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Group and home-based tai chi in elderly subjects with knee osteoarthritis: a randomized controlled trial

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Objective: To evaluate the effects of tai chi consisting of group and home-based sessions in elderly subjects with knee osteoarthritis.
Design: A randomized, controlled, single-blinded 12-week trial with stratification by age and sex, and six weeks of follow-up.
Setting: General community.
Participants: Forty-one adults (70 $\pm$ 9.2 years) with knee osteoarthritis.
Interventions: The tai chi programme featured six weeks of group tai chi sessions, 40 min/session, three times a week, followed by another six weeks (weeks 7–12) of home-based tai chi training. Subjects were requested to discontinue tai chi training during a six-week follow-up detraining period (weeks 13–18). Subjects in the attention control group attended six weeks of health lectures following the same schedule as the group-based tai chi intervention (weeks 0–6), followed by 12 weeks of no activity (weeks 7–18).
Main outcome measures: Knee pain measured by visual analogue scale, knee range of motion and physical function measured by Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) were recorded at baseline and every three weeks throughout the 18-week study period. Data were analysed using a mixed model ANOVA.
Results: The six weeks of group tai chi followed by another six weeks of home tai chi training showed significant improvements in mean overall knee pain ($P = 0.0078$), maximum knee pain ($P = 0.0035$) and the WOMAC subscales of physical function ($P = 0.0075$) and stiffness ($P = 0.0206$) compared to the baseline. No significant change of any outcome measure was noted in the attention control group throughout the study. The tai chi group reported lower overall pain and better WOMAC physical function than the attention control group at weeks 9 and 12. All improvements disappeared after detraining.

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Conclusions: The group and home based tai chi programme provided significant knee pain reduction and physical function improvement in elderly subjects with knee osteoarthritis. These effects were not sustained after detraining.

Introduction

Osteoarthritis is a major cause of disability in the ageing population with its prevalence increasing and consequences significantly impacting society.[1] There is no known cure for osteoarthritis, and it can significantly alter activities of daily living. Symptoms include pain, stiffness in the morning, joint swelling, limited range of motion, decreased physical function, restriction of social activities and/or compromised work capacity.[2] Non-operative management of osteoarthritis, including drug therapy[3–7] and exercise prescriptions, is emphasized by the medical community.[8]

As a non-invasive management of osteoarthritis, group and home-based exercise programmes such as aerobics, resistance training, and hydrotherapy have been shown to improve physical function and decrease knee pain.[9–14] However, depending on its nature, exercise does not always benefit osteoarthritis. The duration of heavy physical activity has been found to be associated with risk of knee osteoarthritis.[15] The selection criteria in terms of type, intensity, and duration for exercises beneficial to knee osteoarthritis remains unclear.[16]

As a low-impact, low-intensity alternative exercise therapy, tai chi has been proposed as a potential option for the management of osteoarthritis.[17] Only two published studies have prospectively assessed the effects of tai chi on osteoarthritis.[18,19] Hartman *et al*. evaluated the effects of 12 weeks of tai chi exercise and found significant improvements in osteoarthritis symptoms such as fatigue, total arthritis self-efficacy, feelings of tension and satisfaction with general health status.[18] Song *et al*. further demonstrated that tai chi resulted in significantly less pain and stiffness in joints, fewer perceived difficulties in physical functioning, improved balance and improved abdominal strength in osteoarthritis patients.[19]

The objectives of this randomized, controlled trial were to evaluate (1) the effects of a tai chi exercise programme consisting of six weeks of instructed group training followed by another six weeks of home-based practice, on knee pain (primary outcome), as well as knee range of motion and physical function (secondary outcomes) in subjects with knee osteoarthritis, and (2) if such effects would diminish after detraining. The rationale for such a tai chi programme is to teach patients to practise tai chi first during instructed group sessions for a limited period of time, followed by home practice with video instructions, allowing long-term exercise therapy. The six-week period for the group tai chi programme was selected because it is a typical time period of physical therapy intervention for osteoarthritic patients.[20] A home-based tai chi programme was investigated as it could become an affordable choice for patients after six weeks of supervised tai chi. Since it is common for patients to discontinue practice once they feel improvement of symptoms owing to the exercise therapy, it is of value to investigate the possible outcomes as the result of detraining. Therefore, a period of detraining follow-up was included in this study.

