the effect of tai chi on an actual reduction in falls until now,[15] and few studies have adjusted for the heterogeneity of background medical characteristics. Furthermore, despite the fact that clinically based tai chi exercise has been reported to improve balance and reduce psychological trauma in older people, to facilitate greater feasibility and generalizability to older populations,[14,15,23,24] it is important to determine the effects of adherence to a tai chi program in communities on falls and related functional outcomes.

Therefore, a 2-year community intervention trial was conducted to examine the effect of a tai chi program on injurious falls among older people in Taiwan. Furthermore, the effect of the program on fall-related outcomes, such as balance, gait, and fear of falling, also was measured.

Method

Study Subjects

Shin-Sher township, located in Taichung County in west central Taiwan, is a rural area. Out of 13 villages in Shin-Sher, 6 villages with larger older populations were selected for the study. Two adjacent villages (Ta-Nan and Shin-Sher) with the largest older populations were selected purposely to promote tai chi exercise, primarily because they had existing public places that could be used for exercise by older people (referred to in our study as "tai chi villages"). Another 4 villages (Yung-Yuen, Hsieh-Cheng, Chung-Hsing, and Tung-Hsing) with the second largest older populations served as control villages. On the basis of records in the Shin-Sher Household Registration Office, in which demographic information is collated and stored, 754 people aged 65 years and older in the tai chi villages and 1,318 people in

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the control villages were selected, with information on name, address, birth date, sex, and education. Of the 2,072 registered people, 472 in the tai chi villages (226 from Ta-Nan and 246 from Shin-Sher) and 728 in the control villages (195 from Yung-Yuen, 224 from Hsieh-Cheng, 154 from Chung-Hsing, and 155 from Tung-Hsing) agreed to participate in the study. On the basis of the sample size, the estimated study power was .78 when a reduction in injurious falls of 30% in the tai chi villages, an incidence rate for injurious falls of 0.14, and a significance level of .05 for 2-tailed testing were used.[26] Of the 872 subjects who did not participate, 24 had died, 59 were hospitalized or bedridden, 252 had moved out of the area, 323 were not at home during the assessment period, and 214 declined to be interviewed. A flow diagram of the study population is shown in Figure 1. Compared with the participants, the nonparticipants had similar distributions of sex and educational level but tended to be older (data not shown). Verbal consent was obtained from all participants.

Initial Assessment

In the initial assessment, subjects were personally interviewed at the subjects' residences; interview procedures and interviewer attitudes were standardized through participation in a 4-hour training course. In the interview, information was collected on demographics, type of regular exercise (eg, free movement, general walking, brisk walking, jogging, tai chi, other traditional exercises, and others), frequency of exercise in the last 2 weeks (measured as the number of days in which they had exercised), length of time exercised per day (minutes), fall history in the past year, use of walking aids, comorbidity, number of medications used, cognition, and independence in activities of daily living (ADL). Comorbidity was assessed on the basis of a list of 24 chronic conditions that are likely to affect older people. The level of depression was assessed with the 15-item Geriatric Depression Scale,[27,28] with a score of higher than 10 being indicative of depression.[29] Cognitive status was assessed with the Mini-Mental State Examination (MMSE)[30,31]; MMSE scores were categorized into 3 levels, 0 to 17, 18 to 23, and 24 to 30, indicating severe, mild, and no cognitive impairment, respectively.[32] The Older Adults Resources and Services ADL Scale,[33,34] consisting of 7 items for physical ADL and 7 items for instrumental ADL, was used to assess independence, with a higher score indicating greater dependence.

Interventions

Educational program. Information on fall prevention was provided to the older people in all 6 study villages throughout the entire second year of the study by hanging posters in public places where older people often congregated and by distributing pamphlets to each participant. With simple words, large letters, and attractive pictures and drawings, the posters and pamphlets provided instruction on 3 types of exercises (eg, lower-limb stretching and strengthening and tai chi), use of walking aids, and environmental improvements (eg, lighting stairways, using nonskid carpets and rubber mats, keeping items on the lower shelves of cabinets, coiling cords and wires, keeping objects off the floor, and fixing loose or uneven steps) to facilitate older people initiating and continuing these activities independently. Older people who exercised routinely also were encouraged to continue doing so.

Tai chi program. At the first follow-up visit, each participant living in the 2 tai chi villages was informed that a free class for teaching and practicing tai chi, especially for people aged 65 years and older, would be held in each village in the second year; furthermore, for nonparticipants at the follow-up visit, this information also was posted at places where older people often visited. Chen-style tai chi with 13 movements was taught and practiced at existing public places for exercise by an instructor and 5 assistants who volunteered from a local association for Chen-style tai chi in Taichung County. The tai chi exercise was scheduled for 1 hour per day in the morning at 5:30 to 6:30 AM 6 days per week in each village, and each 1-hour session consisted of a 10-minute warm-up, 45 minutes of tai chi practice, and a 5-minute cool-down.

