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Detraining effects of regular Tai Chi exercise on postural control ability in older women: A randomized controlled trial

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ABSTRACT

Background/Objective: This study aimed to investigate the training and detraining effects of Tai Chi (TC) on postural control ability in single leg stance (SLS) by conducting a single-blind randomized controlled trial.

Method: Forty-eight older women were randomly divided into the TC, brisk walking (BW), and control(C) groups by using computer-generated program. The participants completed a 16-week intervention training and 8-week detraining program. Postural control ability in SLS was tested at the baseline, 16 t h, 20 t h, and 24 t h weeks. The primary outcomes included single-leg stance time (Time) and secondary outcomes included maximal displacement of the center of pressure (COP) in the anterior–posterior (AP) direction (D-ap), maximal displacement of the COP in the medial–lateral (ML) direction (D-ml), total length of the COP trajectories (Lng), and 95% confidence ellipse area of the COP movements (area), mean AP total excursion velocities (V-ap), and mean ML total excursion velocities (V-ml).

Results: Significant within-group difference compared with the baseline and between-groups difference compared with control group were found at 16 t h, 20 t h, and 24 t h weeks in the TC group and at the 16 t h and 20 t h weeks in the BW group in all the primary and secondary outcomes. Most of secondary outcomes including Lng, D-ml, V-ml, Area increased significantly at the 24 t h week compared with that at the 16 t h week in BW group.

Conclusions: TC was effective in improving postural control ability and maintaining intervention gains, and was recommended as an appropriate exercise to prevent falls in the older adults.

Introduction

The risk of falling in the older adults increases with aging. Approximately one-third of older adults over 65 years of age fall at least once a year.[1] Falls could result in severe injuries, such as fractures, head injuries, and even death.[2] Moreover, the high costs of health care resulting from falls have placed an enormous burden on families. The total costs reached about 23.3 billion in the USA and 1.6 billion dollars in the UK.[3] Declining postural control ability in single-leg stance (SLS), which is profoundly challenging for older adults, is a significant predictor of falls[4] in the elderly. Nearly 50% of falls occur during the single-leg support phase, such as stepping over obstacles and climbing stairs.[5,6]

Regular Tai Chi (TC) could improve postural control ability.[7,8] A cross-sectional study reported that long-term TC practitioners performed well in SLS tests with their eyes closed,[9] possessed less body sway in perturbed single-leg stance,[10] leaned further without losing stability, and showed a good control of their leaning trajectory.[11] Longitudinal studies also provided evidence of the benefits of TC for postural control ability. After a 24-week intervention, the TC group showed significantly shorter total, medial–lateral, and anterior–posterior center of pressure (COP) sway paths compared with the control group.[7] Similarly, another study also corroborated that a 10-week TC training could decrease the COP path and area during postural control tests in the older adults.[12] Furthermore, TC exercise could improve joint kinesthesia,[13] muscle strength in

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lower extremities,[14] and neuromuscular reaction in older women.[15]

Although TC has been recognized as an effective exercise to improve postural control in older adults, few detraining effects on postural control ability were known. Some older people have stopped training for various reasons, including diseases, injuries, and travels, and they may go on retraining. After post-exercise, some intervention effects on the physical function could start to diminish.[13] Nevertheless, few data offered the magnitude and retention of the maintenance of postural control ability during detraining periods.

Alternatively, brisk walking (BW) was one of the prevalent moderate-intensity aerobic exercise forms across all ages. Although some longitudinal studies have proven that BW could improve static and dynamic balance abilities and lead to the reduction of fall risk in the older adults,[16,17] others affirmed the inconsistent results on postural stability.[18] To our knowledge, TC and BW are safe methods of exercise for older women and require an equivalent energy expenditure.[19] Nonetheless, the detraining effects of both exercises on postural control ability in older women remained unclear.

The present study aims to compare the detraining effects of TC and BW on postural control in the older adults. The following hypotheses are formulated: (1) after the 16-week intervention, the postural control with SLS will improve in both groups, and (2) TC will be effective for maintaining SLS during a detraining period.

