THE INFLUENCE OF REGULAR TAI CHI EXERCISE ON NEUROMUSCULAR REACTION IN OLD PEOPLE

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The purpose of this study was to investigate the impacts of regular Tai Chi (TC) exercise on neuromuscular reaction in old people. 21 old TC practitioners with regular practicing TC for more than 4 year and 22 sedentary non-practitioners were recruited to respectively form the TC group and sedentary control group. Electromyography (EMG) was used to detect the neuromuscular reaction of the leg muscles to an unexpected ankle inversion perturbation. The latency of muscles, defined as the time from the moment of perturbation begins to the first EMG response (i.e. onset), was evaluated. The results indicated that regular TC practitioners activated their rectus femoris and anterior tibialis muscles to an unexpected perturbation significantly faster than their sedentary counterparts, which might be helpful for timely correction of postural disturbances.

KEYWORDS: Tai Chi, neuromuscular reaction, muscle latency, EMG.

INTRODUCTION: As a traditional Chinese exercise, TC has been widely accepted to have particular benefits on postural stability in old people by acting on a number of sensorimotor systems that contribute to postural control. A number of studies showed that TC practitioners had better balance capacity, proprioceptive function, and muscle strength (Hong, Li & Robinson, 2000; Jacobson, Chen, Cashel & Guerrero, 1997; Xu, Hong, Li & Chan, 2004). However except of acute proprioception and adequate muscle strength, the prevention of falls also depends on the timely initiation of an appropriate postural response to control the body's center of mass once a displacement occurs (Horak, Shupert, & Mirka, 1989). Greater postural sway and the increased incidence of falls observed in elderly persons suggest that older individuals may be slower in correcting postural disturbances (Stelmach & Worringham, 1985). By EMG analysis, measurement of the muscle response to unexpected perturbations showed there were significant differences of 7 to 10 ms in lower extremity muscles latencies in old versus young populations (Nardone, Siliotto, Grasso, & Schieppati, 1995), and older faller versus nonfallers (Studenski, Duncan, & Chandler, 1991). A delay in the latency of muscle activation delays the onset of postural response, which could result in insufficient correction of the postural perturbation. Therefore, maintaining information processing speed during aging is important because of the role it plays in many everyday events such as in operating an automobile safely or in restoring balance after a near fall. TC movements contain many training components for postural control, such as the shift of body weight form unilateral to bilateral, and change of double-stance and single-stance maneuvers. Could TC exercise produce positive impacts on neuromuscular reaction in the elderly? The present study was designed to answer this question, which was helpful for further exploring the mechanism that TC exercises improve the balance control.

METHOD:

Subjects: By means of a questionnaire with a complementary interview regarding the practice of physical and sporting activities, 21 old TC practitioners and 22 sedentary non-practitioners were recruited to respectively form the TC group and sedentary control group. All the subjects were 60 years old or over and they were predominantly healthy. The TC exercisers had regularly practiced TC for the past 4 years or more, while the sedentary counterparts had not engaged in any regular exercise training for more than 4 years. No significant difference was noted in gender, age, body height, and body weight across the two groups.

Testing protocol: EMG was used to detect the neuromuscular reaction of the leg muscles to an unexpected perturbation on ankle (medio-lateral plane) in this study. The latency of muscles, defined as the time from the moment of perturbation begins to the first EMG response (i.e. onset), was evaluated.

Figure 1: The trap door used to cause the inversion perturbations of the ankle joint when the subjects stand on it.

