INFLUENCE OF LONG-TREM TAI CHI PRATICE AND JOGGING EXERCISE ON MUSCLE STRENGTH AND ENDURANCE IN ELDERLY PEOPLE

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The purpose of the study was to investigate the influence of regular Tai Chi (TC) practice and jogging exercise on muscle strength and endurance of the lower extremities in older people. Twenty-one long-term older TC practitioners were compared with 18 regular older joggers and 22 sedentary counterparts. The strengths of knee extensors and flexors in the control group at the higher velocity were significantly lower than those in the jogging group and marginally lower than those in the TC group. The subjects in both the TC group and the jogging group generated more torque in their ankle dorsiflexors. In addition, the muscle endurance of knee extensors was more pronounced in TC practitioners than the controls.

KEY WORDS: Tai Chi, muscle strength, Jogging exercise, older people

INTRODUCTION: Tai Chi (TC) is an ancient Chinese conditioning exercise. Its non-vigorous and gentle movements are suitable for older people. TC is performed in a semi-squat posture that can place a large load on the muscles of the lower extremities. The movements demand guided motions of the hip, knee and ankle joints in various directions, requiring concentric and eccentric contractions of the hip, knee and ankle muscles. These movements are similar to resistance exercises such as lunges, knee bends and squats, in terms of the degrees of hip and knee flexion and extension that are required (Jacobson, Chen, Cashel, & Guerrero, 1997). Indeed, several studies have reported the benefits of TC exercise on muscle strength. Even though TC practice is effective in the improvement of muscle strength in the old people, the related information is not complete. Firstly, declines in muscular strength, particularly ankle strength, have been associated with falls amongst the elderly (Fiatarone & Evans, 1993; Whipple, Wolfson, Amerman, 1987). To date, assessments of TC exercise on muscle strength have only focused on knee extensors or flexors. Little has been mentioned about the effects on the muscles of the ankle joint. Secondly, there is a lack of comparison with other common physical activities. Regularly scheduled physical activity definitely promotes muscle function, but the effects of exercise on muscle strength are not identical due to the different exercise forms, intensity or duration. Hence, the study described herein measured the isokinetic strength of the knee and ankle joints, and knee muscle endurance amongst long-term TC practitioners, long-term jogging exercisers and their sedentary counterparts. Jogging is one of the most common forms of exercise in older people, and was thus selected as a contrast to TC exercise. The purpose of this study was to more comprehensively understand the effect of TC exercise on muscle function in the older people.

METHODS: Subjects were recruited by means of a questionnaire with a complementary interview about their physical and sporting activities. All the subjects were 60 years or above and predominantly healthy. TC group was composed of 21 subjects with 4 or more years of TC experience. They regularly practiced TC everyday for approximately 60 minutes, but were not involved in any other regular physical activity. Jogging group included 18 older people who had engaged in at least one hour of jogging exercise per day during the past 4 years or more. The joggers occasionally performed other physical activities (swimming and bicycling), but had no TC experience. For the sedentary controls, no regular exercise for more than 5 years. No significant difference was noted in age, body height, body weight and ratio of gender across the three groups.

All tests were performed on each subject's dominant leg. The Cybex Norm isokinetic dynamometer system (Cybex Corporation, USA) was used to measure the torque and work produced by specific muscle groups.

Knee joint: Isokinetic strength was measured using preset angular velocities of 30° and 120°/sec of concentric actions for knee flexors and extensors at full available range of motion. Three maximal contractions were measured and the highest peak torque (PT) was reported. A 1.5 - minute rest period was allowed between the two sets of data collection at the different velocities. All torque data were normalized per kilogram of body weight for analyses (PT %). After 3 minutes of relaxation, the dynamic endurance of the knee extensors and flexors was assessed from a recording of 40 repeated maximum isokinetic contractions with an angular velocity of 180° / sec. Subjects were instructed to push and pull "as hard as fast as possible" in every single movement. The work expended by a knee angular motion of 10 to 80° was recorded. The endurance index (EI) was defined as the ratio of the work during the last five contractions over the first five contractions.

Ankle joint: After 20 minutes of relaxation, the isokinetic contractions of ankle dorsiflexors and plantar flexors were performed at an angular velocity of 30° / sec. The subjects were instructed to push the foot away from them and pull it towards them at maximum velocity through the full available range of motion for each repetition. PT was determined as the highest torque generated from the three trials, and the PT% data were analyzed.

Data analysis: One-way analysis of variance was used to determine significant differences amongst the groups. Post hoc Tukey tests were performed when necessary to isolate the differences and $P < 0.05$ was considered to be statistically significant.

RESULTS:

Knee joint: The mean concentric PT% of knee flexors and extensors at the velocity of 30°/sec in TC and jogging subjects showed a clear trend for being greater than those in the control group, although the differences did not reach significant levels. The differences in muscle strength amongst the three groups were significant at the velocity of 120°/sec. Post-hoc comparisons indicated that the concentric strengths of knee extensors and flexors in the control group were significantly lower than those in the jogging group and marginally lower than those in the TC group. No significant differences in knee muscle strength were found between the TC and jogging groups (Table 1).

