Effect of tai chi exercise on proprioception of ankle and knee joints in old people

D Xu, Y Hong, J Li, K Chan

Objectives: To assess if tai chi, a traditional Chinese form of exercise, could improve proprioception in old people and if the effects of tai chi on proprioception are more evident than other exercise forms in the elderly.

Methods: By detecting the threshold of passive movement, ankle and knee joint kinaesthesia was measured in 21 elderly long term tai chi practitioners (TC group), 20 elderly long term swimmers/runners (S/R group), and 27 elderly sedentary controls (control group).

Results: Ankle joint kinaesthesia differed significantly among the three groups (p = 0.001). Subjects in the TC group could detect a significantly smaller amount of motion than those in the S/R group (p = 0.022) and control group (p = 0.001). No significant difference was found between the S/R group and the control group (p = 0.701). The threshold for detection of passive motion was significantly different in knee extension and flexion. For knee flexion, the TC group showed a significantly lower mean threshold for detection of passive motion than the control group (p = 0.026). There were no significant differences between the S/R group and control group (p = 0.312), or between the TC group and S/R group (p = 0.533). For knee extension, no significant difference was noted among the three groups (p = 0.597).

Conclusions: The elderly people who regularly practiced tai chi not only showed better proprioception at the ankle and knee joints than sedentary controls, but also better ankle kinaesthesia than swimmers/runners. The large benefits of tai chi exercise on proprioception may result in the maintenance of balance control in older people.

Tai chi, a traditional Chinese exercise, has been practiced for centuries in China by the elderly and young to attain agility, balance, and posture control. Its beneficial effects on health have been observed, and the maintenance of balance control in older people in particular has drawn increasing attention from scientific researchers. A number of cross sectional and longitudinal studies have provided positive evidence that tai chi practitioners not only have better cardiorespiratory function, but also perform better in balance control, flexibility, and muscle strength tests. Moreover, a study conducted by Wolf et al. identified that the intervention of tai chi exercise (yoga and soft gymnastics) appeared to have a greater effect on balance control in the elderly than bioenergetic physical activities. However, the authors did not suggest any underlying reasons.

Tai chi exercise requires continuous, slow movement with small to large expressions of motion, the shift of body weight from unilateral to bilateral, and circular movements of the trunk and extremities, involving both isometric and isotonic contractions. All forms of tai chi emphasise conscious awareness of body position and movement, which seem to contain the characteristics of proprioceptive exercise. Therefore does tai chi exercise have particular benefits for old people’s proprioception? Jacobson et al. reported that a 12 week tai chi programme could increase participants’ shoulder kinaesthetic sense at 60°. However, the mean (SD) age of the subjects was 30.4 (4.3) years, and the investigators did not consider the principal joint systems of the lower extremity (ankle, knee, and hip) involved in postural control. This study was therefore designed to investigate the proprioception of ankle and knee joints in elderly long term tai chi practitioners, long term swimmers/runners, and sedentary controls. The purpose was to assess whether long term tai chi practice could improve proprioception and whether the effect of tai chi on proprioception was more evident than other common activities in the elderly. Such information would help to explain the mechanism whereby tai chi exercise improves balance.

METHODS

Subjects

By means of a questionnaire with a complementary interview about their physical and sporting activities, 68 old people were recruited to the study. They were predominantly healthy with no history of major cardiovascular, pulmonary, metabolic, musculoskeletal, or neurological diseases. Twenty one subjects had regularly practiced tai chi for approximately
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1.5 hours a day over the previous four years or more (TC group). Twenty subjects had swum and/or run for at least one hour a day for four or more years (S/R group). The subjects in the TC and S/R groups had not done any other regular physical activity in the previous five years. Twenty seven subjects had not engaged in any regular exercise for more than four years (control group). No significant difference was noted in sex, age, height, and weight across the three groups (table 1).

Each subject gave written informed consent before participation. The study was approved by the local medical ethics committee.

Measurement procedures
Joint kinaesthesis is the sensation of joint movement; it is an important technique used to evaluate proprioception. Kinaesthesis is usually determined by establishing the threshold at which passive motion is detected, an assessment of the ability to detect relatively slow passive joint motion.17 We used it to assess knee and ankle joint proprioception.

Testing was performed in a well lit and well ventilated room. The room was sound attenuated and isolated so as to reduce any auditory or visual interference that might distract the participants. After their weight and height had been measured, each subject participated in two separate data collection sessions: measurement of ankle joint kinaesthesis and, after a brief rest period, measurement of knee joint kinaesthesis.

Ankle joint kinaesthesis test
Data were collected using the instrumentation and procedures described by Lentell et al9 with minor modifications. As illustrated in fig 1, the custom made device is a box with a movable platform that rotates about a single axis in two directions. With the foot resting on this platform, plantar dorsiﬂexion of ankle movements can occur. This platform is moved by an electric motor which rotates the foot on an axis at a rate of 0.4˚/s. Movement can be stopped at any time by the use of a hand held switch. The angular displacement achieved by the platform is calculated by the dents that the motor rotates.

The device is also equipped with a hanging scale and a fixed pulley supported by a trestle, which is outside of the device. A thigh cuff attached to the lower end of the scale is wrapped around the lower thigh of the subject. By adjustment of the length of the cuff, the extremity is lifted by the scale, and its weight is recorded when the subject fully relaxes the thigh. The thigh cuff is then attached to one end of the rope around the pulley and the other end is hung with weights. The extremity can then be adjusted to where the foot is in contact with the platform. By adding or reducing the weights, the investigator can standardise the weight of the lower extremity resting on the platform during testing.