Instruments: Using the design reported in many related studies (Javed Walsh & Lees, 1999, Konradsen, 2002), a customized trap door was constructed with two movable platforms to stimulate an ankle inversion situation (Figure 1). The amplitude of the completed tilt was constant at 18° in this test. The Bagnoli-8 EMG system (Delsys, USA) was used to collect surface EMG signals in four muscles on the right leg of each subject: the quadriceps (rectus femoris R), the hamstrings (semitendinosus S), the anterior tibialis (T), and the lateral gastrocnemius (G). The raw EMG signals were sampled at 1000 Hz by Labview Software (National Instruments, USA) and stored in a computer for off-line data reduction.
Procedures: When the subjects came to the laboratory, they were given two practice trials on the trap door in order to familiarize themselves with the test process. After this, the EMG electrodes were placed over the center of the muscle bulk by the same investigator. Subjects were asked to stand barefoot on the trap doors, with the body weight evenly distributed between both feet. The axis of rotation of the trap doors was just medial to the sole of the feet. One of the trap doors was released when the muscles were relaxed, i.e. when the EMG signals showed the baseline resting level, confirmed by the examiner. The computer program sampled EMG data from 500 ms before the onset of tilting until 1 second after the inversion moment. In order to reduce anticipatory effects, both feet were randomly tilted at least seven times respectively. As the subjects did not know which side was to be released, the recorded EMG signals were responses to either the ipsilateral angular displacement stimulus (right trap door tilted) or contralateral stimulus (left trap door tilted). The ipsilateral reaction time (a direct reaction time) was analyzed.
Data reduction: The raw EMG signals were rectified. The onset latency is the time interval in milliseconds (ms) between the initiation of trapdoors and the first rising front of the EMG burst from the baseline to a clearly activity, determined by visual inspection. In order to reduce observer bias, the data for the two groups were analyzed simultaneously by the same investigator.
Data analysis: All variables were presented as means and standard deviations. Student t-test was used to estimate significant differences between groups and $P < 0.05$ was considered statistically significant.

RESULTS: The mean onset latency for the R, S, G, and T muscles in different groups is shown in Table 1. Analysis by student t-test revealed that there were significant differences for the latency of R and T muscles between the two groups, while no differences for S and G muscles.

Table 1 The onset latency (ms) of different muscles in the two groups (mean SD).

	TC group (n = 21)	Control group (n = 22)
Rectus femoris (R)	84.21 (10.23)	91.70 (10.02) *
Semitendinosus (S)	83.90 (11.02)	88.06 (10.25)
Gastrocnemius (G)	91.59 (13.19)	96.31 (8.36)
Anterior tibialis (T)	81.91 (8.20)	88.52 (6.67) *

Notes: * $P < 0.05$, compared with the TC group.

DISCUSSION: Although situations jeopardizing balance occur in all age groups, postural adjustments in the older adult have been characterized as lacking the speed and the adroitness necessary to ensure recovery of stability. Exercise training is one of the best ways to counteract some parts of the age-related decline in postural response. Hu and Woollacott (1994) identified that 15-day multisensory balance training had an effect in optimizing the muscle reaction of postural response in older adults. In our present study, regular TC exercise produced the similar results: the onset times of the R and T muscles for detecting the postural disturbance in frontal plane of the ankle joint was much shorter in the TC subjects than those in controls. TC exercise consists in slow movements performed sequentially under different postural conditions. The better central integration favored by the practice of such coordinated movements appears to allow for more appropriated motor responses.

Gaining postural stability after body perturbation is controlled by three motor systems: short-loop latency reflex, medium-latency responses, and long-latency responses (Schmidt & Wrisberg, 2000). The short-loop latency reflex is spinally mediated, which is the first motor response to an external perturbation. The reflexes do not contribute directly to the recovery of balance. The first response against falling is an automatic reaction, seen in EMG, which occurs as medium-latency muscle responses. Long-latency responses have been found to co-occur in the antagonist muscle. The first muscular reaction measured after sudden inversion of the ankle is in the peroneal muscles, which are stretched muscles. The emphasis of this study was to understand the automatic postural responses (medium and long muscle latency) to lateral perturbation that should definitely occur in the other muscles of the lower extremity. Therefore, the response of the peroneal muscles was not included in this study. 10 to 20 ms after the response of peroneals, an EMG response can be measured in the thigh muscles while EMG signals in the unilateral anterior tibilias muscle are seen at the same time or later than the peroneal signal (Brunt et al., 1991; Konradsen & Ravn, 1990). The loaded leg showed a flexion of hip and knee and a dorsiflexion of the ankle (Konradsen & Ravn, 1990). The objective of this activation strategy seems to control stability and lessen the load on the inverting foot. From the present results, R and T muscles in the TC exercisers showed faster responses than those in controls, which was obviously helpful for timely correction of postural disturbances.

CONCLUSION: The muscle latency provides the information about the speed of neuromuscular reaction. In the present study, regular TC practitioner showed significantly faster muscle response than the sedentary controls, which might benefit for old people to maintain postural stability.

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