Methods

Study design

A single-blinded randomized controlled trial was designed to compare the effects of TC and BW on body balance in SLS during a 16-week training and an 8-week detraining (Figure 1). Both TC and BW groups participated in one 60-min intervention exercises at 5 times a week for 16 weeks. The control group attended group session with the same schedule as the two intervention groups. After stopping the exercises, all participants were prohibited to perform regular exercises for 8 weeks. Postural control ability was tested at the baseline and at the 16 t h, 20 t h, and 24 t h weeks.

Participants

Sample size estimation

G*Power software was used to calculate the sample size with the formula by Hopkins.[20] The following data were determined: effect size = 0.35, two-tailed significance, statistical power = 0.8, α value = 0.05, and drop-out rate = 25%.[18] So three groups of 48 participants were the required sample size.

Participant recruitment and randomization

48 older women aged 60–70 years were recruited through newspapers, leaflets, and community advocacy from Jinan city, China. The exclusion criteria were as follows: having any regular exercise experience and any records of cardiovascular, neurological, falling history, and musculoskeletal diseases. All participants were randomly divided into the TC (n = 16), BW (n = 16), and control (C) groups (n = 16) by using computer-generated program. This study was approved by the ethics committee of Shandong Sport University (No.201613). All the participants were requested to sign a written informed consent statement. The total study period was 6 months.

Exercise intervention

During the 16-week training periods, each group participated in a 60-min session at 5 times a week for 16 weeks. In addition, at least 64 attendance sessions of 80 (80%) were required for each participant among the three groups.

The participants were individually taught to perform a24-form TC exercise by a qualified TC master in the first 3 weeks. Each session included a 10-min warm-up, 20-min learning new movement forms, 20-min reviewing learned movements before, and 10-min cool-down. Subsequently, they practiced with master supervision for the 13 weeks. Each session included a 10-min warm-up, 40-min TC, and 10-min cool-down.

Brisk walking was defined as walking at a 1.79 m/s speed value.[21] During this exercise, the participants perceived that their breathing significantly accelerated, that their body got extremely hot, and that their sweat streamed down.[18] A professional instructor asked the participants to regulate their pace and speed on a pedestrian road. The time of walking increased from 10 to 40 min progressively over the first 3 weeks and then remained constant at 40-min for the later 13 weeks. A session consisted of a 10- minutes warm-up, 40- minutes BW, and 10- minutes cool-down.

The control group was asked to watch TV programs, read newspapers, or attend healthy education lectures with the same schedule as the two other groups. However, they were prohibited to perform any regular exercise and were allowed to maintain their dietary habits.

During the 8-week detraining, the participants of the three groups were asked to stop the intervention exercise and any regular exercise. The researchers called all participants on a weekly basis to confirm whether they participated in any programmed exercises.

Outcomes

Primary outcomes

The SLS tests were performed to assess postural control ability in a quiet testing room, which reported good interclass correlation coefficient (ICC = 0.95 to 0.99) and within the rater interclass correlation coefficient (ICC = 0.73 to 0.93).[22] This measurement procedure asked the participants to stand on the ground in SLS with eyes open and closed, arms hanging on the sides of their relaxed bodies while the other leg was flexed 90° at hip and knee joint. When the balances with eyes open were tested, participants were required to gaze at a dot on the wall 2.5 m away. The length of time was recorded from the moment the participants' foot was off the floor until it touched the floor again. The SLS with the participants' eyes open and closed were performed thrice, and the longest one was selected for analysis. A 1-min break was given between trials.

Secondary outcomes

The tests were performed with a foot pressure plate (RSscan footscan 2D Balance 0.5 m system).[23] Each participant was asked to stand barefoot in a comfortable self-chosen stance facing the positive anterior–posterior (AP)direction on a plate with the dominant leg, which is described as the preferred leg for kicking a football,[24] as motionless as possible. The other leg was fixed 90° at hip and knee joint flexion. Both arms hung relaxed at the sides. Two conditions of standing were tested randomly: one when participants were asked to perform single-leg standing for 22 s with eyes open while looking straight ahead at a dot on the wall 2.5 m away[25]; another one was when they performed single-leg standing for 12 s with eyes closed.[26] The trial was unavailable and repeated if the participants moved the supported leg or if the non-weight leg touched the supporting surface during the testing duration. Three successful trials of each SLS with eyes open and closed were tested after two familiarized test procedures. The time interval for breaks was 1 min between two trials. All measurement procedures were performed under the supervision of a technician.

