Effectiveness of Tai Chi as a Community Based Falls Prevention Intervention: A Randomized Controlled Trial

Denise Taylor, PhD,* Leigh Hale, PhD,† Philip Schlute, PhD,‡§ Debra L. Waters, PhD,* Elizabeth E. Binns, MHSc,* Hamish McCracken, MPH,** Kathryn McPherson, PhD,* and Steven L. Wolf, PhD††‡‡§§¶¶

OBJECTIVES: To compare the effectiveness of tai chi and low-level exercise in reducing falls in older adults; to determine whether mobility, balance, and lower limb strength improved and whether higher doses of tai chi resulted in greater effect.

DESIGN: Randomized controlled trial.

SETTING: Eleven sites throughout New Zealand.

PARTICIPANTS: Six hundred eighty-four community-residing older adults (mean age 74.5; 73% female) with at least one falls risk factor.

INTERVENTION: Tai chi once a week (TC1) (n = 233); tai chi twice a week (TC2) (n = 220), or a low-level exercise program control group (LLE) (n = 231) for 20 wks.

MEASUREMENTS: Number of falls was ascertained according to monthly falls calendars. Mobility (Timed-Up-and-Go Test), balance (step test), and lower limb strength (chair stand test) were assessed.

RESULTS: The adjusted incident rate ratio (IRR) for falls was not significantly different between the TC1 and LLE groups (IRR = 1.05, 95% confidence interval (CI) = 0.83–1.33, P = .70) or between the TC2 and LLE groups (IRR = 0.88, 95% CI = 0.68–1.16, P = .37). Adjusted multilevel mixed-effects Poisson regression showed a significant reduction in logarithmic mean fall rate of −0.050 (95% CI = −0.064 to −0.037, P < .001) per month for all groups. Multilevel fixed-effects analyses indicated improvements in balance (P < .001 right and left leg) and lower limb strength (P < .001 but not mobility (P = .54) in all groups over time, with no differences between the groups (P = .37 (right leg), P = .66 (left leg), P = .21, and P = .44, respectively).

CONCLUSION: There was no difference in falls rates between the groups, with falls reducing similarly (mean falls rate reduction of 58%) over the 17-month follow-up period. Strength and balance improved similarly in all groups over time. J Am Geriatr Soc 2012.

Key words: elderly; falls; tai chi; strength; balance

There is a recognized need to reduce the incidence of falls in older adults, as clearly reflected in the health strategies of many countries, including the United Kingdom, United States, Australia, and New Zealand. Tai chi is increasingly available in communities as a falls prevention intervention, and in New Zealand, for individuals aged 65 and older with a falls risk, the Accident Compensation Corporation (ACC) (a government funded agency that provides personal injury coverage for all New Zealanders) subsidizes attendance at tai chi classes, but the evidence for tai chi as an effective falls prevention intervention remains inconclusive. A meta-analysis reported that tai chi had a moderate effect in reducing falls in community-dwelling older adults (incident rate ratio (IRR) = 0.63, 95% confidence interval (CI)=0.52–0.78), whereas another study concluded that there was insufficient evidence of tai chi’s effectiveness in falls prevention, reporting a pooled IRR of 0.79 (95% CI = 0.60–1.03).
That study also compared tai chi with exercise controls and reported a pooled estimate of the IRR of 0.51 (95% CI = 0.38–0.68) in favor of tai chi. This finding was unexpected because the difference between exercise interventions and tai chi was considered, a priori, likely to be small. Only two trials were included in this analysis, so the results could have occurred by chance. An earlier meta-analysis attempted to determine the characteristics of exercise programs related to a reduction in falls. It found that a high dose of exercise and the inclusion of challenging balance exercises are necessary components of successful falls prevention programs.

