THE INFLUENCE OF TAI-CHI EXERCISE ON DYNAMICS OF LOWER EXTREMITY FOR THE ELDERLY DURING SIT-TO-STAND

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The purpose of this study was to investigate the influence of Tai Chi exercise on sit-to-stand in the elderly. Ten healthy female elders (normal group) and nine healthy Tai-Chi female practitioner (Tai-Chi group) participated in this study. The results indicated: (1) During the forward flexion phase, normal group showed significantly greater hip flexion angle and moment than Tai-Chi group ($p<.05$); (2) During the extension phase, normal group showed significantly greater hip and ankle extension moments than Tai-Chi group ($p<.05$). Results indicated that the normal group tended to use excessive hip flexion strategy in shorter time to stand, while the Tai-Chi group used smooth strategy instead. Therefore, we suggested that the regular Tai-Chi training could reduce the fatigue and instability of sit to stand for the elderly.

KEY WORDS: sit-to-stand movement, exaggerated trunk flexion, older adults,

INTRODUCTION: A sit-to-stand (STS) movement is defined as moving the body's center of mass upward from a sitting position to a standing position without losing balance (Roebroeck, Doorenbosch, & Harlaar, 1994), which is one of the important activities of daily living. A STS movement requires greater peak joint moment and muscle strength than other daily activities such as walking or stair climbing (Rodosky, Andriacchi & Anderson,1989; Gross, Stevenson & Charette, 1998), and yields higher peak hip joint contact pressure than other movements such as walking, jogging or jumping (Hodge, Carlson, Fijan, Burgess, Riley, Harris & Mann, 1989). Muscle function of the lower limbs has been found to decrease markedly in the middle and older ages, many older adults have difficulty in rising from a chair. Previous studies indicated that Tai-Chi exercise not only can prevent chronic diseases, circulatory and respiratory systems, but also enhance the functional ability of the body such as isokinetic contraction strength (Christou, Yang & Rosengren, 2003), isometric strength (Qin, Choy, Leung, Leung, Au & Hung, 2005), balance (Wong, Lin, Chou, Tang & Wong, 2001), and the muscle strength of the lower limbs (Lan, Lai, Chen & Wong, 2000; Wu, Zhao, Zhou & Wei, 2002). These capabilities may help control and improve the performance of daily functional movements. Therefore, the purpose of this study was to evaluate the kinematics and kinetic differences between elderly Tai-Chi practitioners and normal elderly during sit-to-stand movement.

METHODS: The study enrolled 19 elderly females without lower limb disorders. To assess the influences of Tai-Chi exercise on the characteristics of an STS movement, nine subjects (age: 66.31±6.82 yrs, height: 159±11.16 cm, mass: 54.62±7.17 kg) with 5 years Tai-Chi experience were recruited as the Tai-Chi group. The remaining 10 subjects with regular and systematic physical exercise (age: 63.42±6.85 yrs, height: 155.27±9.62 cm, mass: 52.71±6.24 kg) were recruited as the normal group. Subject height, weight, and body mass index values were not different between the two groups. Written informed consent was obtained from all subjects after a full explanation of the experimental purpose and protocol. We fully familiarized the 19 subjects with a sitting posture and movement manner during measurements. In a sitting posture, subjects kept both legs with bare feet at shoulder width, stretched the trunk in a straight line, held a 90° ankle angle, and folded the arms in front of the chest. All participants were asked to sit to stand at regular speed. Considering the effect of fatigue, each subject performed the STS movement three times with a 1-min rest.
Ten Vicon high-speed cameras (MX13+ Oxford Metrics Ltd., Oxford, England, 250Hz) and three Kistler force plates (Kistler, 9287B, Switzerland, 1000Hz) were synchronized to collect kinetic data. A Butterworth digital recursive filter with 6Hz cutoff frequency was used to filter the random noise. Vicon Nexus 1.81 and Visual3D V5 software were used to analyse

kinematics and dynamics. All the data were submitted to an independent sample *t*-test. The significance level set at α= .05.

RESULTS: The STS movement in this study was divided into three distinct movement phases: The forward flexion phase, the momentum-transfer phase and the extension phase (Schenkman, Riley & Pieper, 1996; Ebara & Yamamoto, 2001). Table 1 shows no significant differences in leg length of subjects and movement time existed between the Tai-Chi group and normal group during the STS movement (p>.05).

