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The Effects of Tai Chi and Neck Exercises in the Treatment of Chronic Nonspecific Neck Pain: A Randomized Controlled Trial

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Abstract: **This study aimed to test the efficacy of Tai Chi for treating chronic neck pain. Subjects with chronic nonspecific neck pain were randomly assigned to 12 weeks of group Tai Chi or conventional neck exercises with weekly sessions of 75 to 90 minutes, or a wait-list control. The primary outcome measure was pain intensity (visual analogue scale). Secondary outcomes included pain on movement, functional disability, quality of life, well-being and perceived stress, postural and interoceptive awareness, satisfaction, and safety. Altogether, 114 participants were included (91 women, 49.4 ± 11.7 years of age). After 12 weeks Tai Chi participants reported significantly less pain compared with the wait list group (average difference in mm on the visual analogue scale: −10.5; 95% confidence interval, −20.3 to −.9; *P* = .033). Group differences were also found for pain on movement, functional disability, and quality of life compared with the wait list group. No differences were found for Tai Chi compared with neck exercises. Patients' satisfaction with both exercise interventions was high, and only minor side effects were observed. Tai Chi was more effective than no treatment in improving pain in subjects with chronic nonspecific neck pain. Because Tai Chi is probably as effective as neck exercises it may be considered a suitable alternative to conventional exercises for those with a preference toward Tai Chi.**

Perspective: ***This article presents results of a randomized controlled trial comparing Tai Chi, conventional neck exercises, and no treatment for chronic nonspecific neck pain. Results indicate that Tai Chi exercises and conventional neck exercises are equally effective in improving pain and quality of life therefore representing beneficial interventions for neck pain.***

Key words: *Neck pain, chronic pain, Tai Chi, neck exercises, spinal exercises, randomized controlled trial, efficacy.*

Musculoskeletal pain syndromes, such as back and neck pain, are common public health problems in industrialized countries that most people experience at some point in their life.[2,22] The lifetime prevalence of chronic neck pain is approximately 50%, and it is associated with substantial societal and

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individual burden.[13-15,54] Exercise therapy has been found beneficial for chronic nonspecific neck pain, with no differences regarding the type of exercise including isometric or isotonic neck strengthening or endurance exercises.[29,45] However, stretching exercises have been reported to have only limited effects.[24] Complementary medicine exercise approaches such as yoga and qigong have also been found efficacious for neck pain,[16,42,47,53] providing patients with alternatives to conventional exercises. Tai Chi is a low-impact mind-body exercise originating in China, that integrates dynamic musculoskeletal, breathing, and meditation training.[61] Tai Chi is regularly used for health purposes,[3,40] and a growing body of evidence[66] supports its potential to benefit subjects suffering from back pain,[26] rheumatological disorders,[32,39,57,58] or psychological disorders.[59] Despite the fact that musculoskeletal disorders including neck pain have been found predictive of Tai Chi use,[3] no study to date has investigated its effects in subjects with chronic nonspecific neck pain. Furthermore, Tai Chi as well as conventional neck exercises can easily be taught in larger groups, with groups not only offering social support,[10] but are also less costly than individual treatments.

This study aimed to investigate the efficacy of group Tai Chi compared with group neck exercises and no treatment to improve neck pain, disability, and quality of life in subjects with chronic nonspecific neck pain. The primary hypothesis was that Tai Chi was superior to no treatment to improve chronic nonspecific neck pain after 12 weeks of intervention. The secondary hypothesis aimed to explore whether Tai Chi was more or less effective compared with conventional neck exercises regarding the reduction of neck pain.

Methods

Ethical Approval and Trial Registration

The trial was conducted between September 2014 and March 2015 in the Department of Complementary and Integrative Medicine in Essen, Germany. The study was approved by the ethics committee of the University Hospital Essen (approval number: 13-5672-BO) and registered at ClinicalTrials.gov (registry number: NCT02222051), before subject recruitment.

Design

This was a randomized controlled 3-armed parallel group trial. Tai Chi was compared with a wait list control group and another active control intervention (neck exercises). Both active interventions were offered in a group format (ie, 10–15 participants per group met once weekly for a 75–90 minute intervention for 12 weeks in total). To minimize personality bias, both groups were led by the same instructor, a graduate sport scientist at the MSc level and certified Tai Chi master who is experienced in working with subjects suffering from back and neck pain. Both active interventions followed a manual prepared before the trial, and participants were provided with written material to foster self-practice at home, which was recommended for at least 15 minutes per day. Measurements were conducted at weeks 0, 12, and 24, with 12 weeks defined as the primary outcome measure time point.

Participants

Subjects were recruited via local newspaper advertisements, with a research assistant screening interested people by phone to assess their eligibility. Subjects who met the inclusion criteria were then invited for an in-person assessment in which they received detailed written information about the study, and their written informed consent was obtained. A study physician checked subjects' medical histories, examined their physical health, and examined cervical flexibility and neurological function (sensitivity, motor function, and reflexes) to exclude subjects presenting with red flags for prolapse or protrusion. The physician also checked subjects' medical records (eg, any laboratory findings, x-rays, or magnetic resonance imaging results that subjects provided). If they met all study eligibility criteria, subjects were included in the trial.

Trial participants were required to be at least 18 years of age and to have chronic nonspecific neck pain for at least 3 consecutive months for at least 5 days a week. They also had to report moderate pain of 45 mm or higher on a visual analogue scale (VAS) ranging from 0 to 100 mm,[31] with 100 mm described as 'worst neck pain imaginable.' Patients with other musculoskeletal pain, such as arm pain or lower back pain, in addition to neck pain as defined previously were eligible.

The trial exclusion criteria included neck pain caused by trauma, disc protrusion, whiplash, congenital deformity of the spine, spinal stenosis, neoplasm, inflammatory rheumatic disease, neurological disorder, active oncologic disease, severe affective disorder, addiction, and psychosis. In addition, subjects who were pregnant or who had had invasive treatment of the spine within the previous 4 weeks (eg, acupuncture, injections), or spinal surgery within the previous year, or had initiated or modified their drug regimen recently or were taking opiates were excluded. Finally, subjects with regular practice of Tai Chi, Qigong, or Yoga in the past 6 months, or those with any disability precluding exercise practice, were also excluded.

Randomization and Allocation Procedure

Participants were allocated to 1 of 3 groups in order of appearance adopting a computer-generated (Random Allocation Software, version 1.0.0) nonstratified block randomization with randomly varying block sizes. The trial coordinator who was not involved in participants' outcome assessments prepared sealed opaque envelopes with randomization assignments. Envelopes were labeled according to the study participant's identification number, and for eligible participants, envelopes were opened in ascending order by the study physician to determine the group allocation. Neither participants nor the interventionist were blinded to the intervention,

however the outcome assessor was blinded to the group allocation at 12 and 24 weeks.

Intervention

After baseline measurements and randomization, participants were given pain and medication logs, and were provided with their respective intervention time table.

Tai Chi

Participants in the Tai Chi group met once weekly for a 75- to 90-minute session for 12 weeks in total. The Tai Chi intervention was on the basis of a popular and internationally recognized Yang style (13 forms from Mantak Chia).[9] Each session included a warm-up of 5 to 10 minutes, the Tai Chi form practice, and 5 to 10 minutes of relaxation at the end. Tai Chi forms followed explicit protocols outlined in a training manual, as required during teacher training certification.[9] Sessions also included educational units and breathing exercises, and they were accompanied by relaxation music. Participants received illustrated written information that covered movement sequences learned in the previous session. They were asked to practice Tai Chi outside of classes for at least 15 minutes each day. This length of home practice was chosen to increase compliance with, and memorization and reinforcement of the exercises taught in class. Fifteen minutes of home practice is also a common recommendation for beginner Tai Chi students.

