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ScienceDirect

Journal of Sport and Health Science 5 (2016) 297–303

www.jshs.org.cn

Original article

Effects of Tai Ji Quan training on gait kinematics in older Chinese women with knee osteoarthritis: A randomized controlled trial

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Received 15 September 2015; revised 9 December 2015; accepted 18 December 2015

Available online 15 February 2016

Abstract

Background: Although Tai Ji Quan has been shown to relieve pain and improve functional mobility in people with knee osteoarthritis (OA), little is known about its potential benefits on gait characteristics among older Chinese women who have a high prevalence of both radiographic and symptomatic knee OA. This study aims to assess the efficacy of a tailored Tai Ji Quan intervention on gait kinematics for older Chinese women with knee OA.

Methods: A randomized controlled trial involving 46 older women in Shanghai, China, with clinically diagnosed knee OA. Randomized (1:1) participants received either a 60 min Tai Ji Quan session ($n = 23$) 3 times weekly or a 60 min bi-weekly educational session ($n = 23$) for 24 weeks. Primary outcomes were changes in gait kinematic measures from baseline to 24 weeks. Secondary outcomes included changes in scores on the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) and Short Physical Performance Battery (SPPB).

Results: After 24 weeks the Tai Ji Quan group demonstrated better performance in gait velocity (mean difference, 8.40 cm/s, $p = 0.01$), step length (mean difference, 3.52 cm, $p = 0.004$), initial contact angle (mean difference, 2.19°, $p = 0.01$), and maximal angle (mean difference, 2.61°, $p = 0.003$) of flexed knees during stance phase compared to the control group. In addition, the Tai Ji Quan group showed significant improvement in WOMAC scores ($p < 0.01$) (mean difference, −4.22 points in pain, $p = 0.002$; −2.41 points in stiffness, $p < 0.001$; −11.04 points in physical function, $p = 0.006$) and SPPB scores (mean difference, 1.22 points, $p < 0.001$).

Conclusion: Among older Chinese women with knee OA, a tailored Tai Ji Quan intervention improved gait outcomes. The intervention also improved overall function as indexed by the WOMAC and SPPB. These results support the use of Tai Ji Quan for older Chinese adults with knee OA to both improve their functional mobility and reduce pain symptomatology.

Keywords: Gait; Pain; Physical function; Rheumatic diseases; Tai Chi Quan

1. Introduction

The incidence of knee osteoarthritis (OA), an articular pathology, increases with age,[1] with older adults being the most frequently affected. In China, epidemiological studies have shown a high prevalence of knee OA among middle-aged and older Chinese.[2–5] For example, a cross-sectional study in Beijing indicated that 15% of women and 5.6% of men aged 60 years and over had symptomatic knee OA.[2] The study further showed that when compared with Caucasian women of the same age living in the US (i.e., from Framingham, MA), older women in Beijing had a roughly 50% higher prevalence of both radiographic and symptomatic knee OA and a twofold higher prevalence of bilateral cases.[2,3] From a global public health perspective, knee OA is considered a major cause of chronic disability, particularly for older adults who often experience deterioration in physical function, thereby impacting their quality of life and requiring medical treatments that add significant costs to the healthcare system.[6,7]

Peer review under responsibility of Shanghai University of Sport.

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http://dx.doi.org/10.1016/j.jshs.2016.02.003

Exercise, which has been shown to help alleviate symptoms and improve physical function,[8] is recommended in all clinical guidelines[9–12] as a non-pharmacological approach for managing and treating knee OA. However, many forms of physical activity are either very intense or highly monotonous, making them difficult to implement and maintain in practice. One approach that does not have these disadvantages is Tai Ji Quan (also known as Tai Chi Chuan and Tai Chi). This traditional Chinese practice has long been used to cultivate and nurture physical and mental well-being, prevent chronic disease progression, and enhance fitness.[13] Research increasingly shows that many OA signs and symptoms, such as reduced joint mobility, poor balance, pain, increased joint stiffness, and limited physical function, can be ameliorated by Tai Ji Quan training.[5,14–20] The accumulating evidence has led the American College of Rheumatology to recommend Tai Ji Quan as a treatment option for patients with knee OA.[12]

Due to the degradation of the knee joint, people with knee OA exhibit gait impairments such as reduced walking speed, shorter step length, and decreased knee-joint motion,[21–24] characteristics that could have a significant impact on their ability to perform routine daily activities. Previous randomized controlled trials (RCTs), however, have rarely utilized objective measures to quantify changes in gait characteristics[18,19] following Tai Ji Quan training. Therefore, the extent to which this modality promotes functional gait characteristics remains to be further evaluated. Furthermore, the need to establish its treatment efficacy is of high public health importance in China, where no RCTs have been conducted among Chinese women. Finally, no RCTs have been conducted specifically using tailored Tai Ji Quan movements to evaluate its therapeutic benefits for those with knee OA.