Table 1
Subjects leg length and sit-to-stand movement time data.

	Tai-Chi group	Normal group
Leg length(cm)	41.06(4.18)	39.88(3.29)
Forward flexion phase(s)	0.84(0.18)	0.71(0.17)
Momentum-transfer phase(s)	0.15(0.14)	0.10(0.06)
Extension phase(s)	1.59(0.62)	1.22(0.27)
Whole phase(s)	2.58(0.70)	2.01(0.51)

*Significantly different between Tai-Chi group and Normal group. (p<.05).

The kinematics parameters at ankle, knee, and hip joints during the STS movement were showed in Table 2. During the forward flexion phase, hip flexion angle of the Tai-Chi group was significantly smaller than normal group (p = 0.04). During the extension phase, the angle at ankle, knee, and hip had no significant difference between two groups (p>.05).

Table 2
Sit-to-stand movement flexion and extension angle data.

	Tai-Chi group	Normal group
Ankle flexion angle	5.24(1.20)	2.62(1.12)
Knee flexion angle	3.56(1.58)	6.59(2.86)
Hip flexion Angle	14.76(2.61)	25.44(5.16) *
Ankle extension angle	-20.9(5.02)	-17.73(6.98)
Knee extension angle	71.33(10.70)	74.74(7.80)
Hip extension Angle	-62.12(10.48)	-75.87(13.0)

*Significantly different between Tai-Chi group and Normal group. (p<.05).

The hip joint flexion moment in normal group was greater than Tai-Chi group (p = 0.026), while no differences in ankle and knee joint flexion moments were found. The ankle and hip joint extension moments were greater in normal group than Tai-Chi group during (p_{ank} = 0.019)(p_{hip}= 0.012). Significant differences were not observed on the maximum vertical ground reaction force and loading rates between Tai-Chi group and normal group during the STS movement (Table 3).

Table 3
Sit-to-stand movement joint moment and kinetic data.

	Tai-Chi group	Normal group
Ankle joint flexion moment (Nm/kg)	0.23(0.08)	0.22(0.04)
knee joint flexion moment (Nm/kg)	0.82(0.16)	0.67(0.09)
Hip joint flexion moment (Nm/kg)	0.62(0.11)	0.69(0.17) *
Ankle joint Extension moment (Nm/kg)	0.17(0.07)	0.23(0.6) *
Knee joint Extension moment (Nm/kg)	0.86(0.17)	0.8(0.6)
Hip joint Extension moment (Nm/kg)	0.55(0.1)	0.62(0.13) *
Max. vertical ground reaction force (B.W)	1.19(0.17)	1.25(0.16)
Loading rate(B.W/s)	1.07(0.30)	1.25(0.38)

*Significantly different between Tai-Chi group and Normal group. ($p<.05$).

DISCUSSION: This study examined the influence of Tai-Chi exercise on lower limb function and characteristics of the STS movement. From these results, we found the knee angle changes slightly from the initial flexed position during the forward flexion phase. The hip flexion moment during the beginning of the phase reached 45% of its peak values, while the knee flexion moment remains near zero during the early portion of the forward flexion phase, In addition, Papa and Cappozzo (2000) reported that trunk flexion and the time from the initiation of movement to hip lift-off during a STS movement in the elderly become longer due to the decreases in the muscle function of the lower limbs as compared with young adults. The relation between the peak joint moments at the hip and knee joints was complementary and the sum of those moments needed to be greater than 1.53 N-m/kg in order to perform a successful STS (Yoshioka, Nagano, Himeno & Fukashiro, 2007). Therefore, the normal group adopted excessive hip flexion strategy in shorter time to complete sit-to-stand movement successfully. It is assumed that if the elderly have a marked decrease in muscle function of the lower limbs, their STS movements might become more unstable (Yamada & Demura, 2007). Further study will need to analyse more about the stability of body center of mass in the horizontal, lateral, and vertical directions of STS movement and EMG data to explore the ability to accomplish STS movement with Tai-Chi training.

CONCLUSION: Considering these results, we reviewed the influence of Tai-Chi exercise to hip joint moments of the lower limbs on an STS movement of the elderly adult. We suggest that the regular Tai-Chi exercise may enhance the ability to complete the STS movement for older adults and have the body equilibrium to be well controlled.

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