

Effects of T'ai Chi on Balance

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Objective: To determine if the practice of T'ai Chi significantly improves balance.

Methods: Twenty-two persons with mild balance disorders were studied. Five measures of balance were obtained, including 3 objective measures (moving platform posturography, Romberg testing, and reach testing) and 2 disability questionnaires (Dizziness Handicap Inventory and a modified Medical Outcomes Study general health survey). To be included, patients were required to be able to stand in the eyes-closed regular Romberg position for 30 seconds. The subjects underwent 8 weeks of T'ai Chi training and practice and then were retested.

Results: Highly significant improvements were found on both the posturography test and the Dizziness Handicap Inventory questionnaire scores ($P < .001$ and $P = .004$, respectively). Trends toward improvement were also noted in Romberg test results and the Medical Outcomes Study survey ($P = .03$ for both). Reach was not improved.

Conclusion: These findings suggest that T'ai Chi training improves balance.

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T'AI CHI is an exercise discipline derived from the tradition of Chinese ethnomedicine and martial arts. It is generally practiced as a daily exercise routine called a *form* that consists of a sequence of movement modules, which we will call *movements*. The form typically lasts 30 minutes. The movements typically are slow and flowing, are performed while standing, and appear similar to a slow dance. About 108 movements are available to the practitioner of traditional (Yang style) T'ai Chi. There are also several other styles or "schools" of T'ai Chi (eg, Chen, Wu, Wu-Hao, and Sun), each providing additional or variant movements.

In recent years, it has been appreciated that physical therapy is frequently helpful for patients with imbalance.^{1,2} Activities called *balance retraining* or *balance rehabilitation* incorporate exercises intended to improve gaze stability and postural stability. Balance exercises consist of static and dynamic balancing tasks. Difficulty is progressively increased over several sessions by increasing the speed or duration of the exercise or by reducing relevant sensory input.³

We noted that T'ai Chi exercises largely consist of static and dynamic bal-

ancing tasks and that the progressive nature of balance training is similar to the process of learning a T'ai Chi form. Accordingly, we hypothesized that T'ai Chi might be an appropriate vehicle for balance therapy.

RESULTS

The **Table** shows the mean scores on all measures for patients prior to and following 8 weeks of T'ai Chi training and the significance of change in scores (analysis of variance). All measures showed improvement. Because multiple tests were used (with a significance level of $P < .05$ to account for the Bonferroni correction), we considered $P \leq .01$ to indicate a significant change. Using this criterion and considering all ages, highly significant improvements were found for the posturography and DHI measures. Trends toward improvement were also noted in the Romberg test and the MOS survey results. Reach was not improved.

Figure 2 shows that baseline stability as assessed by posturography and Romberg and reach testing declined with advancing age. Scores on the MOS, a general indicator of health, also declined slightly. Surprisingly, scores on the DHI question-

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SUBJECTS AND METHODS

Thirty subjects with self-perceived mild balance disorders that were stable for a period of at least 3 months were recruited from the community through newspaper advertisements. Eight subjects did not complete the study (4 for reasons of poor health and 4 because of lack of interest); the results for 22 subjects are reported here. There were 5 men and 17 women. For analysis, they were divided into 3 age groups (20-60 years, 61-75 years, and 76 years and older) containing 6, 7, and 9 subjects, respectively. Subjects were required to be ambulatory and to be able to stand in the regular Romberg position for 30 seconds with their eyes closed without stepping (see subsequent description of the Romberg test procedure). We excluded patients with the diagnosis of benign paroxysmal positional vertigo, since specialized physical maneuvers are indicated for this condition; patients with other types of vestibular problems were included. For most patients, a definitive diagnosis was not available. We excluded patients with ataxia known to be caused by cerebellar dysfunction or cerebral palsy, since we expected these conditions to be unresponsive to training. We also excluded patients with medical conditions so severe that mild activity was judged inadvisable. The project was approved by the institutional review board of Northwestern University, Chicago, Ill, and informed consent was obtained from all subjects.