The primary objective of the current study was to determine whether ACC’s 5-month program of modified tai chi was more effective than an active control (low-level exercise (LLE) program) in reducing the rate of falls in community-dwelling older adults. The primary hypothesis was that tai chi for 5 months would reduce the rate of falls over the period of the intervention and at 11- and 17-month follow-up more than an active control exercise program. Secondary hypotheses were that mobility, balance, and strength measures would improve over time and that the reduction in falls over the 5-month intervention and at 11- and 17-month follow-ups would be greater in the group doing tai chi twice a week (TC2 group) than in the group doing tai chi once a week (TC1 group).

METHODS

Design
This multicenter randomized controlled trial was conducted in New Zealand. Participants were randomly allocated (1:1:1 ratio) to one of three groups: tai chi once a week, tai chi twice a week, or the control group (LLE class delivered once a week). The trial was conducted between June 2006 and November 2008 in 11 locations across New Zealand. Falls were recorded monthly during the 20-wk intervention period and for a further 12 months follow-up. The primary outcome (number of falls) was measured continuously from baseline to 12 months after the intervention. Secondary outcome data (mobility, balance, and leg strength) were collected at baseline, immediately after the intervention and at 11 and 17 months. Physical activity data were collected at baseline using the New Zealand Physical Activity Questionnaire Short-form. The ethics committees of AUT University, University of Otago, and ACC approved the research protocol, and all study participants gave written informed consent before enrollment in the study.

Participants
Participants were recruited from the community through newspaper advertisements; local radio and television; and posters and flyers placed in local community centers, doctors’ and physiotherapists’ offices, libraries, and churches. Participants telephoned study recruiters if they were interested in participating. Participants were included if they were aged 65 and older (55 yrs if Māori or Pacific Islander to account for ethnic disparities in health) and had experienced at least one fall in the previous 12 months or were considered to be at risk of falling. Risk of falling was identified using the Falls Risk Assessment Tool (FRAT). A score of 1 or greater considered to identify those who had a fall risk factor (history of falls, use of multiple medications, stroke or Parkinson’s disease, balance difficulty, or lower limb muscle weakness). All participants had medical clearance to participate in an exercise program of low to moderate intensity obtained from their general practitioner. Participants were excluded if they were unable to ambulate independently (with or without walking aid), had a chronic medical condition that would limit participation in low- to moderate-intensity exercise, had severe cognitive limitations (score <23 on the Telephone Mini-Mental State Examination), had participated in tai chi within the last year, or were currently participating in an organized exercise program aimed at improving strength and balance. Recruitment took place over a 12-month period beginning in June 2006. Trained research assistants determined eligibility for inclusion into the trial through telephone interviews using a standardized study eligibility questionnaire. Those who met the inclusion criteria were invited to a baseline assessment at which demographic, mobility, balance, and leg strength data were measured. Trained assessors completed all assessments, with assessors remaining blinded to group allocation throughout the trial.

After baseline assessment, participants were randomly assigned to one of the three study arms using a central, web-based, computer-generated blocked random number system (generated by the study biostatistician; PS). At the end of the baseline assessment, each participant was given a sealed opaque envelope containing group allocation details and was instructed to open the envelope after leaving the assessment venue and not to discuss the assignment with any of the assessors. A contact telephone number was provided if participants wished to contact the study coordinators. The allocation list was placed in a locked cabinet for the duration of the study.

Interventions
Providers of ACC’s funded modified tai chi classes delivered the modified tai chi. All instructors were experienced at teaching tai chi and had attended an ACC training program based on a modified 10-form Sun style. The tai chi programs were delivered in a group setting in the community once or twice a week for 20 wk. Each class lasted approximately 1 hour, and the maximum instructor to participant ratio was 1:13. Participants in the LLE program served as an active control group that was dose-matched to the TC1 program and delivered in a group setting in the community once a week for 20 wk. The hour-long class comprised mainly seated exercises including stretching, low-level strength, and low-level cardiovascular exercise. Participants walked (warm-up and cool-down) for 7 min in each class, remaining seated or standing with arm support the rest of the time. No exercises that specifically targeted the training of balance were included. Exercise instructors were trained in delivery of the program and were provided with a manual. Exercise progression in the LLE group was standardized, with each class undertaking the same exercises in each week of the program. The maximum instructor to participant ratio
was 1:15. The organization of the classes was such that there was no crossover in time, helping to prevent cross-contamination of the groups.

