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Original Article

Effects of Tai Chi exercise on pain, functional status, and quality of life in patients with osteoarthritis or inflammatory arthritis

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ABSTRACT

Objectives: This study aims to assess the impact of a Tai Chi exercise program (TCEP) on pain, spinal flexibility, muscle strength, stability and balance, functional status, and quality of life (QoL) among home-dwelling patients with osteoarthritis (OA) or inflammatory arthritis (iA).

Patients and methods: Between October 2018 and April 2019, a total of 28 participants (4 males, 24 females; median age: 62 years; range, 34 to 79 years) who completed the training program participating in at least 18 sessions were included. The TCEP consisted of 50 sessions for 60 min twice a week. The average attendance rate was high (78%, 39 sessions).

Results: Chest mobility (breathing index, $p<0.001$), sagittal mobility of cervical ($p<0.001$), thoracic ($p=0.009$), and lumbar spine (Schober's test, $p<0.001$) improved significantly in participants with OA and iA. The improvement in functional status was significant only in participants with OA (Lequesne index, $p=0.014$). Although the change in Lequesne index was statistically significant, the median value remained in the range of severe disability and the change did not reach the minimal clinically important difference. Although the trends were positive, the changes in pain (Visual Analog Scale pain, $p=0.599$), stability and balance (functional reach test, $p=0.341$), muscular strength (wall sit test, $p=0.069$), and health-related QoL (15D, $p=0.065$) were non-significant in participants with OA and iA.

Conclusion: Our study results suggest that a 25-week TCEP is safe and can improve chest and spinal mobility in home-dwelling individuals with OA or iA.

Keywords: Arthritis, muscle strength, postural balance, physical functional performance, Tai Chi.

In the adult population, carefully tailored exercise programs should aim to improve all important aspects of health-related physical fitness such as cardiorespiratory capacity, strength and endurance of muscles, flexibility, neuromotor performance (coordination, balance, speed), and body mass and composition.[1] Tai Chi, as part of Chinese tradition, merges meditation with slow and gentle rhythmic movements, deep breathing techniques and relaxation.[2] The therapeutic potency of Tai Chi may be due to its integrative approach, bolstering strength, balance, and preventing falls, while simultaneously addressing depression and fostering self-efficacy.[2] The European Alliance of Associations for Rheumatology (EULAR) has recognized the importance of regular physical activity (PA) and exercise for management of osteoarthritis (OA) and inflammatory arthritis (iA). The EULAR outlines four (safe and feasible) key domains of PA for patients with OA and iA: cardiorespiratory exercise, muscle strength, flexibility, and neuromotor performance.[3] Neuromotor exercise training is recommended in elderly to maintain or

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even improve physical function and to reduce the risk of falling especially in those with increased risk.[3-5] It aims at improving motor skills (balance, coordination, gait speed) through proprioceptive exercise training and multifaceted activities such as Tai Chi and Yoga. Currently, Tai Chi is strongly recommended by the American College of Rheumatology (ACR) in OA of the knee and/or hip. Additionally, the American College of Physicians (ACP) strongly recommends Tai Chi as a non-invasive and non-pharmacological treatment for patients with chronic low back pain (LBP).[6,7]

The Erasmus + European Union Program for Sporting Activities provided co-funding for the #WushuElixir project, which took place in Belgium, Croatia, Slovenia, and Spain from October 2018 to April/July 2019. The scope of this study is limited to the results of the investigation which took place in Zagreb, Croatia. The aim of our part of the research was to assess the efficacy of Tai Chi exercise program (TCEP) in home-dwelling patients with OA or iA in reducing pain, improving spinal mobility, muscular strength, stability and balance, functional status, and health-related quality of life (HRQoL).