Wait List Control Group

Participants in this group were advised to continue their usual activities and therapies, but not to initiate any new therapeutic regimen for symptom management. At the trial's end, participants in the wait list group were offered as a courtesy the option to participate in a Tai Chi and neck exercise group.

Neck Exercises

Participants in the neck exercise group met once weekly for a 60- to 75-minute session for 12 weeks in total. This group was instructed in neck exercises, which were similar to those taught in rehabilitation programs containing exercises and education for a healthy back. Classes contained basic training of ergonomic principles (bodily alignment while standing), proprioceptive exercises, and isometric and dynamic mobilization, stretching, and strengthening neck and core exercises (Supplementary Table 1, Supplementary Fig 1). Similar to Tai Chi, the sessions opened with 5 to 10 minutes of warm-up exercises and ended with relaxation exercises. Participants also received illustrated and written information that covered the most important exercises, and they were asked to execute the exercises for at least 15 minutes each day. This intervention was to control for effects due to increased levels of physical activity and the group setting in the Tai Chi group.

Assessment

Participants' Expectation

At the assessment visit all participants rated their expectations that Tai Chi or neck exercises would be able to improve their neck pain on a 0 to 10 numerical rating scale[48] with 10 indicating 'highest possible expectation.' Expectation was included as a covariate in the analysis.

Attendance and Home Practice

Attendance rate was measured using a record of attendance in each class. Home practice was assessed using a daily log, in which participants filled in daily practice time during the 12-week study period themselves.

Questionnaires

A variety of questionnaires were used to investigate the effects of interventions on pain, disability, and quality of life in chronic neck pain, as recommended by the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials (IMMPACT) statement.[19] Furthermore, outcomes related to stress, well-being, and interoceptive and postural awareness were measured, because these behaviors are actively targeted by Tai Chi.

Current pain intensity was measured using a 0- to 100-mm VAS from the German Pain Questionnaire[35,44] with 0 mm indicating 'no neck pain at all' and 100 mm indicating 'worst neck pain imaginable.'

Participants were also asked to indicate the level of pain that they would render tolerable in general on a 0- to 100-mm VAS. This was used to determine whether participants could be considered 'responders' regarding their own level.

To measure pain on movement (POM),[38] participants were asked to flex, extend, laterally flex, and laterally rotate their necks to the left and right. The evoked pain was measured on a 100-mm VAS, for each direction. An average POM score was then calculated from these data for each participant. The POM scale has been found valid and reliable.[38]

Participants' functional neck-related disability was measured using the Neck Disability Index (NDI).[17,52] This 10-item questionnaire determines how participants see their neck pain affecting their daily activities. The maximum score is 50. Scores of <4 indicate no disability; 5 to 14 indicate mild disability, 15 to 24 moderate disability, and 25 to 34 severe disability. Scores >35 indicate complete perceived disability.

Health-related quality of life was assessed using the Short Form 36 Health Survey Questionnaire (SF-36).[6] This widely used comprehensive 36-item questionnaire yields an 8-scale health profile as well as 2 component summaries of physical and mental health-related quality of life.

Psychological well-being was measured using the Questionnaire on the Assessment of Physical Well-being.[34] This questionnaire is comprised of 4 subscales, each containing 4 items: stress resistance, ability to enjoy, vitality, and inner peace.

The degree to which participants perceived their lives as stressful was determined using the German version of the Perceived Stress Scale,[7,11] which consists of 10 items. Participants indicate how often they have found their lives unpredictable, uncontrollable, and overloaded in the past month; higher scores are indicative of higher perceived stress in life.

The Postural Awareness Scale was used to determine the degree of consciousness toward body posture and movement patterns that might contribute to the development of chronic neck pain (manuscript in preparation). The instrument consists of 6 items each on 2 scales, which are: *Forced Awareness and Detachment* and *Effortless Awareness and Connectedness*; and it has shown good psychometric properties (manuscript in preparation). The *Forced Awareness and Detachment* scale indicates low levels of postural awareness; substantial amounts of attention and focus are necessary to become aware of the bodily posture, and often only pain or discomfort will remind participants of dysfunctional posture. The *Effortless Awareness and Connectedness* scale reflects high postural awareness; the subject regularly becomes aware of their posture, and being aware requires only low efforts. Higher scores on both scales are indicative of higher forced awareness and detachment (*Forced Awareness and Detachment*), and higher awareness and connectedness (*Effortless Awareness and Connectedness*).

Interoception (ie, the sensitivity toward stimuli originating from within the body), was measured using the Multidimensional Assessment of Interoceptive Awareness instrument,[4,41] which consists of 40 items that result in 8 separate dimensions of interoceptive awareness; and higher scores each represent higher awareness.

Daily Log

All participants used a log to record the intensity of their neck pain (VAS), whether they exercised and whether they took analgesics or received other treatments for their neck pain. Analgesic consumption and concomitant treatments, analyzed according to their frequency, and for analgesics, also by the defined daily doses, were calculated.[63]

Satisfaction With Interventions

At the end of each 12-week study period participants were asked to judge how beneficial their respective treatment was on a 100-mm VAS with 100 mm indicating 'highest benefit possible.' They were also asked whether they would use this intervention in the future and whether they would recommend it to family or friends on a 'yes'/'no' basis.

Safety

Participants were asked to report any adverse event during the study period, even if considered insignificant (eg, having a cold). Adverse events were defined in accordance with Good Clinical Practice[20] as any untoward medical occurrence (ie, any abnormal laboratory finding, symptom, or disease temporally associated with study intervention), whether or not caused by the intervention. All adverse events were recorded by the study coordinator, and participants experiencing such events were asked to see the study physician to assess their import and initiate any necessary response.

Primary and Secondary Outcome Measures

The primary outcome measure was pain intensity after 12 weeks measured using the VAS. Secondary outcome measures included pain intensity (VAS) after 24 weeks; POM, functional disability (NDI), quality of life (SF-36), well-being (Questionnaire on the Assessment of Physical Wellbeing), stress (Perceived Stress Scale-10), postural (Postural Awareness Scale), and interoceptive awareness (Multidimensional Assessment of Interoceptive Awareness) after 12 and 24 weeks; and pain intensity (VAS) and medication from the daily log, compliance, satisfaction, and safety. At 12 weeks the number of responders (ie, participants experiencing at least 30% or 50% pain reduction), and participants reaching their own tolerance level of pain were analyzed.

Sample Size Calculation

The calculation for the required sample size was on the basis of a trial that investigated the effects of Qigong for chronic neck pain compared with a usual care group.[47] With an effect size of Cohen d = .69 and a 2-sided 5% level t-test, 34 participants would be needed per group to detect such a group difference between the active intervention and a non-treated control group with a statistical power of 80%. Because no data were available for the comparison of Tai Chi versus conventional exercise the same group size was used for that comparison. We planned to include 114 participants in this trial, assuming a potential loss of analytical power due to participant withdrawal.

Statistical Analysis

All analyses were on the basis of the intention to treat population (ie, each participant providing baseline data was included in the final analysis). Missing data were completed using the Markov chain Monte Carlo multiple imputation method in the Statistical Package for Social Sciences software version 22.0 (IBM Corp, Armonk, NY). A set of 50 imputations was generated, and the mean score was used for the analyses.