The present study is different from previous studies[18,19] on tai chi and osteoarthritis in that it is the first study (1) to include and investigate the effects of group and home video tai chi exercise intervention programmes, (2) to assess the sustainability of the effects of tai chi on osteoarthritis after cessation of the exercise intervention, (3) to include measurements taken at intermediate time points to allow more in-depth evaluation compared with the pre- and post-measures taken in previous studies,[18,19] and (4) to use a standardized form of tai chi exercise that has been most widely employed in published longitudinal tai chi studies for various health issues.[21]

Materials and methods

Study design

A randomized, controlled, 12-week prospective trial with a six-week follow-up and five measurement periods (baseline, 3, 6, 9 and 12 weeks) was

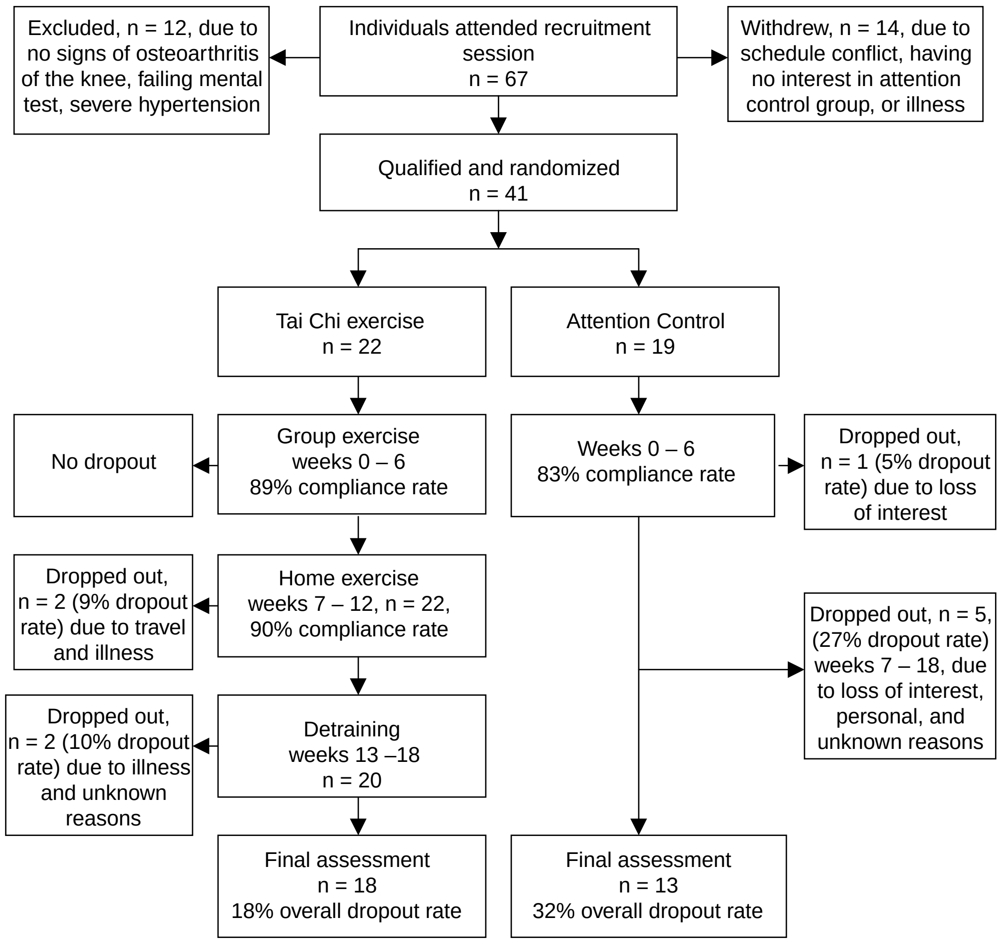

Figure 1 Study design and CONSORT diagram showing the flow of participants.

conducted (see Figure 1). The assessors were blinded to the participants' treatment assignments. The 12-week trial period preceded a six-week follow-up period with measurements taken at weeks 15 and 18.

Participants

Subjects aged 50 years or older with knee pain were recruited through local TV, newspaper advertisement and flyers. Selection of subjects was based on the Classification Criteria of the American Rheumatism Association for Osteoarthritis of the Knee.[22] This classification, based exclusively on clinical criteria, has been reported to yield 84% specificity and 89% sensitivity for diagnosis of osteoarthritis of the knee.[22] Subjects were excluded from taking part if they could not read or write English, could not ambulate at least 25 feet (7.6 m), had a medical condition involving knee trauma or intra-articular knee injection within one month, exercise-induced or uncontrolled angina within three months, severe dyspnoea at rest, terminal illness, uncontrolled hypertension, acute or chronic renal failure, bilateral total knee arthroplasties, or a Mini-Mental State Exam[23] score of 23 or lower. The number of participants in the treatment arms at each stage of the study are shown in Figure 1. This study was approved by the local Institutional Review Board. All subjects signed written informed consent before participating in the study.