At the time of the initial assessment, 3 subjects in Shin-Sher reported practicing tai chi at home on their own. During the intervention period, 88 subjects (32 in Ta-Nan, 51 in Shin-Sher, 2 in Yung-Yuen, 1 in Hsieh-Cheng, and 2 in Tung-Hsing) participated in the tai chi program (referred to in our study as "tai chi practitioners"). Class attendance by these practitioners at the tai chi sessions was recorded throughout the intervention year.

Follow-up Measures

Ascertainment of falls. A *fall* was defined as an event that resulted in an individual coming to rest unintentionally on the ground or other lower level, not as a result of a major intrinsic event (eg, a stroke) or overwhelming hazard (eg, an earthquake).[4] To minimize the disturbance to older people because of memory lapses, only injurious falls (ie, falls that required medical care) were counted in the study. Participants were asked to report their falls, by telephone or postcard, when an injurious fall occurred. A research assistant also contacted each participant by telephone at 3-month intervals over the 2-year study period to ascertain the occurrence of injurious falls.

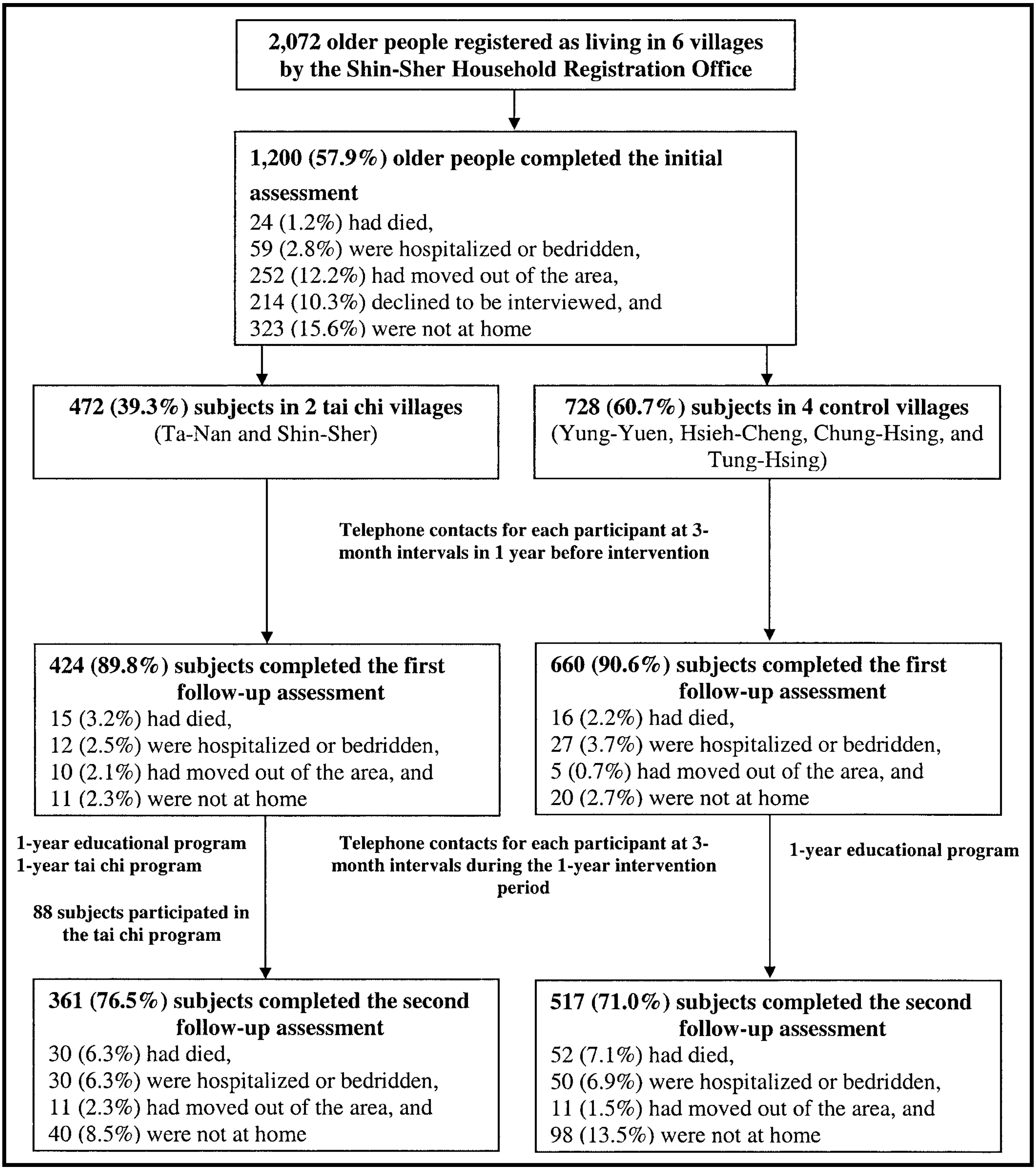

Figure 1.
Flow diagram of the study subjects.