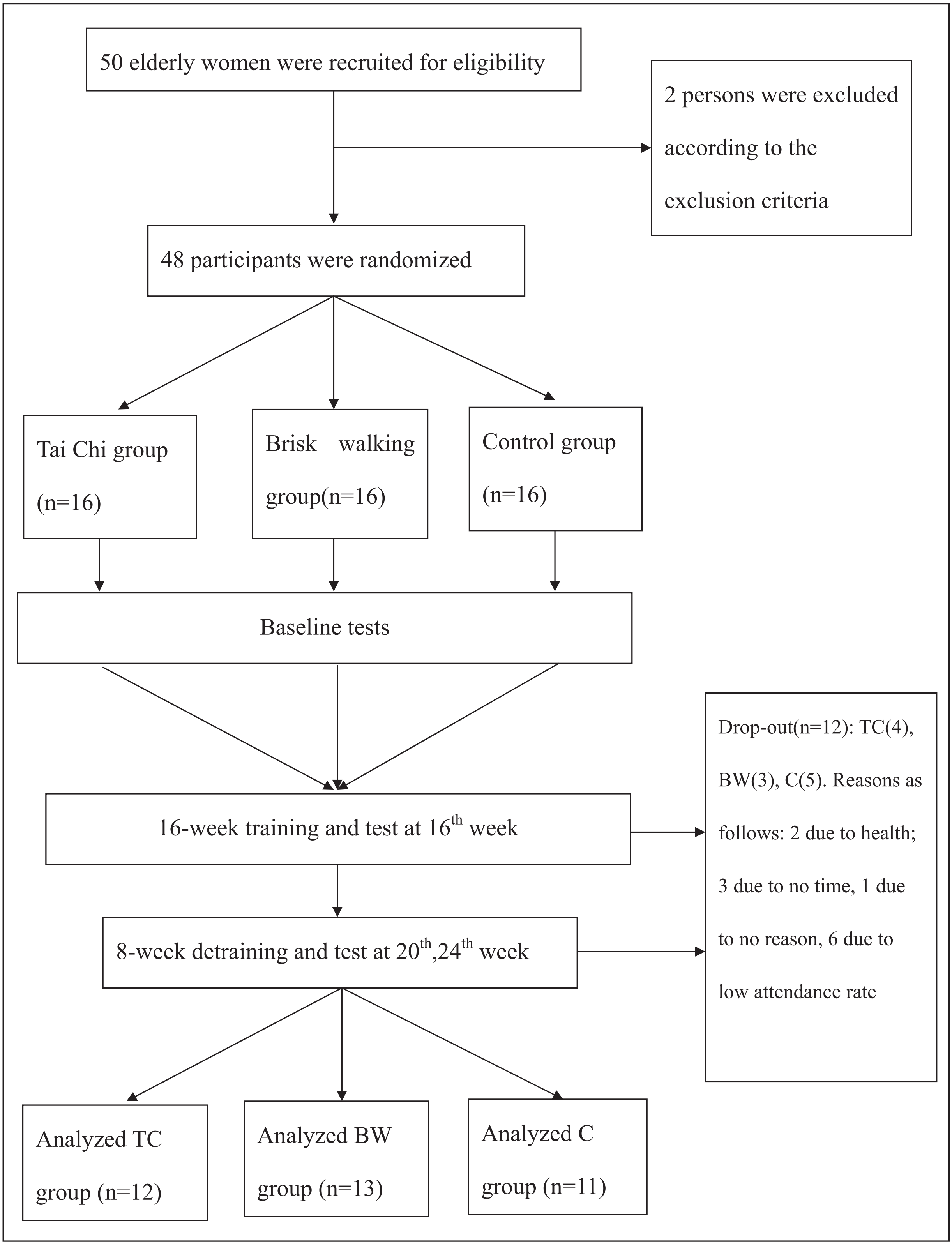

Figure 1. Flow diagram for randomized controlled trial.
TC, Tai Chi; BW, brisk walking; C, control.

