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CLINICAL STUDY

# Gait analysis of patients with knee osteoarthritis before and after Chinese massage treatment

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## Abstract

The objective of this study was to evaluate the effectiveness of Chinese massage therapy in patients with knee osteoarthritis (OA) by measuring lower-limb gait parameters. We recruited 20 women with knee OA, who then underwent Chinese massage therapy three times per week for 2 weeks. The patients underwent gait evaluation using a six-camera infrared motion analysis system. They completed Western Ontario and McMaster Universities Osteoarthritis Index questionnaires before and after treatment. We calculated the forward speed, step width, step length, total support time percentage, initial double support time percentage, and single support time percentage. We also measured the angles at the knee, hip, and ankle during the stance phase of walking. The results showed statistically significant mean differences in knee pain relief, alleviation of stiffness, and physical function enhancement after therapy ($P < 0.05$). The patients gained significantly faster gait speed, greater step width, and increased total support time percentage after the Chinese massage therapy ($P < 0.05$). There were no significant differences in the range of motion or initial contact angles of the knee, hip, or ankle during the stance phase of walking. We concluded that Chinese massage is a beneficial complementary treatment and an alternative therapy choice for patients with knee OA for short-term pain relief. Chinese massage may improve walking ability for these patients.



**Key words:** Gait; Osteoarthritis, Knee; Massage

## INTRODUCTION

Osteoarthritis (OA) is estimated to be the fourth leading cause of disability strongly associated with aging, and populations in the Asian region are aging rapidly.

Most of the disability burden is attributable to knee OA.[1] A recent survey in six Chinese cities reported that, for people aged ≥ 40 years, 32.8% of women and 23.5% of men have been diagnosed with radiographically confirmed knee OA.[2] Patients suffering from knee OA also experience knee pain, limited daily activities, and loss of functional independence ¾ all of which affect their quality of life.

Traditional Chinese massage therapy has a history of more than 2000 years and is one of the most popular complementary and alternative therapies in China for patients with knee OA. Patients with knee OA commonly undergo Chinese massage therapy two or three times a week for 2 weeks. Although some studies showed beneficial effects of this alternative therapy for reducing pain and improving physical knee function, these studies were evaluated primarily by medical imaging and self-assessment questionnaires.[3-7] The outcome of subjective questionnaires is dependent on patient self-reporting. Medical imaging cannot provide adequate insight into the kinematics that occur during daily activities, such as walking. Movement analysis offers a more accurate way to study joint kinematics. Gait analysis is a particularly effective tool for examining changes in movement patterns in joints and has been used to study the gait data for knee OA.[8-11] The purpose of this study was to apply motion analysis to assess the efficacy of Chinese massage in improving kinematic features in patients with knee OA.

## MATERIALS AND METHODS

### *Patients*

A total of 20 women diagnosed with knee OA were recruited from Yueyang Hospital of Integrated Traditional Chinese and Western Medicine in Shanghai between January 2012 and May 2013. Inclusion criteria were based on the clinical criteria for knee OA (bilateral) as indicated in the clinical criteria of the American College of Rheumatology[12] for those 50-70 years of age. All patients were diagnosed with knee OA based on a clinical assessment that included knee radiography and a physical examination. The main physical examination included determining the range of motion (ROM) and location of the knee pain. The anterior drawer test was used to evaluate injury of the anterior cruciate ligament, and the McMurray test was used to determine if there was a meniscal injury. Only those with negative anterior drawer and McMurray tests were included in the study. Radiographic assessment of the erect anteroposterior and mediolateral views of both knees was undertaken. The classification was based on anteroposterior tibiofemoral radiographs using the Kellgren-Lawrence (K/L) grading scale (0-4) for knee OA,[13] in which a grade of ≥1 was regarded as indicating the presence of knee OA. Subjects were recruited (K/L 1-2) according to the K/L scale classification.

Patients were excluded if they had had previous lower limb surgery, other orthopedic problems of the hip, knee, or ankle, or a neurological disease (e.g., Parkinson's, dementia, vertigo, cerebral apoplexy).

