NEUROMUSCULAR REACTION OF TRUNK AND LOWER LIMBS IN OLDER TAI CHI AND JOGGING PRACTITIONERS DURING LATERAL POSTURAL CONTROL

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SUMMARY
This study examined the effects of regular practice of Tai Chi and jogging on neuromuscular reaction indicated by muscle latency of the trunk and lower limb muscles on the unperturbed side in older people during lateral postural perturbation. A total of 42 people aged 65 or older participated in this study, and formed Tai Chi group, jogging group, and sedentary control group based on their exercise habits. Surface electromyography (EMG) data were collected at peroneus longus, tibialis anterior, gluteus medius, and erector spinae on the unperturbed side during the lateral perturbation. The results showed that control group showed significantly longer muscle latency of the erector spinae than those of the Tai Chi and jogging group. Tai Chi group also showed shorter muscle latency of the tibialis anterior than the control group. The results of this study indicated that regular practice of Tai Chi benefits neuromuscular reaction of these muscles to lateral postural perturbation in the elderly people.

INTRODUCTION
Studies show that age-associated impairments in lateral stability may be a particularly important aspect of balance dysfunction, which leads to falls and fall-related injuries. Lateral stability has been found to be associated with past falls, future falls, and recurrent falls in elderly people [1, 2]. The latency of muscular activation is one of the most common parameters used to evaluate neuromuscular reaction. It is defined as the time from the first moment of perturbation to the onset of the EMG response. Research shows a significant difference of 7–10 ms in the lower extremity muscle latency of old versus young people and of older fallers versus non-fallers [3]. Tai Chi, a traditional Chinese exercise, has been documented to have beneficial effects on the neuromuscular reaction of ankle and knee muscles and postural stability [4]. It is unclear if regular practice of Tai Chi improves the neuromuscular reaction of the trunk muscles that are associated with posture correction. The objective of the study was to investigate the effects of long-term, regular practice of Tai Chi on the neuromuscular reaction of the muscles of the ankle and spine on the unperturbed side during lateral perturbation. We also examined if there is a difference in the neuromuscular reactions between long-term, regular Tai Chi practitioners and joggers, considering that jogging is one of the most popular forms of exercise in older people.

METHODS
Forty-two community-dwelling men aged 65 years or older participated in this cross-sectional study. All participants were right-hand and right-leg dominant. Exclusion criteria include any disease or disorder that may affect the performance of postural control and muscular reaction in the past 12 months. Based on their exercise habits, the participants were grouped into the Tai Chi group (n = 14), in which members regularly practice Tai Chi for approximately 1 h every day for 3 years or more; jogging group (n = 14), in which members jog at least 1 h every day in the past 3 years or more and without involving other type of exercise; and the sedentary control group (n = 14), in which members have not been doing any form of regular exercise in the past 3 years.

A lateral perturbation device was developed based on a previously published work [5]. It is a platform (70 × 50 cm) that is free to slide in the orthogonal direction along two additional shafts; thus, the platform can move to any horizontal direction. The maximum displacement, velocity, and acceleration were 0.09 m, 0.2 m/s, and 2 m/s², respectively. Noraxon EMG system (Noraxon, USA) was used to collect surface EMG signals from four muscles on the unperturbed side of body: peroneus longus, tibialis anterior, gluteus medius, and erector spinae. The EMG signals were sampled with a gain of 1,000 times and bandwidth (~3 dB) of 10–1,000 Hz. DEWEsoft (Dewetron, Austria) was used to record the synchronized signals of perturbation and EMG.

Before data collection, the participants were told that they would receive a perturbation while on the platform, and that they should react naturally to prevent themselves from falling in response to the perturbation, i.e., to maintain balance without taking a step. To record the EMG signals, dual Ag/AgCl snap electrodes with a 1 cm diameter of each circular conductive area and a 2 cm center-to-center spacing (Noraxon, USA) was positioned on the muscle belly of the selected muscles of the unperturbed side. The EMG data were collected during 10 perturbation trials. All EMG were initiated 500 ms prior to the onset of perturbation and had a sampling duration of 2 s. The onset latency was the time interval in milliseconds (ms) between the initiation of the perturbation and the first rising response of the EMG burst from the baseline to clear activity, which was determined by visual inspection [6]. One-way analysis of variance (ANOVA) was used to examine the significant differences in the physical characteristics and muscle latencies between groups. Post-hoc Tukey tests were performed when necessary to isolate the differences and a probability level of P < 0.05 denotes statistical significance.
RESULTS AND DISCUSSION

Table 1 provides the participants’ information. The mean onset of latency for the measured muscles during perturbation in the different groups is shown in Table 2. No significant difference was found in the latency of peroneus longus and gluteus medius between the groups (F = 2.193, P = 0.126 for the peroneus longus muscle, F = 0.280, P = 0.757 for the gluteus medius muscle). Further tests indicated that the muscle latency of tibialis anterior and erector spinae in the Tai Chi group was significantly shorter than that of sedentary control group (P = 0.007 for the tibialis anterior, P = 0.000 for the erector spinae); the erector spinae muscle of the jogging group was also activated significantly faster than that of sedentary control group (P = 0.019). No significant difference was found for the muscle onset latencies between the Tai Chi and jogging groups.