To fill these gaps, we designed an RCT to determine the efficacy of a specifically tailored Tai Ji Quan training intervention to enhance objectively quantified gait kinematic outcomes among older Chinese women with knee OA. On the basis of prior research,[18] we hypothesized that a tailored Tai Ji Quan intervention would improve spatiotemporal gait and knee range-of-motion outcomes.

2. Methods

2.1. Trial design

The study used a parallel-group RCT design to compare a Tai Ji Quan intervention with a health education control across a 24-week period. The trial included a 3-time-per-week intervention with classes conducted in local community centers. The study design and protocols (assessment, group assignment, and training) have been described elsewhere.[25] The trial protocol was approved by the Ethics Committee of the Shanghai University of Sport and was performed in accordance with the World Medical Association Declaration of Helsinki-Ethical Principles for Medical Research involving Human Subjects. A written informed consent was received from all participants. Chinese Clinical Trial Registry (June 16, 2013): ChiCTR-TRC-13003264.

2.2. Study population and participants

Chinese women were the targeted study population because they have been shown to have a high prevalence of symptomatic and radiographic knee OA.[2–5] Major inclusion criteria for participating included (1) having a clinical diagnosis of knee OA per the criteria provided by the American College of Rheumatology,[26] diagnosed through the use of knee radiographs and physical examination, (2) being between 60 and 70 years of age, and (3) being available 3 times a week over a 24-week period. In addition, a radiographic assessment of the erect anterior-posterior and medial-lateral views of both knees was conducted with classification made on the anterior-posterior and tibial-femoral radiographs using the Kellgren–Lawrence (K/L) grading scale (0–4) for knee OA,[27] in which a grade of ≥1 was regarded as knee OA. Individuals who met the KL 1–3 grade standard were recruited.

Exclusion criteria included (1) having had lower limb surgery, (2) having other orthopedic problems of the hip, knee, or ankle, (3) having a neurological disease (e.g., Parkinson's, dementia, vertigo, or cerebral apoplexy), or (4) engaging in a current program of regular exercise. Also excluded were individuals who were unable to stand or walk and those who had received other forms of therapy in the preceding 2 months. Finally, those who expected to have major changes in their medication regimen or who were part of a rehabilitation program during the study were also excluded.

Participants were recruited between January and March in 2013 through contacts with community leaders and presentations at various community centers. A follow-up appointment was made for those who responded to the study promotion and indicated an interest in participating. These individuals were asked to visit a designated research facility where a detailed knee OA screening procedure and baseline assessments were conducted. Those who qualified per the study eligibility criteria were subsequently assigned to either the Tai Ji Quan group (TG) or the control group (CG). Intervention began within 1 week after the baseline assessment was completed.

2.3. Randomization and blinding

The individuals who met the eligibility criteria were allocated in a 1:1 ratio using a computer-generated random sequence with a permutated block size of 4. All assignments were made by a research staff member who was not directly involved in the trial. The assessors who conducted the outcome measures were blind to group allocation and were unaware of the study hypotheses. All statistical analyses were performed with masking maintained.

2.4. Intervention

2.4.1. Tai Ji Quan group

Individuals in this group participated in a 60 min session 3 times weekly for 24 weeks. The training protocol included 8 Tai Ji Quan forms: "Withdraw and push", "Fan through the back", "Wave hands like clouds", "Lift hand", "Brush knee and twist steps", "Step back to repulse monkey", "Fair lady works at shuttles", and "Golden pheasant stands with one leg (right and left)". All 8 forms were adapted primarily from a 24-form practice routine.[28] To avoid over-strenuous activities around the knee joints, modifications were made to specifically focus on