PATIENTS AND METHODS

Recruitment and setting

This study was conducted at University Hospital Centre Zagreb, Departments of Rheumatology and Physical and Rehabilitation Medicine between October 2018 and April 2019. The TCEP for participants with OA or iA was conducted in two groups at two locations outside the hospital facilities: the Sport Center Vinko Bek, and Sport Center of the Association of Disabled Workers. Participants with OA or iA were recruited from patient records using the hospital database. Association of Disabled Workers database was also used to identify patients with OA and iA. We employed a non-probabilistic sampling approach for our study. Participants were selected based on their expressed interest in participating, rather than randomly sampling from the entire database. Once they indicated their interest, potential eligibility was determined through a scripted interview. Only home-dwelling individuals who met the specified inclusion criteria were selected for the research. Inclusion criteria were as follows: having a diagnosis of OA of the spine, knee or hip established by a physical medicine and rehabilitation specialist or having a diagnosis of iA established by a rheumatologist in accordance with the EULAR and ACR criteria.[8-10] Those who received physical therapy one month prior the enrollment and those with severe medical conditions that might restrict involvement in the TCEP, and individuals who could not bear weight on the lower extremities were excluded from the study. Radiographic staging of severity of OA was not performed. There were no drug changes allowed for the participants throughout the duration of the study. All participants maintained their prescribed medication regimen without any modifications. The sample size of 44 participants was primarily determined by logistical and practical constraints.

Participants

Of a total of 44 participants, 28 (4 males, 24 females; median age: 62 years; range, 34 to 79 years) completed the training program participating in at least 18 sessions (Table 1). The cut-of value for completed the TCEP was set arbitrarily at 36% of training sessions (18 out of 50 sessions). Two participants with chronic LBP withdrew from the study due to pain associated with standing exercises. There were no serious adverse events reported in this study. The average attendance rate was high (78%, 39 sessions). Moreover, 24 (85.7%) participants out of 28 participated in at least 70% (35 sessions) of the exercise program. Most of the 28 participants had OA (Table 1). Among participants with OA, one male participant had endoprosthesis of both knees, one female had hip endoprosthesis, three females had osteoporosis, and one female had a fracture of patella two years before the study. Five participants had iA (rheumatoid arthritis [RA], psoriatic arthritis, reactive arthritis, and undifferentiated arthritis). Half of participants had disturbed sleep, 67.9% had hypertension, 7.1% had diabetes mellitus, and 78.6% used medications.

Tai Chi intervention program

We aimed to enable participants to adopt the basic knowledge and habits necessary for practicing Tai Chi Chuan and Qigong. To achieve that goal, the Croatian Wushu Federation (HWUS) expert team, consisting of certified Tai Chi Chuan and Qigong trainers with multi-year experience in teaching, developed a specific teaching methodology and training program, characterized by a very gentle and gradual approach to exercises. The method emphasizes the movements which are coordinated with breathing, circular, light, and never violent. During the exercises the joints are slightly bent, never fully extended, and never completely closed, and the muscles are elastically relaxed, and the spine is held upright but relaxed.

TABLE 1
Descriptive data of participants (n=28)

Variables	n	%
Age group (year)		
≤45	23	82.1
46-60	9	32.1
61-70	11	39.3
≥71	5	17.9
Sex		
Male	4	14.3
Female	24	85.7
Diagnosis		
Osteoarthritis of the spine, hip, or knee	23	82.1
Inflammatory arthritis; RA (n=1), PsA (n=1), ReA (n=1), UA (n=2)	5	17.9
Medications		
No	6	21.4
Yes	22	78.6
Disturbed sleep		
No	14	50.0
Yes	14	50.0
Hypertension		
No	19	67.9
Yes	9	32.1
Diabetes mellitus		
No	26	92.9
Yes	2	7.1

RA: Rheumatoid arthritis; PsA: Psoriatic arthritis; ReA: Reactive arthritis; UA: Undifferentiated arthritis.

The TCEP was practiced for 25 weeks. It consisted of 50 sessions 60-min long, performed twice a week. The program consisted of basic and advanced parts. Every session included a warm-up routine involving all joints and the spine (10 min), followed by Tai Chi Chuan and Qigong training (40 min), and concluded with cool-down exercises (5 to 10 min). The training sessions were led by four trainers (two for each group), all of whom are members of the HWUS expert team.

Outcome measures

Outcome measures were pain, stability and balance, chest mobility, spinal mobility, muscular strength, physical function, and QoL. Outcome assessment was performed by physiotherapist at Week 1 (before the first session, baseline values or pre-test), and at Week 50 (after the last session, final values or post-test).

Pain was assessed using the Visual Analog Scale (VAS; 0=without any pain, 10=maximal pain level).

The Functional Reach Test (FRT) was used to measure balance and stability.[11] For the FRT, a tape measure was aligned on the wall parallel to the ground, at the level of the participant's acromion on the dominant arm side. We asked the participant to position their feet at a convenient distance from each other, make a fist, and elevate the dominant arm forward close to a 90-degree angle. Maintaining this stance, participants were instructed to stretch forward to their utmost limit without taking a step or making contact with the wall. The span in centimeters from the initial to the final position was determined with the metacarpal head of the third finger serving as the benchmark.

