



ISB 2013  
BRAZIL

XXIV CONGRESS OF THE INTERNATIONAL  
SOCIETY OF BIOMECHANICS

XV BRAZILIAN CONGRESS  
OF BIOMECHANICS

## ANALYSIS OF LOWER LIMB JOINT MOMENTS DURING STAIR-TO-FLOOR TRANSITION IN TAI-CHI ELDERLY

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### SUMMARY

The aim was to investigate the difference between Tai-Chi (TC) exerciser and normal elderly in sagittal lower limb joint moments during stair-to-floor transition. There were 12 TC practitioner elderly and 12 matched controls participated in this study. Ten Vicon high-speed cameras (250Hz), one force plate (1000Hz) were synchronized to collect data. Results showed that TC group had greater hip extension moment, ankle plantarflexion moment, support moment and step length during stair-to-floor transition, and also had faster descending and following-walk velocity. It concluded that TC group had been showed better abilities to transform body to move forward more efficiently, produce more support, have better control during stair-to-floor transition. Tai-Chi would be interpreted as maintaining the daily activities ability and reducing the weakness caused by aging.

### INTRODUCTION

During transition from stair descent to following walk (stair-to-floor transition), not only required more kinetic energy which altered by potential energy but also the abilities to transform body moving forward. Stair negotiation would require higher joint moments in the lower limbs [8]. However, physical abilities of elderly adults would decline with age, stair-to-floor transition became a challenging task.

Dieën et al. [3] found that falls occurred by a lack of control momentum, and longer step length would allow control of forward and angular momentum while following landing. That ability in elderly was poor. Bento et al. [2] also indicated that the reduced ability to rapidly develop torque seems to be a typical characteristic in the elderly.

Among all exercises, Tai-Chi has been promoted and widely accepted that the motion characteristics are quite suitable for older people. Nowadays, many studies about the effects of Tai-Chi on human body focused on physiological test, gait and balance control, we assumed that Tai-Chi would enhance the abilities of functional movement in daily life in elderly. The purpose of this study was to investigate the difference between TC exerciser and normal elderly in sagittal lower limb joint moments during stair-to-floor transition.

### METHODS

Twelve Tai-Chi(TC)-practitioner elderly ( Tai-chi period:  $10.2 \pm 3.3$  years; age:  $73.0 \pm 6.0$  years; height:  $1.67 \pm 0.06$  m;

weight:  $58.5 \pm 6.0$  kg) and 12 matched control elderly (age:  $65.6 \pm 2.1$  years; height:  $1.64 \pm 0.07$  m; weight:  $65.6 \pm 2.1$  kg) were participated in the study. Ten Vicon high-speed cameras (250Hz), one force plate (1000Hz) were synchronized to collect data. The staircase used in this study consisted of three steps, each step with a rise 18 cm and a run of 28 cm. Each practitioner performed stair descent and then forward walking after contacting ground in self-selected speed. Sagittal kinetic parameters were calculated by kinematics and GRF using Visual3D software. The stair-to-floor phase was defined as the time period between toe-off on stair2 (height: 36cm) and toe-off from the force plate on the floor. Differences in variables between two groups were assessed using t-test. The significant level set at  $\alpha = .05$ .

### RESULTS AND DISCUSSION

The data of peak lower limb joint moments were shown in Table 1. Peak hip extension, ankle plantarflexion and support moment in TC group were greater than control group. Peak hip moment in both groups (0.77 and 0.58 Nm/kg) were greater than that during stair descent (0.42~0.53 Nm/kg) [1,7,9], because of that stair-to-floor transition would be needed more energy to transform body to move forward. Hip moment showed extension moment at 42% to 64%/54% (TC/control) of stair-to-floor phase, and flexion moment presented at 64%/54% to 100% of stair-to-floor phase. Greater peak hip extension moment and longer action period referred that TC group had better ability while stair-to-floor transition, and it reflected as faster following-walk velocity (0.94 vs. 0.82 m/s).

There were no differences in knee flexion and extension moment. Knee moment presented flexion moment at 42% to 50%/48% (TC/control) of stair-to-floor phase, and extension moment presented at 50%/48% to 100% of stair-to-floor phase. In the initiation of foot contacting ground, knee flexion moment would move COP closer to the knee joint center for reducing the external knee moment [9].

Toe-landing used most frequently while stair descent landing [4], ankle joint played a most important role. During stair descent, the eccentric plantar flexor moment was shown smaller in older adults and contributed to the smaller support moment [6]. And lower plantarflexor moments in older adults would attribute to weakness [8]. In present study, greater ankle plantarflexion moment and support moment would be presented the benefits of Tai Chi.

In order to simulate diary-life performance, the speed and step length were not restricted in the study. TC group descended with faster velocity, and longer step length controlled forward and angular momentum while contacting the ground [3]. Stride length tends to decline accompanied with aging. It would be more likely for older people to have a higher risk of falls if their degraded stride length cannot catch up the tendency to ‘rush down’ during stair descent [5]. The benefits of Tai-Chi also had been found can be interpreted as maintaining the abilities of daily activities and reducing the weakness caused by aging.

### CONCLUSIONS

In the study, TC group had been showed better abilities including greater hip extension moment to transform body to move forward, greater ankle plantarflexion moment and support moment produced more support, faster descending velocity and larger step length to have better control during stair-to-floor transition. Tai-Chi would be interpreted as maintaining the abilities of daily activities and reducing the weakness caused by aging.

### ACKNOWLEDGEMENTS

The authors are grateful to National Science Council (NSC 100–2410–H–003–132) for financial support.

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**Table 1:** Peak lower limb joint moments and step length, velocity during stair-to-floor transition.

	TC group	control group
<b>Peak Moment (Nm/kg)</b>		
Hip flexion	0.74 ± 0.18	0.76 ± 0.11
Hip extension*	0.77 ± 0.15	0.58 ± 0.22
Knee flexion	0.37 ± 0.09	0.37 ± 0.16
Knee extension	0.57 ± 0.18	0.59 ± 0.27
Ankle plantarflexion*	1.44 ± 0.17	1.23 ± 0.26
Support moment*	2.46 ± 0.27	1.90 ± 0.21
<b>Step Length (m)*</b>	0.50 ± 0.06	0.34 ± 0.06
<b>Cycle Duration (s)</b>	1.16 ± 0.12	1.19 ± 0.10
<b>Descending Velocity (m/s)*</b>	0.71 ± 0.08	0.62 ± 0.08
<b>Following-walk Velocity (m/s)*</b>	0.94 ± 0.11	0.82 ± 0.17

\*  $p < .05$