The data were sampled at 17 Hz and low-pass filtered with a cut-off frequency of 6 Hz (Butterworth).[23] Each trial data of the first and the last 1 s were not considered for stability. Three trial data with the same visual condition were averaged for analysis. All output variables were calculated based on the mathematical formula in the previous study.[27,28] The maximal displacement of the COP in the AP direction (D-ap), the maximal displacement of the COP in the medial–lateral (ML) direction (D-ml), the total length of the COP trajectories (Lng), and the 95% confidence ellipse area of the COP movements (area), the mean AP total excursion velocities (V-ap), and the mean ML total excursion velocities (V-ml) were calculated.

Statistical analysis

The SPSS 17.0 was used for data analysis. All variables were presented as mean ± standard deviation. The variables of referring to four times were named $week_0$, $week_{16}$, $week_{20}$, and $week_{24}$ in this study. One-way ANOVA was employed to compare the differences of the demographic and baseline variables among the three groups. Two-way repeated ANOVA was used to determine the main effects of groups, time durations, and their interaction on the measurements. If any significant main and interaction effects were found, the Boneferroni method was conducted for post-hoc comparisons. The significant level was set at 0.05.

Results

Baseline characteristics of the participants

A total of 50 participants were screened for eligibility; 48 were qualified and were divided into three groups; and 36 participants (12, 13, and 11 in the TC, BW, and control groups) completed the whole 24-week study. Twelve participants dropped out because of health issues (2C), low attendance rate (3 B W, 3 TC), and no time (1 TC, 2C), and for no reason at all (1C) (Figure 1). The characteristics of the participants were showed in Table 1.

Postural control ability results during the 16-week training period

Tables 2 and 3 show no significant between-groups difference across all the variables at $week_0$ among the three groups. During the training periods, after the 16-week interventions, the participants in the TC and BW groups have significant better within-group performance than during $week_0$ and better between-groups performance compared with the control group in all the variables with the two visual conditions. No significant difference between pre- and post-exercise in the control group during training periods existed.

Postural control ability results during the 8-week detraining period

Table 2 shows that during detraining periods, the significant within-group difference compared with $week_0$and the significant between-groups difference compared with the control group were found across all the variables with the eyes open condition at the last three tests in the TC group. The significant within- and between-group differences were found in time, area, V-ap, and V-ml with eyes open at the last three tests in the BW group. However, the gains decreased significantly at $week_{24}$ in D-ap, D-ml, and V-ml compared with $week_{16}$ during detraining periods in the BW group. No significant difference was found in the control group.

Table 3 shows that during detraining periods, the significant within-group difference compared with $week_0$ and the significant between-groups difference compared with the control group were found across all the variables with the eyes closed condition, except for D-ml in the last three tests of the TC group. Significant within-group difference was found in D-ml at $week_{24}$ compared with $week_{16}$ in the TC group. With the eyes closed condition, significant within-group difference compared with $week_0$ and significant between-group difference compared with the control group in D-ml at $week_{16}$ and $week_{20}$ were found during the detraining periods in the TC group. With the eyes closed condition, significant within-group difference compared with $week_0$ and significant between-group difference compared with the control group in Lng, D-ap, V-ap, and V-ml at $week_{16}$, $week_{20}$ and $week_{24}$ were found during the detraining periods in the BW group. The gains decreased significantly at $week_{24}$ in time, area, and D-ml compared with $week_{16}$ during the detraining periods in the BW group. No significant difference was found in the control group.