Breathing index (i.e., chest expansion) was taken as a measure of chest mobility. A circumferential measurement by tape measure was performed in the standing position of the participant. Chest circumference was measured by tape measure in the standing position of the participant at the level of the fourth intercostal space. The result was the difference between chest circumference in centimeters during maximal exhale and maximal inhale.[12]

Sagittal mobility indices were used to assess the mobility of the cervical and thoracic spine. While measuring the cervical spine mobility the participant was in a standing position and the physiotherapist marked the spinous process of seventh cervical

vertebrae and external occipital protuberantia. The participant bent his head in full flexion and, then, in full extension. The physiotherapist measured the distance between the two markings in centimeters in full flexion (measure one) and extension (measure two). The result was the sum of the two measures. While measuring the thoracic spine mobility the participant was in a standing position and the physiotherapist marked the spinous process of first thoracic vertebrae and 30 cm below. The participant bent in full flexion and then in full extension. The physiotherapist measured the distance between the two markings in centimeters in full flexion (measure one) and extension (measure two). The result was the sum of the two measures.[12]

The Schober's measure was used to assess lumbar spine motility. The participant was in a standing position and the physiotherapist marked the spinous process of fifth lumbar vertebrae and 10 cm above. The participant bent in maximal flexion while the physiotherapist measured the distance between the two markings in centimeters which represents the Schober's measure.[12]

Muscular strength was measured using the wall sit test. The participant stood with their back lining against the wall, with feet shoulder-width apart, hips flexed at 90-degree, and knees directly above ankles. While holding that stance participants were asked to maintain continuous contact between their back and the wall. The physiotherapist measured the subject's time held in that position in seconds.

The assessment of QoL was conducted using the 15D© instrument. It is a generic and comprehensive self-administered instrument designed to measure HRQoL in adults. A set of preference weights is employed to calculate the 15D score, represented as a single index number on a scale from 0 to 1. The instrument assesses mobility, vision, hearing, breathing, sleeping, eating, speech, elimination, usual activities, mental function, discomfort and symptoms, depression, distress, vitality, and sexual activity.[13]

The Stanford Health Assessment Questionnaire (HAQ-DI) 20-Item Disability Scale was used to assess physical function in iA. It has eight domains: dressing, arising, eating, walking, hygiene, reach, grip, and activities. Scoring within each domain is from 0 (without any difficulty) to 3 (unable to do).[14]

The Lequesne index of severity for OA was used in a subsample (n=16) for algofunctional assessment of hip and knee OA. The index consists of 11 questions and includes three domains: pain or discomfort, maximum distance walked and activities of daily living with the scoring range from 0 (no pain or disability) to 24 (maximal pain and disability).[15]

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). After testing for normality using the Kolmogorov-Smirnov test, non-parametric tests were used in the analyses. Continuous data were expressed in median and interquartile range (IQR), while categorical data were expressed in number and frequency. The chi-square test was used to analyze differences between categorical parameters. The Wilcoxon signed-rank test was used to analyze differences between quantitative variables for each investigated measure at the beginning and at the end of the study. A p value of <0.05 was considered statistically significant.

RESULTS

In the final analysis, the data from 28 participants, having finished a minimum of 36% of the training regimen, were analyzed. The median rate of attendance was 78% (39 sessions out of 50). The majority of the participants had OA (23, 82.1%). Five participants (17.9%) had iA.

The participants with OA and iA exhibited a statistically significant improvement in chest movement (as indicated by the breathing index), as well as in the sagittal movement of the cervical, thoracic and lumbar region of the spine (based on sagittal mobility indices and Schober's test) (Table 2). The median value of the breathing index increased from 6.00 at baseline to 7.00 in the final visit (p<0.001). The sagittal mobility indices improved from the median value of 6.50 at baseline to 8.00 in the final visit (p<0.001) for cervical spine, and from 4.00 at baseline to 5.00 in the final visit (p=0.009) for thoracic spine. There was a significant increase in the median value of Schober's test, improving from 7.00 at baseline to 9.00 in the final visit (p<0.001).