Demographic and baseline characteristics of subjects

Information on age, sex, pain medication, physical activity level, knee pain (visual analogue scale) and function using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[24] was obtained by self-report from the participants, while body weight, height, blood pressure and heart rate were measured. Outcome measures for knee pain, knee range of motion, and function are described in the Outcome measures section.

Randomization

After baseline measurement, participants were randomly assigned to either tai chi or attention control group using a randomization table. Randomization was stratified by age (<70 years old and ≥ 70 years old) and sex (male/female) to control for the extraneous effects of the attribute variables of age/sex and to avoid discrepancies in distribution of subjects between the tai chi and attention control groups.

Sample size

Sample size was estimated based on predictions of 30% change in pain and 20% in WOMAC scores observed between tai chi and attention control groups.[19] Assuming an attrition rate of 10% based on our previous tai chi clinical trials, and an alpha level of 0.05, a sample size of approximately 40 subjects (20 in each group) at baseline was needed to provide at least 80% power in detecting significant (two-sided) differences in both the WOMAC and pain scores.

Intervention protocol

The intervention began one week after the baseline measures were administered. Attendance was recorded for each participant and compliance was defined as the number of sessions completed divided by the total number of sessions prescribed. Participants were also asked to maintain their regular diet, medication intake if any, normal daily activities and lifestyle throughout the study. The details of the tai chi and attention control intervention programmes are described below.

Tai chi exercise programme

Subjects in the tai chi group attended three instructed group tai chi classes each week for six weeks, followed by another six weeks (weeks 7–12) of home video tai chi practice at the same frequency. Both group and home classes consisted of 5 min of warm-up exercise, 30 min of tai chi training and 5 min of cool-down exercise. Subjects were taught by an instructor to practise the 24-form simplified Yang-style tai chi,[25,26] a standardized and most popular tai chi routine. Tai chi exercise featured gentle, smooth, graceful, coordinated and flowing movements of different body parts, emphasizing constant shifting of body weight between two legs with both knees slightly flexed all the time. The tai chi routine was repeated five times during the training period based on the standard speed of about 6 min per routine.[25,26] The instructor explained and demonstrated how the exercise should be performed, and subjects followed. The videotape for the home practice was especially produced for this research, and featured a typical group class taught during the first six weeks by the same instructor.

While attendance during the group exercise phase was determined through the research personnel's records, subjects were asked to maintain exercise log books and report the number of prescribed exercise sessions completed during the home tai chi phase. After the home exercise period, subjects were requested to discontinue tai chi practice for six weeks of detraining (weeks 13–18).

Attention control group activities

Subjects in the attention control group attended three 40-min group sessions per week for six weeks, with the same meeting timing, duration and location (same campus but different building) as the tai chi group. Each session consisted of 30 min of lecture, followed by 10 min of discussion. The lectures covered health-related topics such as osteoporosis, ageing, cardiovascular disease, stroke and diabetes. The attention control group did not take part in any further activity beyond the six-week group sessions (weeks 7–18).

Adverse events

Participants were questioned about the presence of any adverse events before and after each exercise class. The instructor also monitored participants during the class for any sign of such events.

Outcome measures

Outcome measures of this study included the following: (1) knee pain as the primary outcome measure, and (2) knee range of motion and physical function as the secondary outcome measures. Investigators evaluating the outcome measures were blinded to intervention allocation, tai chi instructors were blinded to outcome measures, and participants were instructed not to disclose their group allocation. Only the measurements of the knee considered by each subject as most symptomatic at baseline were taken.

Assessment of knee pain

The severity of knee pain during the week preceding each data collection session was quantitatively measured using a 10-cm visual analogue scale with a scale from 0 (no pain) to 10 (unbearable pain) for maximum and overall knee pain for the knee studied.[27–29] The use of the visual analogue scale to assess pain[27] and most specifically musculoskeletal knee pain[30] has been found to be a valid and reliable measurement tool.

Assessment of knee range of motion

Active range of motion for flexion and extension of the knee was measured in the supine position using standard goniometry.[31] Criterion validity and reliability of knee range of motion measurements have been found to be high using standard goniometry.[32] In the current study, inter-rater reliability of knee range of motion measurements was established between two blinded investigators who took all range of motion measurements with an intraclass coefficient correlation of 0.74.