The primary outcome was analyzed using a univariate analysis of covariance, which modeled the post-treatment outcome as a function of treatment group (classified factor), and the respective baseline value (linear covariate). A gatekeeper stepwise analysis[18] was conducted to preserve the overall false positive rate, starting with the comparison Tai Chi versus no treatment, and followed by Tai Chi versus neck exercises. Using this stepwise procedure, no α-level adjustment for the primary outcome was necessary to maintain the overall type I error rate of 5%.[21,67] Within this model the treatment effect was estimated, accompanied with a 95% confidence interval. The P value was calculated on the basis of a 2-sided t-test within this statistical model. For categorical variable χ^2 tests were used to determine group differences.

Secondary outcomes were analyzed using the same statistical method, however, secondary outcomes were reported exploratively only, and no P values are

reported. Results from the daily log were analyzed using repeated measures analysis of variance. Therefore, weekly averages of pain intensity, medication use, and concurrent treatments were calculated. In cases for which interaction effects were observed, exploratory post hoc tests were applied.

All analyses were performed using the Statistical Package for Social Sciences software version 22.0 (IBM Corp).

Results

Participants

Of the 195 subjects initially screened by telephone, 126 subjects were seen by the study physician, of whom 114 were enrolled and subsequently randomized. The most common reasons for excluding subjects were not meeting the inclusion criteria, scheduling issues, or lost interest in the study. During the 12-week intervention,

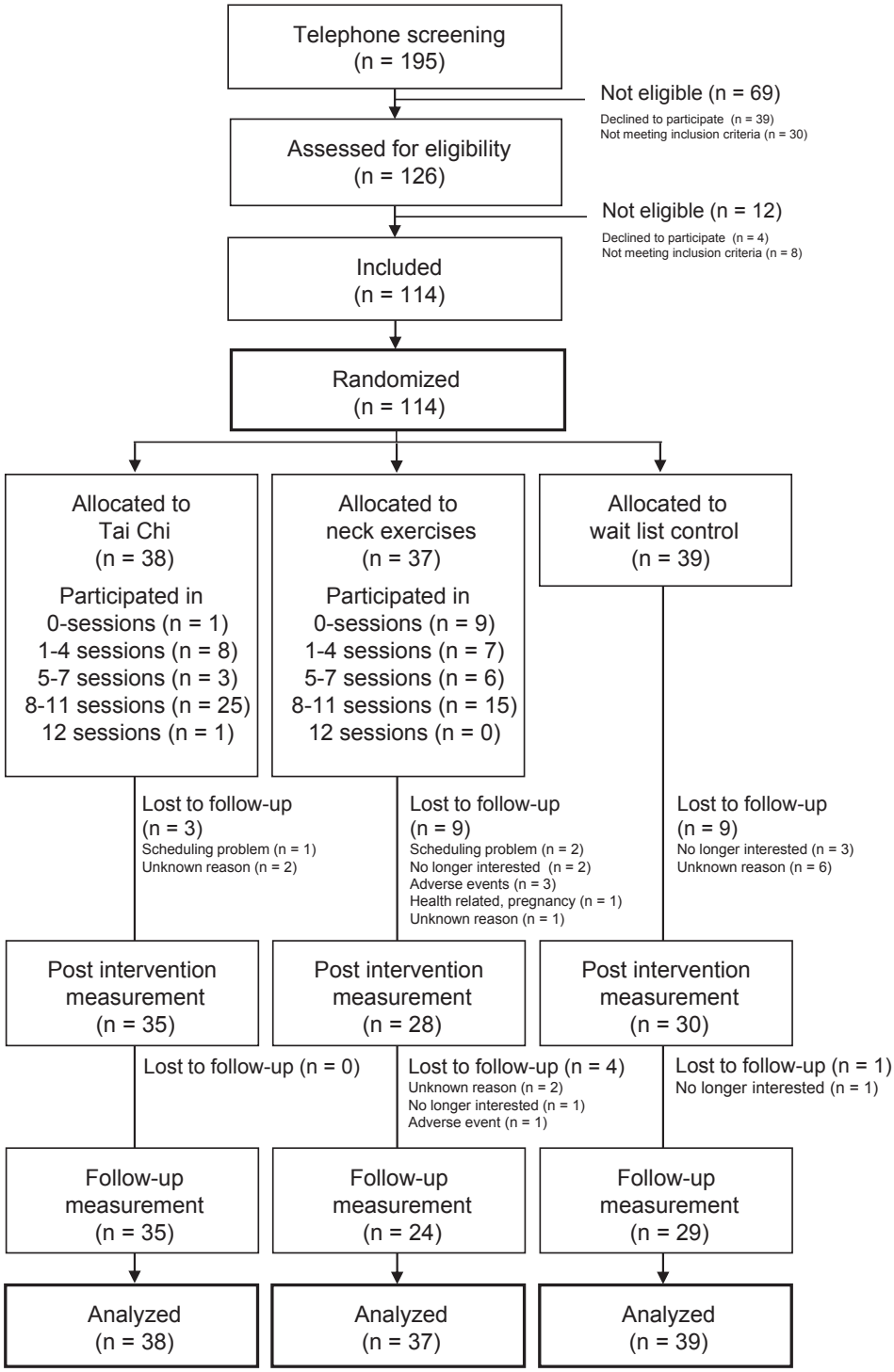

Figure 1. Consolidated Standards Of Reporting Trials flowchart of patient recruitment.

Table 1. Baseline Characteristics of Trial Participants According to Study Arm

Item	Tai Chi (N = 38)	Neck Exercises (N = 37)	Wait List (N = 39)
Age, y	52.0 ± 10.9	47.0 ± 12.3	49.2 ± 11.7
Sex, female/male	28/10	31/6	32/7
BMI	27.2 ± 4.0	25.8 ± 6.0	26.4 ± 4.6
Marital status			
Single	6	6	5
In relationship, married	27	28	29
Separated, divorced, widowed	5	3	5
Education			
Less than high school	20	14	18
High school	7	12	9
University degree	11	11	12
Employment, n			
Unemployed	4	1	2
Employed	32	32	32
Retired (health-related)	2 (0)	4 (1)	5 (1)
Previous therapies received			
Medication	13	21	24
Physiotherapy	20	24	30
Surgery on the spine	1	0	0
Injections	11	8	14
Rehabilitation center	8	8	5
Efficacy expectation			
Expectation (0–10) toward the respective intervention	7.3 ± 1.5	6.5 ± 1.7	
Pain			
Recent pain intensity	54.2 ± 20.5	46.2 ± 19.2	51.5 ± 21.1
Pain considered tolerable	21.7 ± 14.5	20.5 ± 11.7	20.7 ± 12.1

Abbreviation: BMI, body mass index.
NOTE. Data are presented as n or mean ± SD.

21 participants were lost to follow-up, 3 in the Tai Chi group, and 9 each in the neck exercise group and in the wait list control group. Despite multiple attempts to contact study participants, reasons for withdrawal could not be determined in all cases, but those who provided reasons stated scheduling problems, lost interest, or adverse events as reasons. During the follow-up period another 4 participants were lost. Because all participants provided baseline data, 114 participant data sets could be analyzed (see Fig 1 for the Consolidated Standards Of Reporting Trials flowchart).

