

Tai Chi versus brisk walking in elderly women

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Abstract

Purpose: to compare the effects of a short style of Tai Chi versus brisk walking training programme on aerobic capacity, heart rate variability (HRV), strength, flexibility, balance, psychological status and quality of life in elderly women.

Methods: nineteen community-dwelling, sedentary women (aged 71.4 ± 4.5 years) were randomly assigned to Tai Chi Chuan (TCC; $n = 11$) or brisk walking group (BWG; $n = 8$). A separate group of elderly women was recruited from the same population to act as a sedentary comparison group (SCG; $n = 8$). The exercise groups met for 1 h, three days per week for 12 weeks. Outcomes measured before and after training included estimated VO_2max , spectral analysis of HRV (high-frequency, low-frequency power as well as high- and low-frequency power in normalised units) as a measure of autonomic control of the heart, isometric knee extension and handgrip muscle strength, single-leg stance time, the State Trait Anxiety Inventory (STAI), Profile of Mood States (POMS) and Short Form-36 (SF-36) questionnaires.

Results: significant improvement was seen in estimated VO_2max in the TCC group (TCC versus SCG $P = 0.003$, TCC versus BWG $P = 0.08$). The mean within-person change of high-frequency power in normalised units (HFnu) increased [8.2 (0.14 – 16.3)], representing increased parasympathetic activity, and low-frequency power in normalised units (LFnu) decreased [-8.7 (-16.8 – 0.5)], representing decreased sympathetic activity, in the TCC group only. Significant gains were also seen in the non-dominant knee extensor strength and single-leg stance time (TCC versus BWG $P < 0.05$).

Conclusions: a short style of TCC was found to be an effective way to improve many fitness measures in elderly women over a 3-month period. TCC was also found to be significantly better than brisk walking in enhancing certain measures of fitness including lower extremity strength, balance and flexibility.

Keywords: aged, physical fitness, rehabilitation, Tai Chi, elderly

Introduction

Tai Chi Chuan (TCC) is a slow and graceful Chinese exercise that includes a form of mindful meditation known for its health benefits [1]. There are different forms of TCC [2]. Many studies use a long form of TCC (Yang style—108 movements) that takes 20–30 min to perform, is harder to learn and is more physically demanding than shorter TCC forms (8–13 movements) often taught in the West. Long forms of TCC are a safe method of exercise for the elderly

and require an energy expenditure that is equivalent to brisk walking [3, 4]. A long form of TCC has been shown to be superior to a standard home-based cardiac rehabilitation protocol in middle-aged men after coronary bypass surgery [5]. Short forms of TCC improve balance and co-ordination and reduce the risk of falls in the elderly [6–8]. Two studies have shown that short forms of TCC have positive effects on blood pressure [9, 10], but it is not known whether a short form of TCC can provide a cardiovascular training effect similar to that of a walking protocol in elderly.

Because ageing results in a faster decline in fitness and this deconditioning leads to greater mortality rate in women [11–13], it is important to know whether alternative forms of exercise such as short forms of TCC that have also been shown to improve balance can prevent a decline in cardiopulmonary fitness, particularly in this group.

Exercise training shown to improve aerobic power (VO_2max) in older subjects also causes positive changes in autonomic regulation of the heart as measured by heart rate variability (HRV) [14, 15]. There is a steady decline in HRV with age, and low HRV has been shown to predict the risk of coronary heart disease and mortality in the elderly [16, 17]. Some studies suggest that TCC can have a positive effect on autonomic function, but these studies have either lacked adequate control groups [18, 19], did not assess women [20], evaluated experienced TCC practitioners or did not compare TCC with other exercise modalities [21]. It is not known whether a short form of TCC will change HRV when compared to brisk walking in sedentary older women.

