

EFFECTS OF LONG-TERM TAICHI ON THE STABILITY OF THE ELDERLY DURING STAIR DESCENTS UNDER DIFFERENT ILLUMINATIONS

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This study investigates the effectiveness of Tai Chi on the stability of the elderly during stair descents under illumination of 3 lx and 300 lx. A total of 30 healthy elderly who are aged between 65 and 70 years old are recruited as subjects. Two force plates and eight Vicon cameras were used to collect data. The results indicated that Tai Chi exercise may increase the lower limb strength of the elderly, the stair descent strategies was influenced by Intensity of illumination, it may increase the risk of fall during stair descent under lower Intensity of illumination.

KEY WORDS: elderly, stability, tai chi, illumination.

INTRODUCTION: Aging presents an important issue in numerous countries, and China is no exception. According to the demographic census in 2006 that shows a trend of aging in China, 8.2% of the Chinese populations are aged over 65 years old, which confirms that China has become an “aging society.” According to the UN, a country is considered an “aging society” when people who are aged over 65 years old are above account for 7% of the total population. The incidence of morbidity, disability and mortality among the Chinese elderly, which bring a heavy burden on the country, have significantly increased as the aging continues to surge. Stair descent is an inherently risky and demanding task that the elderly often encounter in their daily lives. Falls are the leading cause of fractures, trauma-related hospital admissions, loss of independence, and death due to injury among older adults (Matteo Bertuccio et al., 2009). The visual system significantly changes as a person grows older. Therefore, a change in illumination may affect the safety during stair descent. Low illumination may influence the detection of stair edges and transition regions. The intensity of illumination significantly affects the first vertical peak force (or cautious landing) of the elderly under different illuminations (Kathryn A. et al., 2002). Therefore, poor illumination, which is often related to stair accidents, creates a high-risk environment.

Tai Chi is a traditional Chinese conditioning exercise that is suitable for the elderly. Previous studies have shown Tai Chi to be beneficial to muscle strength (Lan C et al. 2000). Elderly Tai Chi practitioners are also reported to have a significantly better postural control and a reduced risk of falls (Alice M. Wong et al., 2001). William et al. (2006) interviewed 24 Tai Chi practitioners and revealed that long-term Tai Chi practitioners had a better antero-posterior standing balance control compared to short-term practitioners.

This study aims to determine the effects of Tai Chi on the stability of the elderly during stair descents under illumination of 3 lx and 300 lx.

METHODS: Subjects: A total of 30 healthy elderly who are aged between 65 and 70 years old were recruited for this study. Subjects with musculoskeletal or neurological impairments were excluded from the sample. 15 of them who have practiced Tai Chi for at least three years were included in the Tai Chi group, whereas the others with no regular exercise routine were included in the control group. All of the subjects wear uniform throughout the entire study. **Testing Protocol:** Each subject warmed up for five to six minutes. The morphological indices including weight, height, leg length, knee breadth, ankle breadth, elbow breadth, wrist breadth, and palm thickness of the subjects were measured. The subjects were subsequently asked to complete five stair descent trials without using a handrail with a rise of 17.0 cm and a run of

29.0 cm under illumination of 3 lx and 300 lx. These luminance levels represent the upper and lower limits of civil twilight respectively. The order of the illumination was randomized during the trials.

Data Collection: Two force plates (KISTLER, 9287BA and 9281CA, Switzerland) were used to collect plantar pressure data at a sample rate of 1000 Hz. The acquisition time was set to 5 seconds. Eight Vicon cameras (Vicon Company, England) were placed around the stairs to record the movements of each subject at a sample rate of 100 Hz when going down the stairs. Thirty-five landmarks based on the Vicon full body model were automatically digitized from the video recordings.

Data Reduction: The ground reaction force and gait cycle duration of the entire foot was calculated during the experiment. The four characteristic parameters of the ground forces (Figure 1), namely, the first and second peaks of the vertical force curve (F_1 and F_2), the first and second peaks of the antero-posterior force curve (F_3 and F_4), Gait cycle duration, single support phase duration, the head and trunk inclination angles were likewise calculated by Vicon system. The force on GRF of each foot was normalized to the body weight of each subject.

Data Analysis: Two-way analysis of variance (MANOVA) with mixed design was used to compare the differences between the two groups and between the two intensity of illumination. Illumination condition was used as a repeated measure, whereas group was used as an independent measure. Independent t-tests was performed to identify the differences between the two groups if no significant interaction effect is observed between condition and group but group produces a significant main effect. If a significant interaction effect of condition and group is detected, one-way ANOVA with repeated measures was performed to compare the variables between the two conditions and between the two groups. A Type 1 error rate of 0.05 will be used to indicate statistical significance.

