T'ai Chi and Postural Control in the Well Elderly

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In this study, we investigated the potential value of t'ai chi in promoting postural control of the well elderly. T'ai chi, a traditional Chinese exercise, is a series of individual dancelike movements linked together in a continuous, smooth-flowing sequence. Performance on five balance tests of 9 t'ai chi practitioners was compared to that of 9 nonpractitioners. An analysis of variance demonstrated that in three of the tests, the t'ai chi practitioners had significantly better postural control than the sedentary nonpractitioners (p < .05). It was also found that men performed significantly better than women in both the practitioner and non-practitioner groups on the same three tests (p < .01).

Health promotion and disease prevention have become increasingly important to health professionals in the 1990s. A position paper of the American Occupational Therapy Association (1989), entitled Occupational Therapy in the Promotion of Health and the Prevention of Disease and Disability, states:

Promoting health and wellness is the basis of prevention efforts and should be the cornerstone of all therapeutic intervention... The promotion of health and wellness is compatible with the fundamental beliefs and theoretical foundations of occupational therapy. (p. 806)

Recently, preventive care for the elderly has received increased attention, due perhaps to the rapid increase in the elderly population and their resulting disproportionately high medical expenses. The proportion of the non-working elderly population will continue to grow, while the younger working population, who are the source of financial input for the welfare system, will shrink comparatively. In 1987, people aged 65 years and over constituted 12% of the U.S. population but consumed 21.1% of total health care expenditures (U.S. Department of Commerce, 1989).

A high incidence of falling is a common problem among elderly people (Butler, 1989) and often causes severe physical and psychological trauma. According to the National Safety Council (1988), among persons aged 65 years and over, falls were the leading cause of accidental death in 1987. It has been estimated that hip fractures secondary to new falls cost approximately 2 billion dollars during 1980 (Robinson, 1984). As a result, there has been a great increase in research on health and fitness in the elderly (Fiatarone et al. 1990; Grimby, 1986; Hopkins, Murrah, Hoeger, & Rhodes, 1990; Spirduso, 1980) and on the effects of exercise on postural control (Barry, Steinmetz, Page, & Rodahl, 1966; Bassett, McClamrock, & Schmelzer, 1982; Crilly, Willems, Trenholm, Hayes, & Delaquerrre-Richardson, 1989; Stones & Kozma, 1987; Vanfraechem & Vanfraechem, 1977).

The purpose of this study was to investigate the potential value of t'ai chi, a popular form of dancelike exercise that originated in China, in promoting postural control in the well elderly. Differences were compared in performance on balance tests between elderly t'ai chi practitioners and a control group of elderly nonpractitioners.

Postural Control

Postural control is the ability to maintain equilibrium in a gravitational field by keeping or returning the center of body mass over its base of support (Horak, 1987). Lee (1989) defined the same concept as balance, referring to "the location or trajectory of the body's center of mass relative to the edges of the current or anticipated base of
Postural Control and Motor Learning Theory

The neural mechanisms of postural control can be understood in the light of motor learning theory. Schmidt (1982) theorized that human movement is controlled by a combination of two fundamental processes: closed-loop control (peripheral, negative feedback) and open-loop control (central, feedforward). According to Schmidt, closed-loop systems involve the processing of feedback against a reference of correctness, the determination of an error, and a subsequent correction. In humans, feedback is provided by various sensory receptors, for example, by the vestibular apparatus, the Golgi tendon organs, and muscle spindles. This closed-loop mode of control is often executed when a person is encountering a novel situation in which sensory input is continuously required to guide movement along the expected pattern or trajectory (e.g., walking on a balance beam or feeling one’s way through a dark room).

Open-loop systems involve no feedback analysis or error corrections. The output is preprogrammed at the higher centers of the brain and feed forward to be executed at other parts of the system (Schmidt, 1982). Thus, the open-loop mechanism contributes to the generation of motor programs in humans. One example is the onset of automatic and anticipatory electromyography activity of the back and lower extremities before that of the focal voluntary movement of upper extremities (e.g., reaching out to open a door), thus saving the person from falling forward as a result of redistribution of the center of mass. Open-loop systems differ from closed-loop systems in their speed and spontaneity. This phenomenon of automatic excitation of postural muscles prior to focal voluntary movement has been studied by several researchers (Balen'kit, Gurfinkel, and Pal'tsev, 1967; Horak et al., 1984; Lee, 1990; Zattara & Bouisset, 1988).