Each subject participated in one T'ai Chi course, which consisted of 8 one-hour sessions held over 2 months, with 1 meeting per week. The class size was 10. A physical therapist (L.F. or L.W.), a T'ai Chi instructor (J.K.), and at least 2 volunteer spotters were present for each session.

naire, a measure of perceived disability caused by dizziness (higher scores here indicate less disability), were generally higher for subjects 61 years or older than for those 60 years or younger, in spite of objective measures indicating decreased stability in the older groups. Figure 2 also shows changes in test scores after T'ai Chi training as a function of age group. Posturography scores improved in all age groups, and improvements were significant in those less than 60 years ($P = .001$) and those 76 years and older ($P = .008$). Similar results were found for the Romberg test, except for the group aged 61 to 75 years, which improved relatively less than the older ($P = .03$) or younger ($P = .03$) groups. There was no change in the comparison of the reach test scores. For the disability questionnaires, improvement was found in all age groups, but relatively less improvement was reported by those 76 years and older than for the younger groups. Significant improvement using the criterion of $P \leq 0.01$ was not found for any age subgroup for either the DHI or MOS score.

COMMENT

Our study revealed that 8 weeks of T'ai Chi training and practice was associated with significant improvements in several measures of balance. The results are compatible with other reports suggesting that T'ai Chi has beneficial

Students were asked to practice at home every day for at least 30 minutes, and they were given a practice videotape and written materials that illustrated the exercises. We did not measure compliance. Seven distinct movements selected from the Yang, Pa-Kua, and the Wu schools of T'ai Chi were used and are listed below.

Movement	Source
1. Preparation (holding the ball)	Kotsias, ⁴ 1989
2. Turning the wheel	Ho'o, ⁵ 1986
3. Brush knee and twist step	Huang, ⁶ 1973
4. Step back to repulse monkey	Huang, ⁷ 1973
5. Walking the circle	Smith, ⁸ 1967
6. Kick heel to left and right	Jou, ⁹ 1980
7. Part the wild horse's mane	Lee, ¹⁰ 1982
8. Closing (holding the ball)	Kotsias, ⁴ 1989

The exercise "turning the wheel" exemplifies these movements (**Figure 1**). Detailed instructions for carrying out each movement can be found in the references provided above. For safety, with one exception (movement 6, "kick heel to left and right"), we avoided movements that involved bending at the waist or the sustained support of body weight on one leg. The movements were introduced gradually over the course of the 8-week sessions at the rate of approximately 1 new movement every week. Instruction in deep breathing, relaxation, and good posture, as is ordinarily done in T'ai Chi instruction,⁴ was also provided.

Prior to entrance into the T'ai Chi course and after the course was concluded, each patient underwent an evaluation to quantify balance. Three objective tests of balance were performed, including moving platform posturography, the Romberg test, and the reach test. Two subjective tests were performed, including a modified subset of the

effects on health^{16,17} and are consistent with a recent report that T'ai Chi training may reduce falling in the elderly.^{18,19} Since we excluded those subjects who were unable to perform the eyes-closed Romberg test, our results are limited to those with mild imbalance. Also, because of the design of our study, we are unable to exclude the possibility that a placebo effect or a nonspecific effect of exercise or activity was responsible for these improvements. Nevertheless, our results suggest that T'ai Chi exercise may be a useful modality for balance rehabilitation.

In our subjects, improvements following T'ai Chi were noted for all measures in all age groups (Table and Figure 2), and significant improvements were found when all ages were pooled for the posturography test and DHI questionnaire scores. While we used a conservative criterion based on the Bonferroni correction for significance ($P \leq .01$), a less stringent criterion, such as $P \leq .05$, might be justified in view of the high likelihood that our chosen measures may assess, at least in part, a common underlying quantity (balance). Using $P \leq .05$, significant improvement would have occurred on all measures except the reach test.

In our study, significant improvement was clearly documented for posturography testing in those 76 years and older. This result emphasizes the potential for improvement of balance in persons older than 75 years. Previous studies have not documented uniform improve-

Medical Outcomes Study (MOS) short-form questionnaire¹¹ and the Dizziness Handicap Inventory (DHI).¹²

The moving platform posturography assessment was performed with a computer-controlled balance platform (Smart Balance-Master; Neurocom Inc, Clackamas, Ore). We used this device to quantify peak-peak sway amplitude over 20 seconds with eyes open and eyes closed, as well as other measures of balance in which visual or somatosensory feedback is altered. The entire protocol, called the *Sensory Organization Test* by the manufacturer, incorporates 3 sets of 6 subtests and requires about 10 minutes to complete. A detailed description of the protocol can be found elsewhere.¹³ To minimize learning effects, the main features of each forthcoming subtest were described by the operator immediately before every trial (eg, "the next test is eyes-closed, teeter-totter"). The composite score, computed from a weighted sum of subtest scores,¹³ was used for subsequent analysis.

