TAI CHI INCREASED BODY STABILITY AMONG THE ELDERLY UNDER THE DUAL TASK CONDITION DURING STAIR ASCENT

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Our work aimed to find out whether Tai Chi (TC) exercise could improve body stability among the elderly under a physical-cognitive dual task (DT) condition during stair ascent. 15 elderly persons who regularly exercised TC and 15 no exercise (NE) participants were asked to walk ascending stairs under single task (ST) and DT conditions in this study. The results showed the TC group had a lower lateral impulse and center of mass-center of pressure (COM-COP) ap/ml separation under the DT condition; Compared with the ST condition, the TC group increased foot clearance, the NE group increased their lateral impulse and COM-COP ml separation under the DT condition. Under DT, body stability decreased among the NE group, but the TC group had better body stability during stair ascent under both ST and DT conditions.

KEYWORD: Tai Chi, cognitive, dual task, gait strategy, stair ascent

INTRODUCTION: Stair walking contributed to 26% of self-reported falls and became the leading cause of accidental death for the elderly (Buckley, Heasley, Scally, & Elliott, 2005). The ability to move while simultaneously performing a secondary cognitive task, commonly referred to as a dual task (DT), is essential to many activities of daily living (Wayne et al., 2015). It has been proved that the risk of falls during stair walking increases while performing cognitive tasks (Ojha, Kern, Lin, & Winstein, 2009).
Tai Chi (TC) is a traditional Chinese conditioning exercise. There is emerging evidence to suggest that interventions combined with cognitive and physical tasks may improve gait and balance (Smith-Ray, Makowski-Woidan, & Hughes, 2014). TC integrates training in balance and neuromuscular coordination with a number of cognitive components including heightened body goal-oriented training, which may have benefits to gait health and posture control (Wayne et al., 2015).
To our knowledge, the effect of TC exercise on body stability under a DT condition during stair ascent remains ambiguous. At present, there is no drug therapy proven to delay preclinical cognitive deterioration (Lam, Chan, Kwok, & Chiu, 2014). Therefore, it would be helpful for the elderly if certain exercise improved body stability.

METHODS: Participants: Thirty healthy, active elderly persons participated in this study. Fifteen (5 men, 10 women; 68.6±8.6 years; 162.8±8.0 cm; 57.6±7.6 kg; and TC experience: 9.8±5.6 years) who regularly exercised TC for at least 10 years, half one hour per day, three times per week participated as TC participants. Gender matched fifteen elderly (5 men, 10 women; 67.7±5.2 years; 160.3±7.7cm; 57.2±7.9 kg) with no regular exercise history participated as no exercise (NE) participants.

Testing Protocol: The participants were asked to ascend the stair step-over-step under two conditions: Single task (ST) stair ascending only, then DT stair ascending and performing subtraction of serial sevens from a three-digit number (Vallabhajosula, Tan, Mukherjee, Davidson, & Stergiou, 2015).
Data collection: A simulated staircase with six steps was constructed for data collection. Two force platforms (KISTLER, 9287BA and 9281CA, Switzerland) were embedded in the 3rd and 4th steps to collect ground reaction force data. The stair ascent test was recorded by an eight-camera motion analysis system (Vicon, Oxford Metrics Ltd., England).
Data Analysis: Sub-group comparisons were assessed via respective 95% confidence intervals of mean difference. Significant differences were confirmed if the respective 95% confidence intervals of mean difference did not cross 0. Effect size (Cohen’s d) and power were calculated for each dependent variable.

Table 1: Kinematic variables during stair ascent

Variables	TC Group		NE Group	
	Dual Task	Single Task	Dual Task	Single Task
Horizontal Velocity (mean±SD, mm/s)	551.51±21.95	550.80±8.05	561.56±22.71	553.44±11.40
Subgroup Comparisons (95%CI, mm/s)	a) -27.83/7.72	c) -11.81/13.23	d) -7.86/24.10	b) -10.35/5.07
Effect Size and Power	small; 0.33	trivial; 0.07	small; 0.43	trivial; 0.11
Foot Clearance (mean±SD, mm)	41.57±14.11	**31.54±8.76**	35.74±10.46	35.85±10.83
Subgroup Comparisons (95%CI, mm)	a) -4.24/15.92	**c) 3.89/16.16**	d) -5.45/5.22	b) -12.06/3.45
Effect Size and Power	small; 0.35	**moderate; 0.91**	trivial; 0.05	small; 0.32
Head Inclination Angle (mean±SD, °)	9.93±5.07	8.39±4.79	17.44±7.61	16.81±7.49
Subgroup Comparisons (95%CI, °)	**a) -12.55/-2.48**	c) -1.01/4.09	d) -2.63/3.89	**b) -13.31/-3.53**
Effect Size and Power	**moderate; 0.93**	small; 0.31	trivial; 0.09	**Large; 0.97**
Trunk Inclination Angle (mean±SD, °)	10.08±5.66	7.15±3.83	19.12±11.25	16.52±12.02
Subgroup Comparisons (95%CI, °)	**a) -15.88/-2.19**	c) -0.01/5.87	d) -1.63/6.82	**b) -16.14/-2.62**
Effect Size and Power	**moderate; 0.86**	small; 0.56	small; 0.21	**moderate; 0.88**