**Outcome Measures**

The primary outcome measure was number of falls. A fall was defined as “an unexpected event in which the participant comes to rest on the ground, floor, or lower level.” Participants recorded fall incidents as they occurred on provided calendars that they returned monthly by mail. Participants who did not return their monthly calendars had reminder telephone calls within 2 wk, and assessors blinded to group allocation collected data related to any falls over the telephone. If a participant recorded a fall on the calendar, they were telephoned to confirm that the fall met the study definition. Falls were monitored in the same way throughout the 20-wk intervention and over the follow-up period. Participants were asked at the end of the intervention whether they thought the program had caused them any problems; if so, details were recorded on an adverse events form. Secondary outcomes (mobility, balance, and leg strength) were assessed at baseline, immediately after the intervention, and at the 11- and 17-month follow-ups. During the 11- and 17-month follow-up assessments, participants were asked whether they were engaged in any organized exercise, and if yes, they were asked to specify the type of exercise.

The Timed Up and Go (TUG) Test is reliable and valid in quantifying functional mobility and was used to assess mobility. The step test is reliable and valid in quantifying dynamic balance and was used to measure balance but is known to have a floor effect with patients who have severe dysfunction. Test–retest reliability in elderly adults is high (intraclass correlation coefficient >0.9). The 30-second chair stand test was used to test lower limb strength and is reliable (correlation coefficient (R) = 0.84–0.92) and valid (R = 0.71–0.78).

**Sample Size**

Power calculations were based on the anticipated number of people who were expected to fall in each group. From falls rates for community-dwelling older adults and sample size calculations in other similar trials, it was assumed that 40.0% of LLE, 33.3% of TC1, and 26.7% of TC2 participants were likely to fall during the period of the trial, producing a detectable effect size difference of 0.163. A sample of 160 per group gave 90% power to detect this effect size difference at the 5% significance level. Allowing for 30% attrition throughout the trial (in view of the age of participants), the sample size was increased to 228 per treatment group, or 684 participants in total.

**Statistical Methods**

Crude and adjusted negative binomial regression models were employed to analyze total falls counts between treatment groups. Exposure for each participant was equated to the available number of months of the calendar falls data that individual submitted. Because the trial was conducted in 11 locations, clustered sandwich estimators of variance were used for the calculation of standard errors and confidence intervals. Two different parameterizations of the negative binomial model are commonly available: with dispersion a function of the expected mean of the counts and with dispersion a constant for all observations. In the absence of any preference, both parameterizations can be separately fitted, and the model with the larger (least negative) log likelihood statistic selected, as was undertaken here. The covariates included in the adjusted regression analyses were sex, age, the use of walking aids indoors, the use of walking aids outdoors, living alone or not, the presence of medical conditions, and whether a fall had occurred in the previous 12 months. These were selected from the literature as possible factors that influence falls. Crude and adjusted multilevel mixed-effects models were used to analyze the change in falls over time and the secondary outcome variables with cities, class site, and participants treated as random effects. The covariates included in the adjusted multilevel mixed-effects analysis were sex, age, the use of walking aids indoors, the use of walking aids outdoors, living alone or not, the presence of medical conditions, and whether a fall had occurred in the previous 12 months. Analyses were performed using STATA version 10.0 (StataCorp, College Station, Texas) and an alpha of 5% defined significance. No interim statistical analysis was conducted, and analysis was undertaken according to original assigned groups, regardless of adherence.