Assessment of physical function

Physical function was quantified using the WOMAC questionnaire with a scale from 26 (no difficulty) to 130 (extreme difficulty) indicating the level of difficulty associated with overall functional activities due to knee pain, including subscales of knee pain (35 points), stiffness (10 points) and physical function (85 points).[24,33] WOMAC scoring has been found to be a valid and reliable tool to use in knee osteoarthritic subjects.[34,35]

Statistical analyses

Statistical analyses were performed using SAS software Release 9.1.3 (SAS, Inc., Cary, NC, USA). Data from all subjects who entered the study and did not withdraw within the first week of the trial were used to minimize bias and to provide a more realistic indication of the generality and effectiveness of the intervention. A value of $\alpha = 0.05$ was used to define significance. Following the study design, the key analysis performed to identify the effects of the 12-week tai chi intervention was a 2 (treatments) $\times 4$ (periods) mixed model ANOVA, with baseline value (week 0) and body mass index covariates, to make within- and between-group comparisons. Furthermore, blocks for binary age (less than 70 or at least 70) and sex were included in the model to account for the stratified randomization scheme used in assigning treatments to subjects. For the detraining period, 2 (treatments) $\times 2$ (periods) mixed model ANOVA was conducted.

Normality assumption was tested for each outcome variable. Omnibus tests were conducted to determine the significance of group, time and group*time for the outcome variables considered. To maintain control of family-wise type I error rates, contrast testing was carried out. The homogeneity of slopes test was performed for body mass index and baseline covariates. Multiple comparison adjustments were made using Rom's multiple comparison procedure.[36] Dunnett–Hsu adjusted P-values were used in the treatment specific contrast tests.

In addition, two-sample t-tests were used to determine baseline comparability of treatment groups for the demographic and outcome (dependent) variables. Chi square analyses were carried out to evaluate difference between drop-out rates of tai chi and attention control groups, and to determine if gender was a significant determinant of non-participation, while a t-test was used to evaluate the significance of age as a factor of drop-out and the difference between the tai chi and attention control groups in class attendance. Pearson's correlation coefficient (r) was computed to evaluate relationship between the baseline physical characteristics (age, height, weight, body mass index) and group class compliance for both tai chi and attention control subjects, as well as home compliance for the tai chi subjects. Pearson's r was also computed to assess the association of the outcomes variables with group and home exercise compliance.

Results

Baseline characteristics

Baseline characteristics by group are summarized in Table 1. Baseline comparability tests confirmed no significant differences between the attention control and tai chi groups in all baseline variables.

Adverse events

Sporadic complaints of minor muscle soreness and foot and knee pain were made mainly during the first few days of the intervention. No other adverse effect associated with the practice of tai chi was reported by the participants.

Attrition and compliance

Details of attrition are shown in Figure 1. Neither gender nor age was a significant factor of drop-out. Analysis showed no significant difference in the demographic and baseline measures between the drop-outs and the participating subjects ($P > 0.05$). Compliance for the first six weeks was 89% for the tai chi group and 83% for the attention control group, with no significant difference between groups. The tai chi subjects

Table 1 Baseline characteristics

Characteristic	Tai chi ($n = 22$)	Attention control ($n = 19$)	*P*-value*
Age, years, mean ± SD	70.8 ± 9.8	68.8 ± 8.9	0.51
Sex, *n* (%)	0.42		
Male	3 (13.6%)	4 (21.1%)	
Female	19 (86.4%)	15 (78.9%)	
Blood pressure, systolic/diastolic, mmHg, mean ± SD	144/81 ± 18.3/9.3	139/82 ± 15.3/10.6	0.50
Heart rate, pulse/min, mean ± SD	74.2 ± 8.5	77.7 ± 12.7	0.32
Weight, kg, mean ± SD	71.6 ± 21.8	75.2 ± 19.6	0.97
Height, m, mean ± SD	1.63 ± 0.08	1.65 ± 0.08	0.65
Body mass index. kg/m^2, mean ± SD	27.96 ± 5.92	27.7 ± 6.57	0.89
Pain medication, including NSAID use, *n* (%)	4 (18.1%)	4 (21.1%)	0.9
Physical activity, *n* (%)	0.52		
No activity	8 (36.4%)	5 (26.3%)	
1–3 times/week	7 (31.8%)	10 (52.9%)	
≥ 4 times/week	7 (31.8%)	4 (21.1%)	
Mini-Mental State Exam	29.05 ± 1.47	28.59 ± 1.56	0.34
Baseline pain VAS[a]			
Maximum, mean ± SD	5.66 ± 2.53	5.41 ± 1.95	0.72
Minimum, mean ± SD	2.88 ± 2.56	2.71 ± 1.70	0.81
Overall, mean ± SD	4.67 ± 2.59	4.16 ± 1.79	0.46
Baseline knee range of motion			
Flexion/extension, degrees, mean ± SD	123 ± 13.07	125 ± 14.28	0.65
Baseline WOMAC[b]			
Pain, mean ± SD	16.48 ± 5.33	16.9 ± 4.23	0.78
Stiffness, mean ± SD	5.57 ± 1.17	5.11 ± 1.37	0.26
Physical function, mean ± SD	42.74 ± 12.07	37.63 ± 10.61	0.17
Overall, mean ± SD	64.58 ± 17.44	59.63 ± 15.22	0.36

