Why Tai Chi Chuan exercise can improve balance control in elderly people?

Youlian Hong
Department of Sports science and Physical Education, The Chinese University of Hong Kong
hong.youlian @ gmail.com

Abstract

This article is to explain why Tai Chi exercise can improve the balance control in elderly people. The cross sectional studies showed that long-term older Tai Chi practitioners performed better than their sedentary counterparts in muscle strength and endurance, neuromuscular reaction, knee and ankle joint proprioception, and single and double leg stance tests than their sedentary counterparts. The biomechanics analysis of individual Tai Chi movements and whole set of Tai Chi exercise demonstrated that properly performing of Tai Chi movements highly demanded the control of angular motion of lower extremity and linear motion of the center of gravity, coordination of knee and ankle joint muscle contraction, and proper exertion of insole forces. These characteristics are related to the beneficial effects of Tai Chi exercise shown in the cross sectional studies. However, the relatively shorter term, such as 16 weeks, Tai Chi intervention could not reach the advantage that shown with the long-term, such as 4 years, Tai Chi practitioners, indicating that long term Tai Chi exercise is needed to improve the balance control related physical factors.

Keywords: Tai Chi, EMG, insole force, proprioception, muscle latence, balance control,

Tai Chi (TC) is derived from Chinese Martial Art traditions, handed down from generation to generation for more than 1200 years. The studies showed that Tai Chi exercise improved balance control. A study in United States showed that the intervention of TCC reduced the risk of multiple falls by as much as 47.5% (Wolf et al. 1996). Another study found that Tai Chi had better effects in postural control and falls prevention than the computer-based biofeedback training (Wolf et al. 1997). Aging is associated with change of movement control and reaction, which is caused by decrease in muscle strength and endurance, loss of fine coordination, and decline in neuromuscular response. The contribution of sensory system in maintenance of static postural stability include vision (21.3%), Vestibular (22.4%) and Proprioception (56.3%) (Lord et al. 1991). However, to date only a limited study has been devoted to explore the underlying mechanism of TCC exercise improving balance control and thus prevention of falls is limited. Hence, this article is to review the previous studies in this effort.

Cross-sectional studies

To answer the question that “among the factors that influence postural stability in movement system, which ones are significantly trained by Tai Chi”, cross-sectional approaches have been conducted to
compare the balance stability, proprioception, neuromuscular reaction, muscle strength and endurance between long-term Tai Chi practitioners, joggers, and sedentary controls.

A study by Hong et al. (2000) showed that older Tai Chi practitioners had significantly better scores in resting heart rate, three minutes step test heart rate, modified sit-and-reach, total body rotation test in both right and left side, and in both right and left leg standing with eyes closed. Further studies showed that older regular TC practitioners possessed better ankle joint proprioception than their jogging/swimming and sedentary counterparts, and better knee flexion proprioception than the sedentary counterparts (Xu et al. 2004). The rectus femoris and anterior tibialis muscles of the older regular TC and jogging practitioners showed faster reaction than their sedentary counterparts (Xu et al. 2005). Finally, the older long-term TC practitioners and joggers showed higher strength of knee extensors and flexors and ankle dorsiflexors than the sedentary counterparts. The muscle endurance of knee extensors was more pronounced in older long-term TC practitioners than their sedentary counterparts (Xu et al. 2006).

**Longitudinal studies**

To answer the question “how long Tai Chi exercise can result in training effects”, longitudinal studies have been conducted. Li et al. (2008) found that 16 weeks Tai Chi intervention improved the kinesthesia of knee flexion and extension and single-leg stance with eye open. This intervention also increased in muscle strength of the knee flexors and neuromuscular reaction in semitendinosus muscle (Li et al. 2009). The improvement in kinesthesia of ankle joint, single leg stance with eye closed, the strength and neuromuscular reaction in other knee and ankle joints was not significant. It is speculated that the 16 weeks are not long enough for TC intervention to show the advantage as shown by long-term TC practitioners.