For data collection, each subject was seated on an adjustable chair and his or her dominant foot was placed on the platform so that the axis of the apparatus coincided with the plantar dorsiﬂexion axis of the ankle joint. The hip, knee, and ankle were positioned at 90°. To standardise the sensory cues from the contact between the instrument and the plantar surface of the foot, 50% of the lower extremity weight was rested on the platform by the use of the thigh cuff suspension system. During testing, subjects kept their eyes closed and wore headphones with music playing to eliminate visual and auditory stimuli from the testing apparatus.

Each test movement began with the foot placed on the horizontal platform—that is, the starting position was 0°. The subjects were instructed to concentrate on their foot and to press the hand switch when they could sense motion and identify the direction of the movement. After two practice trials had been performed, the motor was engaged to rotate the foot into dorsiﬂexion or plantarﬂexion at a random time interval between two and ten seconds after subject instruction. The researcher recorded the rotation angles of the platform and the direction of movements as passive motion sense. At least six randomised trials were conducted: three for plantarﬂexion, three for dorsiﬂexion. The mean values of the three angles sensed in one direction were calculated.

Knee joint kinaesthesis test
The method of assessing knee kinaesthesia was similar to those described in previous studies.7 18 As shown in fig 2, the apparatus consists of electric motor, governor, counter system, transmission, and linkage system. A moveable frame can rotate around a single axis in two directions at a velocity of 0.4°/s. Angular displacement of the frame is calculated by the dents that the motor rotates.

Each subject performed two practice tests to become familiar with the test process before completing the trials. At least six randomised trials (three trials for extension, three trials for ﬁexion) were performed on the dominant leg according to the following protocol. The subjects wore shorts to negate any extraneous skin sensation from clothing at the knee area. They sat in an adjustable chair with legs hanging

Table 1 Characteristics of elderly tai chi practitioners (TC group), swimmers/runners (S/R group), and sedentary controls (Control group)

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (n=21, 12M, 9F)</td>
<td>66.1 (5.2)</td>
<td>163.4 (7.9)</td>
<td>64.8 (9.9)</td>
</tr>
<tr>
<td>S/R (n=20, 12M, 8F)</td>
<td>65.4 (3.0)</td>
<td>164.1 (8.6)</td>
<td>66.5 (12.4)</td>
</tr>
<tr>
<td>Control (n=27, 15M, 12F)</td>
<td>65.6 (3.9)</td>
<td>163.9 (7.8)</td>
<td>68.5 (10.9)</td>
</tr>
</tbody>
</table>

Values are mean (SD). M, male; F, female.
freely over the edge of the seat 5 cm proximal to the popliteal fossa. A custom made inflatable cuff was fitted above the knee joint and inflated to 20 mm Hg to neutralise cutaneous sensation. The axis of rotation of the knee joint was aligned with the axis of rotation of the frame. Then the researcher placed the lower part of the shank of the subject on the frame. An ankle inflatable cuff was applied and inflated to 20 mm Hg to reduce multisensory afferent discharge at the shank-machine interface. To further reduce unwanted sensory input, the subjects kept their eyes closed and wore headphones with music playing to eliminate the sight and sound of the apparatus.

The starting position of each trial was 45˚ of knee flexion as measured by an electrogoniometer (Penny and Giles, Christchurch, Dorset, UK). Subjects were told that their legs could move in a flexed or extended direction beginning at a random delay of 2–10 seconds after the examiner signalled the start of the test. Once the subject detected motion of the leg, he or she pressed a hand held stop button and confirmed the direction of the motion. The rotation angles of the frame were defined as the threshold of detection for the knee joint. Mean values of three trials in one direction were used for analysis.

**Data analysis**

All variables are presented as mean (SD). Values for passive motion sense of ankle and knee joint in different directions were respectively compared using paired t test in each group. Because there were no significant differences between the directions of ankle movement, plantarflexion, and dorsiflexion, data were averaged to produce ankle kinaesthesis. One way analysis of variance indicated significant differences in passive motion sense in knee flexion across the three groups (p = 0.025). Further analysis showed that the TC group had a significantly lower mean threshold for detection of passive motion than the subjects in the control group (p = 0.026). There were no significant differences between the S/R group and control group (p = 0.312), or between the TC group and S/R group (p = 0.533). For knee extension, no significant difference was found among the three groups (p = 0.597) (fig 4).

**RESULTS**

**Ankle joint kinaesthesis**

Ankle joint kinaesthesis differed significantly among the three groups (p = 0.001). Movements of 1.21 (0.33)⁰ were perceived in the TC group, 1.78 (0.82)⁰ in the S/R group, and 1.95 (0.66)⁰ in the sedentary control group. The post hoc test showed that the TC group could detect a significantly smaller amount of motion than the control group (p = 0.001) and S/R group (p = 0.022), while no significant difference was found between the S/R group and sedentary control group (p = 0.701) (fig 3).

**Knee joint kinaesthesis**

The threshold for detection of passive motion was significantly different in extension and flexion for each group; the knees were more sensitive to a flexion arc than to an extension arc. One way analysis of variance indicated significant differences in passive motion sense in knee flexion across the three groups (p = 0.025). Further analysis showed that the TC group had a significantly lower mean threshold for detection of passive motion than the subjects in the control group (p = 0.026). There were no significant differences between the S/R group and control group (p = 0.312), or between the TC group and S/R group (p = 0.533). For knee extension, no significant difference was found among the three groups (p = 0.597) (fig 4).

**DISCUSSION**

Although many studies have indicated that adoption of regular physical activity can attenuate the age related decline in many physiological systems, few have examined the effects of exercise on proprioception of old people, especially...
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The elderly people who regularly practiced tai chi not only showed better proprioception of the ankle and knee joints than sedentary controls, but also showed better ankle kinesthesia than elderly regular swimmers/runners. The prominent benefits of tai chi exercise on proprioception may be helpful in maintaining balance control in the elderly.

References

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