

## Comparative Study of the Effect of Tai Chi and Isometric Exercises on the Severity of Pain and Balance in Patients with Knee Osteoarthritis

Ehsan Ariayi, M.Sc.<sup>1</sup>, Ali Sarchahi, M.Sc.<sup>2</sup>, Seyed Ali Akbar Hashemi Javaheri, Ph.D.<sup>3</sup>

1- Department of Exercise Physiology, Sport Injuries and Corrective Movements, Faculty of Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran (Corresponding author; Ariace\_1370@yahoo.com)

2- Department of Exercise Physiology, Sport Injuries and Corrective Movements, Faculty of Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

3- Associate Professor, Faculty of Sport Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

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### Abstract

**Background:** Osteoarthritis is a chronic and debilitating disease that often occurs in elderly populations, causing pain and loss of balance. The aim of this study was to compare the effect of Tai Chi and isometric exercises on the pain and balance in patients with knee osteoarthritis.

**Methods:** In this study, 24 male subjects with knee osteoarthritis were selected and divided into two groups of 12 persons. Visual Analog Scale was used for pain measurement and Berg Balance Scale (BBS) was applied to measure the balance. The training program included 3 sessions exercise per week, 60 minutes each (10-min warm up, 40-min specialized training, 10-min recovery and mild stretching exercises) for duration of 8 weeks. Data were analyzed through SPSS 16 and using Kolmogorov-Smirnov, t-test and independent t-test.

**Results:** Tai Chi exercises had a significant effect on both pain severity ( $P=0.001$ ) and balance ( $P=0.002$ ). While, isometric exercises had a significant effect only on pain severity ( $P=0.004$ ).

**Conclusion:** It was concluded that Tai Chi exercises have a better effect on pain relief and balance improvement than isometric exercises, and it is advisable to use Tai Chi-isometric exercises to increase balance in patients with osteoarthritis.

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### Introduction

Osteoarthritis (OA) is a chronic and debilitating disease often seen in elderly populations. The most common involved joint is the knee joint (1-3). Osteoarthritis is involved in destruction of synovial joints and affects articular cartilage, leading to articular cartilage loss, synovial membrane inflammation, thickening of the joint capsule, muscle

weakness and bone formation, decreased muscle strength and proprioception (4-9). Decreased proprioception can lead to changes in muscle reflex response and disturbs joint stability (10). According to the previous studies, one of the important complications affecting people with osteoarthritis is balance disorder. Balance disorder in these patients has been reported

as increased amplitude and velocity of balance changes (4, 7, 8, 11).

The main goals of the treatment of osteoarthritis are to reduce pain, restore function and improve the patient's quality of life. The treatment methods for this disease can be divided into three main groups: pharmaceutical, non-pharmacological and surgical procedures (12). Pharmaceutical and surgical procedures have irreparable complications and are often not recommended (13-15). In the last decade, many studies have investigated the effects of weight loss and exercise on reducing pain and improving the function of patients with knee osteoarthritis (16, 17). Various studies have shown that isometric exercises are effective in the treatment of knee osteoarthritis (18-20).

For eliminating OA-related symptoms such as pain, stiffness and reduced muscle strength, isometric and isotonic exercises for knee muscles have been recommended (21-25). A research has shown that isometric exercises stimulate the muscles and, therefore, cause opioids release, which act as sedatives and reduce joint pain. On the other hand, muscle spasms on one side of the body causes numbness in the other side of body also indicating the central response to pain relief (24).

Therefore, isometric exercise can be a good choice to reduce pain in knee arthritis. Recently, researchers have discovered that psychophysiological intervention, an alternative treatment, may reduce the symptoms of knee osteoarthritis by increasing the amount of endorphin and enkephalin (26-28). Tai Chi is a kind of psychophysiological intervention. Tai Chi is characterized as controlled gentle movements and proper body position along with awareness of the body and focus (29). This exercise can be considered as a

relatively easy activity. The mean Metabolic Equivalent of Task (MET) of this exercise is about 3.1 (30).