Postural Control and the Elderly

Various studies have been done on the effect of aging on the postural control system of the elderly. Most studies demonstrate that with age come varying degrees of morphological and neural deterioration in various components of the postural control system: vision (Fozard, Wolf, Bell, McFarland, & Podolsky, 1977); vibration sense (Brocklehurst, Robertson, & James-Groom, 1982; Keshlo, 1977; Komen, Bossemeyer, Barney, & Williams, 1977); vestibular apparatus (Overstall, Hazell, & Johnson, 1981); muscular changes (Grimby, 1986); and postural responses to perturbations (Woollacott, Shumway-Cook, & Nashner, 1986).

Of the various studies on the effects of exercise on the elderly, some have documented improvement of different aspects of postural control (Stones & Kozma, 1987; Vanfraechem & Vanfraechem, 1977), whereas others claim that exercises that were originally aimed at improving postural control actually improved other physical performance but not postural control itself (Barry et al., 1966; Bassett et al., 1982). Crilly and colleagues (1989) found no changes in postural sway after 36 classes of an exercise program.

In view of the difference in duration, content of exercise programs, parameters of measurement, compliance, initial physical status, and medical history of subjects, it is difficult to draw conclusions from these studies. There appears, however, to be a consensus among investigators that active elderly people show a different pattern and speed of physiological changes than their inactive counterparts (Bassey, 1978; Grimby, 1986; Kroll & Clarkson, 1978; Spirduso, 1980).

T'ai Chi as a Health-Promoting Exercise

T'ai chi is said to have been founded by Chang San-Feng, a legendary Taoist priest in the 13th century who had the inspiration for t'ai chi after observing a fight between a crane and a snake (Koh, 1981). The basic exercise is a series of individual dancelike movements linked together in a continuous sequence that flows smoothly from one movement to another. It is performed in a slow, rhythmical, and well-controlled manner, engaging not only movement of all joints of the body but the full concentration of the mind (Plummer, 1982). T'ai chi has been practiced in China throughout the centuries as a health-promoting exercise.

In a study performed in China on the medical benefits of t'ai chi, Qu (1980) found that a group of healthy subjects aged 50 to 89 years who practiced t'ai chi had better cardiovascular, respiratory, and skeletal-muscular function than a similar non-practicing group. Koh (1982), a physician and anesthetist who had moderately severe ankylosing spondylitis (Marie-Strümpell disease) for 15 years, reported improvement in his condition and an im-
proved ability to relax after 2½ years of daily practice in t’ai chi. Brown, Mucci, Hetzler, and Knowlton (1989) studied the cardiovascular and ventilatory responses during t’ai chi exercise. They concluded that the practice of t’ai chi led to a more efficient use of ventilatory volume and suggested that the physiological benefit of t’ai chi was associated with the potential to develop ventilatory efficiency without the presence of cardiovascular stress.

Therapeutic value of t’ai chi exercise, as reported in these studies, has been found in the following areas: (a) improvement in cardiovascular and pulmonary functions; (b) promotion of muscle strength of quadriceps; (c) promotion of range of motion; and (d) enhancement of relaxation. However, in view of limitations in the number of subjects and the scale of these investigations, further research is needed to validate the findings.

T’ai Chi and Postural Control

No studies were found on the effects of t’ai chi on the postural control of elderly persons. In light of motor learning theories, mechanisms of postural control, and personal experience, we speculated that the practice of t’ai chi would promote postural control for the following reasons:

1. All t’ai chi movements are circular, slow, continuous, even, and smooth. Patterns of movement flow from one to the next. The even, slow tempo facilitates a sensory awareness of the speed, force, trajectory, and execution of movement throughout the exercise.
2. Because movements are well controlled, all unnecessary exertion is avoided, and only sufficient effort is used to overcome gravity (Plummer, 1982). Muscle coordination instead of rigid co-contraction can therefore be promoted.
3. Throughout the exercises, the body is constantly shifted from one foot to the other. This is likely to facilitate improvement of dynamic standing balance.
4. Throughout the exercises, different parts of the body take turns in playing the role of stabilizer and mover, allowing smooth movements to be executed without compromising the balance and stability of the body. This relationship between the firmly held position (postural stabilization) and the moving parts (focal movement) of the body have been the focus of postural control in many studies.