**RESULTS**

One thousand ninety-five people was screened for eligibility, and 684 of these participated in the trial from three cities: 389 (57%) from Auckland, 204 (30%) from Dunedin, and 91 (13%) from Christchurch. Within these cities, 11 separate sites were used for intervention delivery, with a median of 53 participants (range 38–128 participants). Two hundred thirty-three participants (34%) were randomized to the TC1 group, 220 (32%) to the TC2 group, and 231 (34%) to the LLE group. Figure 1 shows the flow of the participants through the study. The mean age of the sample was 74 ± 6 (range 55–95), and there were 12 participants who identified as Māori or Pacific Islander ethnicity. Participant baseline characteristics are presented in Table 1. Overall, 393 (59%) participants reported having had at least one fall in the 12 months before enrollment in the study. At baseline, the groups were similar in terms of mean minutes spent in physical activity per week (TC1, 55 ± 92 min; TC2, 62 ± 92 min; LLE, 67 ± 92 min).

**Falls Outcome**

Of the 684 participants, 646 (94.4%) provided falls information for at least 1 month, and 528 (81.7%) provided falls information for the entire trial. From the point of entry in the study to the 17-month final assessment point, there were 1,060 falls reported over 793 person-years exposure (Table 2).

Typical for fall counts, these data are overdispersed, with the empirical dispersion index (variance to mean ratio) equaling 3.98. Taking dispersion to be a function of the expected mean yielded a negative binomial regression model log likelihood statistic of −1,110.5 for the model.
presented in Table 2, whereas taking dispersion as a constant for all observations yielded a log likelihood statistic of \( -1.112.0 \). Based on these log likelihood statistics, the model taking dispersion as a function of the expected mean was preferred and adopted hereafter.

Results from crude and adjusted negative binomial regression analyses of the total fall counts according to treatment group, clustered according to trial location, are presented in Table 3. In crude and adjusted analyses, the IRR was not significantly different between the TC1 \( (P = .36) \) and LLE \( (P = 0.70) \) groups or between the TC2 \( (P = .23) \) and LLE \( (P = 0.37) \) groups. The estimated dispersion parameter was significant for crude and adjusted regression models (both \( P < .001 \)).

When investigating the month-by-month falls data, results from an adjusted multilevel mixed-effect Poisson regression analysis revealed that there was no difference in falls rates between groups at baseline \( (P = .13) \) and no difference in the reduction in falls rates over time between treatment groups \( (P = .25) \). Dropping the interaction term (group by time) because it was nonsignificant, there was a significant reduction in the logarithmic mean fall rate of \( -0.050 \) (95% CI = \( -0.064 \) to \( -0.037 \), \( P < .001 \)) per month for all groups. This represents a 58% reduction in the mean fall rate for all groups across the whole study period. The lack of difference in the reduction in falls rates over time between treatment groups supports the negative binomial regression results for total fall counts reported above.

A multilevel mixed-effects binomial analysis was used to investigate month-by-month patterns of missing data for the participants. A significant difference in the level of missing data between groups at baseline was seen \( (P < .001) \), together with a significant time dependency \( (P < .001) \), with more missing data as time passed but no change in the rate of missing data between groups over time observed \( (P = .19) \). Specifically, there were significantly more missing data in the LLE group at baseline.
Table 1. Frequencies and Percentages of Demographic Characteristics and Important Covariates at Baseline for the Study and According to Treatment Group