The purpose of this study is to compare the effects of a short form of TCC with brisk walking in elderly women on aerobic fitness and HRV. We also intended to evaluate the effects of TCC on other indicators of fitness including muscle strength, flexibility and balance (see Appendix 1 for this supplemental data on <http://www.ageing.oxfordjournals.org>). We hypothesise that a short form of TCC can improve fitness in elderly women and is more effective than brisk walking.

Methods

Study population

Twenty-six sedentary healthy women aged ≥ 65 years were recruited from the Boston area through advertisements and the Harvard Cooperative Program on Aging. Sedentary status was defined as not participating in exercise more than once per week for the last year. A computer-generated random number was used to assign subjects to TCC or brisk walking group (BWG). An additional age-matched group of eight healthy women aged ≥ 65 was recruited from the same population and assigned, but not randomised, to the sedentary comparison group (SCG) using the same inclusion and exclusion criteria. The purpose of the SCG was to observe the natural history of a sedentary lifestyle on fitness. All subjects were contacted by telephone, and those interested underwent a full physical examination. Subjects with a history of major orthopaedic, neurological, psychiatric, cardiovascular, metabolic, pulmonary or peripheral vascular disease that would limit participation in exercise and subjects on medications that could alter heart rate were excluded. Eligible subjects gave written informed consent. The study was approved by the Institutional Human Investigation Review Board.

Exercise training

The TCC programme was a modified 10-movement Yang style taught by an experienced Tai Chi instructor similar in

style to the routine proposed by Wolf [22]. One-to-two movements were taught each week for 8 weeks. The complete form was practised for the last 4 weeks of the study. Emphasis was placed on performing the movements in a slow, relaxed way. The TCC sessions were held three times per week for 12 weeks with four to six subjects per group and consisted of 15–20 min of warm up including flexibility exercises of the knees, hips and back as well as isolated static Tai Chi movements and 40–45 min of the 10-movement form.

The 1 h BWG exercise was performed in a local indoor shopping mall three times per week for 12 weeks with four subjects per group and led by an experienced physical therapist. Subjects were taught to monitor their heart rates by palpating their radial pulses. The walking protocol consisted of 15 min of warm-up period with flexibility exercises of the knees, hips and back followed by 40 min of walking and 5 min of cool down. The time spent walking briskly at 50–70% of their calculated target heart rate ($220 - \text{age}$) was progressively increased from 10 to 30 min over an 8-week period and then maintained at 30 min for the final 4 weeks. The SCG was asked to continue with their normal daily activities, but to not start a new exercise programme during the 12-week study period.

Exercise test

Subjects were told to come to the gym 1 h before the test and to avoid the consumption of food, alcohol, caffeine and fluid, except water for 2 h before arrival. Subjects were also asked to abstain from strenuous exercise for 24 h before the test. The primary outcome was estimated VO_2max , which was determined using the American College of Sports Medicine submaximal bicycle (Monark Exercise Ergometer, Monark Exercise AB, Varberg, Sweden) YMCA exercise test under controlled environmental conditions. A physician trained in sports medicine performed the testing and was blind to the group assignment. A continuous recording of the heart rate with an ECG monitor was used to estimate VO_2max . Exercise was performed until exhaustion (subject cannot exercise further or symptom limited exercise). The workload was 0 W for the first 3 min and then increased by 25 W every 3 min. The pedal cadence was maintained at 50 rpm with both a visual meter and an auditory metronome.

HRV

To avoid the variability seen with 24 h Holter recordings, the researchers derived HRV from short-term (5–10 min) studies [23]. Frequency-domain analysis of HRV enables us to calculate the respiratory-dependent high-frequency and low-frequency power. High-frequency absolute power (HF) is mediated by vagal activity. While some consider low-frequency absolute power (LF) [24] to represent predominantly sympathetic modulation, others consider it a combination of sympathetic and parasympathetic influences. Low-frequency power in normalised units (LFnu) [$\text{LF}/(\text{Total Power} - \text{VLF}) \times 100$] and the LF/HF ratio or sympatho-vagal balance may provide a better estimation of the sympathetic influence on the heart rate [25]. The 5 min resting ECG recording with data acquisition via an analogue–digital interface onto a

Windows-based PC (LabView software, National Instruments Corporation, Austin, TX, USA) was performed before the exercise test. Before the data acquisition period, subjects were asked to breathe normally and rest for 10 min to accommodate to the environment. HRV was calculated in general agreement with current standards [23]. The data of subjects with $\geq 5\%$ ectopy were dropped.

