DETRAINING EFFECTS OF TAI CHI ON STATIC BALANCE IN OLDER WOMEN

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This study aimed to investigate the detraining effects of Tai Chi (TC) on balance ability in single leg stance (SLS). TC, brisk walking (BW), and control (C) groups completed a 16-week intervention and 8-week detraining program. Time and center of pressure trajectory in SLS was tested with pressure plate at baseline, 16th, 24th week. Primary outcome (Time) and secondary outcomes (Lng, Area, D-ap, D-ml) improved significantly at the 16th week in the TC and BW groups. Most outcomes increased significantly at the 24th week compared to the 16th week in the BW group. TC was effective to improve balance ability and maintaining intervention gains and is recommended as an appropriate exercise to prevent falls in the older adults.

KEY WORDS: Tai Chi, aging, postural control, RCT design

INTRODUCTION: Approximately one-third of older adults over 65 years of age fall at least once a year(Gill, Taylor, & Pengelly, 2005). Falls could result in severe injuries, such as fractures, head injuries, and even death. Declining balance ability in single-leg stance(SLS), which is profoundly challenging for older adults, is a significant predictor of falls(Enderlin et al., 2015) in older adults. Regular Tai Chi (TC) could improve balance ability(Li et al., 2012). A cross-sectional study reported that long-term TC practitioners performed well in SLS tests with their eyes closed, possessed less body sway in perturbed single-leg stance, leaned further without losing stability, and showed good control of their leaning trajectory(Hong, Li, & Robinson, 2000). Although TC has been recognized as an effective exercise to improve balance in older adults, few detraining effects on balance ability were known. Brisk walking (BW) was one of prevalent moderate-intensity aerobic exercise forms across all ages. TC and BW are safe methods of exercise for older women and require an equivalent energy expenditure(Lan, Chen, & Lai, 2004). Nonetheless, the detraining effects of both exercises on balance ability in older adults remain unclear. The present study aims to explore the detraining effects of TC and BW on balance in older women. The following hypotheses are formulated: (1) after the 16-week intervention, SLS balance with SLS will improve in both groups, and (2) TC will be effective for maintaining SLS during a detraining period.

METHODS: 48 older women aged 60 to 70 years were recruited and randomly divided into the TC (n=16), BW (n=16), and control (C) groups (n=16). The exclusion criteria were as follows: having any regular exercise experience and any records of cardiovascular, neurological, falling history, and musculoskeletal diseases. All the participants were requested to sign a written informed consent statement.
During the training periods, each group participated in a 60-min session 5 times a week for 16 weeks. The TC group performed a 24-form TC exercise with supervision by a qualified TC master. The BW group walked at about 1.79m/s speed (Murtagh, Boreham, & Murphy, 2002), 5 times a week for 16 weeks. A professional instructor asked the participants to regulate their pace and speed on a pedestrian road. 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. During the 8-week detraining, the participants of the three groups were asked to stop the intervention exercise and any regular exercise.
Primary outcomes: The SLS tests with eyes open were performed to assess static balance in

a quiet testing room at baseline, 16_{th}, 24_{th} week. The tests were performed with a foot pressure plate sampling at 17 Hz. Each participant was asked to stand barefoot on a plate with the dominant leg which was the preferred leg for kicking a football(Gribble, Tucker, & White, 2007), as motionless as possible. Three successful trials of each SLS with eyes open (20 s) were conducted. The longest time in SLS was analyzed. Secondary outcomes: The maximal displacement(mm) of center of pressure(COP) in the anterior-posterior direction(D-ap), the maximal displacement(mm) of the COP in the medial–lateral direction(D-ml), the total length (mm) of the COP trajectories (Lng), and the 95% confidence ellipse area (cm^2) of the COP movements (area) were calculated to assess static balance ability.

One-way ANOVA was employed to compare the differences of the demographic and baseline variables among the three groups. Two-way repeated measures 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 Bonferroni method was conducted for post-hoc comparisons. The significant level was set at 0.05.

RESULTS: A total of 36 participants completed the whole 24-week study. At $week_0$ there was no significant difference (P>0.05) in characteristics of participants among the three groups before the intervention (Table 1). Table 2 showed that after the 16-week intervention, TC and BW groups had significant improvement in balance stability measures in Time, Lng, Area, D-ap, D-ml. During detraining periods, the significant between-groups difference compared to the control group was found in the TC group. Significant within-group difference in Time, Area, D-ml were found in the BW group.