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Overall</th>
<th>Tai Chi 1/ wk (n = 233)</th>
<th>Tai Chi 2/ wk (n = 220)</th>
<th>Low-Level Exercise (n = 231)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>182 (27)</td>
<td>72 (31)</td>
<td>55 (25)</td>
<td>55 (24)</td>
</tr>
<tr>
<td>Male</td>
<td>502 (73)</td>
<td>161 (69)</td>
<td>185 (75)</td>
<td>176 (70)</td>
</tr>
<tr>
<td>Age, mean ± standard deviation</td>
<td>74.5 ± 6.5</td>
<td>75.3 ± 7.0</td>
<td>74.4 ± 6.2</td>
<td>73.7 ± 6.2</td>
</tr>
<tr>
<td>Use of walking aid indoors^a</td>
<td>Yes</td>
<td>27 (4)</td>
<td>10 (4)</td>
<td>8 (4)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>647 (96)</td>
<td>218 (96)</td>
<td>207 (96)</td>
</tr>
<tr>
<td>Use of walking aid outside^b</td>
<td>Yes</td>
<td>130 (19)</td>
<td>48 (21)</td>
<td>37 (17)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>550 (81)</td>
<td>184 (79)</td>
<td>181 (83)</td>
</tr>
<tr>
<td>Does anyone live with you^b</td>
<td>Yes</td>
<td>388 (57)</td>
<td>127 (55)</td>
<td>121 (56)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>292 (43)</td>
<td>104 (45)</td>
<td>97 (44)</td>
</tr>
<tr>
<td>Presence of medical conditions^b</td>
<td>Yes</td>
<td>556 (82)</td>
<td>188 (81)</td>
<td>177 (81)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>124 (18)</td>
<td>43 (19)</td>
<td>42 (19)</td>
</tr>
<tr>
<td>Fell in last 12 months^c</td>
<td>No</td>
<td>275 (41)</td>
<td>91 (40)</td>
<td>95 (44)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>393 (59)</td>
<td>137 (60)</td>
<td>119 (56)</td>
</tr>
</tbody>
</table>

Observations missing for
^a 10 participants.
^b 4 participants.
^c 16 participants.

Table 2. Fall Numbers, Characteristics, and Person-Year Exposure Over the Trial According to Treatment Group

<table>
<thead>
<tr>
<th>Falls and Person-Year Exposure</th>
<th>Tai Chi 1/ wk (n = 233)</th>
<th>Tai Chi 2/ wk (n = 220)</th>
<th>Low-Level Exercise (n = 231)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls, n</td>
<td>412</td>
<td>298</td>
<td>350</td>
</tr>
<tr>
<td>Fallers, n (%)</td>
<td>132 (59.5)</td>
<td>111 (53.1)</td>
<td>140 (65.1)</td>
</tr>
<tr>
<td>Frequent fallers (2 &gt; falls), n (%)</td>
<td>56 (25.2)</td>
<td>32 (15.3)</td>
<td>48 (22.3)</td>
</tr>
<tr>
<td>Follow-up time, months, mean ± standard deviation</td>
<td>14.8 ± 4.5</td>
<td>14.8 ± 4.6</td>
<td>14.5 ± 4.9</td>
</tr>
<tr>
<td>Person-years exposure</td>
<td>273.9</td>
<td>258.5</td>
<td>260.6</td>
</tr>
<tr>
<td>Falls rate per person, years (95% confidence interval)^a</td>
<td>1.55 (1.23–1.97)</td>
<td>1.16 (0.92–1.48)</td>
<td>1.38 (1.24–1.53)</td>
</tr>
</tbody>
</table>

^a Estimated from negative binomial regression, clustered according to center, using robust estimators of variance.

(n = 22, 9.5%) than in the TC1 (n = 12, 5.2%, P = .001) and TC2 (n = 11, 5.0%, P = .005) groups but no difference in the level of missing data between the TC1 and TC2 groups (P = .72). Whether those who fell during the trial were more likely to withdraw from the trial and thus, potentially inflate the size of the falls reduction was also examined. Participants who reported having fallen were 1.43 (95% CI; 0.94–2.17) times as likely to withdraw as those who had not (P = .10). There was no significant difference in withdrawing according to treatment group (P = .48).

Secondary Outcomes

Mean and standard deviations for the secondary outcomes measures are presented in Table 4. The TUG data were highly skewed and were therefore logarithmic transformed. The pursuit multilevel mixed-effects analysis showed no significant time effect (P = .54), no significant group difference at baseline (P = .24), and no time-by-group interaction (P = .44). Multilevel mixed-effects analysis of the step test right leg data yielded a significant time effect, with the number of steps performed increasing over time (P < .001). No significant group differences at baseline (P = .68) and no time-by-group interaction (P = .37) were observed. Similarly, for the step test left leg, the analysis demonstrated a significant time effect, with the number of steps performed increasing over time (P < .001) but no significant group difference at baseline (P = .84) and no time-by-group interaction (P = .66). Finally, the analysis of the chair stand test demonstrated a significant time effect, with the number of chair stands increasing over time (P < .001) but no significant group difference at baseline (P = .94) and no time-by-group interaction (P = .21).