For details regarding the acquisition of the strength, flexibility and balance data, see Appendix 1 on <http://www.ageing.oxfordjournals.org>.

Statistical methods

This study was a standard comparative pilot trial testing the effects of two interventions on aerobic fitness. Ten to eleven subjects per group were estimated to provide 70% power to detect a 20% difference between groups. Continuous variables are summarised as mean \pm SD. Improvements in outcomes were calculated as the differences between the post-intervention and the baseline measures. Within-group change was determined using mean within-person change, and 95% confidence intervals were calculated. Confidence intervals that do not include zero suggest that the mean within-person change was statistically significant at an α -level of 5%. An ANOVA was used to detect differences among groups at baseline and following the exercise interventions. Tukey post hoc test was used to identify differences between groups (Statview or SAS software; SAS Institute, Cary, NC, USA). Comparisons of these differences were made between the two exercise groups on all measures. However, comparison between the exercise groups and the SCG was limited to the primary outcome measurement of estimated VO_2max . The other fitness measures were not taken on the SCG because this group was not part of the randomization process and was only included to observe the natural history of the effects of a sedentary life style on aerobic fitness. HRV measures were also collected on all subjects because the data necessary to calculate HRV were simultaneously collected during the measurement of VO_2max . However, because of the significant baseline differences between the groups on some measures of HRV, between-group comparisons were not made. Results were considered statistically significant if the P -value was <0.05 .

Results

Subject characteristics

Thirty-four of 50 subjects screened met the inclusion criteria. Of these, only 26 had the time to participate in a 3-day-a-week exercise protocol for 12 weeks, and the other eight agreed to participate in the SCG. Following randomisation, seven subjects from the BWG dropped out because they wanted to be in the TCC group leaving 11 in the TCC group and eight in the BWG. All completed the study. The drop-outs were not different from those who completed the study on any baseline characteristic. Compliance with the exercise protocol was measured with daily attendance sheets. Both active exercise groups had a 95% attendance rate, and no subject missed more than two sessions. Table 1 summarises the baseline characteristics of each group. There were no significant

differences between groups on any baseline characteristic with the exception of the HRV measures; LFnu was higher and HFnu lower in the TCC group. Thus, between-group comparisons were not made on these measures of HRV.

Exercise test

There was no difference between groups in VO_2max at baseline. Figure 1 shows the mean within-person changes in VO_2max . Only the TCC group showed gains in VO_2max with confidence intervals that did not include zero, suggesting a significant within-group change because of the intervention. ANOVA for multiple comparisons showed a significant difference between groups in the change in VO_2max (F ratio 8.90, P -value 0.0014). Significant improvements in VO_2max were seen in TCC when compared to SCG ($P = 0.003$). A trend towards significance in between-group comparison of the TCC versus BWG ($P = 0.08$) and BWG versus SCG ($P = 0.09$) was also noted.

HRV

Significant differences between groups at baseline were seen in HFnu and LFnu. Only the TCC group showed an increase in HFnu and a decrease in LFnu with confidence intervals that did not include zero after training (Figure 2), suggesting a significant within-group training effect. A significant number of subjects in the BWG (three of eight) had $\geq 5\%$ extra systolic beats, and their data had to be dropped making interpretation of the results difficult. Therefore, between-group comparisons was not done.

See discussion of the supplemental data on strength, flexibility and balance in Appendices 1 and 2 on <http://www.ageing.oxfordjournals.org>.