A summary of the patients' demographics appears in Table 1.

Table 1 Demographics of all patients with knee osteoarthritis

| Characteristic | Mean (*SD*) | Range |
|---|---|---|
| Age (years) | 60.35 (5.18) | 50-70 |
| Height (cm) | 158.35 (8.23) | 140-175 |
| Weight (kg) | 62.45 (8.59) | 45-78 |
| BMI (kg/m$^2$) | 24.93 (3.15) | 17.58-31.05 |
| K/L grade[a] | Ⅰ: 15, Ⅱ: 25 | Ⅰ-Ⅱ |

Notes: *SD*: standard deviation; OA: osteoarthritis; BMI: body mass index; K/L: Kellgren-Lawrence. [a]Grades I and II of the K/L radiographic classification for knee OA were assigned to 15 and 25 patients, respectively.

The Research Ethics Committee of the Yueyang Hospital of Integrated Traditional Chinese and Western Medicine, affiliated with Shanghai University of Traditional Chinese Medicine, approved the trial protocol. The study was conducted according to the common standard guidelines of the Declaration of Helsinki. All patients were requested to sign a written informed consent statement before the study. The trial was registered in the Chinese Clinical Trial Registry (ChiCTR-TRC-1300396).

### *Chinese massage treatment protocols*

Patients with knee OA underwent 25- to 30-min sessions of Chinese massage therapy three times a week for 2 weeks provided by a professional Chinese massage therapist. Each session consisted of pressing and thumb-kneading on eight acupoints following World Health Organization standard acupuncture point locations[14] around the knee area: Yinlingquan (SP 9), Xuehai (SP 10), Liangqiu (ST 34), Heding (EX-LE 2), Xiyan (EX-LE 5, inside and outside Xiyan), Zusanli (ST 36), Yanglingquan (GB 34), Weizhong (BL 40).[15,16] Various muscles and ligaments on the thigh and leg were massaged by thumb-kneading the quadriceps femoris, gracilis, sartorius, semimembranosus, semitendinosus, biceps femoris, peroneus longus, gastrocnemius, and tibialis anterior muscles, as well as the quadriceps, patellar, and hamstring tendons and the iliotibial band.

### *Gait analysis*

In a gait laboratory at Yueyang Hospital of Integrated Traditional Chinese and Western Medicine in Shanghai, all patients performed barefoot walking trials at their self-selected, comfortable walking speed. Three successful gait cycles for each limb were recorded for each patient, visually verified by the test leader. A Helen Hayes retroreflective marker set (Motion Analysis Corp., Santa Rosa, CA, USA) was used to determine

the three-dimensional kinematics.[17] Walking data were obtained using a six-camera infrared motion analysis system (Santa Rosa, California, Motion Analysis Corp, USA). Data collection was performed using EvaRT 5.0.4 (Santa Rosa, California, Motion Analysis Corp, USA), at 100 Hz. The data were assessed using OrthoTrak Analysis software (Santa Rosa, California, Motion Analysis Corp, USA).

***Clinical evaluation***

The clinical evaluation included disability measures of knee pain, stiffness, and function. These parameters were assessed using the answers the patients provided on the Western Ontario McMaster Universities Osteoarthritis Index (WOMAC) questionnaire.[18] The WOMAC questionnaire included 24 questions that were assessed on a 10-cm visual analog scale, which was used to measure scores in three domains: five pain questions, two stiffness questions, and 17 function questions.

***Statistical methods***

A paired Student's *t*-test was used to compare significant differences between pretreatment and posttreatment parameters included in the WOMAC questionnaire as well as the gait data we had obtained. Two-tailed $P < 0.05$ indicated statistical significance. Results are presented as the mean and standard deviation ( $\bar{x} \pm s$), and the pretreatment and posttreatment parameters also with 95% confidence intervals (CI). All statistical analyses were performed using SPSS 13.0 for Windows (IBM Corp., Armonk, NY, USA).