Four variants of the timed Romberg test were used, including all possible combinations of 2 visual conditions (eyes open and eyes closed) and 2 stances (feet side by side and in tandem position). Five trials were obtained for each variant of the Romberg test, and the mean results from the last 3 trials were used for subsequent analysis. The ability to maintain a stance without stepping for 30 seconds was considered "perfect." Improvement was only possible for the tandem Romberg test variants because only subjects who could stand for 30 seconds in the 2 nontandem variants of the Romberg test positions were included in the study. Accordingly, the mean scores for the tandem variants were averaged to produce a Romberg score for each participant. In general, performance was worse on the eyes-closed variant.

The reach test was performed as described by Duncan et al.¹⁴ A yardstick was fixed to the wall at shoulder

height. Subjects extended their arm, and the position of their most distal fingertip was recorded. They were then asked to reach as far forward as possible without falling, and the position of their fingertip was again recorded. Reach was computed by taking the difference between final and initial position in inches. Five trials were performed, and results from the last 3 were averaged and used for subsequent analysis.

A 14-question adaptation of the MOS short-form general health survey¹¹ was used to obtain a subjective assessment of functional limitation of activities of daily living related to balance. Ten questions assessed current limitation of activity (score range, 1-3) and 4 questions assessed health-related limitation of activity over the previous 4 weeks (score range, 1-2). Higher scores (range, 14-38) indicate less limitation.

The DHI¹² was also administered. The DHI incorporates 25 questions addressing 3 areas related to the impact of dizziness on the patient's life: functional limitation, emotional distress, and physical symptoms. As originally described, the total DHI score could range from 0 to 100, with higher scores indicating a greater impact of dizziness. To facilitate graphic comparison with the other measures, in which greater scores indicate better performance, we modified the scoring method using a linear transformation so that higher scores (range, 0-50) indicate less disability. Our scores can be converted back to the original scale by subtracting 2 times our score from 100.

Data were analyzed using the Systat computer program (version 8.0; SPSS Inc, Chicago, Ill).¹² Since before and after residuals were distributed normally according to the D'Agostino test of normality,¹⁵ parametric statistics (repeated-measures analysis of variance) were used for comparisons between before and after data.

ment. Judge and associates²⁰ reported the effects of postural exercises that were performed 1 to 3 times per week and included simple T'ai Chi movements; 21 older women participated in the study. No improvement was found for double-stance measurements, although 1 subgroup showed improvement in single-limb stance. Our results also differ from those of a similar study of Wolf and associates,²¹ in which T'ai Chi training of 72 older subjects was not associated with reduced sway even though subjects had fewer falls and less fear of falling than the control group. Different exercise protocols or measurement instrumentation may explain these different results.

The results of previous work examining whether conventional exercise programs improve the balance of older persons have also been mixed. Crilly and associates²² found no significant reduction in static postural sway area after a 12-week program of balancing and strengthening exercises in 50 elderly women. Lichtenstein and co-workers²³ also reported negative effects of a similar exercise program with respect to postural sway area in a study of 50 older women.

On the other hand, Vanfraechem and Vanfraechem²⁴ found that a 10-week exercise program benefited 10 individuals who were sedentary and institutionalized, improving the duration that they could stand on one leg. Similarly, Hopkins and associates²⁵ reported

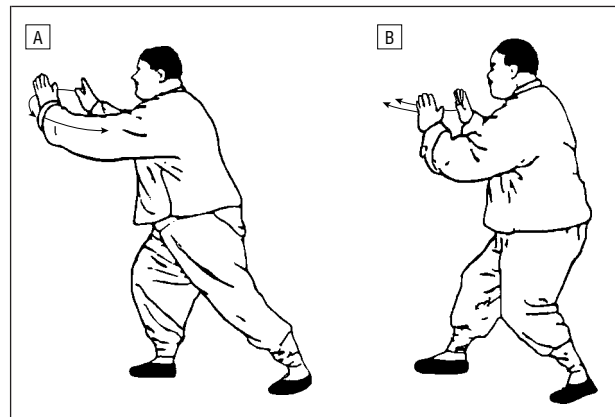


Figure 1. Turning the wheel. This movement was adapted from the Yang school of T'ai Chi. The student slowly shifts the body weight forward and backward while smoothly moving the arms in a circular fashion as if holding a handle on the rim of a wheel roughly 2 ft in diameter. In position A, the hands are extended at shoulder width and the trunk is forward. While moving the trunk backward to position B, the hands are brought slowly backward following a half-circular trajectory corresponding to the bottom half of the wheel. On returning to position A, the arms extend and the hands are brought upward and forward, again following a half-circular trajectory corresponding to the top half of the wheel. The head moves on the trunk synchronously to keep the head horizontal in space. At least 3 repetitions are performed.