To avoid a possible bias of differential collection of injurious falls between the tai chi villagers and the control villagers, the research assistant who collected information on falls by telephone interviews every 3 months was unaware of which villages were participating in the tai chi intervention program. Furthermore, 6 of 9 clinics in the study villages responded to our request to provide numbers of older people who needed medical care because of consequences of falls over the study period to validate the self-reported injurious falls in the telephone interviews. Time trends for the rates of injurious falls at 3-month intervals from the 2 data sources (telephone interviews and clinical records) were compared to determine whether they were similar.

During each telephone contact, information on exercise frequency and duration within the last 2 weeks among tai chi practitioners, non–tai chi practitioners, and control villagers also was collected to determine whether the tai chi program produced a community-level effect for older people who did not practice tai chi (ie, whether there was a dissemination effect or a benefit of the tai chi program from practitioners to neighboring nonpractitioners). The mean changes in exercise duration before and after the tai chi program in the 3 groups were calculated, and the pair-wise differences in these mean changes were compared by use of the *t* test.

Balance, gait, and fear of falling. Three secondary outcomes—balance, gait, and fear of falling—were assessed at 2 follow-up assessments at a 1-year interval (ie, immediately before and after the intervention); in these assessments, personal interviews with structured questionnaires were carried out at the subjects' residences. The Performance-Oriented Assessment of Mobility Problems test,[35] comprising 2 components (balance and gait), can be applied easily to a large community-based sample and yields reliable and valid data.[36] The balance component consists of 13 maneuvers: sitting balance, sit to stand, immediate standing balance (in the first 3–5 seconds), standing balance, balance with eyes closed, turning 360 degrees, nudging the sternum (slightly pushing the chest), turning the neck, unilateral stance, extending the back, putting down and picking up an object, and sitting down. The score on the balance component varies from 0 to 26, with a higher score indicating better balance ability. The gait component consists of 9 maneuvers: initiation of gait, step height and length, step symmetry and continuity, path deviation, trunk stability, walking stance, and turning while walking. The score on the gait component varies from 0 to 9, with a higher score indicating better functional mobility. Minimum scores for the balance and gait components were assigned for subjects who were unable to do the test. Fear of falling was assessed by use of a 10-cm visual analog scale. The ends of the scale were marked with the labels "No fear" and "Extremely fearful." Each participant was asked to place a mark on the line at a point representing the extent of his or her fear.

Data Analysis

The logistic regression model was applied to identify factors associated with incomplete telephone contacts; these factors subsequently would be controlled for in an attempt to eliminate selection bias when estimating the independent effect of the tai chi program on each outcome of interest. Baseline characteristics were compared to examine whether they were balanced among the control villagers, tai chi villagers, and tai chi practitioners by use of the Pearson chi-square test for categorical variables and the Mantel-Haenszel chi-square test for ordinal variables. There were 1 primary outcome (ie, injurious falls) and 3 secondary outcomes (ie, balance, gait, and fear of falling) of interest in this study; therefore, differences in rate changes for injurious falls and score changes for each secondary outcome before and after the intervention also were compared for the 3 groups.

Because injurious falls were count data, the Poisson regression model was applied to investigate the independent effect of tai chi on changes in the rates of injurious falls after adjustment for other variables. Because correlation existed in the repeated measures for each subject over the study period, the Poisson distribution assumption was violated in this study. Therefore, we used the method of generalized estimating equations (GEEs)[37] to account for within-subject correlations to estimate correct regression parameters and their standard errors in the Poisson regression model. Two dummy variables were created to represent tai chi practitioners and all subjects who lived in the tai chi villages (including 88 practitioners and 384 nonpractitioners) in comparison with the control villagers (the reference group); the 2 variables indicated, respectively, individual- and community-level effects of the tai chi program on injurious falls among older people. By use of the univariate analysis of the Poisson regression model, variables with a P value of $\leq .25$ were identified as potential confounders for the relationship of the tai chi program with rate changes for injurious falls; therefore, they were included in the subsequent multivariable analyses.[38] In the final model, the 2 dummy variables and those with P values of $\leq .05$ were selected. In the model, the exponential function of the regression coefficients of the interaction of the intervention groups (ie, the 2 dummy variables) with time was interpreted as rate changes for injurious falls over the 1-year intervention period in comparison with the results for control villagers (the reference group).