## RESULTS

***WOMAC scores***

The overall clinical status of the patients improved following Chinese massage treatment. The WOMAC scores demonstrated that the patients achieved significant pain relief (in both left and right knees, $P = 0.001$), stiffness alleviation (left knee $P = 0.004$, right knee $P = 0.002$), and physical function (left knee $P = 0.004$, right knee $P = 0.003$) (Table 2).

***Gait parameters in temporospatial differences***

Significant increases were observed in self-selected walking speed (left knee $P = 0.034$, right knee $P = 0.021$) and step width ($P = 0.033$) after Chinese massage intervention. There were no significant differences, however, in step length (left knee $P = 0.695$, right knee $P = 0.051$). There were significant differences in the total support time percentage (left knee $P = 0.020$, right knee $P = 0.015$), initial double support time percentage (left knee $P = 0.044$, right knee $P = 0.029$), and single support time percentage (left knee $P = 0.017$, right knee $P = 0.014$), with a significant increase in the total support time percentage and initial double support time percentage and a significant decrease in the single support time percentage (Table 3).

***Gait parameters of joint kinematics***

Although the sagittal ROMs of the knee, hip, and ankle were increased during the stance phase, there were no differences in the ROM gain or the initial contact angle at the knee, hip, or ankle ($P > 0.05$) (Table 4).

## DISCUSSION

In the long history of Traditional Chinese Medicine, Chinese massage is one of the most popular remedies for knee OA. Our findings demonstrated significant improvements in the level of knee joint pain, degree of stiffness, and physical functions after 2 weeks of Chinese massage. These results suggest that Chinese massage could be used as an antiinflammatory and analgesic agent to relieve knee pain in the elderly. Our results are similar to observations from previous clinical trials.[5,6,19,20]

The principal advantage of gait analysis is that the resultant measures are not solely dependent on patient self-reporting. Motion analysis has provided important information concerning gait patterns and variability among patients regarding the degree of severity of their knee OA. Moreover, the variability of gait parameters is an index of gait stability and complexity.[21,22] Previous studies reported that knee OA was associated with reduced gait speed, impaired ROM, and a shorter stance period.[23-29] Our posttreatment observation was that pa-

Table 2 Pretreatment and posttreatment WOMAC scores in patients with knee OA [mean (*SD*)]

| Parameter | Pretreatment WOMAC score | Posttreatment WOMAC score | *P* value |
|---|---|---|---|
| L. pain | 4.05 (2.44) | 3.35 (1.87) | 0.001 |
| R. pain | 3.75 (1.71) | 3.15 (1.46) | 0.001 |
| L. stiffness | 2.10 (2.05) | 1.45 (1.50) | 0.004 |
| R. stiffness | 1.95 (1.88) | 1.25 (1.29) | 0.002 |
| L. function | 13.95 (7.73) | 13.35 (7.55) | 0.004 |
| R. function | 11.95 (7.40) | 9.80 (5.32) | 0.003 |

Notes: WOMAC: western ontario mcmaster universities osteoarthritis index; OA: osteoarthritis; *SD*: standard deviation; L: left knee; R: right knee. $P < 0.05$ was considered statistically significant.

Table 3 Pretreatment and posttreatment temporospatial gait parameters in patients with knee OA [mean (*SD*)]

| Gait parameter | Pretreatment | Posttreatment | *P* value |
|---|---|---|---|
| R. walking speed (m/s) | 99.34 (15.66) | 104.29 (12.75) | 0.021 |
| L. walking speed (m/s) | 99.20 (15.41) | 103.85 (14.01) | 0.034 |
| R. step length (cm) | 54.57 (6.06) | 56.03 (5.37) | 0.051 |
| L. step length (cm | 54.51 (5.27) | 54.86 (4.32) | 0.695 |
| Step width (cm) | 10.82 (2.84) | 11.97 (2.11) | 0.033 |
| R. TST (% GC) | 60.44 (3.32) | 62.62 (1.84) | 0.015 |
| L. TST (% GC) | 60.27 (2.82) | 61.96 (1.67) | 0.020 |
| R. IDST (% GC) | 10.49 (2.86) | 12.03 (1.81) | 0.029 |
| L. IDST (% GC) | 10.93 (2.97) | 12.58 (1.67) | 0.044 |
| R. SST (% GC) | 39.82 (2.89) | 38.00 (1.62) | 0.014 |
| L. SST (% GC) | 39.61 (3.39) | 37.45 (1.89) | 0.017 |