Discussion

Our study shows that a short form of TCC can have a significant effect on aerobic fitness in older women (estimated VO_2max). Secondary outcome measures, including HRV, knee extensor strength, flexibility and balance, also showed significant improvements. Furthermore, there was a trend to show that TCC is more effective than brisk walking in enhancing aerobic fitness.

The TCC group showed a substantial and clinically significant improvement in aerobic power of 19.6% over the 3-month study period, whereas no change (0.8%) was seen in the BWG. In a study of elderly men (mean age 56.5) who had recently undergone coronary bypass surgery, aerobic fitness improved by 10.3% over a 12-month period following a long style of Tai Chi exercise. In that study, a brisk walking cardiac rehabilitation programme resulted in essentially no change in aerobic power [5]. The results of our study also compare favourably with those of a study of healthy, sedentary elderly women (mean age 72.9) who showed a 28.5% improvement after a 2-month exercise intervention on a bicycle ergometer [26].

Several studies have shown that exercise training has a positive influence on measures of HRV in the elderly. Two studies have shown approximately 15% improvement in HRV after a vigorous training period [14]. A recent meta-

Table 1. Baseline characteristics of participants in the study

	Mean (SD)			
	Tai Chi (<i>n</i> = 11)	Brisk walking group (<i>n</i> = 8)	Sedentary controls (<i>n</i> = 8)	<i>P</i> -value
Age (years)	71.5 (4.6)	71.3 (4.4)	73.5 (5.7)	0.96
Weight (lbs)	152 (39.4)	157 (20.9)	161 (25.0)	0.91
Exercise test	(<i>n</i> = 10)	(<i>n</i> = 8)	(<i>n</i> = 8)	
VO ₂ max (ml/min/kg)	21.55 (5.2)	23.73 (4.7)	26.8 (8.3)	0.22
Peak HR	143 (17.9)	132 (14.5)	121 (20.2)	0.19
HRV	(<i>n</i> = 9)	(<i>n</i> = 5)	(<i>n</i> = 7)	
Total power	1,111,369.9 (252,109.0)	1,202,588.1 (275,176.3)	1,127,293.0 (210,732.0)	0.79
Low frequency	775.5 (718.5)	182.9 (112.1)	361.3 (481.3)	0.15
LFnu	74.6 (11.5)	54.8 (16.8)	49.9 (22.4)	0.02 ^a
High frequency	302.8 (350.7)	204.2 (219.0)	347.1 (441.0)	0.79
HFnu	23.9 (12.3)	42.8 (18.5)	49.6 (22.7)	0.03 ^a
SV balance (LF/HF)	4.8 (4.2)	1.7 (1.3)	1.9 (2.5)	0.14
(LF/HF) strength (Newton/meter)	(<i>n</i> = 11)	(<i>n</i> = 8)		
Right grip	15.0 (3.4)	15.6 (5.0)		0.85
Left grip	14.0 (3.5)	14.5 (4.4)		0.85
Right knee Ext	69.1 (14.9)	62.0 (19.7)		0.55
Left knee Ext	66.9 (16.0)	59.0 (19.1)		0.41
Flexibility (degrees)	(<i>n</i> = 11)	(<i>n</i> = 8)		
Right hip IR	24.5 (5.9)	28.0 (6.0)		0.30
Left hip IR	21.1 (7.0)	26.3 (6.8)		0.12
Right hip ER	18.0 (7.6)	22.5 (6.6)		0.18
Left hip ER	19.1 (9.8)	24.0 (8.1)		0.28
Right hip Ext	5.7 (9.7)	10.3 (8.5)		0.68
Left hip Ext	6.8 (10.7)	9.3 (9.4)		0.91
Right hip Flex	105.6 (8.1)	104.2 (8.0)		0.50
Left hip Flex	104.5 (7.5)	105.4 (8.9)		0.97
Right SLR	61.7 (14.4)	60.3 (12.6)		0.88
Left SLR	57.5 (20.1)	57.1 (16.9)		0.88
Toe touch (inches)	0.64 (4.0)	2.0 (6.3)		0.24
Single-leg balance (seconds)	(<i>n</i> = 11)	(<i>n</i> = 8)		
Eyes open, right	30.9 (25.8)	22.9 (21.1)		0.50
Eyes open, left	20.1 (20.5)	13.5 (12.2)		0.50
Eyes closed, right	2.4 (1.4)	2.7 (1.6)		0.60
Eyes closed, left	2.3 (1.8)	2.3 (0.6)		0.71