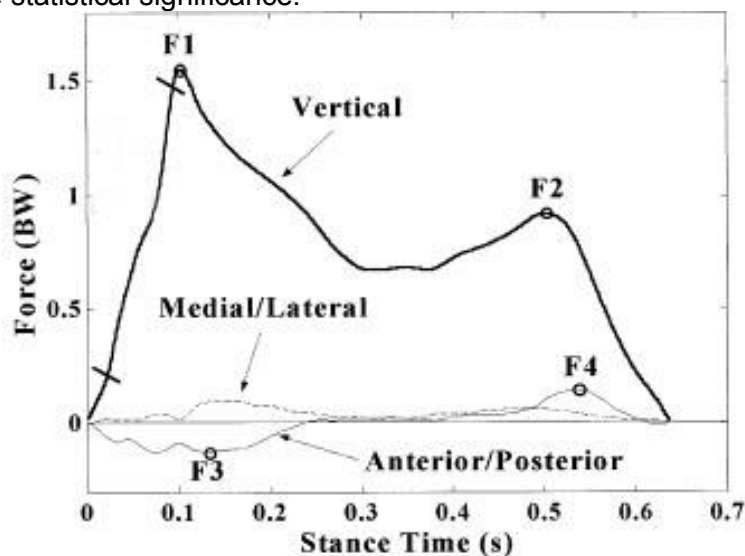


Figure 1. Two components of GRF for a typical stair descent trial. The four dependent variables for the analysis (F_1 to F_4) are shown.

RESULTS:

Table 1 showed two directional peak ground reaction force (GRF) immediately after the subjects landing on the stairs. There were significant differences among groups under the same light condition in the first peak of the vertical force, but no significant differences were detected in antero-posterior force. There were significant differences in TG and CG in the first peak of the vertical force. However, the second peak of the vertical force and the antero-posterior force did not have any difference.

Table 2 showed the posture and temporal variables during stair descent, there were significant differences in the head and trunk inclination angle of different groups in the same light condition,

and with the light condition changed from 300lx to 3lx, the head and trunk inclination angle increased significantly for both the two groups. Gait cycle duration did not have any difference in different light conditions, but TaiChi group was lower than that in Control group.

Table1
GRF variables during stair descent

	TG		CG	
	3lx	300lx	3lx	300lx
F ₁ (BW%)	1.52±0.05	1.13±0.07 ^a	1.91±0.07 ^a	1.45±0.06 ^{bc}
F ₂ (BW%)	0.89±0.13	0.87±0.12	0.91±0.13	0.89±0.14
F ₃ (BW%)	-0.16±0.023	-0.15±0.034	-0.11±0.027	-0.12±0.024
F ₄ (BW%)	0.18±0.035	0.18±0.025	0.15±0.018	0.10±0.021 ^b

a: p<0.05vs.TG in 3lx b: p<0.05vs.TG in 300lx c: p<0.05vs.CG in 3lx

Table2
Posture and temporal variables during stair descent

	TG		CG	
	3lx	300lx	3lx	300lx
Head inclination angle (°)	19.65±4.24	14.90±3.45 ^a	30.95±3.57 ^a	26.60±3.73 ^{bc}
Trunk inclination angle (°)	12.55±2.78	9.85±3.24 ^a	16.20±2.57 ^a	14.75±3.26 ^{bc}
Gait cycle duration (s)	0.93±0.13	0.97±0.95	1.31±0.17 ^a	1.37±0.21 ^b
Single support phase duration(%)	74.00	74.26	75.92	77.43 ^b

a: p<0.05vs.TG in 3lx b: p<0.05vs.TG in 300lx c: p<0.05vs.CG in 3lx

DISCUSSION: According to the study of McFadyen et al. (1988), the first peak of vertical force can reflect foot shock. In this experiment, the F₁ of CG under different intensity of illumination was higher than that in TG, this result may indicated that the muscles of supporting leg is stronger enough to control when the swinging leg touches down. Lieber et al. (1992) have argued that muscles did eccentric contraction when F₁ arrived its highest value,, at the same time muscles were stretched, then potential harm would happen with the increasing contraction speed, so subjects in CG may be harmed during stair descents. Under 3lx light conditions, the F₁ of two groups were higher, this result was same as Kathryn A.(2002), which can be interpreted as a more cautious style of landing.

During stair descents, the foot that steps out first contact with the stairs first, at the same time the stair produces a posterior force to the foot. When the foot contacts to the ground completely, the foot begins to push off the stair, and the stair produce a forward force to the foot. Because of the physiological characteristics, the antero-posterior force of elderly would decline (Kathryn A.2002). However, the F₄ of subjects in CG under 300lx illumination is significantly higher than TG, and the supporting leg may have more muscles strength.

According to the study of Pozzo et al. (1995), the range of motion for the head and trunk inclination is smaller, subjects have more abilities to maintain the stability The increasing of trunk inclination angle may induce the intervertebral disc pressure increase, and further lead to muscle pain or injury (Rohlmann A et al. 2001). Tai chi practitioners require upright body motions, and this is the basic point to safeguard their balance during stair descents. Subjects may reduce their head and trunk inclination angle because of their exercise habits. Successful stair descent requires both the proper visualization and proper kinesthetic feedback(Guy G.Simoneau,1991). The visual system would degenerate gradually along with the growth of age, so under the low illumination the elderly may need increased the trunk and head inclination angles to see the stairs clearly, but it increased the risk of falls at the same time.

CONCLUSION: Tai Chi could increase low limb strength of the elderly, so it may reduce the risks of falls during stair descents. When the elderly walk down stairs, they were influenced by the intensity of illumination, they would choose the cautious strategies under lower illuminations.

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