EFFECTS OF LONG-TERM TAI CHI EXERCISE ON BALANCE CONTROL IN OLDER ADULTS

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This study assessed the static and dynamic balance control of older adults who have 10 years of Tai Chi exercise experience and compared their characteristics with their sedentary counterparts. The abilities were measured using methods: single-leg stance times with eyes open and closed; sway of center of pressure (COP) during static standing with eyes open/closed, and leaning the body in three specific directions. Compared with control group, 1) Tai Chi Group showed longer single-leg stance times with eyes open and closed, 2) slower sway velocity of COP in mediolateral and anterioposterior directions and shorter sway distance in both directions, and 3) shorter total, anterioposterior, and mediolateral routes and shorter time spent during the dynamic balance test. Long-term Tai Chi exercise improves the balance ability, especially the dynamic balance, of older adults.

KEY WORDS: Tai Chi; balance ability; older adults

INTRODUCTION: Falls account for a significant proportion of injuries in older adults. The decline of balance ability caused by aging is an important contributor to falling (Hausdorff, Rios, & Edelberg, 2001). Therefore, the balance ability of older adults should be improved to reduce incidences of falling. Previous studies found that Tai Chi exercise can improve the balance ability of older adults. Practice time included 8 weeks (Tsang, Christina, & Hui, 2005), 12 weeks (Murphy & Singh, 2008), 16 weeks (Li, Xu, & Hong, 2008; Sun & Mao, 2012), 24 weeks (Li, Harmer, Fisher, & McAuley, 2004), 48 weeks (Li, Devault, & Oteghen, 2007), and more than 1 year (Hong, Li, & Robinson, 2000). Test methods include single-leg stance and tandem stance time with eyes open and closed (Li, 2008). However, no study has used body sway to evaluate the static and dynamic balance control of older adults. This study assessed the effect of long-term Tai Chi exercise on the static and dynamic balance control of older adults by using Good Balance equipment.

METHODS: A convenience sample of 45 healthy, active older adult women were included in this study. The Tai Chi and control groups (TCG and CG, respectively) consisted of 19 [age: 60.31±3.16 years; height: 159.32±2.92 cm; body mass: 59.97±5.99 kg; Tai Chi (TC) experience: 12±4.89 years] and 26 (age: 60.30±2.91 years; height: 158.55±4.40 cm; body mass: 62.15±6.03 kg;) women respectively. The exclusion criteria included unstable heart conditions, arthritis, diabetes, visual deficits, vestibular deficits, or any type of neuromuscular problems that could prevent the participants from meeting the project requirements of a healthy individual. All the participants signed an informed consent form prior to testing. Single-leg stance test：The participants use their dominant foot for support and the other leg is

lifted up. Test time is 60 s, and the staff recorded the participants' stand time. Eyes were opened and closed at random. The best record is used for analysis (Tse & Balley, 1991).

Static balance ability test：Good Balance (Finland, Metitur) was used to test the static and dynamic balance abilities of the participants. It is composed of a triangle force plate (800 × 800 × 800 mm), with a channel sample rate of 50 Hz, error >1.0 mm, and body mass > 40.0 kg (Good Balance User's Manual, 2000). The participants were instructed to finish the double-leg eyes open (DLO) and double-leg eyes closed (DLC) test in this measure. During the test, the participants stand straight, focus on a high equal black mark on a wall two meters away, foot stand on the mid-line of the force plate on both sides, the distance between feet is 15 cm to 25 cm (Satu, Pertti, & Markku, 2004). Six tests were performed, three for DLO and three for DLC, using an interval of three minutes.

Dynamic balance ability test：The aim of this test is to determine the ability to maintain balance in a regulated movement. The participants were asked to move their body following the route showed on a screen. The test route is point 1- point 2- point 1- point 3- point 1- point 4- point 1 (Figure 1.). Fourteen variables were analyzed, including single-leg stance time with eyes open (SLO) and closed (SLC), average mediolateral velocity with eyes open (MLVO) and closed (MLVC), average anterioposterior velocity with eyes open and closed, mediolateral sloshing distance with eyes open (MLDO) and closed (MLDC), and anterioposterior sloshing distance with eyes open (APDO) and closed (APDC). The sloshing distance data were normalized with body height to reduce the effect of body height. The other four variables were finish time of moving (TT), total distance of moving (TS), length of COP mediolateral moving route (MLS), length of COP anterial-posterial moving route (APS). A decrease in any of these variables indicates a possible improvement of dynamic balance ability.

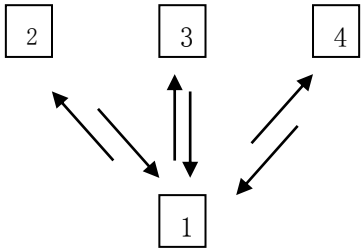

Figure 1. Dynamic test route.