SD, standard deviation; NSAID, non-steroidal anti-inflammatory drug.
**P*-values for Fisher's exact test.
[a]VAS (visual analogue scale) from 0 (no knee pain) to 10 (unbearable knee pain).
[b]WOMAC: Pain subscale from 7 (no pain) to 35 (extreme pain); Stiffness subscale from 2 (no stiffness) to 10 (extreme stiffness); Physical function subscale from 17 (no difficulties with activity of daily living) to 85 (extreme difficulties with activity of daily living). Overall WOMAC scale from 26 (best possible score) to 130 (worst possible score) due to knee pain.

Table 2 Pearson correlation coefficient (*r*) between home tai chi exercise compliance and the outcome measures during (weeks 7–12) and after (weeks 13–18) home exercise period

	Knee range of motion	Knee pain (min)	Knee pain (max)	Knee pain (overall)	WOMAC (pain)	WOMAC (stiffness)	WOMAC (function)	WOMAC (overall)
Weeks 7–9	0.297	–0.334	–0.542**	–0.528*	–0.570*	–0.351	–0.496*	–0.516*
Weeks 10–12	–0.066	–0.103	–0.280	–0.385	–0.398	–0.073	–0.690**	–0.691**
Weeks 13–15	0.193	–0.303	–0.454*	–0.330	–0.670**	–0.704**	–0.692**	–0.693*
Weeks 16–18	0.127	0.027	–0.078	–0.007	–0.115	0.082	–0.092	–0.089

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

self-reported 15 (SD = 5.02) exercise sessions completed on average during the home exercise period, resulting in a compliance rate of 90%. Compliance with the home tai chi programme was found to be significantly related to outcome measures during and after the home training period for the tai chi group. For instance, as shown in Table 2, home compliance during weeks 7–9 was negatively correlated with maximum and overall knee pain (visual analogue scale), overall WOMAC, WOMAC pain and physical function scores at week 9. Subjects were asked to report at each measurement session any change in pain medication or additional exercise regimen during the intervention period, and no changes were reported by the subjects.

Outcome measurements

The normality tests indicated that all except overall pain met the normality assumption. Consequently, the overall visual analogue pain scale was log-transformed. No significant difference was found in knee range of motion within or between the tai chi and attention control groups throughout the intervention period. For the tests for the homogeneity of slopes, Rom's procedure yielded a statistically significant interaction ($P = 0.014$) between groupings and body mass index for maximum pain. Group-by-time interactions of all other outcome variables were statistically insignificant. As a result, tests performed for maximum pain could be somewhat conservative.[37]

The effects of tai chi intervention

Statistical analysis of the present results showed significance for overall pain ($P = 0.0078$), maximum pain ($P = 0.0035$), WOMAC physical function ($P = 0.0075$) and WOMAC stiffness ($P = 0.0206$) during the 12-week exercise intervention period.

Between-group differences

Significant between-group differences are shown in Figure 2a,b and Figure 3, and in Table 3, indicated by the '#' signs. Specifically, the tai chi group reported less overall pain and better WOMAC physical function than the attention control group at weeks 9 and 12 ($P = 0.0089$ and 0.0157, respectively), and less maximum pain at weeks 6 and 9. Significant between-group differences were also found in WOMAC overall and pain subscale at week 9, and physical function subscale at weeks 9 and 12. No significant between-group differences were found in the WOMAC stiffness subscale.

Within-group differences

No significant change of any outcome measure was noted in the attention control group. Significant differences within the tai chi group are indicated by asterisks in Figure 2a,b and 3, and in Table 3. The within-group differences were established by comparing data at different time points with baseline. Significant improvement in overall pain started at week 3, and started at week 6 in WOMAC stiffness subscale. In the maximum pain scale, overall WOMAC and physical function subscales, the significant improvements started at week 9. Improvement in WOMAC pain subscale was shown only at week 9.