Tai Chi, with focusing on both physical and cognitive aspects, compared to other exercises that pay attention to just physical aspect, is more recommended (31). The main intrinsic features of Tai Chi include gentle continuous movement and muscle strength and balance training, which have made this type of exercise as a good non-pharmacological treatment for patients with knee osteoarthritis. Tai Chi has been a useful exercise for relieving pain, increasing the range of motion and flexibility, increasing balance and mental health, reducing the risk of falling, and improving the quality of life of people with knee osteoarthritis (32-34).

Exercise may be severe, uncomfortable, and even tedious for elderly people with knee osteoarthritis. Therefore, choosing an appropriate training method is very important in the rehabilitation of patients with knee osteoarthritis. Different studies have been investigated the rehabilitation of patients with knee osteoarthritis and the effect of different therapeutic methods on these patients, and have shown that each of these methods has its own advantages and disadvantages; some have significant effect on these patients and some do not. One of the most important complications of osteoarthritis is pain, which greatly decreases the quality of life in these patients. Another complication of this disease is loss of motor function, including reduced balance especially in the elderly, which is becoming more and more important with aging.

Therefore, paying attention to these two factors in patients with osteoarthritis makes it more necessary to plan and achieve effective methods of rehabilitation. Also, achieving the best results in less time and recognizing the most effective method in comparison with other methods of rehabilitation is

one of the research priorities in the field of rehabilitation. Therefore, in this study, the effect of isometric exercises, as simple but effective exercises, as well as the effect of Tai Chi exercise, as a new exercise with few researches about it, on pain and balance in patients with knee osteoarthritis were investigated and compared.

### Materials and Methods

This quasi-experimental research with control group had a pre/post-test design, which is a kind of applied research. In this study, 24 patients with knee osteoarthritis referred to Imam Reza Hospital, Mashhad whom knee arthritis had been confirmed by a specialist were selected according to American College of Radiology (ACR) criteria and through convenience sampling method. After obtaining their signed consent form and explaining the stages of the study, the patients were randomly divided into two groups of Tai Chi (n=12) and isometric exercises (12 subjects).

The inclusion criteria were no history of prior experience with Tai Chi or other similar exercises such as qigong or yoga, acute medical conditions, such as dementia, neurological diseases, cardiovascular disease, symptom of angina pectoris, peripheral vascular disease, congestive heart failure, severe hypertension, recent stroke, severe insulin-dependent diabetes, mental illness, kidney disease, liver disease, active cancer or anemia, no damage or fracture in the knee, grade 2 or 3 arthritis based on the Kellgren and Lawrence grading system, failure to perform surgery on each of the lower limbs, lack of rheumatoid arthritis and other systemic inflammatory arthropathies, no history of fracture in the joint and Paget's disease around the joint, chronic infection in the knee joint associated with osteoarthritis, physical activities less than twice a week, ability to walk without help, lack of history of

Intra-articular drug injection in the last three months and not taking oral NSAIDs one week before entering the study.

All inclusion criteria were reviewed by a specialist, and then the patients were identified and referred to the researcher. The exclusion criteria were irregular referring of the patients during the study, the intensification of symptoms, and the patients' unwillingness to continue their cooperation. After the identification of the patients and collecting signed consent forms, the training interventions began.

To measure patients' height, height gauge (Seca model 220, made in Germany) was used. For this purpose, every participant without shoes, back to the wall, stood flat and stretched so that the body weight was evenly divided on both legs, and the shoulders were placed in a straight line, and the heads and the eyes were parallel to the horizon. Then, at the end of the exhalation, the board was horizontally placed on the head, and made a vertical angle with vertical ruler. In this way, the height of each participant was measured in centimeters. To measure patients' weight, a digital scale (Seca model 720, made in Germany) was used. For this purpose, the subject without shoes, wearing minimum clothes, stood on the scale and the weight was measured in kilograms. In order to measure the body mass index (BMI), the subjects weight and height were first measured before physical exercises and body mass index (BMI) was calculated by dividing the weight (in kg) by the square of height (in meters).

To measure knee pain severity, Visual Analogue Scale (VAS) for pain-intensity was used. The balance was measured using Berg Balance Scale (BBS). BBS is an appropriate balance test for middle-aged and elderly people (11), consisted of 14 functional tests including rising from a sitting position, standing without support, sitting on a chair without support, sitting on a chair after a standing position, displacement,

standing with closed eyes, standing with feet together and reaching forward in standing position, picking up an object from the ground, turning to the sides to look back, turning 360 degrees on both sides, putting the legs on the quadrilateral by turns, standing in one leg and the other foot in front. The examiner gives the appropriate score in accordance with the instructions for doing each activity. Each activity is scored based on a 5-likert scale of 0 (the lowest level of performance) to 4 (the highest level of performance). The maximum score of this scale is 56.