Discussion

The first hypothesis was demonstrated in the present study. Our results showed that after the 16-week interventions, the postural control ability with two visual conditions in SLS improved in the TC and BW groups, which concurred with previous studies.[29,30] The variables assessing postural control, including the medial–lateral, total, and anterior–posterior path lengths of the COP trajectories, significantly improved after the TC[7] and BW exercise interventions.[17]

Regular physical activities,[31] especially moderate-intensity exercises,[32] could be helpful in improving postural control ability. Both exercises were moderate-intensity exercises with approximately 55% of maximal oxygen intake.[21,33] Several studies corroborated that TC was an effective practice to improve postural control.[7,8] A study by Zhou[7] examined the effects of 24 weeks of TC on the postural control of the older adults. The results validated that positive improvements were found in time, paths, and velocity of the COP in the TC group. In the current study, positive results were found after 16 weeks. Although the direct comparisons between two studies were infeasible because of different exercise frequencies, participants, and sample sizes, our findings still partly support that TC could improve postural control.

These positive effects of TC on postural control were related to various factors. Postural control ability is the integrated result from the center neural, peripheral nervous, and musculoskeletal

Table 1
The baseline characteristics of the participants.

N	Tai Chi group	Brisk walking group	Control group	F value	P value
	12	13	11		
Age (years)	64.12 ± 3.21	63.26 ± 2.20	65.36 ± 4.31	0.712	0.498
Weight (kg)	62.81 ± 8.37	62.00 ± 7.49	62.63 ± 7.21	0.004	0.996
Height (cm)	157.56 ± 5.45	158.50 ± 4.40	156.45 ± 4.43	2.607	0.089
BMI(kg/m^2)	25.12 ± 3.19	24.69 ± 2.97	26.21 ± 3.82	0.617	0.546

Table 2
Comparisons of study variables with eyes open in single leg stance among three groups.

	TC group (N = 12)	BW group (N = 13)	C group (N = 11)	time		group		time × group	
				P value	η^2_p	P value	η^2_p	P value	η^2_p
Time (second)				<0.001	0.337	0.014	0.229	0.011	0.152
$Week_0$	32.73 ± 16.69	40.80 ± 15.13	38.37 ± 13.73						
$Week_{16}$	55.61 ± 10.20[a,c]	55.03 ± 12.80[a,c]	39.94 ± 8.05						
$Week_{20}$	54.90 ± 10.95[a,c]	56.89 ± 8.78[a,c]	41.18 ± 11.07						
$Week_{24}$	54.20 ± 19.98[a,c]	56.90 ± 28.55[a,c]	39.18 ± 8.56						
Lng (mm)				<0.001	0.346	0.026	0.199	0.074	0.108
$Week_0$	422.57 ± 105.56	363.43 ± 104.7	427.93 ± 152.3						
$Week_{16}$	217.89 ± 45.82[a,c]	245.42 ± 80.48[a,c]	375.9 ± 69.78						
$Week_{20}$	256.27 ± 84.94[a,c]	260.73 ± 83.73[a,c]	357.29 ± 78.42						
$Week_{24}$	319.34 ± 82.98[a,c]	276.83 ± 90.25[a]	367.22 ± 84.32						
Area (cm^2)				<0.001	0.517	<0.001	0.570	<0.001	0.307
$Week_0$	1.45 ± 0.53	1.32 ± 0.61	1.38 ± 0.71						
$Week_{16}$	0.40 ± 0.11[a,c]	0.34 ± 0.25[a,c]	1.29 ± 0.20						
$Week_{20}$	0.44 ± 0.18[a,c]	0.35 ± 0.24[a,c]	1.32 ± 0.14						
$Week_{24}$	0.38 ± 0.13[a,c]	0.63 ± 0.38[a,c]	1.23 ± 0.40						
D-ap (mm)				<0.001	0.413	0.004	0.280	0.026	0.132
$Week_0$	30.07 ± 4.82	28.47 ± 7.96	25.95 ± 6.71						
$Week_{16}$	16.52 ± 3.62[a,c]	15.60 ± 5.64[a,c]	25.61 ± 6.51						
$Week_{20}$	16.46 ± 3.44[a,c]	15.44 ± 4.45[a,c]	27.59 ± 6.08						
$Week_{24}$	16.80 ± 3.49[a,c]	21.47 ± 6.58[b]	25.46 ± 7.22						
D-ml (mm)				<0.001	0.528	0.003	0.293	<0.001	0.417
$Week_0$	33.62 ± 11.49	31.97 ± 9.88	33.59 ± 7.32						
$Week_{16}$	18.61 ± 6.49[a,c]	16.46 ± 6.08[a,c]	29.26 ± 3.96						
$Week_{20}$	19.48 ± 8.22[a,c]	16.71 ± 5.00[a,c]	28.84 ± 8.30						
$Week_{24}$	22.85 ± 7.80[a,c]	24.30 ± 9.37[b]	28.18 ± 5.17						
V-ap (mm/s)				<0.001	0.418	0.002	0.302	0.027	0.130
$Week_0$	7.61 ± 2.61	7.26 ± 2.24	7.63 ± 1.66						
$Week_{16}$	4.22 ± 1.47[a,c]	3.74 ± 1.38[a,c]	6.64 ± 0.90						
$Week_{20}$	4.43 ± 1.86[a,c]	3.79 ± 1.13[a,c]	6.55 ± 1.88						
$Week_{24}$	5.19 ± 1.77[a,c]	4.52 ± 2.58[a,c]	6.40 ± 1.17						
V-ml (mm/s)				<0.001	0.524	0.003	0.301	<0.001	0.413
$Week_0$	6.49 ± 1.18	6.21 ± 1.73	5.66 ± 1.46						
$Week_{16}$	3.56 ± 0.83[a,c]	3.41 ± 1.22[a,c]	5.58 ± 1.41						
$Week_{20}$	3.54 ± 0.79[a,c]	3.36 ± 0.97[a,c]	6.02 ± 1.32						
$Week_{24}$	3.62 ± 0.81[a,c]	4.68 ± 1.43[b]	5.55 ± 1.57						