Intervention Attendance, Retention, Adverse Events, and Continuation of Exercise Participation

Attendance at the exercise programs was calculated as the percentage of available sessions attended. Median attendance rates were 79% (interquartile range (IQR) 49–90%) in the TC1 group, 72% (IQR 44–88%) in the TC2 group, and 67% (IQR 10–85%) in the LLE group. There were no serious adverse events resulting from participation in any of the exercise programs. When asked whether participation in the program caused any problems, 11 participants in the LLE program, 19 in the TC1 group, and 15 in the TC2 group reported problems. The most commonly reported problem was an increase in aches and pains (four
participants in the LLE program, four in the TC1 group, and three in the TC2 group).

At the 11-month follow-up, 535 people answered the questions about ongoing participation in organized exercise; 321 (60%) of these reported that they had continued with some form of organized exercise at least once per week. The numbers of people reporting that they had continued with exercise was similar across the groups (96 (53%) in TC1, 115 (64%) in TC2, and 110 (63%) in LLE). By the 17-month follow-up, participation in organized exercise had decreased to 253 (50%) for the sample overall (86 (49%) in TC1, 71 (43%) in TC2, and 96 (58%) in LLE) and was not different between the groups (Fisher exact P = .13). The most frequently cited exercise types at the 17-month follow-up were tai chi (26%), other strength and balance programs (5%), and walking programs (3%).

**DISCUSSION**

There were no statistically significant differences in reduction of falls between the tai chi groups (delivered once or twice a week) and the control group. The rate of falls significantly and similarly declined in all groups over the 17-month study period, with a mean fall rate reduction of 58%, which is probably clinically significant. Measures of balance and strength improved similarly over time in all groups, whereas the measure of mobility did not change in any of the groups. There was no effect of dose (the TC2 group did not reduce falls more than the TC1 group).

A recent meta-analysis of tai chi as a falls prevention intervention highlighted that the total dose of tai chi is an important factor related to falls reduction and demonstrated that approximately 50 hours of tai chi is required to be effective in reducing falls.\(^2\) It is likely that the current study was underpowered to show a difference in falls rates between the two tai chi groups and also may not have offered a high enough intensity of exercise (20 vs 40 hours of tai chi). In the current study and similarly in a previous study, the average attendance rate was approximately 70% to 80% of available classes.\(^{21}\) For the current study, this would have resulted in, on average, 14 to 16 hours of exercise in the TC1 and LLE groups and 28 to 32 hours of exercise in the TC2 group.

These findings add to those of previous trials investigating the effectiveness of tai chi on falls reduction in older adults in that it compared tai chi with an active (albeit predominantly seated) exercise group. In studies that have compared tai chi with an inactive control group, the findings are clearer; for example, one study compared a tai chi program provided once a week for 16 wk with an inactive wait-list control group and reported no difference in fall rates at the end of the 16-wk intervention but a significant difference at 24-wk follow-up in favor of the tai chi group (IRR = 0.67, 95% CI = 0.47–0.94).\(^{21}\) A study with a cohort similar to the one in the current study compared tai chi delivered three times a week for 6 months with a dose-matched stretching control and found a reduction in falls and a reduction in the number of injurious falls in the tai chi group,\(^{22}\) but a recent study found no difference in falls between a 13-wk, twice-a-week tai chi program and usual care.\(^{23}\)

In the current study, the reduction of falls continued over the 12-month follow-up period. This finding was unexpected because it had been anticipated that the rate of falls reduction would decrease after cessation of the intervention. Participants’ continuation in organized exercise programs may explain, in part, the persistent reduction in fall rate at the 11- and 17-month follow-up points. For the sample as a whole, approximately 60% of participants continued with some form of organized exercise on completion of the 20-wk program, and there were no significant differences between the groups. Other studies investigating the effectiveness of tai chi in reducing the occurrence of falls have reported that fall reduction rates are maintained or continued after the intervention, but only one study reported on continued participation in physical activity after the intervention.\(^{21,24}\) Sixty-five percent of the tai chi participants and 20% of the control participants continued participation in physical activity at least once a week 6 months after the intervention, but post hoc subgroup analysis demonstrated no significant differences with regard to the number of fall events between participants who continued with physical activity and those who did not.\(^{22}\)