The improvement in the functional status was significant in participants with OA (Lequesne index, p=0.014). The median value of Lequesne index improved from 8.50 at baseline to 6.25 in the final visit, but the median value remained in the range of severe disability. The improvement in the functional

TABLE 2
Differences in outcome measures (n=28)

	n	Median	IQR	*p*
Visual Analog Scale pain (0-10)				
Baseline	28	5.00	3.00-7.00	0.599
Final	28	5.00	3.00-7.00	
Functional reach test (cm)				
Baseline	28	30.50	24.50-36.50	0.341
Final	28	31.50	27.50-36.50	
Breathing index				
Baseline	28	6.00	5.00-7.00	<0.001*
Final	28	7.00	5.75-8.00	
Sagittal mobility index of cervical spine				
Baseline	28	6.50	5.50-8.00	<0.001*
Final	28	8.00	6.50-9.00	
Sagittal mobility index of thoracic spine				
Baseline	28	4.00	4.00-5.00	0.009*
Final	28	5.00	5.00-6.00	
Schober's test				
Baseline	28	7.00	5.50-8.00	<0.001*
Final	28	9.00	7.00-10.00	
Wall sit test (sec)				
Baseline	28	29.50	15.00-49.00	0.069
Final	25	30.00	16.00-72.00	
15D average				
Baseline	28	0.90	0.83-0.95	0.065
Final	28	0.92	0.84-0.96	
Stanford HAQ-DI (0-3)				
Baseline	28	0.27	0.08-0.61	0.126
Final	28	0.20	0.02-0.49	
Lequesne index of severity for OA (0-24)				
Baseline	16	8.50	5.50-11.00	0.014*
Final	16	6.25	2.50-9.25	

IQR: Interquartile range; 15D: 15-dimensional self-administered instrument for measuring health-related quality of life; Stanford HAQ-DI: Stanford Health Assessment Questionnaire 20-Item Disability Scale; OA: Osteoarthritis; * Statistically significant; Wilcoxon signed-rank test.

status in those with iA was not significant (HAQ-DI, p=0.126).

There were no significant improvements in the pain intensity (VAS pain, baseline median value 5.00 and final 5.00, p=0.599), muscular strength (wall sit test median baseline 29.50 sec to 30.00 sec on the final, p=0.069), stability and balance (FRT, baseline median value 30.50 cm, and final 31.50 cm, p=0.341), and HRQoL (baseline median value of 15D 0.90, and final 0.92, p=0.065) in participants with OA or iA.

DISCUSSION

Tai Chi has demonstrated its effectiveness primarily in alleviating pain, enhancing physical function, and improving QoL in a variety of health conditions (e.g., OA, Parkinson disease, depression and dementia, chronic pain conditions such as chronic neck pain and LBP, in rehabilitation of chronic obstructive pulmonary disease, cardiac and stroke rehabilitation, and in prevention of falls in at-risk adults and older adults). It is usually safe even

for the elderly and frail. Thus, it has the potential to be widely integrated into healthcare.[16-21]

The results of this study showed that six-month TCEP could significantly improve chest expansion and spinal mobility in home-dwelling patients with OA or iA. This finding is consistent with the studies of Wehner et al.[22,23] The authors observed, in their systematic review and a subsequent study, that Tai Chi improved thoracolumbar spine flexibility, leading to enhanced postural balance. Moreover, spinal mobility and sagittal alignment influence the risk of falling. Reduced lumbar spine mobility and a forward-leaning posture are known risk factors for falls in elderly.[24,25] Thus, particularly for the elderly, maintaining an upright posture and enhancing spinal mobility are important. To the best of our knowledge, this is the first study to show that Tai Chi significantly improves sagittal mobility of the cervical, thoracic, and lumbar spine at the same time in home-dwelling patients with OA or iA using sagittal mobility indices. Previous studies measured thoracolumbar spine flexibility using toe-touch test, straight leg raise test, the sit and reach test, and trunk flexion test from a standing position.[23,26-38] The Schober's test as a measure of lumbar spine mobility was not used consistently to asses efficacy of Tai Chi on spinal mobility even in studies in patients with ankylosing spondylitis.[29,30]