Baseline Characteristics

Participants were 49.4 ± 11.7 years of age on average; and 91 women and 23 men were included (Table 1). Levels of education were mixed, and most participants were employed at the time of the study. Participants most commonly had received physiotherapy for symptom management, and approximately half of them reported receiving previous medication for neck pain. Injections and treatment within a rehabilitation center were reported by only a minority of participants. Participants reported an average pain intensity of 50.7 ± 20.4 mm on the VAS at baseline; and that they would consider a pain level of 20.9 ± 12.7 mm on the VAS as tolerable. Efficacy expectations toward the interventions were quite high (7.3 ± 1.5 for Tai Chi and 6.5 ± 1.7 for neck exercises).

Outcome Measures

Primary Outcome Measure

Analysis of pain intensity revealed a significant group difference between Tai Chi and the wait list control group (difference, −10.5; 95% confidence interval [CI]: −20.3, −.9; $P = .033$) after 12 weeks (Table 2). No group difference was found between Tai Chi and neck exercises (difference 3.4; 95% CI, −9.5 to 12.3; $P = .450$; Table 2).

After 12 weeks, 24 (63.2%), 27 (73.0%), and 15 (38.5%) subjects in the Tai Chi, neck exercises, and the wait list group, respectively, showed a pain reduction ≥30% ($P = .007$). A reduction in pain of ≥50% was reported by 14 (36.8%), 17 (45.9%), and 6 (15.4%) participants in the Tai Chi, neck exercises, and the wait list groups, respectively ($P = .014$). The proportion of participants reporting a reduction of pain of ≥50%, when their own self-reported limits of pain tolerability were accounted for, showed very similar patterns: 14 (36.8%), 16 (43.2%), and 6 (15.4%) participants in the Tai Chi, neck exercises, and wait list group, respectively ($P = .023$).

Secondary Outcome Measures

Group differences between the Tai Chi and the wait list control groups were still present after 24 weeks regarding neck pain intensity (difference, −10.6; 95% CI, −20.9 to −.3), POM, disability (NDI), and quality of life (SF-36; Table 3). No differences were found for psychological well-being, stress, and interoceptive

Table 2. Results of the Statistical Comparison Between the Groups at Week 12

	Tai Chi		*Wait List*		*Neck Exercises*			
	Wk 0	*Wk 12*	*Wk 0*	*Wk 12*	*Wk 0*	*Wk 12*	*Estimated Difference Between Tai Chi and Wait List (95% CI)*	*Estimated Difference Between Tai Chi and Neck Exercises (95% CI)*
Primary outcome								
Pain intensity (VAS), mm	54.2 ± 20.4	32.4 ± 23.5	51.5 ± 21.1	41.8 ± 22.5	46.2 ± 19.2	25.2 ± 18.3	−10.5 (−20.3 to −.9); *P* = .033	3.4 (−5.5 to 12.3); *P* = .450
Secondary outcomes								
POM								
POM (mean score)	43.1 ± 19.2	28.2 ± 20.4	41.3 ± 19.7	39.1 ± 16.5	43.6 ± 14.6	25.8 ± 13.8	−12.0 (−18.7 to −5.4)	3.7 (−3.2 to 10.6)
Disability								
NDI total score (0–100)	30.8 ± 8.0	21.5 ± 12.2	29.3 ± 8.2	27.5 ± 11.4	30.1 ± 9.8	22.7 ± 9.3	−7.2 (−11.7 to −2.7)	−1.7 (−5.9 to 2.4)
Disability in days (VAS)	3.0 ± 4.5	1,5 ± 2.3	2.9 ± 3.8	2.1 ± 2.4	4.2 ± 5.1	1.9 ± 3.2	−.6 (−1.6 to .4)	−.1 (−1.3 to 1.0)
Everyday function (VAS)	31.1 ± 24.7	18.3 ± 21.5	30.0 ± 21.8	27.7 ± 19.5	29.3 ± 19.7	17.9 ± 14.3	−9.9 (−17.8 to −2.1)	−.2 (−7.7 to 7.2)
Leisure (VAS)	38.6 ± 23.8	21.7 ± 25.9	39.5 ± 22.8	32.1 ± 22.8	32.9 ± 20.2	18.4 ± 25.9	−9.9 (−19.0 to −.7)	.7 (−9.0 to 7.7)
Quality of life (SF-36)								
Physical component summary	44.13 ± 7.0	47.3 ± 9.1	43.6 ± 7.3	42.9 ± 5.4	41.8 ± 7.4	45.2 ± 5.4	4.1 (1.1 to 7.0)	.1 (−5.1 to 5.3)
Mental component summary	46.3 ± 10.3	46.8 ± 11.9	46.9 ± 10.5	46.1 ± 10.7	46.9 ± 8.3	47.7 ± 8.5	1.1 (−2.9 to 5.1)	−1.2 (−15.1 to 12.7)
Physical functioning	78.5 ± 13.1	81.1 ± 17.1	79.1 ± 13.6	74.6 ± 19.3	77.4 ± 15.4	80.3 ± 111.5	7.0 (.1 to 13.9)	3.0 (−3.9 to 9.8)
Physical role functioning	62.5 ± 32.8	70.0 ± 37.6	53.2 ± 33.0	53.4 ± 31.7	51.4 ± 34.8	66.1 ± 28.2	11.3 (−2.2 to 24.8)	4.0 (−2.0 to 10.1)
Bodily pain	46.3 ± 25.6	58.5 ± 18.4	50.6 ± 18.1	50.3 ± 11.8	45.1 ± 13.4	55.2 ± 12.3	9.1 (2.1 to 16.0)	2.0 (−4.0 to 8.0)
General health perception	68.3 ± 14.7	70.7 ± 15.7	67.4 ± 19.0	64.5 ± 18.0	64.4 ± 17.6	64.6 ± 15.4	5.6 (−.0 to 11.3)	5.1 (−3.7 to 13.8)
Vitality	51.4 ± 15.5	56.5 ± 17.4	49.9 ± 17.4	49.7 ± 17.0	48.2 ± 15.0	52.5 ± 14.7	5.5 (.5 to 10.5)	−.6 (−16.0 to 14.7)
Social role functioning	73.0 ± 24.1	79.2 ± 23.8	75.6 ± 19.9	70.3 ± 19.8	68.9 ± 19.7	72.6 ± 16.9	10.2 (1.6 to 18.9)	−2.7 (−7.9 to 2.6)
Emotional role functioning	64.0 ± 36.7	68.3 ± 41.6	70.9 ± 39.9	62.9 ± 38.7	72.1 ± 32.9	72.1 ± 28.1	8.5 (−8.3 to 25.2)	.7 (−2.3 to 3.7)
Mental health	68.9 ± 16.1	67.8 ± 18.6	66.8 ± 16.4	65.9 ± 17.7	68.2 ± 12.6	69.9 ± 14.2	.1 (−5.2 to 5.3)	−.5 (−4.2 to 3.2)
Psychological well-being								
HADS, anxiety	6.9 ± 3.8	6.5 ± 4.7	6.7 ± 3.7	6.7 ± 3.2	6.0 ± 3.0	5.5 ± 3.1	−.5 (−1.5 to .5)	.1 (−1.1 to 1.3)
HADS, depression	3.8 ± 2.9	3.9 ± 3.8	4.5 ± 3.0	4.9 ± 3.4	3.8 ± 2.4	3.8 ± 2.3	−.4 (−1.4 to .6)	−.0 (−1.1 to 1.0)
General well-being								
FEW resilience	12.9 ± 3.6	12.9 ± 3.3	12.4 ± 3.6	12.0 ± 3.6	12.1 ± 4.0	12.1 ± 3.2	−.5 (−.5 to 1.5)	.3 (−.9 to 1.5)
FEW vitality	9.0 ± 5.3	10.2 ± 5.0	8.9 ± 5.2	9.0 ± 4.1	9.6 ± 4.4	9.8 ± 3.9	1.2 (−.3 to 2.6)	.8 (−.8 to 2.4)
FEW ability to enjoy	12.3 ± 3.9	12.9 ± 3.7	12.6 ± 3.5	12.0 ± 3.5	12.2 ± 3.0	12.3 ± 3.1	1.1 (.1 to 2.0)	.6 (−.7 to 1.8)
FEW ease of mind	10.4 ± 4.7	11.4 ± 4.6	10.9 ± 3.9	11.0 ± 3.8	11.4 ± 3.8	11.3 ± 3.8	.7 (−.3 to 1.8)	.8 (−.4 to 2.1)
Stress								
PSS sum score	17.5 ± 7.0	16.9 ± 7.2	17.0 ± 6.6	16.3 ± 6.1	15.9 ± 6.4	15.5 ± 5.4	.3 (−1.8 to 2.4)	.3 (−1.7 to 2.3)
Interoceptive awareness								
MAIA noticing	3.5 ± .7	3.7 ± .7	3.5 ± .7	3.4 ± .7	3.5 ± .6	3.5 ± .7	.2 (−.0 to .5)	.2 (−.1 to .5)
MAIA not distracting	1.6 ± .9	1.8 ± .8	1.6 ± .8	1.7 ± .8	1.6 ± 1.0	1.8 ± .9	.1 (−.2 to .4)	−.1 (−.4 to .3)
MAIA not worrying	2.5 ± 1.0	2.7 ± 1.0	2.3 ± 1.0	2.4 ± 1.0	2.5 ± 1.0	2.6 ± .9	.1 (−.3 to .4)	.1 (−9.3 to .4)
MAIA attention regulation	2.6 ± .9	3.0 ± .8	2.4 ± .7	2.6 ± .8	2.6 ± .7	2.7 ± .8	.2 (−.0 to .5)	.2 (−.1 to .5)
MAIA emotional awareness	3.8 ± .7	3.8 ± .8	3.5 ± 1.0	3.5 ± .8	3.6 ± .8	3.6 ± .7	.2 (−.1 to .5)	.1 (−.2 to .4)
MAIA self-regulation	2.5 ± 1.0	2.9 ± 1.0	2.3 ± 1.1	2.6 ± .8	2.4 ± .9	2.7 ± .8	.2 (−.1 to .5)	.1 (−.2 to .4)
MAIA body listening	2.2 ± 1.0	2.8 ± 1.0	2.0 ± .9	2.4 ± .9	2.0 ± 1.0	2.3 ± .9	.3 (−.1 to .6)	.4 (−.0 to .7)
MAIA trusting	3.1 ± 1.1	3.4 ± 1.0	3.0 ± 1.2	3.0 ± 1.2	3.2 ± .9	3.4 ± .9	.3 (.0 to .6)	.1 (−.2 to .4)

Table 2. Continued

	Tai Chi		Wait List		Neck Exercises		Estimated Difference Between Tai Chi and Wait List (95% CI)	Estimated Difference Between Tai Chi and Neck Exercises (95% CI)
	Wk 0	Wk 12	Wk 0	Wk 12	Wk 0	Wk 12		
Postural awareness								
PAS Forced Awareness and Detachment	4.91 ± 1.04	4.49 ± 1.15	5.24 ± .86	5.16 ± .86	5.17 ± .79	4.79 ± 1.00	−.4 (−.5 to −.1)	−.1 (−.5 to .3)
PAS Effortless Awareness and Connectedness	3.56 ± 1.08	3.96 ± 1.01	3.67 ± 1.02	3.76 ± .95	3.45 ± 1.14	3.73 ± .81	.2 (−.2 to .6)	.1 (−.2 to .6)

Abbreviations: HADS, Hospital Anxiety and Depression Scale; FEW, Questionnaire on the Assessment of Physical Wellbeing; PSS, Perceived Stress Scale; MAIA, Multidimensional Assessment of Interoceptive Awareness; PAS, Postural Awareness Scale; ANCOVA, analysis of covariance.

NOTE. Scores are presented as mean ± SD; group differences are estimations from the ANCOVA with 95% CIs.

awareness (Tables 2 and 3), but for the postural awareness subscale *Forced Awareness and Detachment* (Tables 2 and 3) for Tai Chi compared with the wait list control group. Compared with neck exercises, no group differences were found for any of the outcomes (Tables 2 and 3).

Adherence

Participants of the Tai Chi course attended 7.6 ± 3.4 sessions on average, and those in the neck exercise 5.4 ± 4.1 sessions. As can be seen in Fig 1, there were 9 participants in the neck exercise group who did not attend any session at all, and participants in the Tai Chi group were more adherent. Course attendance in general was average to good in Tai Chi, with at least a 50% attendance rate during the course; however, attendance rate in neck exercises group was significantly lower (Mann–Whitney *U*; $P = .017$), mainly due to the 9 participants who did not attend any of the classes. In both groups a steady decline of attendance could be observed (Fig 2). Together, the number of adherent participants (at least 80% attendance) was 26 (68.4%) and 15 (40.5%) in the Tai Chi and neck exercises groups, respectively.

Daily Log

The weekly home practice was comparable between the groups, with participants practicing Tai Chi for 44.9 ± 10.7 (range, 19–59) minutes and neck exercises for 33.1 ± 9.6 (range, 13–48) minutes on average (Fig 3A). A steady decline in pain intensity was found in the Tai Chi and neck exercises groups, but not in the wait list group (Fig 3B). Analysis revealed an interaction effect of time and group; and differences between groups occurred after 7 weeks, with pain ratings in the Tai Chi and neck exercises groups being lower than those in the wait list group for most time points afterward. Analysis of other drug therapies revealed that the average daily doses of analgesics were low; participants took less than 20% of the recommended daily dosage on average (Fig 3C).

An interaction effect of time and group was found, with participants in the neck exercises group reporting the highest intake compared with the Tai Chi group in weeks 1 to 4, however, from week 5 those differences had disappeared. Participants received approximately 2 concomitant therapies per week, with no differences between the groups (Fig 3D). Concomitant therapies mainly included massages and the application of heat without differences between the groups.

Satisfaction With Interventions

Participants reported high perceived benefit of both interventions (Tai Chi, 70.6 ± 29.6 mm; neck exercises, 72.9 ± 30.0 mm) as well as satisfaction after 12 weeks (Tai Chi, 76.1 ± 28.9 mm; neck exercises, 80.0 ± 27.7 mm). In total 85.7% and 88.0% of participants reported that they would consider using Tai Chi and neck exercises again, and 94.2% and 100% would consider recommending Tai Chi and neck exercises to family and friends, respectively.

Table 3. Results of the Statistical Comparison Between the Groups at Week 24

	Tai Chi		*Wait List*		*Neck Exercises*		*Estimated Difference Between Tai Chi and Wait List (95% CI)*	*Estimated Difference Between Tai Chi and Neck Exercises (95% CI)*
	Wk 0	*Wk 24*	*Wk 0*	*Wk 24*	*Wk 0*	*Wk 24*	*Wk 24*	*Wk 24*
Primary outcome								
Pain intensity (VAS), mm	54.2 ± 20.4	35.0 ± 27.7	51.5 ± 21.1	44.6 ± 20.0	46.2 ± 19.2	33.1 ± 20.9	−10.6 (−20.9 to −.3)	−.5 (−11.8 to 10.7)
Secondary outcomes								
POM								
POM, mean score	43.1 ± 19.2	29.1 ± 19.0	41.3 ± 19.7	45.5 ± 19.7	43.6 ± 14.6	34.9 ± 14.4	−14.3 (−22.0 to −6.7)	−5.6 (−13.0 to 1.8)
Disability								
NDI total score (0–100)	30.8 ± 8.0	24.3 ± 14.1	29.3 ± 8.2	29.4 ± 12.7	30.1 ± 9.8	25.1 ± 12.9	−6.6 (−11.6 to −1.6)	−1.4 (−6.7 to 4.0)
Disability in days (VAS)	3.0 ± 4.5	1.9 ± 3.4	2.9 ± 3.8	2.7 ± 3.0	4.2 ± 5.1	2.7 ± 3.7	−.8 (−2.2 to .6)	−.4 (−1.8 to 1.0)
Everyday function (VAS)	31.1 ± 24.7	22.0 ± 24.3	30.0 ± 21.8	29.6 ± 20.5	29.3 ± 19.7	24.4 ± 19.6	−8.0 (−17.5 to 1.5)	−2.9 (−12.6 to 6.9)
Leisure (VAS)	38.6 ± 23.8	26.6 ± 27.3	39.5 ± 22.8	31.1 ± 21.2	32.9 ± 20.2	24.7 ± 21.1	−4.1 (−14.2 to 6.0)	−.8 (−11.1 to 9.5)
Quality of life (SF-36)								
Physical component summary	44.13 ± 7.0	46.5 ± 8.9	43.6 ± 7.3	42.0 ± 8.0	41.8 ± 7.4	44.0 ± 7.5	4.1 (.8 to 7.5)	1.6 (−4.8 to 8.0)
Mental component summary	46.3 ± 10.3	47.0 ± 12.2	46.9 ± 10.5	46.4 ± 10.13	46.9 ± 8.3	46.9 ± 9.1	1.0 (−3.1 to 5.2)	.3 (−12.0 to 12.6)
Physical functioning	78.5 ± 13.1	79.6 ± 17.0	79.1 ± 13.6	74.0 ± 19.1	77.4 ± 15.4	77.2 ± 17.3	6.0 (−.9 to 13.0)	1.0 (−7.0 to 9.0)
Physical role functioning	62.5 ± 32.8	67.7 ± 37.1	53.2 ± 33.0	49.9 ± 23.9	51.4 ± 34.8	60.2 ± 30.6	12.7 (−1.2 to 26.6)	4.4 (−2.5 to 11.4)
Bodily pain	46.3 ± 25.6	58.6 ± 22.4	50.6 ± 18.1	53.6 ± 15.8	45.1 ± 13.4	56.9 ± 15.8	6.8 (−1.4 to 15.1)	2.8 (−4.8 to 10.3)
General health perception	68.3 ± 14.7	68.3 ± 16.1	67.4 ± 19.0	59.7 ± 18.5	64.4 ± 17.6	61.9 ± 18.1	8.1 (11.5 to 14.6)	4.6 (−4.6 to 13.9)
Vitality	51.4 ± 15.5	55.6 ± 20.4	49.9 ± 17.4	47.6 ± 20.1	48.2 ± 15.0	50.7 ± 17.8	6.6 (−.0 to 13.3)	6.0 (−8.7 to 20.7)
Social role functioning	73.0 ± 24.1	77.9 ± 24.6	75.6 ± 19.9	68.9 ± 22.8	68.9 ± 19.7	71.2 ± 20.5	10.3 (.6 to 19.9)	−1.6 (−7.3 to 4.0)
Emotional role functioning	64.0 ± 36.7	68.4 ± 36.1	70.9 ± 39.9	65.2 ± 37.4	72.1 ± 32.9	65.4 ± 32.1	5.2 (−10.8 to 21.3)	.7 (−2.2 to 3.6)
Mental health	68.9 ± 16.1	68.4 ± 20.0	66.8 ± 16.4	65.9 ± 16.7	68.2 ± 12.6	69.4 ± 15.0	.7 (−4.8 to 6.2)	.6 (−3.2 to 4.4)
Psychological well-being								
HADS, anxiety	6.9 ± 3.8	6.1 ± 4.5	6.7 ± 3.7	6.7 ± 3.4	6.0 ± 3.0	5.5 ± 3.1	−.8 (−2.0 to .4)	−.3 (−1.3 to .7)
HADS, depression	3.8 ± 2.9	4.1 ± 3.8	4.5 ± 3.0	5.4 ± 4.0	3.8 ± 2.4	4.1 ± 2.8	−.8 (−1.9 to .4)	−.1 (−1.2 to 1.1)
General well-being								
FEW resilience	12.9 ± 3.6	12.6 ± 3.4	12.4 ± 3.6	11.9 ± 3.5	12.1 ± 4.0	11.7 ± 4.0	.4 (−.7 to 1.5)	.5 (−.9 to 1.9)
FEW vitality	9.0 ± 5.3	10.2 ± 4.9	8.9 ± 5.2	8.9 ± 4.4	9.6 ± 4.4	10.1 ± 4.1	1.2 (−.6 to 2.9)	.3 (−1.4 to 2.1)
FEW ability to enjoy	12.3 ± 3.9	12.2 ± 3.4	12.6 ± 3.5	12.0 ± 3.7	12.2 ± 3.0	11.5 ± 3.7	.4 (−.6 to 1.4)	.6 (−.7 to 2.0)
FEW ease of mind	10.4 ± 4.7	10.9 ± 4.5	10.9 ± 3.9	11.0 ± 3.8	11.4 ± 3.8	10.9 ± 3.8	.3 (−1.0 to 1.6)	.6 (−.7 to 2.0)
Stress								
PSS sum score	17.5 ± 7.0	16.5 ± 8.5	17.0 ± 6.6	16.2 ± 6.0	15.9 ± 6.4	15.3 ± 6.8	−.1 (−2.6 to 2.4)	.0 (−2.7 to 2.7)
Interoceptive awareness								
MAIA noticing	3.5 ± .7	3.4 ± .8	3.5 ± .7	3.4 ± .7	3.5 ± .6	3.3 ± .7	.1 (−.2 to .4)	.1 (−.2 to .5)
MAIA not distracting	1.6 ± .9	1.6 ± .8	1.6 ± .8	1.8 ± .8	1.6 ± 1.0	1.7 ± .9	−.2 (−.5 to .1)	−.1 (−.4 to .2)
MAIA not worrying	2.5 ± 1.0	2.6 ± .9	2.3 ± 1.0	2.5 ± 1.1	2.5 ± 1.0	2.5 ± .9	−.1 (−.4 to .3)	.1 (−.2 to .4)
MAIA attention regulation	2.6 ± .9	2.8 ± .7	2.4 ± .7	2.6 ± .8	2.6 ± .7	2.7 ± .8	.1 (−.2 to .3)	.1 (−.2 to .4)
MAIA emotional awareness	3.8 ± .7	3.8 ± .7	3.5 ± 1.0	3.5 ± .7	3.6 ± .8	3.6 ± .7	.2 (−.1 to .4)	.2 (−.1 to .4)
MAIA self-regulation	2.5 ± 1.0	2.8 ± 1.1	2.3 ± 1.1	2.5 ± .8	2.4 ± .9	2.4 ± .9	.2 (−.2 to .5)	.2 (−.1 to .6)

Table 3. Continued

	Tai Chi		Wait List		Neck Exercises		Estimated Difference Between Tai Chi and Wait List (95% CI)	Estimated Difference Between Tai Chi and Neck Exercises (95% CI)
	Wk 0	Wk 24	Wk 0	Wk 24	Wk 0	Wk 24	Wk 24	Wk 24
MAIA body listening	2.2 ± 1.0	2.5 ± .9	2.0 ± .9	2.4 ± .8	2.0 ± 1.0	2.1 ± .9	.0 (−.3 to .3)	.2 (−.1 to .6)
MAIA trusting	3.1 ± 1.1	3.2 ± .9	3.0 ± 1.2	3.0 ± 1.1	3.2 ± .9	3.1 ± 1.1	.1 (−.2 to .4)	.2 (−.1 to .5)
Postural awareness								
PAS Forced Awareness and Detachment	4.91 ± 1.01	4.50 ± .90	5.24 ± .73	5.10 ± .75	5.17 ± .79	4.77 ± .98	−.4 (−.6 to −.1)	.2 (−.2 to .6)
PAS Effortless Awareness and Connectedness	3.56 ± 1.08	3.69 ± .82	3.67 ± 1.02	3.67 ± .94	3.45 ± 1.14	3.45 ± 1.06	.1 (−.3 to .4)	.1 (−.4 to .2)

Abbreviations: HADS, Hospital Anxiety and Depression Scale; FEW, Questionnaire on the Assessment of Physical Wellbeing; PSS, Perceived Stress Scale; MAIA, Multidimensional Assessment of Interoceptive Awareness; PAS, Postural Awareness Scale; ANCOVA, analysis of covariance.

NOTE. Scores are presented as mean ± SD; group differences are estimations from the ANCOVA with 95% CIs.

Safety

A total of 14 minor adverse events were recorded during the study. In the Tai Chi group, 4 participants presented with upper respiratory tract infections, 1 reported a single migraine attack, 2 complained of Achilles tendon pain, and 1 participant fell and got bruises at home (not during practice). In the neck exercises group, 4 upper respiratory tract infections occurred and 1 participant each experienced knee pain and vertigo. Serious adverse events occurred in 6 trial participants: 1 participant in the Tai Chi group each reported meniscal tear after running and mononucleosis infection. One participant each in the neck exercise group reported infection with mononucleosis, idiopathic sudden sensorineural hearing loss (before the intervention started), appendicitis, and dental root infection. All participants with serious adverse events were receiving medical treatment at their respective physicians.

Except for knee and Achilles tendon pain, and migraine, all other adverse events were considered unlikely to be related to exposure to Tai Chi or neck exercises by the study physician. No participant in the wait list control group reported adverse events.

Discussion

This trial found that a 12-week Tai Chi course was more effective than no treatment in addressing neck pain, functional disability, and quality of life after 12 and 24 weeks. It was however neither superior nor inferior to a 12-week intervention of conventional neck exercises. Participants were highly satisfied with both active interventions, and except for minor side effects, the interventions were well accepted and tolerated.

Scientific Evidence

Studies have previously investigated effects of exercise on neck pain,[24] however, we are not aware of any studies to date that have evaluated the effects of Tai Chi for chronic neck pain despite Tai Chi being regularly used for neck pain. Studies have, however, investigated the efficacy of Qigong, a mind-body exercise very similar to Tai Chi,[27,37,47,53] for chronic neck pain. In 1 study, Rendant and colleagues[47] compared the effects of Qigong with those of neck exercises and usual care in 123 subjects with chronic neck pain. The authors reported that 18 sessions of Qigong over the course of 6 months were superior to usual care, but not compared with the neck exercises. Although their design and sample were mostly comparable with our current study, our study only used traditional Tai Chi forms without specific focus on neck and shoulder function. Another study by HADS et al[53] investigated the effects of Qigong for elderly subjects with chronic neck pain. The study reported that after 24 sessions within 12 weeks no differences between Qigong and usual care or neck exercises were reported. Participants, however, reported increased

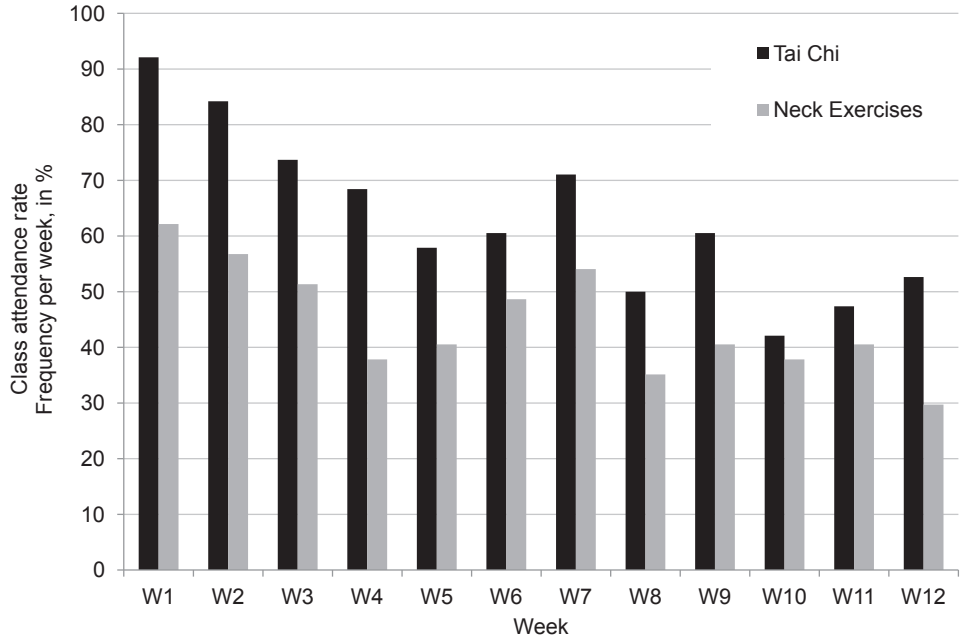

Figure 2. Weekly attendance rate during the 12-week study period, in percentage of study participants who attended the class. Abbreviation: W, week.

relaxation, and calmness,[27] which were not found in our study.

In addition to neck pain, Tai Chi has been investigated in subjects with chronic back pain,[26] with rheumatologic disorders such as osteoarthritis of the knee,[5,39,57] the fibromyalgia syndrome,[32,58] and rheumatoid arthritis.[51,55,56] Patients with such disorders frequently benefit from Tai Chi, as do elderly subjects with enhanced risk of falls and fractures.[23] Tai Chi has also been reported to be beneficial for several

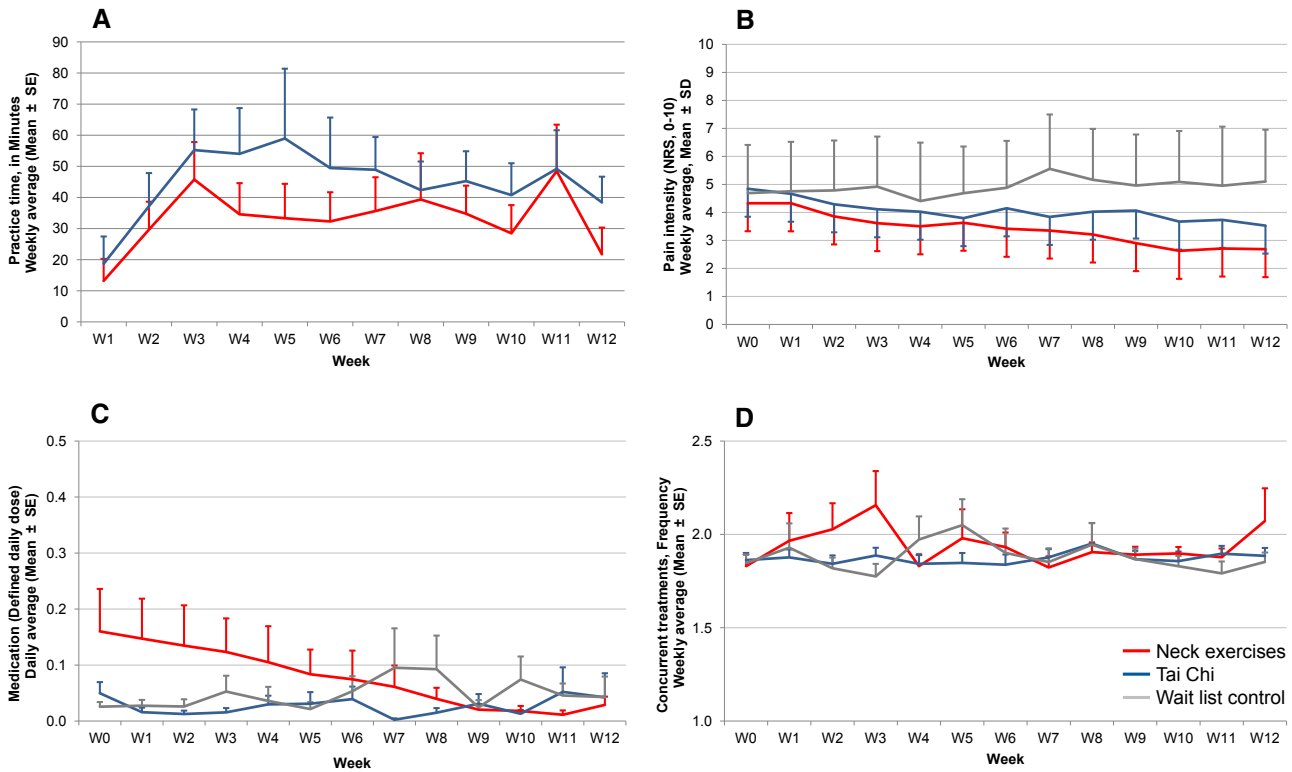

Figure 3. Data from the daily log including **(A)** weekly home practice time in minutes, mean ± SE; **(B)** pain intensity ratings during the 12-week study period, measured using an NRS, weekly average, mean ± SE; **(C)** average defined daily dose according to the WHO of concomitant analgesics, mean ± SE; and **(D)** weekly average of concomitant therapies (other than study interventions), % ± SE. Abbreviations: SE, standard error; W, week; NRS, numerical rating scale; WHO, World Health Organization.

neurological,[1,12,49,68] psychological,[59] and cardiovascular conditions.[65]

The modes of action of Tai Chi are not understood completely, they might include general effects due to exercise such as increased flexibility and mobility of structures; improved muscle strength and endurance; increased tensile strength of ligaments and capsules; increased cardiovascular function, reduced stress, anxiety, and depression; and changes in health beliefs and health-related locus of control.[33] Tai Chi in particular may act via improved postural control as indicated by increases in balance and reduced falls.[8,25,46,50,64] Specific mechanisms of postural control relevant to neck pain may be better muscle tone due to increased muscle strength,[28,30,36] and better kinesthetic control due to improved interoceptive or proprioceptive awareness.[43] Results of this study showed that subjects had fewer difficulties regarding awareness of their posture after Tai Chi classes, however, no changes were found in interoceptive awareness. It can further be assumed that the meditative character might improve psychological well-being, stress, and depressive mood,[59] however, no such correlations were observed in our current study. To establish the exact mechanisms of Tai Chi, further rigorous research is warranted.[62]

We also found Tai Chi as well as neck exercises to be quite safe, with only a few temporary minor side effects reported. This parallels recent systematic reviews considering Tai Chi and neck exercises to be safe interventions for populations with chronic pain and other chronic medical conditions.[33,60] Of note, Tai Chi as well as conventional neck exercises can be practiced at home at low cost and with no need for special equipment; however, at least during the initial stages of training, introductory courses are recommended to assure proper adoption of training principles.

Strengths and Limitations

The strengths of the study include the randomized study design; the predefined sample size, and the use of different comparators including an expert-designed neck exercise group. The use of standardized measurement instruments and the inclusion of the most important outcomes in relation to chronic neck pain, and the evaluation of concomitant medication and treatments are additional strengths of the trial.

Limitations include the lack of blinding of participants and physicians, which is a general problem in nonpharmacological interventional trials. However, expectations toward both active interventions were comparable, indicating no major detection bias. Another limitation may exist because of the initial withdrawal rate in the neck exercise group, the general withdrawal rate during the trial, and the adherence rate, which was sufficient at best for the neck exercises group. The withdrawal rate for the exercises group was substantially higher than in other comparable trials.[26,47,53] Possible reasons might include different patient preferences toward neck exercises and Tai Chi in the samples, or specific differences in trial sites and subjects. Satisfaction was high in those participating in both Tai Chi and neck exercises, indicating suitability of both exercise programs. Furthermore both classes were conducted by the same instructor, which may eliminate personality biases, but may have increased the probability of information contamination across groups. Results may also allow for only limited inference of efficacy of either intervention. The study was primarily powered to detect differences between Tai Chi and usual care, and it may have been underpowered for the comparison with neck exercises. Furthermore, sample size was not nearly sufficient to conduct noninferiority testing. And last, the follow-up did not exceed 24 weeks, which does not allow for conclusive judgement of long-term effects.

Future Studies

Despite preliminary evidence of the efficacy of Tai Chi for chronic neck and back pain, further studies are necessary to confirm and extend those findings. Findings of this study indicate that Tai Chi had a clinically modest effect on average pain scores, however, more than 1 in 3 participants reported a pain reduction by 50%. Further trials should not only apply larger sample to secure sufficient power for head to head comparisons of different exercise interventions, they might also include noninferiority tests to confirm equality of interventions. Future trials should also determine the maximal possible benefit from Tai Chi, and identify subjects' characteristics and factors associated with improvement of neck pain. Other studies might also evaluate whether Tai Chi training might be able to prevent the development of neck pain. Because many people use CD/DVDs or the Internet to learn Tai Chi, advantages and disadvantages to these home-based interventions should also be evaluated.

Practical Implications

Neck strengthening and stretching exercises are regularly recommended for subjects with chronic neck pain. If future studies confirm that Tai Chi is effective and safe, it could be recommended to subjects with a specific preference toward complementary medicine exercise techniques, or to subjects who want to participate in a practice that has a larger focus on body awareness and spirituality. However, the decision for either must also be on the basis of availability and costs.

Conclusions

Twelve weeks of Tai Chi is more effective than no treatment to improve pain, disability, quality of life, and postural control in subjects with chronic nonspecific neck pain. Because Tai Chi proved to be equally efficacious and safe as conventional neck exercises, it may be considered a suitable alternative for subjects with chronic neck pain.

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Supplementary Data

Supplementary data related to this article can be found online at http://dx.doi.org/10.1016/j.jpain.2016.06.004.

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