Ankle joint: The PT% of dorsiflexors significantly differed amongst the three groups, whereas that of plantarflexors did not. Further comparisons showed that the subjects in both the TC group and the jogging group generated more torque in their ankle dorsiflexors. No significant differences in the PT% of ankle dorsiflexors and plantar flexors were observed between the TC and jogging groups (Table 1).

Muscle endurance: As the EI is the ratio of the work during the last 5 contractions over the first 5 contractions, a larger index reflects a greater resistance to fatigue. For knee extensors, the TC subjects demonstrated a significantly greater EI than did the sedentary controls. The mean value of EI in the jogging group was greater than that in the control group, and slightly lower than that in the TC group, but the differences were not significant. Similar data were noted for the knee flexors (Table 1).

DISCUSSION: Old people who have maintained a physically active lifestyle have demonstrated better muscle strength and endurance than their age-matched less-active peers (Laforest, St-Pierre, Cyr, & Gayton, 1990). It seems that our data are not very consistent with these findings. However, it should be noted that almost all of these cross-sectional studies carried out comparisons between active and inactive people. Few studies have considered the possible effects of different forms of exercise. When we individually compared the differences in muscle strength and endurance between the TC practitioners and the controls, and between the joggers and the controls, using an independent t-test, the results were similar to those of most related studies. Almost all muscle strength parameters in the exercisers were significantly better than those in their sedentary counterparts, except for plantarflexor strength in the TC group and the endurance of knee flexors in the jogging

group. Hence, we believe that our results might be a function of the characteristics of the specific forms of exercise. Although it was difficult to accurately compare the exercise intensity between TC practitioners and joggers using the present study design, the subjects in the two groups had similar exercise frequency, duration and years of experience. The physical activity involvement level in both groups should be regarded as equal. Our results are similar to those of Gauchard et al. (Gauchard, Jeandel, Tessier, & Perrin, 1999).
Amongst the four muscle groups of the lower extremities, TC practice stimulated significantly greater gains than in the controls in only the ankle dorsiflexors. This might be because the movements of ankle dorsiflexion are particularly emphasised in almost all forms of TC, such as slowly raising and lowering the toes under tension, dorsiflexed foot turn left or right, and so on. Exercises always give priority to improving the function of the specific muscle groups used in the exercise.
Another interesting finding is that significant effects of jogging exercise on knee muscle strength only showed at higher velocity. The older have fewer, but on average larger and slower, motor units (Larsson, Grimby, & Karlsson, 1979). A relatively greater decrease in torque with increasing speeds was thus characteristic of knee extensors in older subjects (Aniansson, Sperling, Rundgren, & Lehnberg, 1983; Gersten, 1991). In the present study it seems that jogging counteracts this impairment. This might be very important for the older, because high-speed muscle contraction is necessary for them to maintain function in daily activities, such as normal walking speed and timely response to perturbation.
Increased muscle endurance might be of great practical importance to the older as a means of reducing the increased risk of accidents and falling. In our study, TC practitioners achieved the best scores on muscle endurance. From the characteristics of TC movement, TC exercise involves the use of slow-twitch muscle fibres which, when trained, have a higher concentration of myoglobin, a larger number of capillaries and a higher content of mitochondria and thus mitochondrial enzymes, than fast-twitch fibres. These factors enable the slow-twitch fibres to have a high resistance to fatigue due to their high capacity for aerobic metabolism. It is through this training response that regular TC exercise could improve muscle endurance.
In conclusion, our study confirmed that regular physical activity could produce positive effects on muscle function. Although the benefits of the long-term TC practice on muscle strength in the lower extremity did not seem superior to that of long-term jogging, the maintenance of dorsiflexion strength and knee extension endurance in TC practitioners might be of practical importance for older people in everyday life.

Table 1 Isokinetic strength (PT%) and EI of different muscles among three groups (mean ± SD).

	Knee flexors		Knee extensors		Ankle plantarflexors	Ankle dorsiflexors	Endurance index	
	30°/s	120°/s	30°/s	120°/s			Knee flexors	Knee extensors
TC	78.5	53.7	135.2	94.0	67.1	20.4 *	0.60	0.72 *
group	(13.3)	(10.1)	(29.5)	(19.4)	(21.6)	(5.3)	(0.16)	(0.15)
Jogging	80.8	62.9 *	133.6	101.9 *	75.2	20.6 *	0.57	0.69
group	(22.3)	(18.6)	(40.1)	(26.3)	(20.2)	(4.3)	(0.18)	(0.12)
Control	68.9	45.8	119.0	79.3	61.6	16.6	0.51	0.61
group	(13.6)	(11.2)	(19.8)	(15.6)	(13.0)	(4.4)	(0.15)	(0.12)

Notes: * $p < 0.05$, compared with control group.

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