The training program included 3 sessions per week, each session lasted 60 minutes (10-min warm up, 40-min specialized training in each group, 10-min recovery and mild stretching exercises) and for duration of 8 weeks. Knee isometric exercises were performed at three angles of zero, 45 and 90 degrees of knee flexion, each contraction for 6 seconds, and repeated 6 times at each angle. At angle of zero, the subject was asked to exert isometric contraction in the quadriceps muscle. In the next step, by placing a towel under the shank, the patient was asked to press the towel with the contraction of the muscles.

At angles 45 and 90, the patient was asked to extend the knee by exerting a resistance. Tai Chi does not include

complex movements, but it has been designed to focus on the principles of balance and weight transfer and increasing deep sense. These principles are recognized as Qigong (18 forms), which include gentle and slow movements, paying particular attention to the development of calm and attitude of consciousness in the body. In each training session, depending on the progress, other forms are added and it is emphasized on repetition of the forms.

During the first three weeks, the subjects were fully mastered in 18 forms of Tai Chi and within the remaining five weeks, performed the 18 forms. Also, this program includes a brief section of meditation and massage. To comply with the principle of overload, every week, the number of repetitions of each exercise was increased. At the end, data were collected and analyzed through SPSS16. To determine the normality of the data, the Kolmogorov-Smirnov test was used and to determine the homogeneity of variance, Levene's test was used. Also, intra-group variation and intergroup variation were determined using dependent t-test and independent t-test, respectively.

Demographic and physical characteristics of the subjects of the two groups were consistent in the baseline condition and showed no significant difference ( $P > 0.05$ , table 1).

**Table 1.** Anthropometric characteristics and the results of Kolmogorov-Smirnov test in two groups (n=24).

Variable	Mean $\pm$ Standard Deviation		KS test (P-value)	
	Isometric Group	Tai Chi Group	Isometric Group	Tai Chi Group
Age (year)	54.6 $\pm$ 92.27	51.6 $\pm$ 08.69	0.997	0.544
Height (cm)	170.5 $\pm$ 25.69	168.5 $\pm$ 83.52	0.275	0.995
Weight (kg)	83.8 $\pm$ 33.47	77.9 $\pm$ 75.22	0.830	0.844
BMI (kg/m <sup>2</sup> )	28.2 $\pm$ 72.32	27.1 $\pm$ 17.76	0.981	0.992

According to Table 2, isometric exercises have a significant effect on pain in patients with knee osteoarthritis ( $P>0.04$ ), but isometric exercises have no significant effect on

balance ( $P>0.053$ ). The results also show that Tai Chi significantly decreases pain ( $P>0.01$ ) and increases balance ( $P>0.02$ ) in patients with knee osteoarthritis.

**Table 2.** Pre-test and post-test results for pain and balance in the two groups

Variable	Group	Pre-test Mean ± Standard Deviation	Post-test Mean ± Standard Deviation	t	P-value
Pain	Isometrics	1.9±6.6	2±4.1	3.5	0.004
	Tai Chi	1.8±7.1	2±3.6	5.3	0.001
Balance	Isometrics	9.4±27.7	8.3±30.3	-2.1	0.053
	Tai Chi	8.5±28.8	6.9±35.7	-3.9	0.002

Based on the results of Table 3, there is no significant difference in pain and balance between isometric and Tai Chi groups.

**Table 3.** Results of independent t-test and difference in pain and balance between the groups

Variable	Mean Difference	T	P-value
Pain	1	1	0.31
Balance	-4.3	-2	0.52

**Discussion**

In this study, after the intervention, pain intensity in both groups of Tai Chi exercises and isometric exercises was significantly decreased, but pain reduction in the Tai Chi group was significantly more than that in the isometric group. The results also showed that Tai Chi has a significant effect on balance. But, the effect of isometric exercises on balance was not significant.. Intergroup comparison showed no significant difference in pain and balance of patients with knee osteoarthritis between Tai Chi and isometric exercise.