ER, external rotation; Ext, extension; Flex, flexion; HF, high-frequency absolute power; HFnu, high-frequency power in normalised units; IR, internal rotation; LF, low-frequency absolute power; LFnu, low-frequency power in normalised units; Peak HR, peak heart rate during bicycle ergometry; SLR, straight leg raise; SV balance, sympatho-vagal balance, LF/HF.

^aNo differences between groups at baseline except in derived values HFnu and LFnu.

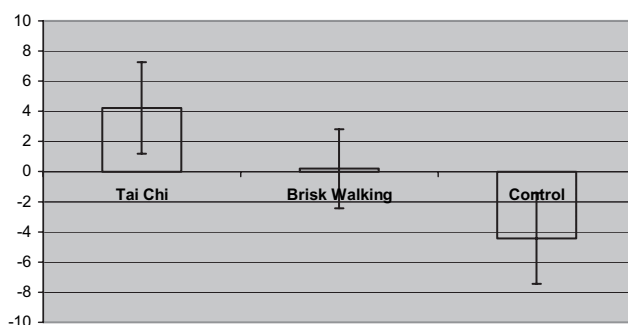


Figure 1. Mean within-person changes in estimated VO₂max (ml/min/kg) with training: Tai Chi group (TCC), 4.2 ± 3.03; brisk walking group (BWG), 0.2 ± 2.63; and sedentary control group (SCG), -4.4 ± 3.01.

analysis of 13 studies including 20 trials on the effect of exercise on HRV found that studies of elderly subjects in general showed a smaller effect size than those of middle-aged or young subjects [27]. Our data suggest a trend towards improved autonomic control with TCC, with an increase of 34% in parasympathetic input and a decrease of 12% in the sympathetic input. These changes were not seen in the BWG and SCG. However, strong conclusions cannot be made given the sample size and the baseline variability in measures of HRV that prevented more meaningful between-group comparisons.

A range of other fitness outcomes were explored, including grip and knee extensor strength, range of motion of lumbar spine and hips and single-leg stance time. Discussion of these results can be found in Appendix 1 on the journal website (<http://www.ageing.oxfordjournals.org>).

Between-group comparisons showed a significant difference between TCC and SCG, but no difference between