a) Between group differences of TC and NE participants under DT condition.
b) Between group differences of TC and NE participants under ST condition.
c) Within group differences of TC participants under ST/DT condition.
d) Within group differences of NE participants under ST/DT condition.

RESULTS: Compared with NE participants, TC participants had a lower head inclination angle and trunk inclination angle under DT; TC participants had a lower head inclination angle and trunk inclination angle under ST (Table 1). Compared with ST, TC participants increased foot clearance under DT.

Table 2: Kinetics variables during stair ascent

Variables	DT		ST	
	TC Group	NE Group	TC Group	NE Group
Loading Rate (mean±SD, BW/s)	5.76±1.43	5.65±1.44	4.34±1.54	4.44±1.60
Subgroup Comparisons (95%CI, BW/s)	**a) 0.24/2.61**	c) -0.28/0.49	d) -1.19/0.99	**b) 0.01/2.42**
Effect Size and Power	**moderate; 0.82**	trivial; 0.09	trivial; 0.08	**moderate; 0.78**
Medial Impulse (mean±SD, BW s)	13.12±3.79	12.37±4.19	11.26±3.95	11.40±5.08
Subgroup Comparisons (95%CI, BW s)	a) -1.22/4.94	c) -1.08/2.58	d) -3.21/2.93	b) -2.70/4.64
Effect Size and Power	small; 0.36	trivial; 0.17	trivial; 0.06	small; 0.14
Laterial Impulse (mean±SD, BW s)	20.83±5.14	20.77±4.30	25.83±6.36	20.86±5.71
Subgroup Comparisons (95%CI, BW s)	**a) -9.55/-0.44**	c) -1.68/1.83	**d) 1.22/8.73**	b) -4.06/3.87
Effect Size and Power	**moderate; 0.75**	trivial; 0.05	**moderate; 0.91**	trivial; 0.06
Propulsive Impulse (mean±SD, BW s)	18.38±7.41	17.52±6.19	25.31±18.63	21.43±14.13
Subgroup Comparisons (95%CI, BW s)	a) -17.74/3.86	c) -1.40/3.11	d) -6.45/14.22	b) -13.21/5.39
Effect Size and Power	small; 0.37	trivial; 0.12	small; 0.21	small; 0.25
Braking Impulse (mean±SD, BW s)	2.32±1.11	2.55±1.09	2.94±1.23	3.34±1.87
Subgroup Comparisons (95%CI, BW s)	a) -1.55/3.11	c)-0.68/0.21	d)-1.32/0.51	b) -1.97/3.90
Effect Size and Power	small; 0.36	small; 0.47	small; 0.23	moderate; 0.58
COP_{ml} Velocity (mean±SD, mm/s)	120.55±34.31	141.06±67.59	143.96±37.37	136.48±34.78
Subgroup Comparisons (95%CI, mm)	**a) -45.54/-1.28**	c) 51.93/10.91	d) -8.12/23.07	b) -39.77/48.92
Effect Size and Power	**moderate; 0.81**	small;0.36	small;0.22	trivial;0.08
COP_{ap} Velocity (mean±SD, mm/s)	220.91±32.24	223.15±23.06	215.66±30.92	218.88±50.97
Subgroup Comparisons (95%CI, mm)	a) -20.01/30.50	c) -15.33/10.85	d) -29.37/22.93	b) -26.01/34.55
Effect Size and Power	trivial; 0.11	trivial; 0.09	trivial; 0.08	trivial; 0.09

a) Between group differences of TC and NE participants under DT condition.
b) Between group differences of TC and NE participants under ST condition.
c) Within group differences of TC participants under ST/DT condition.
d) Within group differences of NE participants under ST/DT condition.

Compared with NE participants, TC participants had a higher loading rate, lower lateral impulse and COPml velocity under DT; TC participants had a higher loading rate under ST (Table 2). Compared with ST, NE participants increased their lateral impulse under DT.

Figure 1 (c, d) presents the charts of COM-COP separation in medio-lateral and anterio-posterior directions, respectively. Compared with NE participants, TC participants had a lower COM-COPml separation, COM-COPap separation under DT condition; TC participants had a lower COM-COPml separation under ST condition. Compared with under ST, NE participants increased their COM-COPml separation under DT.