To anticipate and counteract any disturbance in balance caused by the moving parts of the body, the postural muscles are always the first to be activated by the brain (Horak et al., 1984; Lee, 1990; Nashner, 1977; Zattara & Bouisset, 1988). In t’ai chi, movements involve a continuous interchange of roles between stabilizers and movers and between weight bearing and non-weight bearing. Practicing these movements is likely to enrich the repertoire of motor programs that are stored in the brain. T’ai chi practitioners, therefore, stand a better chance than their sedentary counterparts of maintaining their balance and of not falling.

The hypothesis of the present study is that subjects who practice t’ai chi will have better postural control than sedentary nonpractitioners of similar age, sex, physical status, and cultural background.

Method

This ex post facto research study compared the postural balance of two groups of Chinese well elderly people. One group were practitioners of t’ai chi, while the other group had a primarily sedentary life-style.

Subjects

Nine practitioners of t’ai chi, 6 men and 3 women aged 65 to 84 years, and 9 nonpractitioners of t’ai chi, 6 men and 3 women aged 66 to 86 years, were recruited from the greater Boston area. The t’ai chi subjects had t’ai chi experience ranging from 1 year to more than 20 years. All were Chinese, independent in ambulation and self-care, and, by self-report, had satisfactory health with no major medical problems affecting mobility. In particular, subjects were questioned about diseases with a primary balance disorder, such as Parkinson disease, multiple sclerosis, or residual effects from a cerebrovascular accident.

Instrument

Five balance tests and a questionnaire were administered. The five tests were as follows:

1. Single right leg standing with eyes open
2. Single left leg standing with eyes open
3. Single right leg standing with eyes closed
4. Single left leg standing with eyes closed
5. Heel-to-toe walking with eyes open

A stopwatch was used to measure duration of standing and 2-in. masking tape marked the line for heel-to-toe walking. A questionnaire was administered to establish whether subjects met the requirements for inclusion in the sample and to obtain demographic information.

Test Validity

The single leg standing test has been used widely in various clinical situations, for example, in neurological examinations by physicians (Porvin & Tourtellotte, 1975). It has also been used to test balance of the elderly in various research studies (Bohannon, Larkin, Cook, Gear, & Singer, 1984; Lee, Deming, & Sahgal, 1988). The heel-to-toe
walking test is used in two standardized motor tests for children: the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) and the Sensory Integration and Praxis Tests (Ayres, 1989). It is also a test item in the standard neurological test of balance (Potvin & Tourret-lotte, 1975) and the Ataxia Test Battery (Graybiel & Fregly, 1966).

Procedure
The objectives of the research and the content of the tests were explained to the subjects. The tests were demonstrated, and the subjects were given time so that their best performance could be achieved. Each subject went through the tests in the same sequence, Test 1 through Test 5.

For the first four tests, the subjects were asked to stand on one leg for 60 sec. A maximum of three trials was allowed for each test for subjects to reach the goal of 60 sec. For the fifth test, the subjects were instructed to walk along a straight line for 15 steps and were again given three trials. The score of their best performance on each test was recorded. If the subject reached the goal of 60 sec or 15 steps on the first trial, no further trials were conducted for that particular test.

Data Analysis
An analysis of variance test was used to test for the possible effect of group (i.e., t'ai chi versus non-t'ai chi subjects) on each of the five balance tests. Sex was also included in the analysis as a main effect. The hypothesis that elderly practitioners of t'ai chi would perform better on postural balance tests than non-practitioners was partially supported. The comparatively better performance by t'ai chi practitioners suggests a positive link between t'ai chi and postural control; however, it is still too early to assert that the practice of t'ai chi promotes postural control in the well elderly. Because this study was a post hoc comparison, it could be argued that activities other than t'ai chi were related to the difference in performance. In fact, two of the t'ai chi subjects engaged in other types of physical activity—swimming and aerobics—and their comparatively higher scores on the balance tests may be attributable to a combination effect of all their activities. Additionally, perhaps the t'ai chi subjects' previous occupation or their inherently good sensory integrative skills and interest in mastery of body movement skills contributed to their greater competence in the postural control exercises.

Results
Mean scores and ranges of the five balance tests for the two groups of subjects are summarized in Table 1, and mean scores and ranges on the balance tests by group and sex are shown in Table 2. Because of the obvious differences between male and female scores, sex was entered in the analysis as a covariate to control for age-related error.

Following the analysis of variance, shown in Table 3, we found that there were significant differences between the t'ai chi and the non-t'ai chi groups (p < .05) on three balance tests—single right leg standing with eyes open, single left leg standing with eyes open, and heel-to-toe walking. With sex as a main effect in the analysis, we found significant differences between the performances of the men and women (p < .01 level) on the same three tests.