The act of participating in a group-based exercise program affords important social influences that may help to explain the falls reduction seen in all groups. The relationship between health and social engagement (such as that experienced during an exercise group) is positive and complex.\(^{25}\) Support from within a group engaged in exercise may be beneficial for adherence and self-efficacy.\(^{27}\) Alternatively, merely going out of the house has beneficial long-term health benefits for older adults.\(^{28}\) The exact components of falls prevention programs may be less important than the act of performing regular physical activity in terms of falls prevention. The results of this trial suggest that providing community-based falls preventive exercise programs for older adults who have a risk factor

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean ± Standard Deviation</th>
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<tbody>
<tr>
<td>LLE = low-level exercise group; TC1 = tai chi once a week group; TC2 = tai chi twice a week group.</td>
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Table 4. Secondary Outcome Measures
for falling significantly reduces falls. The exercise programs in this study were of 20 wk duration, yet the fall reduction effect continued for at least the 12 months of follow-up. This finding could, at least in part, be due to the relatively large proportion of the sample who continued in some form of exercise after the end of the 20-wk intervention. This is in itself a good outcome because participation in the study may have encouraged continued engagement in physical activity.

A limitation of the study is that multiple instructors delivered the interventions, although this gives the study high ecological validity because it follows the approach by which the tai chi program is currently delivered in practice in New Zealand. It was attempted to reduce the potential for bias in the class instruction by ensuring that the tai chi instructors chosen had all completed the compulsory training program for delivering modified tai chi for older adults under the ACC tai chi program contract. The LLE program was standardized, with instructors receiving training in addition to a written manual to ensure consistency. A further limitation is that tai chi was not compared with an inactive, or usual care, control group. Although assessors were blinded to group assignment, they may not have been perceived as independent of the program, and desirability bias was potentially present because participants may have been eager to give positive responses with regard to their ongoing exercise participation during the postintervention interview. Similarly, the participants may have been aware that ACC had funded the research and as such given positive responses as a way of ensuring ongoing funding of the program. A further limitation was that the level of missing information was significantly higher in the LLE group than in the TC1 and TC2 groups. Although the LLE group had more missing data, it is likely that the presented analyses are valid because the distribution of falls at baseline between treatment groups was not significantly different (P = .13), the covariates were similar (Table 2), and attrition was not different between groups (P = .19). Moreover, trial withdrawal was not related to falling (P = .10), and there was no difference in withdrawal according to treatment group (P = .48).

Participants were eligible for the trial if they had at least one falls risk factor as identified by the FRAT. This criterion may have introduced some selection bias, excluding those who were at risk of falling but did not answer positively to one of the five questions on the FRAT, but it is likely that the extent of selection bias was limited because the FRAT covers major factors related to falls risk: a history of falling in the previous year, taking four or more medications, a diagnosis of stroke or Parkinson’s disease, any balance problems, and whether the person could stand up from a chair without using their arms (indicating leg strength). In addition, a cutoff score of 1 was used rather than the cutoff score of 3 recommended to identify people who should have further assessment of falls risk. Of the 1,095 people screened for inclusion, only 85 were excluded on the basis of no fall risk factor according to the FRAT.

Accident Compensation Corporation’s modified tai chi program and the LLE program were effective in reducing falls in community-dwelling older adults who had an identified falls risk. Measures of strength and balance also showed improvements over time. Providing targeted exercise-based interventions, even relatively low-level programs, can be beneficial in reducing falls in community-dwelling populations who are at risk of falling. This study supports the growing body of literature that demonstrates that group exercise is an effective method of reducing falls in community-dwelling older adults.