The effects of detraining

Statistical analysis for the detraining period (weeks 13–18) showed significance ($P = 0.0137$) for the knee range of motion. The tai chi group's significant improvement in knee range of motion

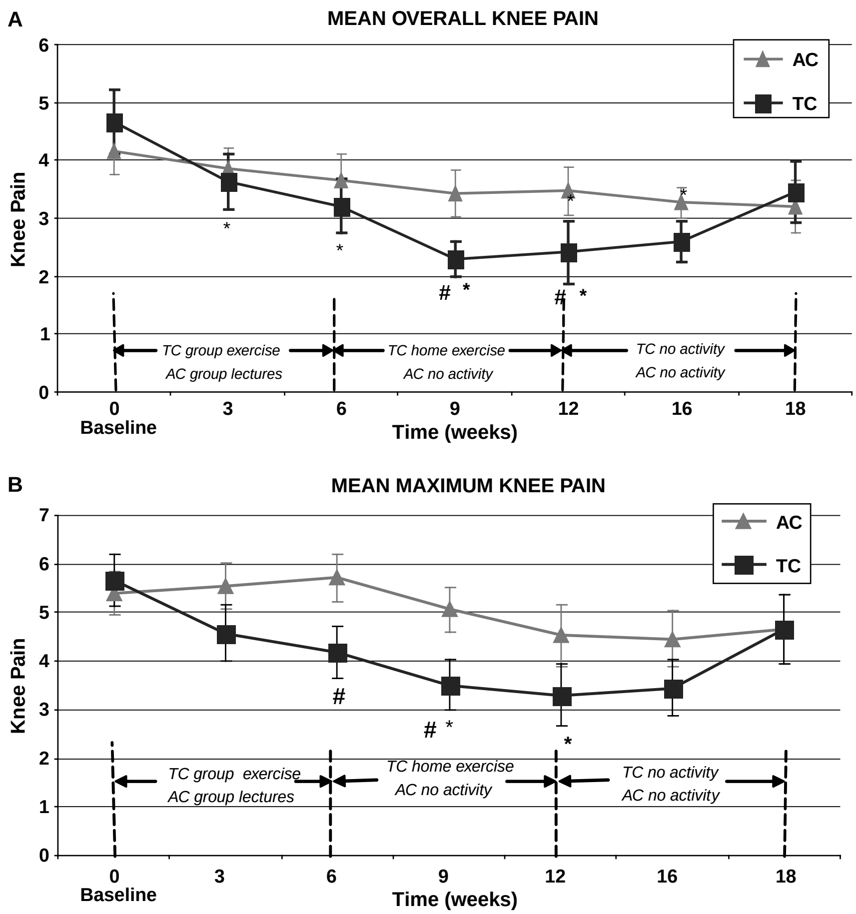

Figure 2 (a) Mean overall knee pain (visual analogue scale) and (b) mean maximum knee pain (visual analogue scale). Error bars represent the standard error of the mean (SEM). *Tai chi (TC) data significantly different from baseline ($P < 0.05$). #Significant difference between tai chi and attention control (AC) ($P < 0.05$).

was noted at week 18 in comparison to week 12 ($P = 0.0296$) (data not shown). However, no significant difference was found in pain or WOMAC within the tai chi or attention control group, or between the two groups throughout the follow-up detraining period.

Discussion

The present results indicated that a 12-week exercise programme including group tai chi for six weeks followed by home tai chi for another six weeks resulted in significant reduction of knee pain and improvement of function in elderly subjects with painful knee osteoarthritis. The present results support those from Hartman *et al.*[18] and Song *et al.*[19] and demonstrate improved pain and function in osteoarthritis patients after 12 weeks of tai chi intervention, although the current intervention used a different tai chi exercise programme including home video practice. The current study further revealed that tai chi intervention resulted in a significant decrease in knee pain relative to baseline starting as early as week 3 (Figure 2a), suggesting tai chi's early beneficial effect on symptoms associated with knee osteoarthritis. Such information has not been previously reported.