Because the 3 secondary outcomes were repeated continuous measures, the linear mixed-effect model for each secondary outcome was applied to estimate how it changed before and after the tai chi intervention and how the change depended on other variables.[39] With specifications of random intercepts and a random effect of village, the linear mixed-effect model can take into account the heterogeneity arising from the repeated measures of each secondary outcome within individuals and within villages. The assumption of normality for each secondary outcome was checked and was found not to be violated, according to the plot of residuals against predicted values of the final mixed model.[40] Two dummy variables representing individual- and community-level effects of the tai chi program and analytical procedures were the same as those used in the Poisson regression model for injurious falls. In the linear mixed-effect model, the regression coefficients of the interaction of the intervention groups with time were interpreted as score changes for each outcome over the 1-year intervention period in comparison with the results for control villagers.

To validate the self-reported injurious falls in the telephone interviews, the Poisson regression model with GEE was used to obtain the coefficients of time based on the telephone interviews and clinical records; the similarities of the 2 coefficients of time were tested further by use of the Wald statistic. Statistical Analysis Software version 8.0* was used for all statistical analyses.

Results

Among 1,146 subjects contacted by telephone at least once, 8 contacts were completed for 589 subjects, 5 to 7 contacts were completed for 279 subjects, and 1 to 3 contacts were completed for 278 subjects. Fifty-two subjects had no contact because they did not have a telephone, they moved out of the township, or they died. The logistic regression model indicated that older people who lived alone (adjusted odds ratio [OR]=2.85; 95% confidence interval [CI]=1.88–4.32), who had a Geriatric Depression Scale score of greater than 10 (OR=1.47; 95% CI=1.14–1.89), and who had an MMSE score of less than 23 (OR=1.96; CI=1.07–3.57) were more likely to have incomplete telephone contacts. The 3 variables were controlled for in the final models with the study outcomes.

Comparisons of baseline characteristics among the control villagers, tai chi villagers, and tai chi practitioners are shown in Table 1. Compared with the control villagers, the tai chi villagers and tai chi practitioners had higher percentages of younger people and women, higher educational levels, and more regular exercise, as well as lower percentages of comorbid conditions, impaired cognition, depression, fall history, and people using a walking aid.

As shown in Table 2, after the tai chi program, the crude incidence rates for injurious falls decreased by 24.3 per 1,000 person-years among the control villagers, by 45.8 among the tai chi villagers, and by 16.7 among the tai chi practitioners. These crude differences in the rate changes were not statistically significant.

As shown in Table 3, after adjustment for other variables that were associated significantly with injurious falls, the tai chi villagers and tai chi practitioners before the tai chi program were, respectively, 16% more (adjusted rate ratio [RR]=1.16; 95% CI=0.67–2.00) and 2% more (RR=1.02; 95% CI=0.37–2.80) likely than the control villagers to have experienced injurious falls. After the tai chi program, injurious falls in the control villagers declined by 44% (RR=0.56; 95% CI=0.34–0.92). Compared with the results for the control villagers, the decline was 31% greater (RR=0.69; 95% CI=0.30–1.56) among the tai chi villagers and 50% greater (RR=0.50; 95% CI=0.11–2.17) among the tai chi practitioners. In other words, injurious falls among the tai chi villagers and tai chi practitioners declined 75% (44%+31%) and 94% (44%+50%), respectively, after the program. The latter results were not statistically significant.

The coefficients of the Poisson regression model with GEE for the rates of injurious falls at 3-month intervals from the 2 sources of data collection (telephone interviews and clinical records) were −.13 and −.09, respectively. With a Wald statistic of .86 and a P value of .39, no significant difference between the 2 coefficients was detected. The results indicate that collection of the self-reported injurious falls by the telephone interviews was reliable.

As shown in Table 4, after the tai chi program, crude changes in the Tinetti Balance Scale scores were −2.0 points for the control villagers, −1.8 points for the tai chi villagers, and 0.1 point for the tai chi practitioners; the score changes between the tai chi practitioners and the control villagers differed significantly. For the Tinetti Gait Scale scores, the corresponding changes were −1.1, −0.7, and −0.2 points, and for the fear of falling, they were −0.2, −0.4, and −0.8 points, respectively; no significant differences in these results between the groups were detected.

The results of the linear mixed-effect model with the Tinetti Balance Scale score, the Tinetti Gait Scale score, and the fear of falling treated as separate outcomes are shown in Table 5. After adjustment for other variables, no significant differences in the 3 outcomes at the baseline were detected among the control villagers, tai chi villagers, and tai chi practitioners. After the tai chi program, scores on the Tinetti Balance Scale for the control villagers declined by 1.4 (95% CI=−2.0 to −0.9) points. Compared with the results for the control villagers, the decline in scores was 0.2 (95% CI=−1.1 to 0.7) point larger for the tai chi villagers but 1.8 (95% CI=0.2 to 3.4) points smaller for the tai chi practitioners; in other words, the balance scores for the tai chi practitioners increased by 0.4 (−1.4 + 1.8) point after the tai chi program. After the tai chi program, scores on the Tinetti