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The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

Author Contributions: Taylor D., Hale L., and Waters DL.: Study concept and design, data collection, data analysis, data interpretation, manuscript editing. Schulter P.: Study design, data analysis, data interpretation, manuscript editing. Binns EE.: Data collection, data analysis, data interpretation, manuscript editing. McCracken H.: Study design, data collection, manuscript editing. McPherson K. and Wolf SL.: Study design, data interpretation, manuscript editing.

Sponsor’s Role: None.

REFERENCES

Dear Author,

During the copy-editing of your paper, the following queries arose. Please respond to these by marking up your proofs with the necessary changes/additions. Please write your answers on the query sheet if there is insufficient space on the page proofs. Please write clearly and follow the conventions shown on the attached corrections sheet. If returning the proof by fax do not write too close to the paper’s edge. Please remember that illegible mark-ups may delay publication.

Many thanks for your assistance.

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<tr>
<th>Query reference</th>
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<td>AUTHOR: Figure 1 has been saved at a low resolution of 123 dpi. Please resupply at 600 dpi. Check required artwork specifications at <a href="http://authorservices.wiley.com/submit_illust.asp?site=1">http://authorservices.wiley.com/submit_illust.asp?site=1</a></td>
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USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-Annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 8.0 or above). (Note that this document uses screenshots from Adobe Reader X)
The latest version of Acrobat Reader can be downloaded for free at: [http://get.adobe.com/reader/](http://get.adobe.com/reader/)

Once you have Acrobat Reader open on your computer, click on the **Comment** tab at the right of the toolbar:

This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the **Annotations** section, pictured opposite. We’ve picked out some of these tools below:

### 1. **Replace (Ins)** Tool – for replacing text.

- Strikes a line through text and opens up a text box where replacement text can be entered.

**How to use it**
- Highlight a word or sentence.
- Click on the **Replace (Ins)** icon in the **Annotations** section.
- Type the replacement text into the blue box that appears.

### 2. **Strikethrough (Del)** Tool – for deleting text.

- Strikes a red line through text that is to be deleted.

**How to use it**
- Highlight a word or sentence.
- Click on the **Strikethrough (Del)** icon in the **Annotations** section.

### 3. **Add note to text** Tool – for highlighting a section to be changed to bold or italic.

- Highlights text in yellow and opens up a text box where comments can be entered.

**How to use it**
- Highlight the relevant section of text.
- Click on the **Add note to text** icon in the **Annotations** section.
- Type instruction on what should be changed regarding the text into the yellow box that appears.

### 4. **Add sticky note** Tool – for making notes at specific points in the text.

- Marks a point in the proof where a comment needs to be highlighted.

**How to use it**
- Click on the **Add sticky note** icon in the **Annotations** section.
- Click at the point in the proof where the comment should be inserted.
- Type the comment into the yellow box that appears.
5. **Attach File Tool** – for inserting large amounts of text or replacement figures.

   Inserts an icon linking to the attached file in the appropriate pace in the text.

   **How to use it**
   - Click on the Attach File icon in the Annotations section.
   - Click on the proof to where you’d like the attached file to be linked.
   - Select the file to be attached from your computer or network.
   - Select the colour and type of icon that will appear in the proof. Click OK.

6. **Add stamp Tool** – for approving a proof if no corrections are required.

   Inserts a selected stamp onto an appropriate place in the proof.

   **How to use it**
   - Click on the Add stamp icon in the Annotations section.
   - Select the stamp you want to use. (The Approved stamp is usually available directly in the menu that appears).
   - Click on the proof where you’d like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).

7. **Drawing Markups Tools** – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

   Allows shapes, lines and freeform annotations to be drawn on proofs and for comment to be made on these marks.

   **How to use it**
   - Click on one of the shapes in the Drawing Markups section.
   - Click on the proof at the relevant point and draw the selected shape with the cursor.
   - To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
   - Double click on the shape and type any text in the red box that appears.

For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: