Prescribing Tai Chi for Fibromyalgia — Are We There Yet?

Gloria Y. Yeh, M.D., M.P.H., Ted J. Kaptchuk, and Robert H. Shmerling, M.D.

Fibromyalgia is a common and poorly understood pain disorder that afflicts an estimated 200 million or more people worldwide.[1] The lack of objective abnormalities detected on physical examination and standard blood and imaging tests has led many physicians to question the existence of this disorder.[2] However, for those experiencing the pain and other associated symptoms (including fatigue, stiffness, and nonrestorative sleep), there is little doubt that the condition is real — and so is the need for relief. Studies over the past decade suggest that fibromyalgia may be due, at least in part, to an alteration in pain sensitivity in the central nervous system.[3] Other potential mechanistic contributors include a genetic predisposition, emotional or physical stress, disordered sleep, and neurohormonal dysfunction.

What relief can we offer persons with fibromyalgia? Once the diagnosis is established with confidence (which is no small feat, since this is a diagnosis of exclusion, with many mimics), standard treatment recommendations include exercise, sleep hygiene, and medications. The ideal exercise program is unclear, although a mix of aerobic and strengthening activities may be best.[4] Other nonmedication approaches include cognitive and behavioral therapies. Pharmacologic agents commonly recommended for fibromyalgia include amitriptyline, cyclobenzaprine, fluoxetine, and several drugs now approved by the Food and Drug Administration (including duloxetine, pregabalin, and milnacipran). Yet even with optimal use of standard measures, the clinical response is often disappointing. For example, in a 12-week, placebo-controlled trial of duloxetine, only 55% of the treated patients, as compared with 33% of those given placebo, had improvement of at least 30% in a standard pain score.[5] Other limitations of standard treatment include significant side effects with pharmacologic approaches and variable compliance with lifestyle changes (especially exercise). Finally, given the chronicity of this disorder, long-term efficacy is of paramount importance; unfortunately, most studies to date have been of short duration, so the durability of even modest improvement is uncertain.

It is no wonder, then, that many people with fibromyalgia seek out less conventional (and less evidence-based) treatments, such as tai chi, yoga, massage, or acupuncture. The limited success of conventional treatments and the efficacy and safety reported in preliminary studies of tai chi[6] make this practice an ideal intervention to study in patients with fibromyalgia. In this issue of the *Journal*, Wang et al. report the results of a randomized, controlled trial of tai chi as a treatment for fibromyalgia.[7]

Tai chi is a gentle, meditative exercise that consists of flowing, circular movements, balance and weight shifting, breathing techniques, and cognitive tools (e.g., imagery and focused internal awareness). Researchers have investigated tai chi as an intervention for a variety of health issues, including balance impairments and cardiovascular disease.[8] Although data from other randomized, controlled trials specifically examining tai chi for fibromyalgia are not available, this practice has been studied as a treatment for other rheumatologic conditions, such as rheumatoid arthritis, and other musculoskeletal conditions, such as osteoarthritis and low back pain.[9] The data suggest that tai chi may be effective, although rigorous studies with adequate sample sizes have not been performed.

In the study by Wang et al., aside from reductions in pain, patients in the tai chi group reported improvements in mood, quality of life, sleep, self-efficacy, and exercise capacity. These results parallel those of small studies of tai chi in other patient populations.[8] Other meditative therapies, such as mindfulness-based stress reduction, have been studied in patients with fibromyalgia. In some cases, symptoms improved, although in general, the results have been equivocal. For example, although an 8-week, randomized, controlled study of mindfulness meditation and tai chi–like movements (qigong) in 128 patients with fibromyalgia showed significant reductions in pain, disability, and depression, these improvements were no better than those seen in the control group, which received educational support.[10] Given this background, the positive results across all outcome measures reported by Wang et al. are striking.

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With such provocative results, this study may have far-reaching implications. But several critical questions remain. How much of the benefit of tai chi is due to a placebo effect? What is an appropriate control for tai chi? And what do these findings mean for clinical practice?

The authors state that they tried to minimize any a priori differences between expectations for tai chi and the control intervention, which consisted of stretching and health education, and they report that expectations in the two groups were similar at baseline. However, it seems likely that when a persuasive and enthusiastic teacher of tai chi first explained its potential benefits to the class, expectations in this group were heightened. The authors dutifully suggest that a sham tai chi intervention would have been desirable as a control. Ideally, a placebo control matches all aspects of the therapeutic intervention except for the "active" element of that intervention. But what is the active element of a complex, multicomponent therapy such as tai chi?[11] Is it rhythmic exercise, deliberate and deep breathing, contemplative concentration, group support, relaxing imagery, a charismatic teacher, or some synergistic combination of these elements? If so, would the matched control include awkward movements, halted breathing, participant isolation, unpleasant imagery, or a tepid teacher? Would the resulting sham intervention be credible, valid, or even genuinely inactive?

Instead of embarking on a quixotic search for the ideal sham, what else needs to be done and what is a reasonable course of action for the physician who must counsel the patient with fibromyalgia? For next steps, we need replications of this study on a larger scale over longer periods of time, with different practitioners and different styles at multiple sites; determination of the optimal "dose"; comparisons with similar therapies such as yoga; and an assessment of cost-effectiveness. In the end, however, it may be that further evidence in support of tai chi for fibromyalgia, even if consistently positive, will never be as fully convincing as the results of double-blind pharmaceutical trials. It is also possible that future studies will not replicate the dramatic findings of this small trial[12] and that not all patients with fibromyalgia will find tai chi acceptable or available. Even so, the potential efficacy and lack of adverse effects now make it reasonable for physicians to support patients' interest in exploring these types of exercises, even if it is too early to take out a prescription pad and write "tai chi."

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

From the Division for Research and Education in Complementary and Integrative Medical Therapies, Harvard Medical School (G.Y.Y., T.J.K.); and the Divisions of General Medicine and Primary Care (G.Y.Y., T.J.K.) and Rheumatology (R.H.S.), Beth Israel Deaconess Medical Center — all in Boston.

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ORIGINAL ARTICLE

A Randomized Trial of Tai Chi for Fibromyalgia

Chenchen Wang, M.D., M.P.H., Christopher H. Schmid, Ph.D., Ramel Rones, B.S., Robert Kalish, M.D., Janeth Yinh, M.D., Don L. Goldenberg, M.D., Yoojin Lee, M.S., and Timothy McAlindon, M.D., M.P.H.

ABSTRACT

BACKGROUND

Previous research has suggested that tai chi offers a therapeutic benefit in patients with fibromyalgia.

METHODS

We conducted a single-blind, randomized trial of classic Yang-style tai chi as compared with a control intervention consisting of wellness education and stretching for the treatment of fibromyalgia (defined by American College of Rheumatology 1990 criteria). Sessions lasted 60 minutes each and took place twice a week for 12 weeks for each of the study groups. The primary end point was a change in the Fibromyalgia Impact Questionnaire (FIQ) score (ranging from 0 to 100, with higher scores indicating more severe symptoms) at the end of 12 weeks. Secondary end points included summary scores on the physical and mental components of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36). All assessments were repeated at 24 weeks to test the durability of the response.

RESULTS

Of the 66 randomly assigned patients, the 33 in the tai chi group had clinically important improvements in the FIQ total score and quality of life. Mean (±SD) baseline and 12-week FIQ scores for the tai chi group were 62.9±15.5 and 35.1±18.8, respectively, versus 68.0±11 and 58.6±17.6, respectively, for the control group (change from baseline in the tai chi group vs. change from baseline in the control group, –18.4 points; P<0.001). The corresponding SF-36 physical-component scores were 28.5±8.4 and 37.0±10.5 for the tai chi group versus 28.0±7.8 and 29.4±7.4 for the control group (between-group difference, 7.1 points; P=0.001), and the mental-component scores were 42.6±12.2 and 50.3±10.2 for the tai chi group versus 37.8±10.5 and 39.4±11.9 for the control group (between-group difference, 6.1 points; P=0.03). Improvements were maintained at 24 weeks (between-group difference in the FIQ score, –18.3 points; P<0.001). No adverse events were observed.

CONCLUSIONS

Tai chi may be a useful treatment for fibromyalgia and merits long-term study in larger study populations. (Funded by the National Center for Complementary and Alternative Medicine and others; ClinicalTrials.gov number, NCT00515008.)

From the Division of Rheumatology (C.W., R.K., J.Y., T.M.) and the Institute for Clinical Research and Health Policy Studies (C.H.S., Y.L.), Tufts Medical Center, Tufts University School of Medicine; and Mind–Body Therapies (R.R.) — both in Boston; and Newton–Wellesley Hospital, Newton, MA (D.L.G.). Address reprint requests to Dr. Wang at the Division of Rheumatology, Tufts Medical Center, 800 Washington St., Box 406, Tufts University School of Medicine, Boston, MA 02111, or at cwang2@tuftsmedicalcenter.org.

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Fibromyalgia is a common and complex clinical syndrome characterized by chronic and widespread musculoskeletal pain, fatigue, sleep disturbance, and physical and psychological impairment.[1,2] Evidence-based guidelines suggest that fibromyalgia is typically managed with multidisciplinary therapies involving medication, cognitive behavioral therapy, education, and exercise.[3-5]

Although exercise is beneficial for fibromyalgia and has been advocated as a core component of its treatment,[6-8] most patients continue to be in considerable pain years after the original diagnosis and require medication to control symptoms; they also remain aerobically unfit, with poor muscle strength and limited flexibility.[9] New approaches are needed to reduce musculoskeletal pain in patients with fibromyalgia and to improve their physical and emotional functioning and quality of life.

Tai chi is a mind–body practice that originated in China as a martial art. It combines meditation with slow, gentle, graceful movements, as well as deep breathing and relaxation, to move vital energy (or *qi*) throughout the body. It is considered a complex, multicomponent intervention that integrates physical, psychosocial, emotional, spiritual, and behavioral elements.[10] Because of its mind–body attributes, tai chi could be especially well suited to the treatment of fibromyalgia. In fact, tai chi is practiced preferentially in the United States by persons with musculoskeletal and mental health conditions.[11,12] A small, nonrandomized study showed that tai chi reduced symptoms and improved quality of life in patients with fibromyalgia,[13] and it has also been shown to have potential therapeutic benefits in patients with other chronic rheumatic conditions, such as rheumatoid arthritis and osteoarthritis.[14,15]

We conducted a single-blind, randomized, controlled trial to compare the physical and psychological benefits of tai chi with those of a control intervention that consisted of wellness education and stretching. We hypothesized that at the end of the 12-week intervention period, patients in the tai chi group would have a greater reduction in musculoskeletal pain and greater improvements in sleep quality, physical and psychological function, and health-related quality-of-life scores than those in the control group.

Methods

Study Participants

We conducted the trial from July 2007 through May 2009 at Tufts Medical Center, a tertiary care academic hospital in Boston. The institutional review board of the Tufts University Health Sciences Campus approved the study protocol. Eligible patients were 21 years of age or older and fulfilled the American College of Rheumatology 1990 diagnostic criteria for fibromyalgia. These criteria include a history of widespread musculoskeletal pain on the right and left sides of the body as well as above and below the waist, with a minimum duration of 3 months, and tenderness on pressure at 11 or more of 18 specific sites (tender points), with moderate or more severe tenderness reported on digital palpation.[16] We excluded persons who had participated in tai chi training within the past 6 months; those with serious medical conditions that might limit their participation; those with other diagnosed medical conditions known to contribute to fibromyalgia symptoms, such as thyroid disease, inflammatory arthritis, systemic lupus erythematosus, systemic sclerosis, rheumatoid arthritis, myositis, vasculitis, or Sjögren's syndrome; women who had a positive pregnancy test or who were planning to become pregnant during the study period; and persons who were unable to pass the Mini–Mental State Examination (i.e., those with a score less than or equal to 24 [out of 30] points).[17] Participants were allowed to continue routine medications and maintain usual visits with their primary care physicians or rheumatologists throughout the study. All patients provided written informed consent.

Study Design

We assigned participants to tai chi or the control intervention in three randomization cycles, using computer-generated numbers. The randomized treatment assignments were sealed in opaque envelopes and were opened individually for each patient who agreed to be in the study.

The sponsors had no role in the design and conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript. The study was conducted in accordance with the trial protocol.

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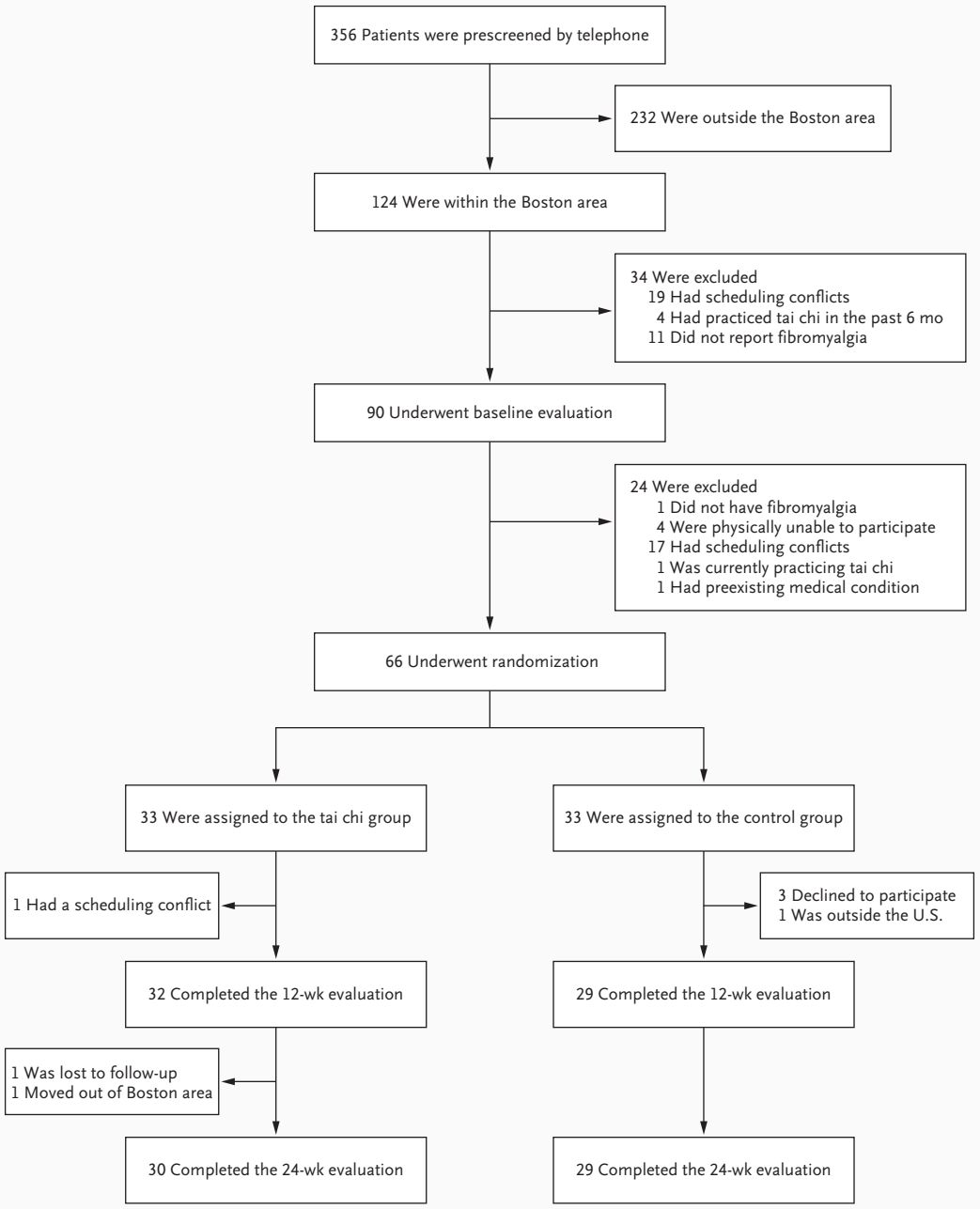

Figure 1. Screening, Randomization, and Completion of 12-Week and 24-Week Evaluations.

TAI CHI INTERVENTION

The tai chi intervention took place twice a week for 12 weeks, and each session lasted for 60 minutes. Classes were taught by a tai chi master with more than 20 years of teaching experience. In the first session, he explained the theory behind tai chi and its procedures and provided participants with printed materials on its principles and techniques. In subsequent sessions, participants practiced 10 forms from the classic Yang style of tai chi[18] under his instruction. Each session included a warm-up and self-massage, followed by a review

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of principles, movements, breathing techniques, and relaxation in tai chi. Throughout the intervention period, participants were instructed to practice tai chi at home for at least 20 minutes each day. At the end of the 12-week intervention, participants were encouraged to maintain their tai chi practice, using an instructional DVD, up until the follow-up visit at 24 weeks.

CONTROL INTERVENTION

Our wellness education and stretching program similarly included 60-minute sessions held twice a week for 12 weeks.[19] At each session, a variety of health professionals provided a 40-minute didactic lesson on a topic relating to fibromyalgia, including the diagnostic criteria; coping strategies and problem-solving techniques; diet and nutrition; sleep disorders and fibromyalgia; pain management, therapies, and medications; physical and mental health; exercise; and wellness and lifestyle management.[20] For the final 20 minutes of each class, participants practiced stretching exercises supervised by the research staff. Stretches involved the upper body, trunk, and lower body and were held for 15 to 20 seconds. Participants were instructed to practice stretching at home for 20 minutes a day.

ADHERENCE TO PROGRAMS

Participants in both groups were encouraged to continue their routine activities during the 12-week intervention period but were asked not to take part in any new, additional exercise programs. Adherence was maximized by an oral and written commitment from all participants at the baseline evaluation. The research staff asked participants who missed a class to attend a make-up class. Throughout the 12-week intervention period, we tracked the number of missed sessions and asked subjects to complete daily logs indicat-

Table 1. Baseline Characteristics of the Study Participants.*

Variable	Tai Chi Group (N=33)	Control Group (N=33)
Female sex — no. of patients (%)	28 (85)	29 (88)
Age — yr	49.7±11.8	50.5±10.5
White race — no. of patients (%)†	20 (61)	17 (52)
High-school or higher education — no. of patients (%)	31 (94)	30 (91)
Body-mass index‡	33.9±8.9	31.5±7.4
Duration of fibromyalgia-related pain — yr	11.8±6.9	10.0±7.2
Medications taken before intervention — no. of patients (%)		
Analgesics	29 (88)	24 (73)
Antidepressants	17 (51)	15 (45)
Anticonvulsants	9 (27)	5 (15)
Muscle relaxants	9 (27)	4 (12)
Benzodiazepines	5 (15)	3 (9)
Self-reported coexisting illness — no. of patients (%)		
Heart disease	0	0
Hypertension	12 (36)	6 (18)
Diabetes	6 (18)	1 (3)
FIQ score§	62.9±15.5	68.0±11
Visual-analogue scale¶		
Patient's global assessment	5.8±2.3	6.3±1.8
Physician's global assessment	5.7±1.9	5.6±2.4
PSQI score‖	13.9±3.1	13.5±3.7
SF-36 score**		
Physical component	28.5±8.4	28.0±7.8
Mental component	42.6±12.2	37.8±10.5

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Table 1. (Continued.)

Variable	Tai Chi Group (N=33)	Control Group (N=33)
CES-D score††	22.6±9.2	27.8±9.2
CPSS score‡‡	5.2±1.9	4.6±2.2
6-Minute walk test — yd§§	522.1±102.7	501.2±106.6
Outcome Expectations for Exercise score¶¶	3.7±0.8	3.9±0.7

* Plus–minus values are means ±SD unless otherwise noted.
† Race was reported by the patients.
‡ The body-mass index is the weight in kilograms divided by the square of the height in meters. This value was missing for one patient in the tai chi group.
§ The Fibromyalgia Impact Questionnaire (FIQ) assesses physical function, common symptoms, and general well-being in fibromyalgia. Scores range from 0 to 100, with higher scores indicating more severe symptoms.
¶ Patient global status was assessed separately by the participant and the study physician with the use of a visual-analogue scale. Scores range from 0 to 10, with 0 equaling no pain.
‖ Scores on the Pittsburgh Sleep Quality Index (PSQI) range from 0 to 21, with higher scores indicating worse sleep quality.
** The Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) is a self-administered, 36-item questionnaire that assesses the concepts of physical functioning, role limitations due to physical problems, social function, bodily pain, general mental health, role limitations due to emotional problems, vitality, and general health perceptions. Note that both the physical and mental component summaries can be combined. Scores range from 0 to 100, with higher scores indicating better health status.
†† Scores on the Center for Epidemiologic Studies Depression (CES-D) index range from 0 to 60, with higher scores indicating more dysphoria. The difference between the scores of the two treatment groups was significant ($P<0.05$).
‡‡ The Chronic Pain Self-Efficacy Scale (CPSS) reflects the patients' confidence in their ability to perform a particular behavior or task and is believed to be a determinant of fibromyalgia symptoms. Scores range from 1 to 10, with higher scores indicating better status.
§§ The 6-minute walk test measures the distance covered during the 6-minute walk (in yards) as an objective assessment of mobility. It was considered to be a proxy for physical function, with higher scores indicating improved functional conditioning in fibromyalgia. To convert yards to meters, multiply by 0.9144.
¶¶ Scores on the Outcome Expectations for Exercise Scale range from 1 to 5, with higher scores indicating high outcome expectations.

ing the amount of time they practiced tai chi or stretching exercises.

OUTCOME MEASURES AND FOLLOW-UP

The primary outcome measure was the change in the Fibromyalgia Impact Questionnaire (FIQ) score from baseline to the end of the 12-week intervention. The FIQ is a well-validated, multidimensional measure of the overall severity of fibromyalgia as rated by patients. Categories include the intensity of pain, physical functioning, fatigue, morning tiredness, stiffness, depression, anxiety, job difficulty, and overall well-being.[21] The total score ranges from 0 to 100, with higher scores indicating more severe symptoms.

Secondary outcomes during the 12-week intervention included FIQ scores (obtained weekly). Global pain status was assessed separately by the participant and the study physician, who was unaware of the group assignment, with the use of a visual-analogue scale (VAS) (range, 0 to 10, with higher scores indicating greater pain). The study physician also determined the number of tender sites (of 18 sites in total) according to the standardized protocol.[16,22] The research staff, who were also unaware of the group assignments, evaluated participants' physical performance by measuring the time to completion of the 6-minute walk test (measured in yards).[23] Additional measures included the score on the Pittsburgh Sleep Quality Index (PSQI) (range, 0 to 21, with higher scores indicating worse sleep quality),[24] the score on the depression scale of the Center for Epidemiologic Studies (CES-D) (range, 0 to 60, with higher scores indicating more severe depression),[25] the score on the Outcome Expectations for Exercise Scale (range, 1 to 5, with 1 indicating no expectations for exercise and 5 the highest expectations for exercise),[26] the score on the Chronic Pain Self-Efficacy Scale (CPSS) (range, 1 to 10, with higher scores indicating greater self-efficacy with respect to the management of chronic pain),[27] and the summary scores for the physical and mental quality-of-life components of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) (range, 0 to 100, with higher scores indicating better health status).[28]

Participants continued to take their regular medications, and we recorded any changes in the use of analgesics, antidepressants, anticonvul-

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sants, muscle relaxants, benzodiazepines, dopamine agonists, or 5-hydroxytryptamine agonists. To test durability of the response, outcome measurements were repeated at the 24-week follow-up visit.

Throughout the entire intervention period, we monitored adverse events, using a standard adverse-event case report form at each visit. This form included a description of all unanticipated benefits and undesirable experiences, particularly falls and exacerbations of fibromyalgia symptoms. Lack of an effect with tai chi or with stretching and wellness education was not considered an adverse event. By the nature of an exercise program, delayed muscle soreness (mild muscle pain or discomfort that occurred after exercise, did not require medical intervention, and resolved within 72 hours) was an expected outcome and thus was not considered an adverse event.

STATISTICAL ANALYSIS

A trial conducted in Sweden, in which 58 participants were assigned to 32 weeks of either aquatic exercise or education (control), showed a significant effect size (i.e., standardized mean difference between groups) of 0.7 points in the FIQ score (mean [±SD] change, −0.9±1.3 in the exercise group vs. 0.0±1.4 in the control group).[29] Guided by these results, we randomly assigned 66 patients to two groups (33 patients to each), which provided 78% power to detect a difference between means at a significance level of 5% with the use of a two-sided t-test.

We compared between-group changes in outcomes at 0, 12, and 24 weeks (and weekly FIQ

Table 2. Changes in Primary and Secondary Outcomes.*

Variable	Mean Change from Baseline (95% CI)		Between-Group Difference (95% CI)	
	Tai Chi Group (N=33)	Control Group (N=33)	Tai Chi Group vs. Control Group	P Value†
FIQ score‡				
Week 12	−27.8 (−33.8 to −21.8)	−9.4 (−15.5 to −3.4)	−18.4 (−26.9 to −9.8)	<0.001
Week 24	−28.6 (−34.8 to −22.4)	−10.2 (−16.4 to −4.0)	−18.3 (−27.1 to −9.6)	<0.001
Patient's global assessment score§				
Week 12	−2.5 (−3.3 to −1.7)	−0.6 (−1.4 to 0.2)	−1.9 (−3.1 to −0.7)	0.002
Week 24	−2.4 (−3.1 to −1.7)	−0.7 (−1.4 to 0.01)	−1.7 (−2.7 to −0.8)	0.001
Physician's global assessment score§				
Week 12	−1.0 (−1.7 to −0.4)	0.02 (−0.6 to 0.7)	−1.1 (−1.9 to −0.2)	0.02
Week 24	−0.5 (−1.2 to 0.1)	0.6 (0.03 to 1.2)	−1.1 (−2.0 to −0.2)	0.02
PSQI score¶				
Week 12	−3.6 (−4.8 to −2.4)	−0.7 (−1.9 to 0.5)	−2.9 (−4.6 to −1.2)	0.001
Week 24	−4.2 (−5.8 to −2.7)	−1.2 (−2.7 to 0.4)	−3.0 (−5.2 to −0.9)	0.007
6-Minute walk test (yd)‖				
Week 12	60.6 (37.9 to 83.3)	16.3 (−6.4 to 38.9)	44.4 (12.3 to 76.4)	0.007
Week 24	49.8 (25.9 to 73.8)	23.2 (0.8 to 47.1)	26.7 (−7.2 to 60.5)	0.12
Body-mass index**				
Week 12	0.02 (−0.4 to 0.4)	−0.2 (−0.5 to 0.2)	0.2 (−0.3 to 0.7)	0.47
Week 24	−0.2 (−0.7 to 0.3)	−0.3 (−0.8 to 0.2)	0.1 (−0.6 to 0.8)	0.76
SF-36 score††				
Physical component				
Week 12	8.5 (5.7 to 11.3)	1.4 (−1.5 to 4.2)	7.1 (3.1 to 11.1)	0.001
Week 24	8.4 (5.6 to 11.3)	1.5 (−1.4 to 4.3)	7.0 (2.9 to 11.0)	0.001
Mental component				
Week 12	7.7 (3.9 to 11.6)	1.6 (−2.2 to 5.4)	6.1 (0.7 to 11.6)	0.03
Week 24	8.5 (4.6 to 12.4)	1.2 (−2.7 to 5.0)	7.3 (1.9 to 12.8)	0.009

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Table 2. (Continued.)

Variable	Mean Change from Baseline (95% CI)		Between-Group Difference (95% CI)	
	Tai Chi Group (N=33)	Control Group (N=33)	Tai Chi Group vs. Control Group	P Value†
CES-D score‡‡				
Week 12	−8.1 (−10.9 to −5.3)	−2.3 (−5.1 to 0.6)	−5.9 (−9.8 to −1.9)	0.005
Week 24	−6.5 (−9.4 to −3.6)	−2.4 (−5.3 to 0.5)	−4.1 (−8.2 to 0.1)	0.05
CPSS score§§				
Week 12	1.5 (0.7 to 2.2)	0.5 (−0.3 to 1.2)	1.0 (−0.03 to 2.0)	0.06
Week 24	1.2 (0.4 to 1.9)	0.6 (−0.2 to 1.4)	0.6 (−0.5 to 1.6)	0.28

* All values are means, with the 95% confidence intervals.
† P values were calculated with repeated-measures analysis of variance.
‡ The Fibromyalgia Impact Questionnaire (FIQ) assesses physical function, common symptoms, and general well-being in patients with fibromyalgia. Scores range from 0 to 100, with higher scores indicating more severe symptoms.
§ Global status was assessed separately by the study participant and the study physician with the use of a visual-analogue scale ranging from 0 to 10, with higher scores indicating greater pain.
¶ Scores on the Pittsburgh Sleep Quality Index (PSQI) range from 0 to 21, with higher scores indicating worse sleep quality.
‖ The 6-minute walk test measures the distance covered during the 6-minute walk (in yards) as an objective assessment of mobility. It was considered to be a proxy for physical function, with higher scores indicating improved functional conditioning. To convert yards to meters, multiply by 0.9144.
** The body-mass index is the weight in kilograms divided by the square of the height in meters. This value was missing for one patient in the tai chi group.
†† Scores on the mental and physical components of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) range from 0 to 100, with higher scores indicating better health status. Values were obtained by means of repeated-measures analysis of variance, which accounts for slight differences from values given in the text.
‡‡ Scores on the Center for Epidemiologic Studies Depression (CES-D) index range from 0 to 60, with higher scores indicating greater dysphoria.
§§ Scores on the Chronic Pain Self-Efficacy Scale (CPSS), which measures patients' confidence in their ability to perform a particular behavior or task, range from 1 to 10, with higher scores indicating improved status.

scores during the 12-week intervention) with mixed models, using time and group as categorical fixed factors, interactions between time and group, random intercepts, and an unstructured covariance matrix. Effects were evaluated on an intention-to-treat basis, and participants who did not complete the follow-up period were considered not to have had any changes in scores. We tested for potential interactions between treatment and covariates, including age, sex, body-mass index, fibromyalgia duration, pain-severity score, coexisting illnesses, health status, and medication use. A two-sided P value of less than 0.05 indicated statistical significance. Results are presented as between-group differences with 95% confidence intervals.

RESULTS

Between July 2007 and December 2008, we screened 356 patients by telephone. Of the 124 patients who resided near Boston, 90 qualified for the baseline evaluation; 24 patients in this group were excluded for various reasons, and the 66 eligible participants were randomly assigned in equal numbers to either the tai chi intervention or the control intervention (Fig. 1).

BASELINE CHARACTERISTICS OF THE PATIENTS

Table 1 shows baseline data for the 66 participants before randomization. Participants had a mean age of 50 years, 86% were women, and 56% were white; the mean body-mass index (the weight in kilograms divided by the square of the height in meters) was 32.7. On average, participants had had fibromyalgia for 11 years. Baseline characteristics were reasonably well balanced between the two groups, except that the tai chi group had a lower CES-D score. The average score on the physical component of the SF-36 was about 2 SD below normal, indicating a cohort with poor health.

The rate of attendance during the 12-week intervention was 77% for the tai chi group and 70% for the control group. Five patients withdrew from the study by 12 weeks, and seven by 24 weeks (Fig. 1).

Table 2 and Figure 2 show changes from base-

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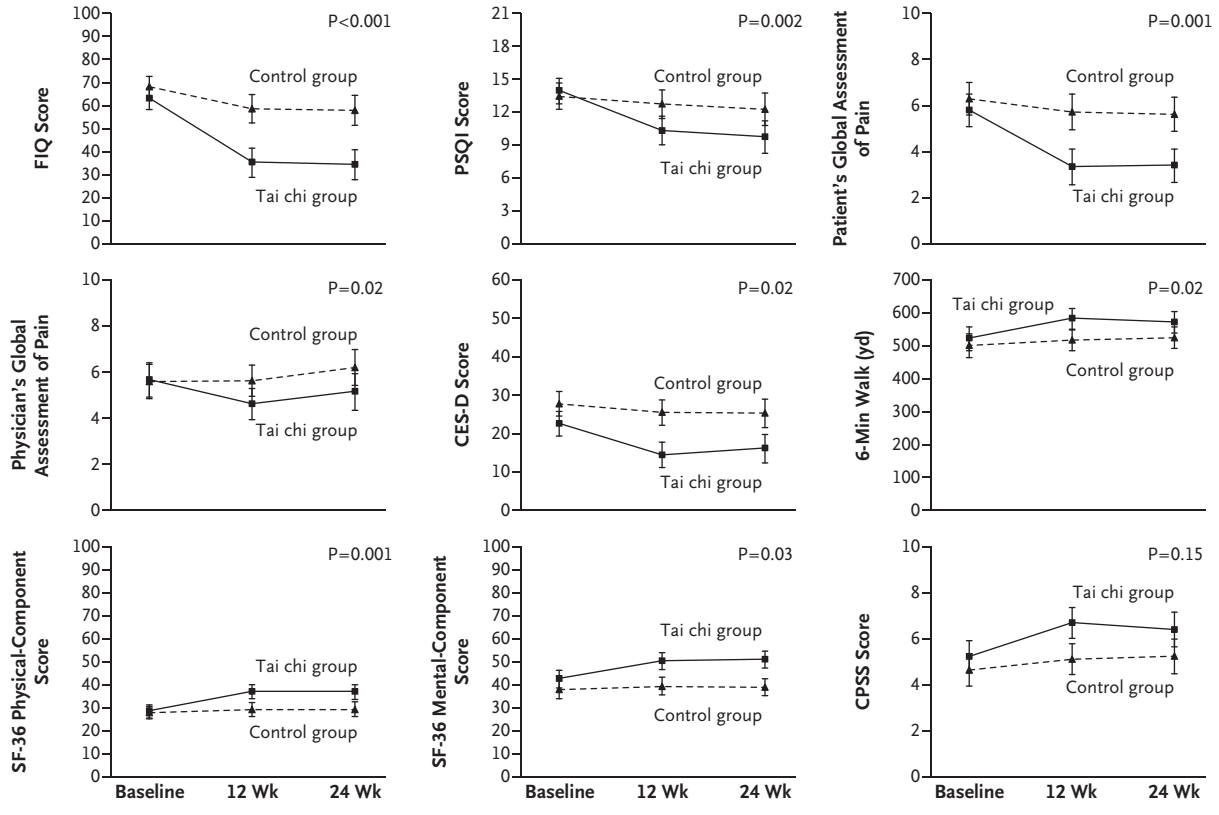

Figure 2. Mean Changes in Nine Secondary Outcomes at 12 and 24 Weeks, According to Treatment Group.

Outcome scores are shown for the tai chi group (squares) and the control group (triangles). The values shown are unadjusted means; I bars indicate 95% confidence intervals. Measurements were obtained at baseline, 12 weeks, and 24 weeks, but data points are slightly offset for clarity. Scores on the Fibromyalgia Impact Questionnaire (FIQ) range from 0 to 100, with higher scores indicating more severe symptoms. Scores on the Pittsburgh Sleep Quality Index (PSQI) range from 0 to 21, with higher scores indicating worse sleep quality. Global assessments of pain were made on a visual-analogue scale (VAS) from 0 to 10, with 0 equaling no pain. Scores on the Center for Epidemiologic Studies Depression (CES-D) index range from 0 to 60, with higher scores indicating more severe depression. The 6-minute walk test is measured in yards (to convert values to meters, multiply by 0.9144). Summary scores on the physical and mental components of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36) range from 0 to 100, with higher scores indicating better health status. Scores on the Chronic Pain Self-Efficacy Scale (CPSS) range from 1 to 10, with higher scores indicating greater self-efficacy with respect to the management of chronic pain. In summary, for the FIQ, the PSQI, the patient and physician assessments on the VAS, and the CES-D, lower scores indicate improvement in outcome. For the SF-36 physical and mental components, the 6-minute walk test, and the CPSS, higher scores indicate improvement in outcome.

line to 12 and 24 weeks in the two groups for all outcomes.

At 12 weeks, the tai chi group had a significantly greater decrease in the total FIQ score than did the control group (–27.8 points [95% confidence interval {CI}, –33.8 to –21.8] vs. –9.4 points [95% CI, –15.5 to –3.4]). The mean between-group difference was –18.4 points (95% CI, –26.9 to –9.8). Figure 3 shows that the mean between-group difference in FIQ scores gradually increased during the intervention. Similarly, at 24 weeks the tai chi group had a significant reduction in symptoms (change in the total FIQ score from baseline to 24 weeks, –28.6 points [95% CI, –34.8 to –22.4]), which was greater than the improvement in the control group; the mean between-group difference in the change from baseline to 24 weeks was –18.3 points (95% CI, –27.1 to –9.6; P<0.001).

At 12 weeks, the tai chi group had greater mean improvement in sleep quality than the control group, as measured by the change in the PSQI score (mean between-group difference, –2.9 points [95% CI, –4.6 to –1.2]; P=0.001). In addition, the tai chi group had greater improvement as measured by the change in the patient's global assessment (mean between-group difference, –1.9

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points [95% CI, −3.1 to −0.7]; P=0.002). The change from baseline to 12 weeks in the physician's objective global assessment also differed significantly between the two groups (mean between-group difference, −1.1 points [95% CI, −1.9 to −0.2]; P=0.02). The 6-minute walk test was significantly better with tai chi at 12 weeks (mean between-group difference, 44.4 yd [95% CI, 12.3 to 76.4]; P=0.007). At 12 weeks, the tai chi group also had greater improvement in the scores for the SF-36 physical component (mean between-group difference, 7.1 points [95% CI, 3.1 to 11.1]; P=0.001), the SF-36 mental component (mean between-group difference, 6.1 points [95% CI, 0.7 to 11.6]; P=0.03), and the CES-D (mean between-group difference, −5.9 points [95% CI, −9.8 to −1.9]; P=0.005). The tai chi group had greater improvement in the CPSS score, but the difference was not significant (mean between-group difference, 1.0 point [95% CI, −0.03 to 2.0]; P=0.06). The body-mass index remained stable in both groups.

Improvements with tai chi were maintained at 24 weeks for sleep quality, the patient's and physician's global assessments, the scores for the SF-36 physical and mental components, and the CES-D score. The changes from baseline to 24 weeks in the 6-minute walk test and the CPSS score also favored tai chi over the control intervention, but the between-group difference was not significant.

Table 3 shows that, with a clinically meaningful change in the FIQ score defined as 8.1 points,[30] significantly more patients in the tai chi group than in the control group had improvement: 79% versus 39% (P=0.001) at 12 weeks, and 82% versus 53% (P=0.009) at 24 weeks. The tai chi group also met standards for clinically meaningful improvement in the patient's VAS score for pain and in sleep-quality, CES-D, and SF-36 scores significantly more often than did controls (Table 3).

All treatment effects remained significant after adjusting for the baseline CES-D score, and no interactions with treatment were found. No adverse events were noted during the study interventions.

MEDICATION USE

At 12 weeks, more subjects had discontinued medication used to treat fibromyalgia in the tai chi group than in the control group, but the difference was not significant (11 of 31 patients vs. 4 of 26, P=0.09).

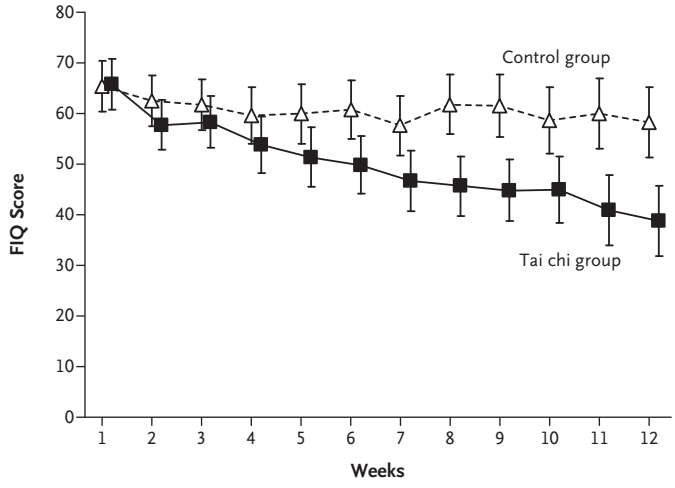

Figure 3. Fibromyalgia Impact Questionnaire (FIQ) Scores during the 12-Week Intervention Period, According to Treatment Group.

FIQ scores, measured weekly over the 12-week intervention period, are shown for the tai chi group and the control group. The FIQ scores range from 0 to 100, with higher scores indicating more severe symptoms and lower scores indicating improvement in outcomes. The values shown are unadjusted means; the data points are slightly offset for clarity. I bars indicate 95% confidence intervals.

DISCUSSION

This randomized, controlled trial shows that tai chi is potentially a useful therapy for patients with fibromyalgia. The effect was evident in the FIQ score, a well-validated, multidimensional instrument for the assessment of fibromyalgia, and in other measures of pain and quality of life and was consistent with both subjective and objective assessments. The observed benefits exceeded the specified thresholds for clinically significant improvement in the FIQ score[30] and in the measures used to assess pain,[31] sleep quality,[24] depression,[32] and quality of life,[28,33] and these benefits were sustained at 24 weeks. No adverse events were reported in the study participants, indicating that tai chi is probably a safe therapy for patients with fibromyalgia.

Our results are consistent with those of a previous, nonrandomized trial of tai chi for fibromyalgia, as well as with the findings in other studies showing the benefits of tai chi with regard to musculoskeletal pain, depression, and quality of life.[13,34] Our findings are also consistent with observations from other clinical trials and meta-analyses that support the benefits of physical exercise and mind–body

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Table 3. Patients with Clinically Meaningful Improvement.

Variable	Tai Chi Group (N=33)	Control Group (N=33)	P Value*
	no. of patients (%)		
FIQ score†			
Week 12	26 (78.8)	13 (39.4)	0.001
Week 24	27 (81.8)	17 (51.5)	0.009
Patient's global assessment‡			
Week 12	18 (54.5)	9 (27.3)	0.02
Week 24	18 (54.5)	9 (27.3)	0.02
PSQI score§			
Week 12	13 (39.4)	4 (12.1)	0.01
Week 24	15 (45.5)	6 (18.2)	0.02
CES-D score¶			
Week 12	24 (72.7)	16 (48.5)	0.04
Week 24	23 (69.7)	13 (39.4)	0.01
SF-36 scores‖			
Physical component			
Week 12	18 (54.5)	5 (15.2)	0.001
Week 24	17 (51.5)	5 (15.2)	0.002
Mental component			
Week 12	14 (42.4)	8 (24.2)	0.12
Week 24	16 (48.5)	8 (24.2)	0.04

* P values were calculated with the use of the chi-square test.
† A change in the score on the Fibromyalgia Impact Questionnaire (FIQ) of 14% (or 8.1 units) indicates clinically meaningful improvement.[30]
‡ A reduction of 30% (or 2 points) on a visual-analogue scale indicates clinically meaningful improvement.[31]
§ A change of greater than 5 in the total score of the Pittsburgh Sleep Quality Index (PSQI) indicates clinically meaningful disturbed or poor sleep.[24]
¶ A reduction of 10% (or 6 points) on the Center for Epidemiologic Studies Depression (CES-D) index indicates a clinically significant change.[32]
‖ On follow-up, changes of 6.5 points on the SF-36 physical-component scale and of 7.9 points on the mental-component scale indicate clinically meaningful improvement.[28,33]

practice for symptom management in fibromyalgia.[35-41]

The biologic mechanisms by which tai chi might affect the clinical course of fibromyalgia remain unknown. As a complex, multicomponent intervention, tai chi may act through many intermediate variables along the pathway to improved health outcomes. Physical exercise has been shown to increase muscle strength and blood lactate levels in some patients with fibromyalgia.[42] Mind–body interventions may improve psychosocial well-being, increase confidence, and help patients overcome fear of pain.[43] Furthermore, controlled breathing and movements promote a restful state and mental tranquility, which may raise pain thresholds and help break the "pain cycle."[44] All these components may influence neuroendocrine and immune function as well as neurochemical and analgesic pathways that lead to enhanced physical, psychological, and psychosocial well-being and overall quality of life in patients with fibromyalgia.[40,45,46]

Our study had some limitations. We did not use a double-blind study design, since this would have required the use of sham tai chi, for which no validated approach currently exists. Devising a sham mind–body intervention poses a set of unique challenges when one attempts to separate the various mind and body components. Nevertheless, the development of some form of sham intervention for use in future studies of tai chi is a desirable goal. To minimize the influence of preexisting beliefs and expectations with respect to tai chi (e.g., its possible placebo effect), we informed participants only that the study was designed to test the effects of two different types of exercise training programs, one of which was combined with education. Deemphasizing tai chi may have lessened participants' expectations and minimized biases. Notably, the baseline outcome expectations of benefit from an exercise intervention were similar in the tai chi and control groups (3.7±0.8 and 3.9±0.7, respectively), indicating that our neutral presentation of the interventions may have been successful.

The fact that treatment was delivered by a single tai chi master at a single center also potentially limits the generalizability of our results. However, the group of patients with poor health status at baseline may in general resemble patients with fibromyalgia. For these reasons, it would be prudent to further explore the benefits of tai chi for fibromyalgia in other settings with other instructors. Since tai chi is a complex mind–body intervention with a variety of active ingredients, such as social support, relaxation, and cognitive behavioral elements,[47] assessment of its placebo effect might require separate evaluations of these ingredients. Finally, we followed participants for only 24 weeks, so the long-term effectiveness of tai chi in patients with fibromyalgia remains to be determined.

In conclusion, our preliminary findings indi-

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cate that tai chi may be a useful treatment in the multidisciplinary management of fibromyalgia. Longer-term studies involving larger clinical samples are warranted to assess the generalizability of our findings and to deepen our understanding of this promising therapeutic approach.

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