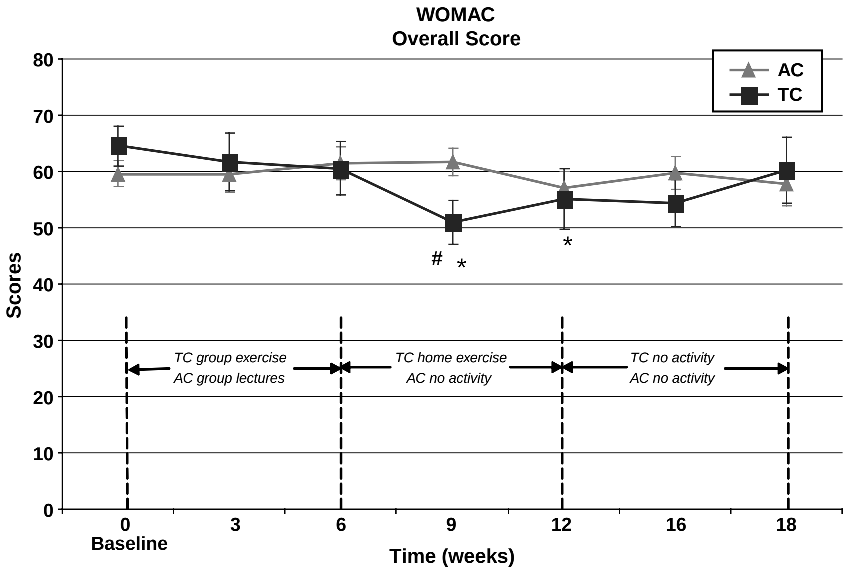

Figure 3 Overall WOMAC. Error bars represent the standard error of the mean (SEM). *Tai chi (TC) data significantly different from baseline ($P < 0.05$). #Significant difference between tai chi and attention control (AC) ($P < 0.05$).

The current knee pain and WOMAC scores suggested that individual home tai chi practice maintained the beneficial effects of the preceding group tai chi taught by an instructor, although improvements were attenuated, especially from week 9 to week 12 of the trial. This indicates that tai chi could be taught in group classes and then continued independently as a home exercise routine in subjects with knee osteoarthritis. Further research allowing parallel instead of sequential comparison between group and home tai chi programmes will be needed to determine the effectiveness of home tai chi versus group tai chi practice in subjects with knee osteoarthritis.

Since both the attention control and tai chi subjects travelled to the intervention facility and were involved in group activity during the first six weeks of the study, the present results suggested that psychosocial variables occurring with travelling to the intervention classes and social interaction associated with group activity were not responsible for the improvements in pain and function observed in subjects with knee osteoarthritis in the tai chi group.

This is the first study to investigate the effects of tai chi on knee osteoarthritis during follow-up detraining. Six weeks is apparently an appropriate follow-up time because (1) it allowed demonstration of the disappearance of tai chi's beneficial effects after detraining, and (2) it did not result in a large drop-out rate which could possibly be a concern with an extended follow-up period. The present follow-up detraining data suggested that tai chi should be practised on a routine basis in order to maintain its beneficial effects on knee osteoarthritis symptoms. Future research could evaluate the effect of a long-term tai chi exercise regimen in subjects with knee osteoarthritis.

The WOMAC overall score data suggested that improvements in physical function took a longer time to occur than improvements in pain. There was a 22% improvement of the WOMAC overall score from baseline to week 9, with a 26% for pain, 24% for stiffness, and 30% for function. These represented significant beneficial effects of tai chi as changes of 20% to 25% in WOMAC score are considered to be clinically important.[37] Similar clinically meaningful gains have been reported previously in subjects with knee osteoarthritis.[19] This is encouraging, as elderly individuals suffering from a mild to moderate degree of symptomatic knee osteoarthritis could experience significant improvements in pain and function, leading to greater ease in performing daily activities, more