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Table 1.
Baseline Characteristics of Control Villagers, Tai Chi Villagers, and Tai Chi Practitioners

Characteristic[a]	No. (%) of: Control Villagers (n=728)	Tai Chi Villagers (n=472)	Tai Chi Practitioners (n=88)
Age (y)			
65–69	209 (28.7)	158 (33.5)[b]	43 (48.9)[c]
70–74	239 (32.8)	170 (36.0)	29 (33.0)
75+	280 (38.5)	144 (30.5)	16 (18.2)
Sex			
Female	279 (38.3)	212 (44.9)[b]	60 (68.2)[c]
Male	449 (61.7)	260 (55.1)	28 (31.8)
Educational level			
Junior high school or above	74 (10.2)	87 (18.4)[c]	20 (22.7)[c]
Elementary school	297 (40.8)	213 (45.1)	37 (42.0)
No formal education	357 (49.0)	172 (36.4)	31 (35.2)
Marital status			
Spouse present	459 (63.0)	332 (70.3)[c]	57 (64.8)
Widowed, divorced, or never married	269 (37.0)	140 (29.7)	31 (35.2)
Living alone			
Yes	111 (15.2)	42 (8.9)[c]	7 (8.0)
No	617 (84.8)	430 (91.1)	81 (92.1)
Type of regular exercise			
No regular exercise	353 (48.5)	190 (40.3)[c]	28 (31.8)[c]
Free movement	94 (12.9)	66 (14.0)	11 (12.5)
Walking	242 (33.2)	181 (38.3)	28 (31.8)
Jogging	7 (1.0)	7 (1.5)	1 (1.1)
Traditional exercises (eg, tai chi)	1 (0.1)	11 (2.3)	13 (14.8)
Others	31 (4.3)	17 (3.6)	7 (8.0)
No. of days exercised in last 2 wk			
0	384 (52.7)	204 (45.7)[b]	29 (34.1)[c]
1–12	61 (8.4)	33 (7.4)	8 (9.4)
13 or 14	283 (38.9)	209 (46.9)	48 (56.5)
Exercise duration (min)			
<30	412 (56.6)	230 (48.7)[b]	32 (36.4)[c]
30–59	167 (22.9)	127 (26.9)	21 (23.9)
60+	149 (20.5)	115 (24.4)	35 (39.8)
No. of comorbid conditions			
0	211 (29.0)	168 (35.6)[c]	28 (31.8)
1	206 (28.3)	147 (31.1)	26 (29.6)
2+	311 (42.7)	157 (33.3)	34 (38.6)
No. of medications used			
0	249 (34.2)	189 (40.0)	31 (35.2)
1	223 (30.6)	139 (29.4)	28 (31.8)
2+	256 (35.2)	144 (30.6)	29 (33.0)
MMSE score for cognition			
0–17	151 (20.7)	62 (13.1)[c]	9 (10.2)[c]
18–22	206 (28.3)	107 (22.7)	16 (18.2)
23+	371 (51.0)	303 (64.2)	63 (71.6)
GDS score for depression			
0–10	675 (92.7)	450 (95.3)	87 (98.9)[b]
11+	53 (7.3)	22 (4.7)	1 (1.1)
Having fallen in past year			
Yes	85 (11.7)	42 (8.9)	6 (6.8)
No	643 (88.3)	430 (91.1)	82 (93.2)
Use of a walking aid			
Yes	88 (12.1)	43 (9.1)	1 (1.1)[c]
No	640 (87.9)	429 (90.9)	87 (98.9)
No. of limited ADL			
0	475 (65.2)	340 (72.0)	65 (73.9)
1 or 2	150 (20.6)	81 (17.2)	19 (21.6)
3+	103 (14.1)	51 (10.8)	4 (4.5)

[a] MMSE=Mini-Mental State Examination, GDS=short form of the Geriatric Depression Scale, ADL=activities of daily living.
[b] $P < .05$.
[c] $P < .01$.

Table 2.
Crude Rate Changes for Injurious Falls Per 1,000 Person-Years Before and After the Tai Chi Program

Group	Incidence Rate Before Tai Chi	Incidence Rate After Tai Chi	Rate Change After Tai Chi	P
Control villagers[a]	98.0	73.7	−24.3	
Tai chi villagers	104.6	58.8	−45.8	.450
Tai chi practitioners	66.7	50.0	−16.7	.810

[a] Reference group.

Table 3.
Poisson Regression Model Analysis: Adjusted Rate Ratios (RRs) and 95% Confidence Intervals (CIs) for Occurrences of Injurious Falls[a]

Characteristic	RR	95% CI
Group		
Control villagers	1.00	
Tai chi villagers	1.16	0.67–2.00
Tai chi practitioners	1.02	0.37–2.80
Time		
Before the tai chi program	1.00	
After the tai chi program	0.56	0.34–0.92
Group × time		
Tai chi villagers × time	0.69	0.30–1.56
Tai chi practitioners × time	0.50	0.11–2.17

[a] Adjusted for age, sex, living alone, number of comorbid conditions, exercise frequency and duration, cognition, depression, fall history, and limited activities of daily living.

