The effect of counter movement jump performance in Middle-Aged Elderly Practicing Tai-Chi exercise

[1]Bo-Jen Ko, [1]Chen-Fu Huang, [2]Tai-Yen Hsu, [3]Tzu-Lin Wong, [1]Po-Chieh Chen
[1]Department of Physical Education, National Taiwan Normal University, Taipei, Taiwan
[2]Department of Physical Education, National Taichung University of Education, Taichung, Taiwan
[3]Department of Physical Education, National Taipei University of Education, Taipei, Taiwan

The purpose of this study was to investigate biomechanical effects of Tai-Chi exercise on the lower-extremity in middle-aged elders during countermovement jump. Twelve middle-aged elders with regular Tai Chi exercise experience and twelve healthy middle-aged elders participated in this study. Ten Vicon Motion System cameras, two Kistler force plates were used simultaneously to capture the kinematic and dynamic parameters of standing vertical jumps. Independent samples *t*-test was performed for statistical analysis (α = .05). Since the jump height of Tai Chi group was significantly higher (p < .05). It showed that practicing Tai Chi exercise could effectively slow down the degeneration of the moment and power at the hip joint. Therefore, middle-aged elders were recommended to engage in long-term Tai Chi exercise.

Keywords: Jump height, Hip joint, Moment, Power

INTRODUCTION: Regular exercise is essential for older adults in order to maintain muscle function. Tai-Chi exercise is a very popular and accepted exercise modality in many countries. Many studies have reported that engaging in Tai Chi exercise may enhance strength, flexibility, and balance (Li, Xu, & Hong, 2009; Mak & Ng, 2003; Thornton, Sykes, & Tang, 2004). Tai Chi exercise programs for older adults have been often designed to combine strength, flexibility and balance training (Gyllensten, Hui-Chan, & Tsang, 2010). Furthermore, the moderate intensity of Tai-Chi exercise is possible for middle-aged elders. In addition, Tai Chi exercise can be performed just about anywhere and with little specialized equipment.

The countermovement jump (CMJ) is a dynamic extremity. This assessment could be used to estimate muscle strength and power performance in older adults (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). Both components of muscle power, muscle force and contraction velocity can be observed during a maximal CMJ.

Previous study suggested that it may be of interest to examine CMJ performance in middle-aged elders that have regularly performed regular Tai Chi exercise. Many studies have reported that muscle strength of lower limbs could be enhanced through Tai Chi training. However, these studies have largely examined isometric or isokinetic strength of single lower extremity joints. These strength assessments do not address muscle power output during a

dynamic, multijoint, weight bearing task such as required in the CMJ. Therefore, The purpose of this study was to investigate biomechanical effects of Tai chi exercise on the lower-extremity in middle-aged elders during countermovement jump.

METHODS: Twelve middle-aged elders with regular Tai Chi exercise experience (Tai chi group: 5 males and 7 females, average age: 60.67 ± 2.71 years old, average height: 162.25 ± 8.16 cm, average weight: 64.79 ± 11.09 kg) and twelve healthy middle-aged elders (control group: 5 males and 7 females, average age: 62.33 ± 1.61 years old, average height: 157.67 ± 8.55 cm, average weight: 60.75 ± 8.08 kg) participated in this study. All subjects of Tai chi group regularly performed traditional Yang Tai Chi exercise (108 forms) at least 5 times per week for more than two years. Tai chi exercise sessions consisted of approximately 10-min Tai chi warm-up, 25-min of main Tai chi exercise, and 5-min of cool-down. Participants who were currently suffering from motor or neuropsychological disorders were not included in this investigation. All subjects had adequate warm-up prior to testing in the laboratory. This research was approved by the local institutional review board and all volunteers signed a written consent form prior to testing.