In the current study, functional performance was improved for participants with the hip and/or knee OA (Lequesne index, p=0.014). Although the change was statistically significant and the median value of Lequesne index improved from 8.50 at baseline to 6.25 in final visit, it remained in the range of severe disability not reaching the minimal clinically important difference (MCID) of 2.75; i.e., the change required for meaningful improvement.[31] The improvement in functional performance measured with HAQ-DI for participants with iA was positive, but small, thus it did not reach statistical significance. The median value of HAQ-DI of 0.28 is recorded in the general adult population.[32] The lack of a statistically significant improvement in HAQ-DI in our study can be explained by the fact that a small number of participants with iA were included in the study and that the baseline functional performance of participants with iA was good (median HAQ-DI basal 0.27; IQR 0.08-0.61) and within the range found in the general adult population suggesting that the inflammatory rheumatic disease was well controlled and/or in the early stage. The change required for a meaningful improvement in the functional performance in RA studies (MCID in HAQ-DI of 0.22) was not reached in our study.[33] Recent studies have suggested even higher MCID, thus a change in HAQ-DI of 0.68 should be considered as a reliable measure of functional improvement.[34]

Previous research has indicated that engaging in Tai Chi practice yields a favorable effect on pain in patients with knee OA,[35-38] and in those with RA.[39] Similarly, research on patients suffering from LBP has also revealed beneficial effects on pain after engaging in Tai Chi exercises.[40,41] However, the results from our study are not consistent with these findings. There was no change in pain level recorded among the participants with OA or iA.

Tai Chi has been widely studied for its potential benefits on balance and stability. For instance, Song et al.[42] found that practicing Tai Chi reduced the fear of falling in older women with knee OA. Similarly, patients with RA experienced enhanced balance and increased confidence in movement after participating in Tai Chi.[39] Wayne et al.[43] reported that Tai Chi improved postural control in postmenopausal women with osteopenia; however, there were no significant improvements in balance or lower limb muscle strength. Tai Chi demonstrated a protective effect on the neuromuscular function of elderly persons suffering from non-specific LBP.[44] In our study, we did not observe significant changes in balance and stability (FRT, p=0.341), or muscular strength (wall sit test, p=0.069) among participants with OA or iA. These findings are in contrast to earlier studies that documented enhancements in the strength and endurance of knee extensor muscle among OA patients.[42,45] Such discrepancies may arise from differences in methodology, participant profiles, or the specific style and duration of Tai Chi practiced.

There are a substantial number of research studies published that have investigated the efficacy of Tai Chi in various arthritic conditions. A systematic review by Uhlig[35] demonstrated that Tai Chi improved the QoL in patients with OA of the knee, hip, and hand, as well as those with RA.[35] Another study highlighted that Tai Chi may alleviate pain and enhance functional status in adult patients with RA.[46] Wang et al.[37] further reported that elderly patients with knee OA experienced improved physical function and a better HRQoL following Tai Chi intervention. This improvement in physical function for knee OA patients was consistent with the findings by Shen et al.[36] Furthermore, a meta-

analysis evaluating the efficacy of Tai Chi for OA patients, including studies with knee OA subjects and one focusing on hip OA patients, concluded that Tai Chi provided beneficial effects in reducing arthritic symptoms and improving physical function.[47]

Our findings for participants with OA complement the results of previous studies, showing a significant improvement in functional performance; however, this improvement was still below the MCID, as discussed earlier. Additionally, our results did not indicate any significant changes in HRQoL (15D, p=0.065).

The main limitations to this study are the lack of randomization and a control group, and a modest sample size of iA participants.

In conclusion, our study results indicate that Tai Chi is an effective and safe exercise program for improving chest expansion and spinal mobility in home-dwelling individuals with OA or iA. Although there is an improvement in physical performance in patients with OA, it does not reach clinical significance.

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the University Clinical Hospital Center Zagreb, Croatia (date: 12.10.2018, no: 8.1-18/196-2). The study was conducted according to the Code of Ethics of the World Medical Association (Declaration of Helsinki, 1964 and Declaration of Tokyo, 1975, as revised in 1983).

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are avilable online.[48]

Author Contributions:

Study design, data collection, data analysis and interpretation, preparation of the manuscript and manuscript revision, and final approval: N.K.; Data collection, data analysis and interpretation, preparation of the manuscript and manuscript revision, and final approval: K.K.D., M.M., N.L.Ž.; Data collection, data analysis and interpretation, and manuscript revision, and final approval: I.Ž., M.P., N.Ž., P.P.; Study design, and preparation of the manuscript, and final approval: A.A., B.K., M.V., P.T.

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