In the present study, isometric exercises significantly reduced pain in patients, which is consistent with the results of Cheing et al. (35), Shakoor et al. (36), Topp et al. (37), and

Saleki et al. (38). Since muscle weakness and loss of quadrilateral muscles strength are generally one of the most obvious complications in the elderly, knee pain increases due to this weakness. Normally, the maximum contractile force of this muscle decreases by 35 to 50% in elderly. Reduction in the total number of type 1 and 2 muscle fibers, and atrophy of type 2 fibers are largely involved in reducing the muscle power in the elderly, which is itself a reason for increasing knee pain.

On the other hand, as musculoskeletal injuries increase by aging, atrophy and loss of tonicity in quadrilateral muscle caused by immobilization of lower limb as a result of illness, trauma and surgery are inevitable. Therefore, the reduction of quadriceps muscle strength and the limitation of range of knee motion can increase knee pain and therefore, do not allow individuals to return to daily and functional activities rapidly and completely. Therefore, isometric exercises are more likely to improve the pain status in patients with knee osteoarthritis through strengthening muscles, increasing contractile force, removing muscle atrophy, improving muscle fibers and increasing the range of motion.

Also, the results of this study showed that Tai Chi have a significant effect on the severity of pain, which is consistent

with the results of Song et al. (39), Brismée et al. (40), Lee et al. (41), and Wang et al. (42). This reduction in pain may be due to the fact that Tai Chi is a type of psychophysiological intervention (43). Psychophysiological intervention, as an alternative treatment, may decrease the symptoms of knee osteoarthritis by increasing the amount of endorphin and enkephalin (44, 45).

Tai Chi intrinsic features include gentle continuous movements, muscular strength and balance training, which has introduced it as a good non-pharmacological treatment for patients with knee osteoarthritis. These features lead to increased muscle strength, reduced inflammation, and decreased pressure on knee tissues, which also affect the amount of pain relief (46). The mean MET of this exercise is about 3.1, therefore, Tai Chi can be considered as an exercise with low difficulty and no increased intensity that impose no pressure on knee tissues and subsequently reduces fatigue in patients with osteoarthritis (47). Also, Tai Chi included both aspects of physical and cognitive, therefore, it can be considered as more beneficial than other exercises which include only physical aspect (48).

The results of this study showed that isometric exercises could increase balance, but this effect was not significant. Therefore, it is suggested to use a combination of isometric and isotonic trainings to increase the balance in the elderly. As research suggests, the combination of isometric and isotonic exercises can increase balance in many patients. This can be due to the fact that combined isometric and isotonic exercises increases the rate of transmission of neural signals and increases perception of deepening and subsequently improves balance. However, isometric exercises, alone, have less effect on balance improvement.

Also, the results of this study showed that Tai Chi has a significant effect on balance, which is consistent with the results of Ding et al., (49), Njuyen et al., (50), Hain et al., (51), Song et al (39), Lee et al., (41). This effect on balance is more likely to be due to the fact that Tai Chi emphasizes on the principles of balance and weight transfer and increases the sense of deepness (52). In Tai Chi exercises, one needs to stand on one leg and transfer his/her body weight from one leg to another slowly, along with an attitude of consciousness to his/her body. This weight control and weight transfer between the two legs, improves balance and postural control constantly in different positions and consequently reduces the risk of falling back (53, 54).

Increasing balance in the present study is probably a reflection of the effect of Tai Chi training on increasing neuromuscular adaptations, improving the performance of atrial and visual systems, and increasing the sense of deepness (55, 56). Also, studies have shown that standing on one leg and transferring weight between the two legs, along with the pressure of the hands in forward movements and the complexity of the reverse movements, improve the reaction time in the lower limbs, increase balance and reduce the risk of falling back (53). Possible reasons for increased balance caused by Tai Chi training can be the change in the feedback of the mechanoreceptors, which leads to reorganization of the central system and sensory-motor integrity and causes a change in motor response (57). Therefore, activation of deep sensory receptors, preparation of motor neurons in a group of muscles and joints for movement, increased coordination and motor integrity, co-contraction of the partner's muscles and increase in deterrence of the opposing muscles can be referred (58).

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