Abbreviations: Time, the single-leg stance time; Lng, the total length of the COP trajectories; Area, the 95% confidence ellipse area of the COP movements; D-ap, the maximal displacement of the COP in the anterior–posterior direction; D-ml, the maximal displacement of the COP in the medial–lateral direction; V-ap, the mean AP total excursion velocities; V-ml, the mean ML total excursion velocities.

[a] Denotes significant difference compared with the $week_0$ value within each group.
[b] Denotes significant difference compared with the $week_{16}$ value within each group.
[c] Denotes significant difference compared with the control group.

systems. Physical function declines with aging; however, regular TC could reshape brain structures, such as thickened cortex in the precentral gyrus and insula sulcus in the right hemisphere[34] and improve lower limb strength,[14] ankle and knee joint proprioception,[13] and neuromuscular reaction ability.[15] The abovementioned factors could help to improve balance and postural control after the intervention in the older adults. Moreover, BW is a popular moderate-intensity exercise, which could also enhance physical function similar to TC.[35] Our results were consistent with those of previous studies,[16,18] which indicated that after a 12-week BW, the participants significantly performed well in the postural control test.

Interestingly, no significant between-group difference was found in all variables at $week_{16}$ between the TC and BW groups. To the authors' knowledge, a 4-week TC[36] and a 12-week BW[16,18] could significantly improve postural control. Perhaps, TC was more efficient than BW in improving postural control. In our study, 16 weeks could be sufficiently long to improve postural control for the two intervention exercises. However, only two tests were performed before and after the intervention in the present study, and no more data to support our speculation came to light.

The second hypothesis was proven as follows: according to our data, during 8-week detraining periods, all variables with two visual conditions, except for D-ml with eyes closed in a single stance, indicated no significant decline in the TC group. The results confirmed that the maintenance of intervention gains for 8 weeks was good in the TC group. Our results were consistent with the findings from the study by Li et al.[8] The results corroborated that the gains of postural stability were maintained during the 12-week detraining periods.[8] The underlying mechanism can be attributed to the following factors in the present study. First, as aforementioned, regular exercise could have positive effects on the central nervous, musculoskeletal, and peripheral nervous systems to improve balance control. Once the plastic structure and physical function changes were established, adequate time to return to the original condition after the post-intervention would be necessary. In the present study, some decreasing trends emerged, but no significant differences came to light. The 8-week detraining may be insufficient to observe significant changes. This standpoint was supported by Miles and Eighmy's study,[37] which showed that experimental monkeys who wore telescopic, fixed-field, and dove prism spectacles for one week experienced vestibule-ocular reflex changes. However, after gaining adaptive reflex, the monkeys needed many days to readapt and readjust the vestibule-ocular reflex once the spectacles were off.[37] Moreover, another study[13] also proved that the improved proprioception at the ankle joint in the TC groups did not significantly decrease after the 8-week intervention was stopped. Finally, intervention exercises could