To summarize, the results indicated that the t'ai chi subjects performed significantly better than the non-t'ai chi subjects on three out of five balance tests; men performed significantly better than women (regardless of group) on three out of five balance tests; and there were no significant differences in performance on the two tests of single leg standing with eyes closed.

Discussion
The hypothesis that elderly practitioners of t'ai chi would perform better on postural balance tests than non-practitioners was partially supported. The comparatively better performance by t'ai chi practitioners suggests a positive link between t'ai chi and postural control; however, it is still too early to assert that the practice of t'ai chi promotes postural control in the well elderly. Because this study was a post hoc comparison, it could be argued that activities other than t'ai chi were related to the difference in performance. In fact, two of the t'ai chi subjects engaged in other types of physical activity—swimming and aerobics—and their comparatively higher scores on the balance tests may be attributable to a combination effect of all their activities. Additionally, perhaps the t'ai chi subjects' previous occupation or their inherently good sensory integrative skills and interest in mastery of body movement skills contributed to their greater competence in the postural control exercises.

Performance varied widely between the two groups and within the groups on certain balance tests. In terms of differences among t'ai chi practitioners, this might be accounted for by the large range in the amount of t'ai chi experience that each subject possessed (range = 1 year to more than 20 years). The number of subjects in the present study is too small for correlations to be meaningful.

We were surprised to find a significant difference in performance between men and women for both the t'ai chi practitioners and the non-practitioners. We reviewed the literature again in light of this result and found that sex differences had also been noted among a group of young adults in three tests for equilibrium with the use of a tilt board (Fisher, Wietlisbach, & Wilbarger, 1988). These investigators speculated that the difference was

Table 1
Scores on Balance Tests for T'AI Chi and Non-T'ai Chi Groups, in Seconds

<table>
<thead>
<tr>
<th>Test</th>
<th>T'ai Chi Group (n=9)</th>
<th>Non-T'ai Chi Group (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>Range</td>
</tr>
<tr>
<td>1.</td>
<td>Right leg standing, eyes open</td>
<td>46.14</td>
</tr>
<tr>
<td>2.</td>
<td>Left leg standing, eyes open</td>
<td>48.19</td>
</tr>
<tr>
<td>3.</td>
<td>Right leg standing, eyes closed</td>
<td>15.72</td>
</tr>
<tr>
<td>4.</td>
<td>Left leg standing, eyes closed</td>
<td>12.45</td>
</tr>
<tr>
<td>5.</td>
<td>Heel-to-toe walking#</td>
<td>13.11</td>
</tr>
</tbody>
</table>

#Number of steps.

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induced by environmental factors, such as more frequent practice of risk-taking games by boys. A similar explanation for the present study could be that men, especially during their working years, tend to participate more in activities or jobs that demand gross motor abilities. Because in the present study there were only 3 women in each of the two groups, further speculation is not in order.

The results showed no differences between t’ai chi practice groups or between men and women on the two balance tests conducted with eyes closed. A possible explanation is that maintenance of balance with vision occluded is not a usual life experience and is, therefore, equally difficult for people regardless of their sex or their activity level.

It is interesting to note that during the tests of single leg standing, some t’ai chi subjects automatically adopted the strategy of the flexed knee, which is inherent in the practice of t’ai chi. In this way, they lowered their center of gravity, allowing their bodies to sway at the ankle, knee, and hip. Other t’ai chi subjects and most of the non–t’ai chi subjects simply stood with straight knees. This finding was not recorded systematically; thus correlations cannot be made between flexed knees and scores on postural control exercises. Perhaps future studies could examine if a relationship exists.

The number of subjects recruited for this study was small and the source limited to the Chinese community of the greater Boston area. In addition, we are aware that performance could have been affected by many variables such as activity history, interests, and occupation. These limitations do not allow the study findings to be generalized to the elderly population at large. Nevertheless, the positive results of this exploratory study indicate a possible relationship between t’ai chi and postural control and show that further investigations should be conducted to test this speculation.

Summary

The practice of t’ai chi in China has a long history. Various therapeutic values for t’ai chi have been described and speculated on, generally without experimentation. The study of t’ai chi with the use of the scientific method has been a recent occurrence, when used at all. In view of the positive findings from recent work as well as the comparatively better performance by t’ai chi practitioners than nonpractitioners in the present study, further research on t’ai chi with the use of more subjects from different cultures, age groups, and diagnostic categories is indicated.

Acknowledgment

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References


Proficiency examiner's manual.