Gait Scale for the control villagers declined by 1.0 (95% CI=−1.3 to −0.7) point; the decline in scores was 0.1 (95% CI=−0.4 to 0.6) point smaller for the tai chi villagers and 0.9 (95% CI=0.1 to 1.8) point smaller for the tai chi practitioners. After the tai chi program, no significant changes in the fear of falling were detected among the 3 groups.

As shown in Figure 2, the monthly attendance rate for the tai chi classes gradually declined over the 12-month intervention period. The mean attendance rate was 0.63, and it varied from 0.87 in month 2 to 0.49 in month 12.

As shown in Figure 3, after the tai chi program, the exercise duration within the last 2 weeks of each 3-month interval for the control villagers apparently increased and then leveled off. The exercise duration slightly increased for the tai chi villagers but soon returned to the levels of the first year. Exercise duration dramatically increased to a plateau for the tai chi practitioners. The mean change in the exercise duration after the tai chi program was significantly larger for the tai chi practitioners than for the tai chi nonpractitioners ($P<.001$) and the control villagers ($P<.001$).

Discussion and Conclusion

Although the community-based tai chi program helped older people to maintain functional balance and gait in the 1-year intervention period, the program did not significantly reduce the occurrences of injurious falls or the fear of falling among participants at both the individual and the community levels. One important explanation for not detecting a significant reduction in injurious falls with the tai chi program is that the study efficiency was decreased to .49 because of the unexpectedly large decline in injurious falls in the control villagers. Furthermore, there was a large variation in the estimate of the overall effect of the tai chi program because of a differential effect for subgroups of subjects; for example, it was more effective for subjects with depression than for those without depression (data not shown). Finally, the adjustment for correlations of repeated observations within individuals and within villages (ie, the cluster effect) in the statistical models for correct inferences about regression coefficients and their standard errors may have reduced the study power to some extent as well.[41,42] In other words, the power of this study would have been overestimated if the statistical models had not taken the correlations into consideration.

The large decline in injurious falls in the control villages was unexpected. On the one hand, it is possible that the decline was confounded by the following nonspecific effects, because education on fall prevention alone often has been reported to be ineffective.[43,44] First, the telephone contacts at 3-month intervals over the study period may have become a cointervention that encouraged the subjects to avoid situations related to a high risk of falling. Second, the subjects may have changed their behaviors because of inclusion in this study (ie, the Hawthorne effect). Finally, a time trend or period effect may have confounded the findings in that a "placebo" control group without intervention was not used in this study. On the other hand, however, the findings are supported by several reasons. First, education on fall prevention may have an effect on certain older populations. For example, members of rural communities are more willing to collaborate actively in focusing on and implementing prevention programs.[45] Specifically, the control subjects, who were farmers and who were initially provided with comprehensive educational information on fall prevention, had a vested interest in not hurting themselves; they may have perceived the importance of fall prevention and actually may have modified their exercise behaviors or environments. Second, in contrast to studies in which a nonsignificant effect of education on preventing falls was reported, the definition of falls in this study was narrower and included only injurious falls. It would be intriguing to determine whether education is effective in reducing the incidence of serious falls rather than minor ones. Finally, the contents of the educational

Table 4.
Crude Changes in the Tinetti Balance Scale Score (Points), the Tinetti Gait Scale Score (Points), and the Fear of Falling (Points) Before and After the Tai Chi Program

	Tinetti Balance Scale				Tinetti Gait Scale				Fear of Falling			
Group	Before Tai Chi	After Tai Chi	Change	*P*	Before Tai Chi	After Tai Chi	Change	*P*	Before Tai Chi	After Tai Chi	Change	*P*
Control villagers[a]	19.6	17.6	−2.0		11.0	9.9	−1.1		3.4	3.2	−0.2	
Tai chi villagers	20.2	18.4	−1.8	.50	11.0	10.3	−0.7	.09	3.3	2.9	−0.4	.69
Tai chi practitioners	22.1	22.2	0.1	.04	12.1	11.9	−0.2	.07	3.1	2.3	−0.8	.33

[a] Reference group.