that low-impact aerobic dance significantly improved the duration of one-leg standing in 65 elderly women. Ledin and associates,²⁶ using a study design similar to our own,

Tests for Changes in Balance Before and After Tai Chi

Test	Before T'ai Chi*	After T'ai Chi*	P†
Medical Outcomes Study‡	28.91 ± 5.59	31.36 ± 4.91	.03
Dizziness Handicap Inventory§	34.05 ± 11.76	38.32 ± 10.09	.004
Posturography	59.59 ± 15.98	64.36 ± 16.64	<.001
Tandem Romberg	13.59 ± 10.09	17.96 ± 10.53	.03
Reach	11.69 ± 4.15	12.15 ± 4.66	P value not available

*Values are mean ± SD.

†Parametric statistics (repeated-measures analysis of variance) were used for comparisons.

‡Range, 0 to 40; higher scores indicate less functional limitation of activities of daily living related to balance.

§Range, 0 to 100; higher scores indicate greater impact of dizziness.

compared multiple measures of balance prior to and following a “vestibular habituation” training program that incorporated jogging and jumping and exercises with balls and on a trampoline. The 15 subjects in this study were aged 70 to 75 years. Ledin and associates also reported significant improvements in the duration of one-leg standing as well as in posturography test scores. The results of our study provide additional evidence that certain forms of exercise may improve balance.

In our study, significant improvement in DHI scores was confined to the younger group. This might be because younger subjects experienced relatively greater objective improvements, or because of a ceiling effect, since our older subjects reported less disability than younger subjects on this scale.

While these observations suggest that T'ai Chi exercise may provide a useful adjunct to a balance reha-

