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GROUND REACTION FORCES AND FRICTIONAL DEMANDS DURING STAIR-TO-FLOOR TRANSITION IN TAI-CHI ELDERLY

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SUMMARY

The aim was to assess the difference between elderly who participated in Tai-Chi (TC) exercise and control group in required coefficient of friction (RCOF) during stair-to-floor transition. There were 12 Tai-Chi 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 breaking force, propulsive force, RCOF at foot strike (μ_rFS) and step length during stair-to-floor transition, and also had faster descending and following-walk velocity. It concluded that TC group would prefer to keep center of mess (CoM) velocity while transition and control group trended to complete step-over-step while descent-to-walk. Tai-Chi would benefit lower limb abilities in elderly.

INTRODUCTION

Stair-to-floor transition is a risky and demanding diary task. Physical abilities of elderly adults would decline with age, stair-to-floor transition will be a challenge task. It is believed that slip while foot contacting the ground surface may lead to stair related falls [3]. The required coefficient of friction (RCOF) is one of the critical factors in determining whether a slip might occur [2].

Tai-Chi has been promoted and the motion characteristics are quite suitable for older people. Many studies about the effects of Tai-Chi on human body focused on physiological test, gait and balance control. Tai-Chi might let stair descent to ground more safety. The aim of this study was to assess the RCOF for safe stair-to-floor transition in Tai-Chi elderly.

METHODS

Twelve Tai-Chi(TC)-practitioner elderly (Tai-chi period: 10.2±3.3years; age: 73.0±6.0years; height: 1.67±0.06m; weight: 58.5±6.0kg) and 12 matched control elderly (age: 65.6±2.1years; height: 1.64±0.07m; weight: 65.6±2.1kg) participated in this study. Whole body kinematics were recorded by using Vicon 10 MX 13+ camera system (250Hz) to compute center of mass (CoM) velocity. Ground reaction forces (GRFs) were recorded while contacting the ground using a Kistler force platform (1000Hz). The raw data of force platform was filtered using a 45Hz four-order Butterworth low-pass filter. RCOF was calculated by horizontal GRFs dividing by vertical GRF. The resultant RCOF showed two peaks, RCOF at foot strike (μ_r FS) at just stepping down and RCOF at pusk off (μ_r PO) at almost maximum propulsive forces were generated (illustrated as figure 1). 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, and at least five successful trials with barefoot for preventing the possible reaction forces at shoe/floor interface. Differences in variables between two groups were assessed using t-test. A significance level set α=.05.

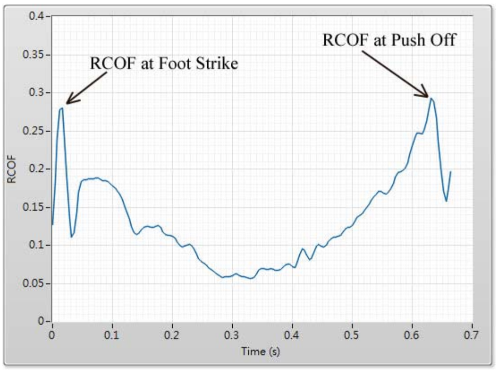

Figure 1: The RCOF illustrated as two peaks, μ_rFS (RCOF at foot strike) and μ_rPO (RCOF at push off).

RESULTS AND DISCUSSION

The results showed the GRFs characteristics of stair-to-floor transition between two groups (Table 1).

Compared to Christina and Cavanagh [3] the first peak of vertical GRFs (F1) in the control group was approximately 0.24 BW higher than that given during stair descent. F1 represented how much impacts while contacted to ground, and the smaller average value of F1 during stair descent might be due to the step length, which was limited in step tread. The second peak of vertical GRFs (F2) was similar between stair descent and the present study, because of the similar motion behavior in the late stance phase.

Breaking force (F3) in early stance phase reduced the forward momentum and prevented trunk forward rotation [4], and propulsive force (F4) in the late stance phase (50%) provided impulse for following forward walk. In TC group, greater F3 was due to faster stair descending CoM velocity and larger step length for better control without falls. Greater F4 was the reason of faster following walk velocity.

RCOF is the resultant parameter calculated by dividing horizontal GRFs by vertical GRFs. Due to the equation of RCOF, the larger value of RCOF indicates that greater relative magnitudes of horizontal GRFs were existed. The other possible reason of affecting the RCOF is the different time relationship between horizontal and vertical GRFs [1]. In this study, TC group had greater μ_rFS and similar μ_rPO compared with control group. And μ_rPO were greater than μ_rFS in control group, but there were no significant differences in TC group. Subjects would reduce the peak RCOF in anticipatory slip [2]. It was speculated that TC group performed similar usage of RCOF while stair-to-floor transition and following walking. And control group preferred to use safety strategies by stepping down carefully while transition. On the other hand, TC group would prefer to keep CoM velocity while stair-to-floor transition and control group trended to complete step-over-step descent, and then walked. The general profiles in elderly had found using more cautious strategy. This cautious strategy in control group was not reflected in the greater LR, which may mean a lack of control at contacting the ground [3].

CONCLUSIONS

The GRFs profiles during transition showed vigorous F1 and similar F2 because of motion characteristics. Greater F3 was due to faster velocity and larger step length, and faster following-walk velocity was emerged by greater F4. By assessing the resultant RCOF, it presented different motion characteristics between two groups during stair-to-floor transition. TC group would prefer to keep CoM velocity while transition and control group trended to complete step-over-step descent, and then walked. The effects of Tai-Chi would enhance lower limb abilities in elderly.

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Table 1: Ground reaction forces and RCOF.

	TC group	**control group**
Ground Reaction Forces (BW)		
First peak vertical (F1)	1.67 ± 0.22	1.73 ± 0.16
Second vertical peak (F2)	1.08 ± 0.07	1.04 ± 0.05
Peak breaking force (F3) *	-0.19 ± 0.02	-0.16 ± 0.03
Peak propulsive force (F4) *	0.21 ± 0.03	0.18 ± 0.03
LR (BW per s)	14.75 ± 3.54	17.62 ± 5.51
μ_r FS *	0.29 ± 0.07	0.23 ± 0.06
μ_r PO	0.35 ± 0.04	0.32 ± 0.08
Step Length (m)*	0.50 ± 0.06	0.36 ± 0.06
Descending Velocity (m/s)*	0.71 ± 0.08	0.62 ± 0.08
Following-walk Velocity (m/s)*	0.94 ± 0.11	0.82 ± 0.17

* $p < .05$

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