Table 5.
Linear Mixed-Effect Model Analysis: Adjusted Relative Differences (RDs) and 95% Confidence Intervals (CIs) for the Tinetti Balance Scale Score (Points), the Tinetti Gait Scale Score (Points), and Fear of Falling (Points)

	Tinetti Balance Scale[a]		Tinetti Gait Scale[b]		Fear of Falling[c]	
Characteristic	RD	95% CI	RD	95% CI	RD	95% CI
Group						
Control villagers	0.0		0.0		0.0	
Tai chi villagers	0.1	−0.6 to 0.8	−0.2	−0.6 to 0.2	−0.1	−0.6 to 0.4
Tai chi practitioners	1.2	0.0 to 2.5	0.4	−0.3 to 1.2	0.1	−0.7 to 1.0
Time (after/before tai chi program)	−1.4	−2.0 to −0.9	−1.0	−1.3 to −0.7	−0.2	−0.7 to 0.3
Group × time						
Tai chi villagers × time	−0.2	−1.1 to 0.7	0.1	−0.4 to 0.6	−0.1	−0.9 to 0.6
Tai chi practitioners × time	1.8	0.2 to 3.4	0.9	0.1 to 1.8	−0.6	−1.8 to 0.6

[a] Adjusted for age, sex, living alone, number of comorbid conditions, cognition, depression, fall history, use of a walking aid, and limited activities of daily living (ADL).
[b] Adjusted for age, sex, living alone, number of comorbid conditions, cognition, depression, use of a walking aid, and limited ADL.
[b] Adjusted for age, sex, living alone, exercise duration, number of comorbid conditions, cognition, depression, fall history, use of a walking aid, and limited ADL.

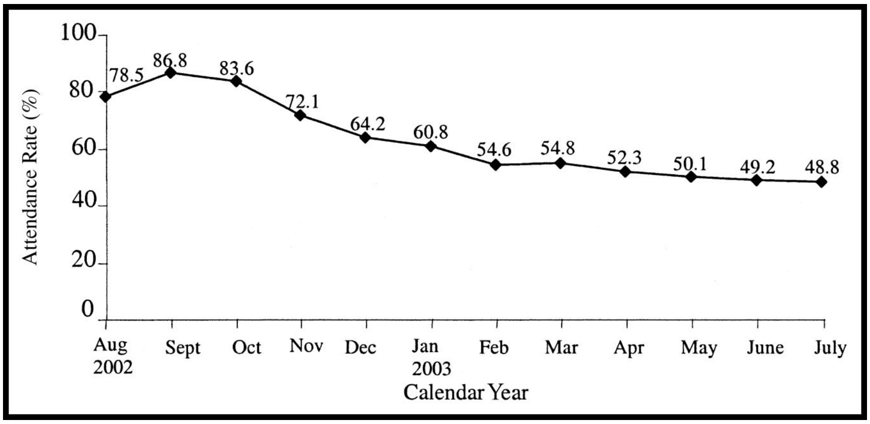

Figure 2.
Attendance rates for the tai chi practitioners over the 12-month intervention period.

material on fall prevention used in this study, posted in public places and depicted in a very simple way in the pamphlets, may have strongly facilitated the safety consciousness of older people in preventing falls in their daily lives. Despite the lack of confirmatory findings in this study, future studies examining whether an easily understood educational program on fall prevention is effective in reducing the incidence of serious falls in certain older populations are warranted.

Some comments are relevant to the tai chi program. First, despite a dissemination effect of the tai chi program from practitioners to neighboring nonpractitioners being intriguing and being explored in this study, the effect of tai chi at the individual level (rather than at the community level) was the inference unit because the tai chi program should not have directly benefited subjects who did not practice it. Second, compared with adherence to other community-based programs for older people,[46] adherence to the tai chi program in the 1-year intervention period was higher, particularly in the first 6 months. However, the reason that most people left the program was because of their physical inability to get to the places where the group exercise were conducted. Therefore, even with a free community-based tai chi