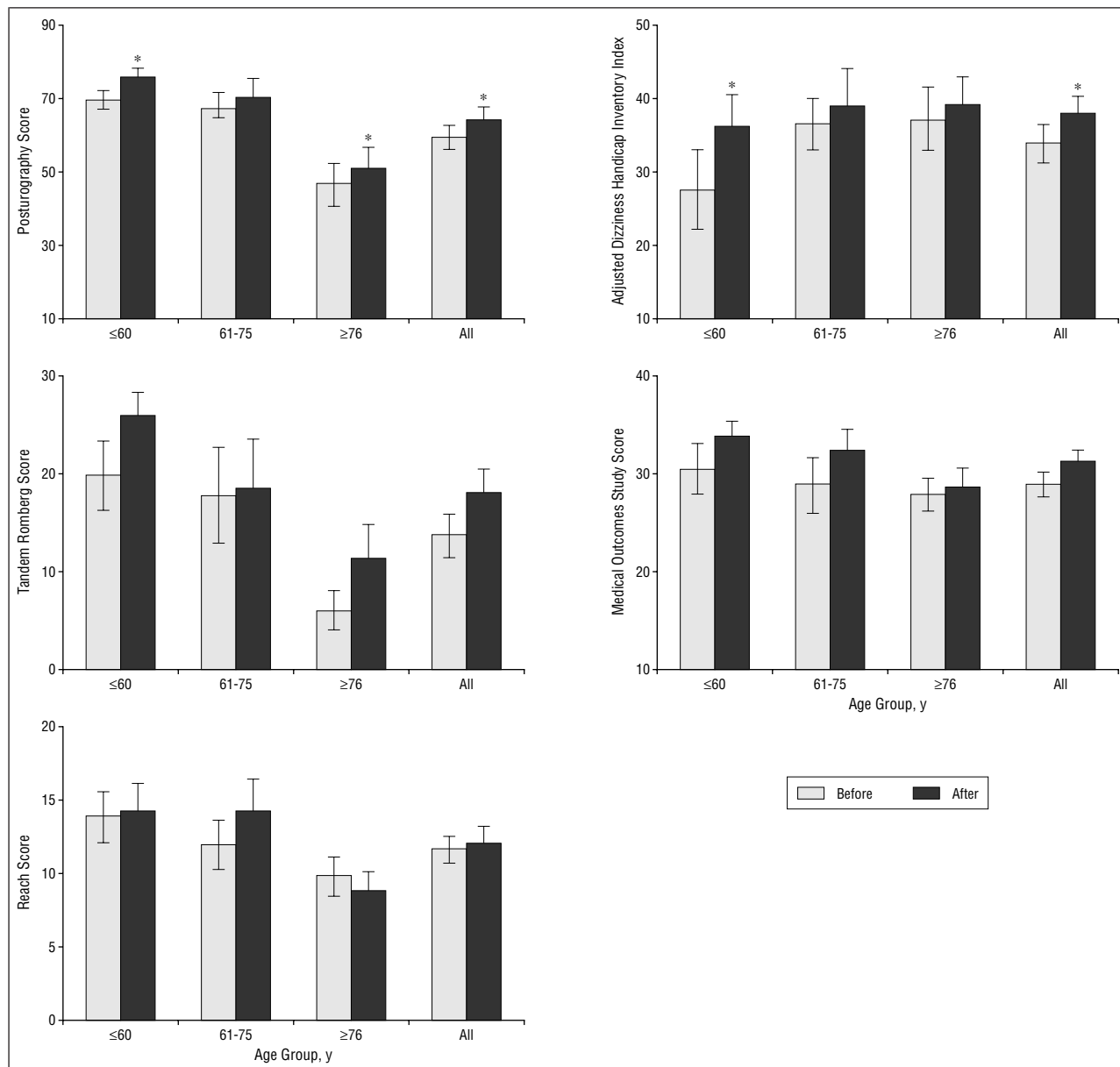


Figure 2. Balance by age group before (baseline) and after 8 weeks of T'ai Chi. Values are mean ± 1 SEM. Asterisk indicates significant change from baseline (P < .01). Lower scores indicate poorer performance.

bilitation program, there are both advantages and disadvantages to T'ai Chi as compared with traditional one-on-one physical therapy programs for balance rehabilitation. Considering advantages first, T'ai Chi may be a less expensive method of obtaining rehabilitation services because it is normally practiced in a group setting. Second, T'ai Chi, which is suited to lifelong practice and is commonly used in this way, may be better suited to the maintenance of health than brief periods of one-on-one physical therapy. There is evidence that in some populations traditional physical therapy is helpful for balance while it is practiced, but the benefits are eliminated when physical therapy is stopped.²⁷ Thus, for balance rehabilitation, it may be desirable to choose a modality that is suitable for long-term practice. Third, T'ai Chi, derived from a rich context of Chinese ethnomedicine, is intrinsically adaptable to a variety of clinical contexts because it can draw from a large repertoire of exercise modules. A particular advantage is that some of the exercise modules of T'ai Chi are quite challenging and therefore may be suitable for individuals who are already functioning reasonably well but wish to improve further. Fourth, T'ai Chi also offers a vehicle for meditation and relaxation training, which may provide additional benefit for certain populations of patients.

There are also several disadvantages of T'ai Chi compared with traditional one-on-one balance rehabilitation. First, safety may be a problem. In our study, with 2 volunteers, the instructor, and a physical therapist present for every class, we aimed for roughly 1 "spotter" for every 2 participants. Although no falls occurred during our study, without this level of close supervision, it is our impression that there would be an appreciable risk of falls in this population. Second, one-on-one physical therapy provides the opportunity for greater customization than group sessions of any type. Third, the broad repertoire of movements available in the numerous variants of T'ai Chi could also be disadvantageous, since some movements derived from the more "martial" forms of T'ai Chi are inappropriate for balance rehabilitation. Finally, one-on-one physical therapy allows closer monitoring of patient progress and the appropriate matching of diagnosis to form of therapy. Considering these problems, if T'ai Chi is to be used as a vehicle for balance rehabilitation, it would seem best to provide it as a structured activity supervised by health care professionals.

While the results of this study are encouraging, many questions remain. How much of the benefit associated with T'ai Chi training is related to physical conditioning, placebo effect, cognitive aspects, central nervous system plasticity, or relaxation? What is the optimum duration of T'ai Chi training? What is the optimum selection and sequence of movements? How does T'ai Chi compare in efficacy with conventional balance retraining when the same patient population is studied? We hope that answers to these questions will emerge from the results of future controlled prospective studies.

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