**Biomechanical studies**

To answer the question “what movement characteristics of Tai Chi might benefit to postural control”, Xu et al. (2003) studied the “Brush Knees and Twist Steps” movement, a typical movement found in different Tai Chi styles, using kinematics and EMG methods. The authors found that the center of gravity continuously changed its position and direction throughout the performance: its rate of motion was low. The overall range of motion of dorsi-plantar flexion, adduction-abduction, and inversion-eversion of ankle joint was high. EMG patterns of the agonist and antagonist of ankle and knee joints showed the well-coordinated recruitment pattern. Chan et al. (2003) studied the kinematics of a typical Tai Chi movement, “ward off, roll back, press, and push”, performed by an experienced Tai Chi master. Results showed that the forward and backward shifts in the centre of gravity were mainly accomplished by increasing and decreasing, respectively, the joint angles of the bilateral lower limbs, rather than by adopting a forward or backward postural lean. The path of the centre of gravity in the anteroposterior and mediolateral direction was unique,
and the sway or deviation from the path was small. The master maintained an upright posture and maintained a low centre of mass (hips, knees, and ankles bent) while traveling slowly and steadily from one position to another. Wu et al. (2004) compared the “Tai Chi Gait”, the stepping-forward gait used in the typical Tai Chi movement “brush knee and twist steps”, with normal walking of 10 healthy young subjects. Tai Chi Gait had longer cycle duration and longer duration of single-leg-stance time. Both joint motion in ankle dorsi/plantar flexion, knee flexion, hip flexion and hip abduction and the lateral body shift were larger. The biomechanical characteristics demonstrated in these studies are related to the training of muscle strength and endurance and the controlled lower extremity joints angular movements to perform the slow and smooth motion of center of gravity during exercise. All theses would ultimately improve the balance control.

The biomechanical studies were also conducted on the whole set of Tai Chi exercise. Mao et al (2006a) identified 7 foot support patterns and 6 step directions in the set of 42 forms Tai Chi Style. Compared with normal walking, the exercise of this set contained more percentage of double-limb and less percentage of single-limb support. The average duration of each support movement was longer, and movement from one pattern to the next was slow. The duration in each step direction was short, and changes of direction were frequent. Support patterns changed slowly, and combined with various step directions, they were found to be better than those of walking in simulating the gait challenges that may be encountered in daily activities. Furthermore, the same group (Mao et al. 2006b) found that in Tai Chi exercise, the medial-lateral displacement of the centre of pressure was greater than during normal walking. The peak pressure and pressure-time integral of the second and third metatarsal heads and the fourth and fifth metatarsal heads were significantly greater than those of other plantar regions during the one-leg stance in normal walking, whereas the peak pressure and pressure-time integral of the first metatarsal head and the great toe were significantly greater than those of other plantar regions during the one-leg stance in Tai Chi exercise. The longer duration of each one-leg stance and the plantar pressure distribution characteristics during the one-leg stance in Tai Chi exercise may be associated with an improved ability to balance on one leg. Finally, Mao et al. (2006c) found that compared with normal walking, the locations of the COP in the TC movements were significantly more medial and posterior at initial contact, and were significantly more medial and anterior at the end of contact with the ground. The displacements of the COP were significantly wider in the mediolateral direction in the forward, backward and sideways TC movements. The displacement was significantly larger in the anterposterior direction in the forward movement. The plantar pressure characteristics of TC movements found in this study may be one of the important factors that TC exercise improves balance control and muscle strength. The characteristics demonstrated above further prove that exercise of the sets of Tai Chi exercises would provide critical challenge to exercisers to maintain the balance using both double and single stances. Among other strategies, proper insole force exertion and function of first metatarsal head and the great toe are enhanced.
Conclusion

The biomechanics analysis of individual Tai Chi movements and whole set of Tai Chi exercise demonstrated that the proper performing of Tai Chi movements would highly demand the control of angular motion of lower extremity and linear motion of the center of gravity, the coordination of knee and ankle joint muscles contraction, and proper exertion of insole forces. In addition, in Tai Chi exercise, support patterns changed slowly, and combined with various step directions, they were found to be better than those of walking in simulating the gait challenges that may be encountered in daily activities. These characteristics of Tai Chi may be the reason that compared with controls, TC practitioners scored higher in the test of strength and endurance, neuromuscular reaction, single leg stance, and kinaesthesia of ankle and knee joints than their sedentary counterparts and scored partly higher than their jogging/swimming counterparts. To attain more pronounced advantage, a long-term Tai Chi exercise is recommended.

Reference


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