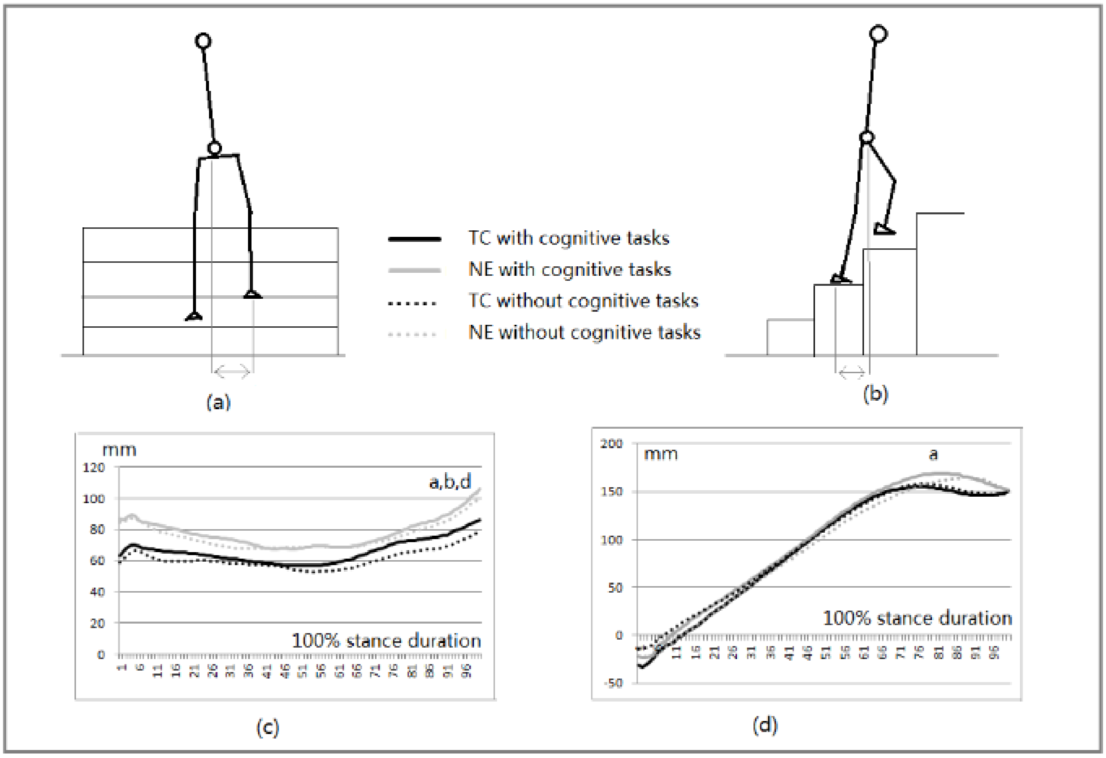

Figure 1. COM-COP separation in medio-lateral and anterio-posterior directions between the two groups

DISCUSSION: NE participants decreased their body stability under DT. Compared with ST, they increased their lateral impulse and COM-COPml separation under DT. These are predictive variables for side falls (Elliott, Foster, Whitaker, Scally, & Buckley, 2015). Higher lateral impulse would result in impaired balance in lateral direction, which is associated with a higher risk of fall (Mao, Li, & Hong, 2006). Lateral impulse is harder to compensate than medial impulse (Elliott et al., 2015). Lateral metatarsal muscles are weak and adjusting body posture is dificult. Gait is not automatic and requires attentional resources (Vallabhajosula et al., 2015). DT-related changes in gait may result from interference caused by competition between the attention demands of gait and by a concomitant cognitive task. Compared with NE participants, TC participants changed their gait strategies to increase body stability. Compared with NE participants, TC participants had a lower head and trunk inclination angle. Falls during stair ascent may occur in the anterior direction (Bosse et al., 2012) as excessive head and trunk inclination angle moves the COM more forward and increases the risk of anterior falls. TC participants could perceive potential risks from DT, and changed their gait strategies to increase body stability. Under DT, TC participants had a lower lateral impulse and COM-COPap separation. It could be referred that TC participants could perceive the potential risks from DT and response with safer strategies. This work showed that TC practice could improve body stability under DT. Combined interventions, like mind-body TC exercise, have demonstrated positive results.

CONCLUSION: Under DT, body stability decreased among NE participants, while TC participants remained unchanged; TC participants had better body stability during stair ascent, compared with NE participants; TC participants could perceive potential risks brought from DT, and respond with safer gait strategies to increase body stability; As a physical-cognitive combined exercise, Tai Chi could improve body stability under physical-cognitive conditions during stair ascent.

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