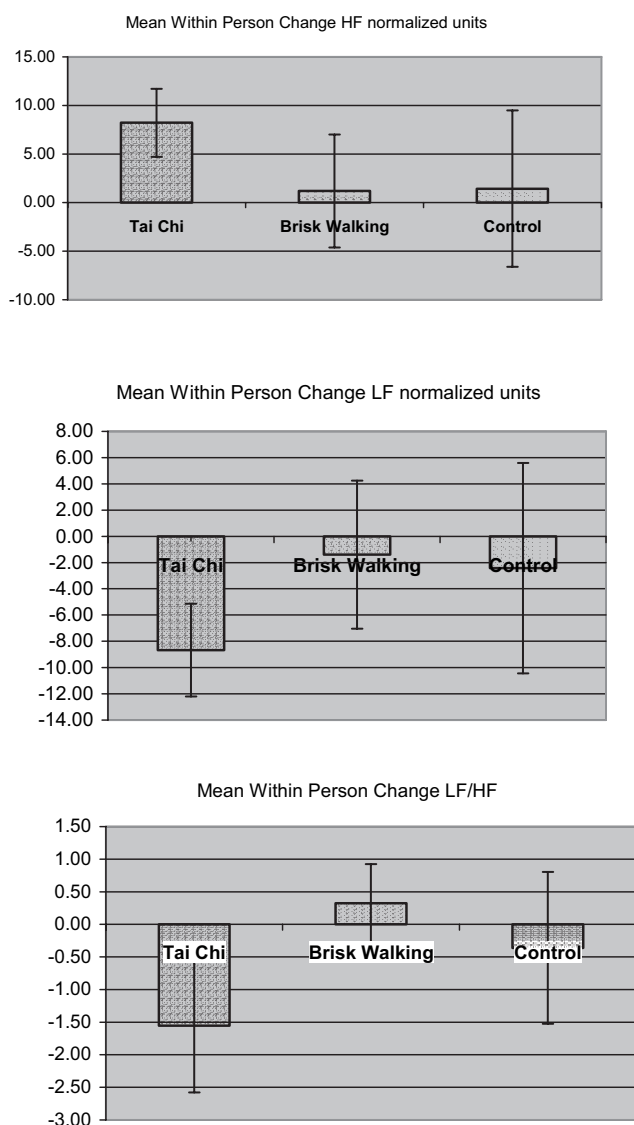


Figure 2. Mean within-person change of high-frequency normalised units (HFnu \pm SD), low-frequency normalised units (LFnu \pm SD) and low-frequency/high-frequency ratio (LF/HF) with training. Tai Chi group (TCC): HFnu 8.2 ± 3.50 , LFnu -8.7 ± 3.53 , LF/HF -1.6 ± 1.03 ; brisk walking group (BWG): HFnu 1.2 ± 5.81 , LFnu -1.4 ± 5.64 , LF/HF 0.3 ± 0.60 ; sedentary control group (SCG): HFnu 1.4 ± 8.05 , LFnu -2.4 ± 8.02 , LF/HF -0.4 ± 1.16 .

BWG and SCG. This may suggest that TCC is better than brisk walking at protecting healthy, sedentary elderly women from a decline in aerobic power over a 3-month period. Our study, however, is limited by its preliminary nature, the small sample size and power and the fact that SCG was not included in the randomisation process. The comparison between TCC versus BWG did not reach statistical significance ($P = 0.08$), but that a short form of TCC was at least as good as a form of exercise with recognised health benefits in the elderly such as walking is an important finding [28]. Furthermore, TCC also had a greater effect on balance and strength.

Another potential weakness is the use of the YMCA submaximal bicycle ergometry test to estimate the VO_2max rather than direct measurements. The YMCA protocol has been found to underestimate VO_2max when compared to open-circuit spirometry. However, given that we were interested in the change score rather than the absolute value of aerobic power, the impact of this error should have been minimised.

In summary, the results of this study suggest that a short form of Tai Chi can produce larger gains in aerobic power and general fitness of elderly women compared to brisk walking. Further research in this area is needed to determine whether such effects are associated with changes in the autonomic control of the heart that may influence cardiac morbidity and mortality.

Key points

- A short form of Tai Chi can have a significant effect on aerobic fitness in elderly women.
- Tai Chi is at least as effective as brisk walking in enhancing aerobic fitness in elderly women.
- Tai Chi has other benefits on fitness including enhancing lower extremity strength and balance that brisk walking does not.

Acknowledgements

The authors thank Sebastian Schneeweiss, for his help in preparing this manuscript.

Funding

Funding for this trial was provided by a minigrant from the Department of Physical Medicine & Rehabilitation, Harvard Medical School.

Conflicts of interest

There were no conflicts of interest in the conduction of this clinical trial.

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Received 13 September 2005; accepted in revised form 19 February 2006