Data analysis：An independent t-test were conducted to assess the differences between the TCG and the CG. The statistical analyses were performed by SPSS 17.0 (Chicago, IL, USA) with a significance level set at 0.05.

RESULTS

Table 1

Single-leg stance time

Group	SLO (s)	SLC (s)
TCG	60±0.00**	18.55±24.94**
CG	43.53±20.55	5.75±4.05

TCG = Tai Chi group; CG = control group; SLO = single-leg stance time with eyes open; SLC = single-leg stance time with eyes closed. *Significant difference between the two groups ($p<0.05$),**High level of significant difference between the two groups ($p< 0.01$).

Table 2

Static balance test results

Variables	Eyes open		Eyes closed	
	TCG	CG	TCG	CG
MLV (mm/s)	2.07±0.65*	2.25±1.15	2.53±0.98	2.52±1.01
APV (mm/s)	4.06±1.26**	4.19±1.37	6.43±2.64	6.29±2.43
MLD (mm)	58.42±23.72*	64.91±36.67	74.16±33.63	74.29±33.13
APD (mm)	117.48±46.21**	122.50±46.56	190.74±83.71	186.99±76.16

MLV = average mediolateral velocity of COP; APV = anterioposterior velocity of COP; MLD = mediolateral sloshing distance; APD = anterioposterior sloshing distance. *Significant difference between the two groups ($p<0.05$),**High level of significant difference between the two groups ($p< 0.01$).

The TCG exhibited better performance compared with the CG in SLTO (P=0.000), SLTC (P=0.010), APVO (P=0.006), MLVO (P=0.030), APDO (P=0.006), and MLDO (P=0.030). Meanwhile, no significant difference was found in the APVC (P=0.420), MLVC (P=0.471), APDC (P=0.304), and MLDC (P=0.304) of the two groups (Table 1 and Table 2).

Table 3

Dynamic balance test results

Group	TT (s)	TS (mm)	MLS (mm)	APS (mm)
TCG	13.67±5.23*	941.75±370.88**	572.00±236.29*	618.54±223.34**
CG	13.92±5.08	948.58±344.86	588.68±224.08	627.19±243.47

TT = total time; TS = total distance; MLS = mediolateral moving distance of COP; APS = anterioposterior moving distance of COP. *Significant difference between the two groups ($p<0.05$),**High level of significant difference between the two groups ($p< 0.01$).

The TCG obtained higher values for TT (P=0.048), TS (P=0.008), MLS (P=0.027), and APS (P=0.004) compared with the CG (Table 3).

DISCUSSION: Tai Chi exercise promotes balance control because it facilitates movement from one side to another, from single-leg stand to double-leg support (Xu, Li, & Hong, 2005). Exercise with single-leg stance improves lower-limb strength and body balance control (Hong, Li, & Robinson, 2000).

The time of single-leg stance is significantly related to balance ability (Hong, 2000). Previous studies reported that Tai Chi has a significant effect on prolonged SLO and SLC. Li et al. (2008) found a significant difference between the SLO of participants who engaged in 16 weeks of Tai Chi training and that of their non-exercising counterparts. Li et al. (2007) also reported a significant difference in the SLC of participants who engaged in 48 weeks of Tai Chi training compared with those who did not participate in the training. Choi, Moon, and Song R (2005) found that after 12 weeks of Tai Chi training, the TCG obtained better results in both SLO and SLC compared with the CG. Hong et al. (2000) found that older adults who engage in Tai Chi exercise (practice year: 13.2 years) exhibited better performance in SLC compared with normal older adults. Our findings are consistent with the previous results mentioned above.

Good static balance control involves satisfactory mediolateral and anterioposterior moving speed and moving distance. Using a Kistler force plate, Tsang et al.(2005) found no significant difference between the mediolateral and anterioposterior moving speed of older

adults who practice Tai Chi and that of healthy younger adults. Our study supports the previous results that Tai Chi exercise can improve balance control in older adults.

In sum, the total dynamic moving distance, total time, and anterioposterior and mediolateral moving distance of the TCG are significantly better than those of the CG, indicating that Tai Chi exercise can improve dynamic balance control in older adults. The dynamic balance test suggests that the body mass affects balanced movement in one direction. Shorter distance corresponds to better balance control. Different from previous studies, which used a single static test, our study employed both static and dynamic tests to consider additional parameters for balance control analysis. Although Tai Chi exercise group showed significantly lower COP sway velocity, the difference in the velocity between groups was small. Future studies are needed to confirm this results.

CONCLUSION: Long-term Tai Chi exercise improves the balance ability, especially the dynamic balance control, of older adults.

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