Table 3 Mean and standard deviation of outcome measures

	Baseline Mean (SD)	3 weeks Mean (SD)	6 weeks Mean (SD)	9 weeks Mean (SD)	12 weeks Mean (SD)	15 weeks Mean (SD)	18 weeks Mean (SD)
Overall knee pain (VAS)							
Control	4.16 (1.79)	3.86 (1.51)	3.66 (1.96)	3.43 (1.79)	3.37 (1.78)	3.17 (1.62)	3.19 (1.97)
Tai Chi	4.67 (2.59)	3.63 (2.23)	3.2 (2.2)	1.43 (0.31)*#	2.41 (2.05)*#	2.7 (2.29)	3.46 (2.45)
Maximum knee pain (VAS)							
Control	5.41 (1.95)	5.56 (2.05)	5.72 (2.01)	5.07 (1.96)	4.63 (2.07)	4.45 (2.32)	4.65 (2.61)
Tai Chi	5.66 (2.48)	4.58 (2.76)	4.18 (2.51)#	3.51 (2.36)*#	3.3 (2.43)*	3.45 (2.68)	4.65 (3.05)
WOMAC overall score							
Control	59.63 (15.22)	59.56 (20.25)	61.54 (17.2)	61.71 (14.57)	57.1 (16.95)	59.75 (16.64)	57.73 (19.58)
Tai Chi	64.58 (17.44)	61.68 (13.1)	60.59 (19.34)	50.9 (20.4)*#	55.18 (24.2)*	54.42 (21.5)	60.28 (23.8)
WOMAC pain subscale							
Control	16.89 (4.23)	16.44 (5.07)	16.64 (4.57)	16.73 (4.27)	15.55 (4.34)	15.25 (3.92)	16 (4.88)
Tai Chi	16.48 (5.33)	15.14 (4.56)	15.39 (5.7)	13.4 (5.95)*#	14.36 (7.11)	13.95 (5.81)	16.39 (6.96)
WOMAC stiffness subscale							
Control	5.11 (1.37)	4.72 (1.67)	4.71 (1.96)	4.56 (1.1)	4.67 (1.4)	4.81 (1.38)	4.54 (1.51)
Tai Chi	5.57 (1.16)	5.43 (1.16)	4.73 (1.42)*	4.5 (1.7)*	4.7 (1.66)*	4.57 (1.6)	5.28 (1.53)
WOMAC function subscale							
Control	37.63 (10.61)	38.72 (13.57)	40.69 (11.89)	39.53 (10.7)	37.77 (11.22)	39.44 (12.09)	37.58 (13.12)
Tai Chi	42.74 (12.07)	39.35 (9.12)	39.5 (12.96)	32.2 (13.3)*#	31.82 (14)*#	34.75 (14.19)	38.61 (15.62)

#ANOVA mixed model: significant difference between tai chi and attention control ($P < 0.05$).
*ANOVA mixed model: tai chi data significantly different from baseline ($P < 0.05$).

active lifestyle and healthier physical activity behaviours as a result of tai chi training. Such improvements in pain and function are similar to those recorded in previous trials[9,13,14] involving elderly subjects with knee osteoarthritis using resistance training programmes, suggesting that quadriceps strength or the knee movements associated with the strengthening programmes are beneficial to subjects with knee osteoarthritis. Future research comparing the effectiveness and cost of these approaches would be valuable.

A drop-out rate of 43% has been previously reported during a 12-week tai chi programme in subjects with symptomatic knee osteoarthritis[19] while a lower tai chi overall drop-out rate of 18% was recorded in the present study. The lower drop-out rate in the present study might be related to the fact that tai chi subjects attended 18 sessions (12 h) of instructed group exercise in the present study, compared with only six supervised exercise sessions before being asked to practise independently at home in the previous study.[19]

The present result agreed with a previous study that no significant difference was found in knee range of motion between the tai chi and attention control groups during the intervention, suggesting that tai chi exercises do not alter flexibility.[19] The mean arc of knee motion for the subjects involved in the present study was 124 degrees, which is lower than that of normal elderly subjects of similar age,[38] suggesting that a ceiling effect did not occur. The fact that tai chi activities do not place the joints in extreme ranges of motion might explain these findings. The improvement in range of motion observed during detraining was interesting but needs further investigation.

Clinical messages

- A 12-week tai chi programme consisting of six weeks of group exercise followed by six weeks of home exercise produced significant pain reduction.
- The positive effects of tai chi were not sustained after six weeks of detraining, suggesting that tai chi should be practised as a regular exercise routine, and should not be presented as a cure for knee osteoarthritis.

This study was limited by its small sample size. The results of the present study should not be extrapolated to a non-ambulatory population with severe knee osteoarthritis. The mean overall and maximum knee pain reported by the subjects at the beginning of the study were 4.4 and 5.5, respectively, on a 10-point visual analogue scale, and all subjects were able to ambulate at least 25 feet (7.6 m) independently. Although some subjects were awaiting total knee arthroplasties and indicated greater severity of knee osteoarthritis symptoms (24% of the participating subjects reported $\geq$ 8/10 maximum knee pain and 17% reported $\geq$ 7/10 overall knee pain), all were ambulatory, which might be a condition of success of such exercise programmes. Further research is needed to evaluate the effects of tai chi on subjects with greater pain and functional losses.

Conclusion

Results of the present study suggest that a 12-week tai chi programme consisting of six weeks of group exercise followed by six weeks of home exercise may provide knee pain reduction and physical function improvement in the elderly with knee osteoarthritis. The positive effects of tai chi were not sustained after six weeks of detraining, suggesting that tai chi should be practised as a regular exercise routine, and should not be presented as a cure for knee osteoarthritis. Further studies with a larger sample size are needed to confirm these findings.

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