This study found that regular practice of Tai Chi benefits neuromuscular reaction of the tibialis anterior muscle. This result is consistent with the research findings of a previous study [7]. In this study, regular long-term joggers did not perform better in the neuromuscular reaction of the tibialis anterior to lateral perturbation than the control group. The differences might be attributed to different biomechanical characteristics of the movements between Tai Chi and jogging. The motion of jogging in the transverse, or coronal, plane is small in magnitude as compared with the sagittal plane [8]. The movement of Tai Chi contains both double-stance weight-bearing and single-stance weight-bearing maneuvers, which further require the pivoting of the whole body about the foot, twisting of the trunk on the hips, and coordination of head, the upper extremities, and lower extremities in multiple directions [4]. The above-mentioned movement characteristics of Tai Chi may improve the neuromuscular reaction of the ankle muscles by training the muscles in the simulated challenge posture.

Ankle joint muscles contribute to postural. Research has found that elderly subjects with a history of falls demonstrate weaker ankle dorsiflexors and plantarflexors compared with those that elderly subjects with a history of falls demonstrate weaker ankle dorsiflexors and plantarflexors compared with those without such history stability [9]. This study showed that regular practice of Tai Chi fastens neuromuscular reaction of the tibialis anterior to lateral perturbation. Regular Tai Chi practicing also improves the ankle joint muscles’ strength and endurance [7]. Therefore, regular Tai Chi exercise would be very helpful in improving postural stability in older people, because ankle strategy corrections generally occur in ankle flexors and muscles starting at the feet and moving upwards toward the trunk. Stronger neuromuscular function of the ankle would enhance the ankle strategy in postural correction. Therefore, Tai Chi could be a good exercise intervention option to improve postural control capacity.

The erector spinae is important in anterior-posterior and medio-lateral postural control [10]. It plays an important role in reactive recovery response to an unexpected slip during locomotion [11]. Poor trunk motion control capacity is used to predict the ability to recover from loss of balance and to avoid falls [12]. Regular practice of Tai Chi fastens neuromuscular reaction of the erector spinae to lateral perturbation in older people. Therefore Tai Chi could be a good exercise intervention option to improve postural control capacity.

CONCLUSIONS

This study provided scientific evidence of the beneficial effects of regular Tai Chi and jogging exercise on neuromuscular reaction during lateral postural perturbation in older men. Ankle joint and trunk muscles of Tai Chi practitioners responded faster to the unexpected medio-lateral perturbations, which would help timely correction when lateral postural distributions occur. Tai Chi would be a good exercise for improving lateral postural control capacity in older people.

REFERENCES


Table 1: General description of the subjects (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Tai Chi group (n=14)</th>
<th>Jogging group (n=14)</th>
<th>Control group (n=14)</th>
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<tbody>
<tr>
<td>Age (year)</td>
<td>72.4±4.1</td>
<td>70.9±4.2</td>
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<td>Height (cm)</td>
<td>169.95±4.52</td>
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<td>168.52± 6.53</td>
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<td>Weight (kg)</td>
<td>67.54±8.82</td>
<td>69.57±10.62</td>
<td>68.17± 12.69</td>
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</table>

Table 2: The onset latency (ms) of different muscles of the unpertubated side during lateral perturbation among the different groups (mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Tai Chi group</th>
<th>Jogging group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroneus longus</td>
<td>88.47±15.25</td>
<td>100.00±16.80</td>
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<td>Anterior tibialis</td>
<td>91.77±17.95a</td>
<td>108.67±26.36</td>
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<td>Gluteus medius</td>
<td>117.64±16.07</td>
<td>114.88±14.94</td>
<td>112.58±20.87</td>
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<td>Erector spinae</td>
<td>90.43±12.50a</td>
<td>108.84±21.40a</td>
<td>123.26±16.02</td>
</tr>
</tbody>
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a, P<0.05, Tai Chi group compared with the control group; b, P<0.05, jogging group compared with the control group.