Ten Vicon Motion System cameras (Vicon MX13+, Germantown, Oxford, UK, 250Hz), two Kistler force plates (Kistler 9281, 60×40 cm^2 , Kistler Instrumente AG, Winterthur, Switzerland, 1000Hz) and Vicon Nexus software were used simultaneously to capture the kinematic and dynamic parameters of countermovement jumps. Visual 3D software was used for calculations. The subjects performed 3 maximal effort CMJs. Each trial was recorded from the beginning of the movement until contact with the force plate after the flight phase of the jump. Subjects were asked to place and keep their hands at their hips while performing the maximal effort CMJ. Each subject was instructed to start in an upright position, rapidly squat down and immediately perform a maximal jump into the air. They were asked to land back on the force plate during all performance trials. The downward depth and speed in which all subjects performed the CMJ was self-selected by the performer. For safety, an experienced research assistant stood alongside each subject while performing the test. The vertical ground reaction force (VGRF) from the force platform was used to calculate the dynamic data according to the following equation. In this study, the data were focus on right lower limb during jump phase and air phase. Independent samples *t*-test was performed for statistical analysis ($\alpha = .05$).

RESULTS: Study analysis showed that jump height in the Tai Chi group was significantly higher than control group (table 1).

Table 1

The jump height in air phase

	Tai chi group		Control group		*p*
	M	SD	M	SD	
COM Jump height (cm)	29.29	4.52	24.55	5.28	0.027*

Ps. * statistics of significant differences ($p < .05$)

The peak vertical velocity, peak hip moment, and peak hip power during the jump phase, as well as the instantaneous velocity at take-off in Tai Chi group were also greater than the control group (table 2).

Table 2

The kinematic and dynamic analysis during jump phase

	Tai chi group		Control group		*p*
	M	SD	M	SD	
Duration (s)	0.34	0.05	0.29	0.06	0.061
COM displacement (cm)	41.50	7.86	33.98	10.30	0.057
Peak vertical force (N/kg)	10.40	0.90	10.33	1.72	0.893
Peak vertical velocity (m/s)	2.15	0.20	1.92	0.28	0.032*
Take-off instantaneous velocity (m/s)	1.64	0.24	1.40	0.28	0.037*
Peak hip moment (N-m/Kg)	-1.07	0.24	-0.80	0.35	0.042*
Peak knee moment (N-m/Kg)	1.19	0.24	1.16	0.38	0.792
Peak ankle moment (N-m/Kg)	-1.32	0.12	-1.34	0.18	0.770
Peak hip power (W/Kg)	3.58	0.71	2.43	1.19	0.009*
Peak knee power (W/Kg)	5.13	1.89	4.63	1.90	0.525
Peak ankle power (W/Kg)	9.12	0.79	9.21	1.03	0.810

Ps. * statistics of significant differences ($p < .05$)

DISCUSSION: These findings support our hypothesis that Tai Chi group had greater jump height during air phase. Tai Chi group also had greater peak vertical velocity of the body COM, peak hip moment and peak hip power during jump phase.

These results shows that middle-aged elderly that regularly participate in Tai Chi exercise appear to have better capacity to generate muscle strength and power during countermovement phase. And this increase in peak hip power may due to the effect of regular

long-term traditional Yang's Tai Chi exercise. The specific movements, such as two-leg deep squat, jumping, and one-leg deep squat are required in 108-forms of Yang's Tai Chi exercise. Many of these movement forms appear to provide an exercise training stimulus for lower limb muscle groups. It had been report that a decline in muscle strength of 1.2~2% per year after the age of 65 years (Skelton, Greig, Davies, & Young, 1994). In this study, those who had regular and Tai Chi exercise may have maintained or even enhanced hip joint muscle strength and hip joint power. Those results may reduce some of the middle age related limitations of associated with functional activities.

CONCLUSIONS: Since the jump height of Tai Chi group was significantly higher ($p < .05$), it was inferred that the lower-extremity muscle strength of the Tai Chi group was stronger than the control group. This might be due to the maximum moment and the power of the hip joint in the Tai Chi group was better than the control group. It showed that practicing Tai Chi exercise could effectively slow down the degeneration of the moment and power at the hip joint. Therefore, middle-aged elders were recommended to engage in long-term Tai Chi exercise.

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