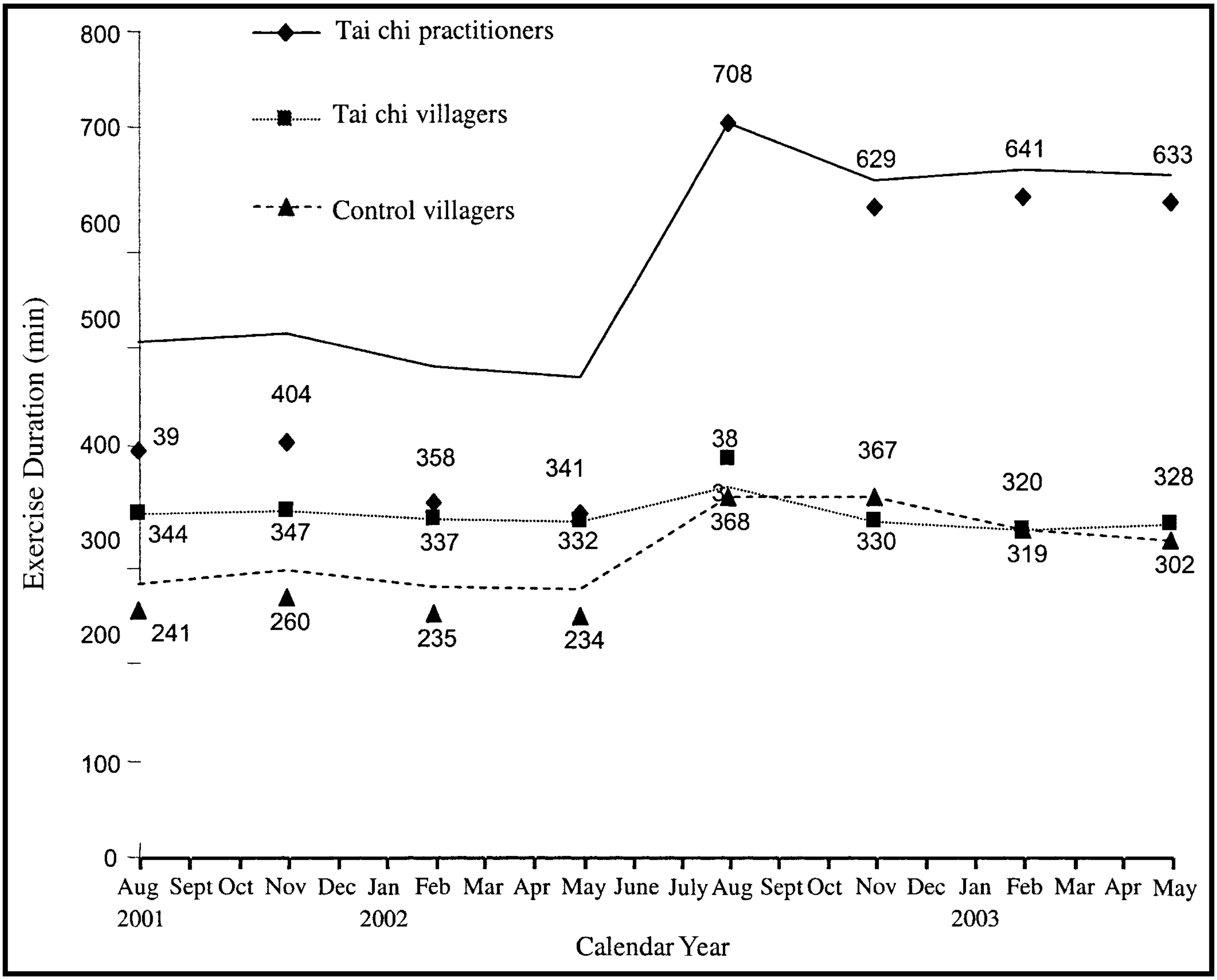

Figure 3.
Exercise duration within the last 2 weeks over the 2-year study period.

program, accessibility and other environmental factors[47] still need to be considered to attract less healthy older people to participate in and adhere to the program. Third, community resources, particularly the exercise centers and the local association for Chen-style tai chi, were mobilized and integrated in the study villages to save research costs (eg, payment of tai chi trainers) as well as to increase program adherence among practitioners. Moreover, through these local organizations and resources, tai chi exercise may be continued easily in the tai chi villages and promoted in the control and other villages. Finally, in addition to physical function and psychological well-being, the tai chi program also may have benefited the social health of older people. Therefore, multidimensional outcome measures, such as health-related quality of life, can be added in future studies to quantify comprehensively the benefits and even risks of the program.

There are several limitations to this study. First, because subjects who initially were in poorer health were less likely to have completed telephone contacts, the control villagers who were in poorer health tended to report fewer injurious falls than did the tai chi villagers and tai chi practitioners. The differential response may have resulted in an overestimation of the reduction in injurious falls among control villagers and in an underestimation of the relative rate of reduction in injurious falls for the tai chi program. Furthermore, this possibility may have led to an underestimation of changes in balance, gait, and fear of falling, particularly when functional measures are not sensitive to change.[36] Second, because this community trial was a quasi-experimental design, some unmeasured behavioral characteristics and environmental factors also may have confounded and biased the study results. For example, the quantity and quality of daily activities among older people may have played an important role, because vigorous older people have been reported to have more severe falls, if any.[48] Despite a more efficient sample and balanced characteristics being required in future studies to validate the study results, few of the unbalanced characteristics would have affected the changes in injurious falls in the intervention and control groups, even though they might have been associated with the study groups and injurious falls at the baseline. Third, tai chi exercise seems to be more effective in reducing falls in healthier older people,[14,15] so that healthier tai chi practitioners would have had lower reductions in injurious falls than of noninjurious falls. Nevertheless, in this study, we chose to collect data on injurious falls instead of both noninjurious and injurious falls because of the possible unreliable memory of older people. Finally, the 3 secondary outcomes—balance, gait, and fear of falling—were treated as interval scales for data analysis in this study as well as in other studies[49,50] and, in fact, they were ordinal scales. It should be noted that there are fundamental deficiencies in the information provided by such scales.[51]

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