Notes: *SD*: standard deviation; R: right knee; L: left knee; GC: gait cycle; TST: total support time; IDST: initial double support time; SST: single support time. $P < 0.05$ was considered statistically significant.

Table 4 Pretreatment and posttreatment gait parameters of joint kinematics in patients with knee OA [mean (*SD*)]

| Sagittal angle (°) | Pretreatment | Posttreatment | *P* value |
|---|---|---|---|
| R. knee contact | 7.44 (6.37) | 8.77 (6.00) | 0.261 |
| L. knee contact | 9.68 (7.38) | 9.74 (5.79) | 0.957 |
| R. knee ROM | 18.28 (7.71) | 19.80 (9.25) | 0.407 |
| L. knee ROM | 16.84 (6.46) | 17.56 (5.21) | 0.644 |
| R. hip contact | 29.40 (11.81) | 31.05 (8.90) | 0.389 |
| L. hip contact | 29.89 (12.72) | 31.52 (10.42) | 0.387 |
| R. hip ROM | 40.64 (3.55) | 41.20 (4.03) | 0.505 |
| L. hip ROM | 41.04 (4.17) | 41.57 (4.33) | 0.573 |
| R. ankle contact | −5.77 (4.96) | −5.55 (5.01) | 0.863 |
| L. ankle contact | −5.41 (4.09) | −5.35 (5.34) | 0.953 |
| R. ankle ROM | 16.31 (3.51) | 17.71 (3.33) | 0.036 |
| L. ankle ROM | 15.78 (3.43) | 16.64 (3.07) | 0.360 |

Notes: *SD*: standard deviation; R: right; L: left; ROM: range of motion. $P < 0.05$ was considered statistically significant.

tients achieved a faster gait speed, longer step, and increased total support time percentage by increasing the initial double support time percentage. These results suggest that Chinese massage could improve the walking ability of patients with knee OA. Although we thought that Chinese massage could improve knee ROM, we found that the angles of the knee, hip, and ankle during the stance phase of walking (including the ROM and initial contact angle) were not improved after treatment. It is well known that cognitive factors, such as fear of pain, can reduce a patient's willingness to begin or increase physical activities, comprising a major factor contributing to their disability.[30,31] A previous study reported that gait velocity significantly correlated with subjective pain and function scores.[32] It is possible that in our study the temporospatial gait parameters improved significantly because of the pain reduction after Chinese massage therapy. The results of our research show that it is not easy to improve joint ROM using only Chinese massage therapy.

There are several limitations in our study that should be addressed. First, only female patients were recruited for our study. Therefore, we cannot conclusively determine the effects of Chinese massage therapy on male patients. Second, the massage therapy on the patients with knee OA was limited ¾ only six sessions over a 2-week period. Long-term results cannot be expected from short-term treatment. Third, Chinese massage is considered a passive treatment. Hence, it is quite difficult to maintain ongoing beneficial effects after the treatment ends. Future studies should include active exercises that patients with knee OA can be taught to perform themselves.

In conclusion, our study showed that Chinese massage therapy effectively relieved pain and improved physical function in patients with knee OA. We also observed that after Chinese massage therapy the patients increased their gait speed, step width, and total support time percentage. Chinese massage may therefore improve walking ability in patients with knee OA. It is

thus a beneficial complementary treatment and an alternative therapy for short-term pain relief and improved physical function in patients with knee OA. Furthermore, this gait analysis method proved useful for evaluating the effectiveness of Chinese massage therapy on the patients with knee OA.

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