Table1: The baseline characteristics of participants

	TC group	BW group	C group	F value	P value
N	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/m2)	25.12±3.19	24.69±2.97	26.21±3.82	0.617	0.546

Table 2: Comparisons of study variables in single leg stance among three groups

		TC group(N=12)	BW group(N=13)	C group(N=11)
Time	$Week_0$	16.78±7.10	15.63±8.30	18.26±7.63
(second)	$Week_{16}$	39.95±11.67*‡	31.68±12.4*‡	19.11±8.19
	$Week_{24}$	35.53±12.09*‡	26.76±11.61*#	20.41±7.55
Lng	$Week_0$	519.51±105.54	582.20±85.69	545.79±98.21
(mm)	$Week_{16}$	194.70±83.76*‡	227.52±113.06*‡	558.55±90.29
	$Week_{24}$	278.14±95.06*‡	278.43±105.95*‡	518.98±104.9
Area (cm^2)	$Week_0$	2.50±1.15	2.28±0.86	2.46±0.91
	$Week_{16}$	1.14±0.97*‡	1.25±0.94*‡	2.17±0.71
	$Week_{24}$	1.58±0.71*‡	1.69±0.93#	2.10±1.10
D-ap (mm)	$Week_0$	41.15±6.12	40.07±7.55	38.96±9.50
	$Week_{16}$	25.88±8.95*‡	21.54±7.38*‡	37.98±7.02
	$Week_{24}$	29.63±10.19‡	25.70±9.06*‡	39.43±9.65
D-ml (mm)	$Week_0$	39.33±8.85	41.75±6.24	38.96±9.50
	$Week_{16}$	25.40±14.83*‡	30.52±8.98*‡	36.16±8.72
	$Week_{24}$	36.17±10.22	36.36±17.68#	35.80±10.12

Note: *, denotes significant difference compared to $Week_0$ within each group; #,denotes significant difference compared to $Week_{16}$ value within each group;‡,denotes significant difference compared to the control group.

DISCUSSION: The results showed that after the 16 week interventions, the SLS balance ability with eyes open improved in the TC and BW groups, which supported the first hypothesis. The previous study of Zhou et al., (Zhou et al., 2015) examined the effects of 24 weeks of TC on the balance of the older adults. The results validated that positive improvements were found in time, paths, and velocity of the COP in the TC group. Maybe the SLS balance improvements was related to physical function. Regular exercise could have positive effects on the central nervous, neuromuscular reaction (Sun et al., 2016), and proprioception (Zhang, Sun, Yu, Song, & Mao, 2014) to improve balance control.

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 and a 12-week BW could significantly improve balance (Gába et al., 2016; Okubo et al., 2015). Maybe TC was more efficient than BW exercise in improving static balance ability in SLS. In our study, 16 weeks could be sufficiently long to improve balance for the two intervention exercises. However, only two tests were performed before and after the intervention in the present study, and no more data supported our speculation. So in further study the measures could be conducted every four weeks to explore the different efficiencies on SLS balance between TC and BW exercises.

The results showed that after 8 week detraining periods, the improvements of SLS balance ability were maintained in the TC group which supported the second hypothesis. Our results were consistent with findings from Li et al. (Li et al., 2012). The underlying mechanism can be attributed to the following factors. First, as shown previously, regular exercise has positive effects on physical function 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. The 8-week detraining may be insufficient to observe significant changes. Second, intervention exercises could reduce the fear of falling and encourage greater involvement in physical activities in daily life in older adults. Conversely, these physical activities could possibly further delay the reduction of balance control.

Balance ability improvements were fully maintained for the TC group and partly for the BW group over the 8 weeks. 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 balance ability(Pei et al., 2008). Moreover, participants concentrated their attention on slow TC movements during practicing, which could improve cognitive function(Sungkarat, Boripuntakul, Chattipakorn, Watcharasaksilp, & Lord, 2017). However, compared with TC, BW was a movement needing less coordination and concentration from participants.

It is noteworthy that in the present study, during the detraining periods, D-ml 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(Paillard, Lafont, Costes-Salon, Rivière, & Dupui, 2004). 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.

Conclusion: TC and BW both improved SLS after 16 weeks training. During the 8-week

detraining, the gains of intervention were fully maintained in the TC group and partly maintained in the BW group. TC was better exercise for the gain of intervention. The gain of TC intervention could be maintained better for static balance after stopping training and could be recommended to older adults for preventing falls.

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