Table 3
Comparisons of study variables with eyes closed in single leg stance among three groups.

	TC group (N = 12)	BW group (N = 13)	C group (N = 11)	time		group		time × group	
				P value	η^2_p	P value	η^2_p	P value	η^2_p
Time (second)				<0.001	0.576	0.005	0.271	<0.001	0.373
Week$_0$	16.78 ± 7.10	15.63 ± 8.30	18.26 ± 7.63						
Week$_{16}$	39.95 ± 11.67[a,c]	31.68 ± 12.4[a,c]	19.11 ± 8.19						
Week$_{20}$	36.77 ± 13.47[a,c]	31.45 ± 11.44[a,c]	19.89 ± 6.93						
Week$_{24}$	35.53 ± 12.09[a,c]	26.76 ± 11.61[a,b]	20.41 ± 7.55						
Lng (mm)				<0.001	0.669	<0.001	0.575	<0.001	0.511
Week$_0$	519.51 ± 105.54	582.20 ± 85.69	545.79 ± 98.21						
Week$_{16}$	194.70 ± 83.76[a,c]	227.52 ± 113.06[a,c]	558.55 ± 90.29						
Week$_{20}$	231.19 ± 85.79[a,c]	241.95 ± 97.73[a,c]	553.50 ± 8870						
Week$_{24}$	278.14 ± 95.06[a,c]	278.43 ± 105.95[a,c]	518.98 ± 104.9						
Area (cm^2)				<0.001	0.362	0.002	0.304	0.072	0.108
Week$_0$	2.50 ± 1.15	2.28 ± 0.86	2.46 ± 0.91						
Week$_{16}$	1.14 ± 0.97[a,c]	1.25 ± 0.94[a,c]	2.17 ± 0.71						
Week$_{20}$	1.40 ± 0.81[a,c]	1.39 ± 0.81[a,c]	2.05 ± 1.00						
Week$_{24}$	1.58 ± 0.71[a,c]	1.69 ± 0.93[b]	2.10 ± 1.10						
D-ap (mm)				<0.001	0.401	<0.001	0.377	<0.001	0.232
Week$_0$	41.15 ± 6.12	40.07 ± 7.55	38.96 ± 9.50						
Week$_{16}$	25.88 ± 8.95[a,c]	21.54 ± 7.38[a,c]	37.98 ± 7.02						
Week$_{20}$	29.17 ± 8.47[c]	24.69 ± 8.15[a,c]	38.40 ± 7.14						
Week$_{24}$	29.63 ± 10.19[c]	25.70 ± 9.06[a,c]	39.43 ± 9.65						
D-ml (mm)				<0.001	0.418	<0.001	0.401	<0.001	0.289
Week$_0$	39.33 ± 8.85	41.75 ± 6.24	38.96 ± 9.50						
Week$_{16}$	25.40 ± 9.83[a,c]	30.52 ± 14.98[a,c]	36.16 ± 8.72						
Week$_{20}$	28.96 ± 10.47[a,c]	35.66 ± 17.25[a,c]	33.86 ± 5.98						
Week$_{24}$	36.17 ± 10.22[b]	36.36 ± 17.68[b]	35.80 ± 10.12						
V-ap (mm/s)				<0.001	0.405	0.005	0.269	0.045	0.119
Week$_0$	13.92 ± 2.68	12.69 ± 2.11	12.62 ± 3.45						
Week$_{16}$	7.93 ± 2.72[a,c]	7.80 ± 2.84[a,c]	10.31 ± 3.07						
Week$_{20}$	9.53 ± 2.33[a,c]	8.91 ± 3.10[a,c]	10.13 ± 3.32						
Week$_{24}$	9.39 ± 2.11[a,c]	9.39 ± 2.25[a,c]	10.54 ± 3.61						
V-ml (mm/s)				<0.001	0.376	<0.001	0.358	<0.001	0.213
Week$_0$	7.48 ± 1.11	7.28 ± 1.61	7.08 ± 1.72						
Week$_{16}$	4.71 ± 1.62[a,c]	3.91 ± 0.92[a,c]	6.91 ± 1.27						
Week$_{20}$	5.30 ± 1.53[a,c]	4.48 ± 1.36[a,c]	6.98 ± 1.29						
Week$_{24}$	5.38 ± 1.85[a,c]	4.67 ± 1.41[a,c]	7.17 ± 1.75						

Abbreviations: Time, the single-leg stance time; Lng, the total length of the COP trajectories; Area, the 95% confidence ellipse area of the COP movements; D-ap, the maximal displacement of the COP in the anterior–posterior direction; D-ml, the maximal displacement of the COP in the medial–lateral direction; V-ap, the mean AP total excursion velocities; V-ml, the mean ML total excursion velocities.

[a] Denotes significant difference compared with the week$_0$ value within each group.
[b] Denotes significant difference compared with the week$_{16}$ value within each group.
[c] Denotes significant difference compared with the control group.

improve balance control and decrease the incidence rate of falls.[8] The older adults could reduce the fear of falling and increase difficult physical activities in daily life. Conversely, these physical activities possibly further delayed the reduction of balance control.

In the BW group, a significant difference was found at week$_{24}$ compared to week$_{16}$. Postural control ability improvements were fully maintained for 4 weeks and partly for 8 weeks in the BW group. The differences on the maintenance of intervention gains during the detraining periods between TC and BW could be caused by different movement characteristics. Tai Chi referred to body–mind movements that required upper extremities to move in coordination with squatting leg movements and eyes to follow the hands. These characteristics may improve coordination of eyes, upper body, and lower extremities and be helpful to enhance postural control ability.[38] Moreover, participants concentrated their attention on slow movements of TC in practicing, which could improve cognitive function.[39] However, compared with TC, BW was a subconscious movement needing less coordination and concentration from participants.

It is noteworthy that in the present study, during the detraining periods, D-ml on two visual conditions and V-ml without vision at week$_{24}$ significantly increased compared with week$_{16}$ in the BW group. This result validated that the balance control maintenance effectiveness of BW in the ML direction was poor. The lack of balance in the ML direction could lead to falls, which was an important indicator of the risk of falling.[17] The poor maintenance effectiveness with eyes closed in single leg stance could be related to BW movement characters and visual condition. Walking movements, including the ankle/knee joint flexion and extension, repeatedly occurred in the sagittal plane. This special uniaxial movement character may be helpful for improving the musculoskeletal system function in the AP direction but not in the ML direction. In addition, the visual information input system was important for postural control. The balance control sway without visual feedback could increase by 20%–70% and rely on joint proprioceptive and vestibular feedback in the older adults.[40] However, a study affirmed that the ankle joint proprioception in the ML direction did not significantly improve during the 16-week BW.[13] The abovementioned factors may lead to poor postural control ability maintenance in the BW group. Therefore, the author recommends that the older adults could take TC to control balance in the ML direction.

This study has three limitations. First, only female participants were recruited; hence, the effects of the two exercises on the balance control with SLS in older men were not detected. Second, 8 weeks was not sufficiently long to measured significant differences during detraining; thus, further study should prolong the detraining periods. Thirdly, only 36 participants completed the entire 24-

week study, so the findings of this study should be interpreted with caution. Further studies with large sample sizes should be required to determine the detaining effects of TCC and BW intervention on balance in elderly.

Conclusion

The 24-form TC and BW significantly improved postural control ability with SLS after the 16-week training in older women. During the 8-week detraining, the gains of intervention were fully maintained in the TC group and partly maintained in the BW group.

Conflicts of interest

None.

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