Songklanakarin J. Sci. Technol.
44 (4), 963–970, Jul. – Aug. 2022

http://www.sjst.psu.ac.th

Original Article

Efficacy of Baduanjin dance versus Thai boxing dance on clinical-related outcomes and balance ability among patients with knee osteoarthritis: A randomized, single-blinded comparative trial

Titi Phanjaroen[1], Pattanasin Areeudomwong[2*], Vitsarut Buttagat[2], and Sinee Tantasatityanon[1]

[1] *Department of Traditional Chinese Medicine, School of Integrative Medicine, Mae Fah Luang University, Mueang, Chiang Rai, 57100, Thailand*

[2] *Department of Physical Therapy, School of Integrative Medicine, Mae Fah Luang University, Mueang, Chiang Rai, 57100, Thailand*

Received: 8 April 2022; Revised: 7 June 2022; Accepted: 9 June 2022

Abstract

This study aimed at comparing the effects of Baduanjin dance (BD) and Thai boxing dance (TBD) on clinical-related outcomes in knee osteoarthritis (KOA) patients. Fifty-six KOA participants were assigned to receive a six-week intervention in either BD or TBD group. Symptoms, balance ability, knee strength, and fear of movement were assessed before and after six weeks, and at three-month follow-up. Both groups showed improvements in symptoms and static balance with eyes closed at two follow-ups while better knee flexor and extensor strength were maintained in BD group. TBD increased dynamic balance and knee flexor and extensor strength at six weeks only. TBD showed greater improvements in symptoms, fear of movement and knee flexor strength at six weeks compared to BD; however, BD demonstrated a superior retention effect on knee flexor strength compared to TBD. In conclusion, BD and TBD improve symptoms, balance ability and knee strength, and could include them to classical therapeutic interventions for KOA rehabilitative program. As BD maintains knee strength in a long-term period, thus it might be a recommended complementary exercise for KOA patients in the communities.

Keywords: Baduanjin, balance, osteoarthritis, pain, Thai boxing

1. Introduction

Knee osteoarthritis (KOA) involves progressive wear and tear of knee joint cartilage, growth in bone osteophytes, and narrowing of space in the knee joint (Neogi, 2013). The prevalence of KOA is estimated at 10–15% of older adults globally (Neogi, 2013) and 35.40% among Thai elderly (Koedwan, Bunin, & Teerasimbut, 2016). It accounts for four-fifths of the highest burden of OA worldwide that causes biopsychosocial limitations (Vitaloni *et al.*, 2019; Vos *et al.*, 2016).

Pain and knee muscle weakness in KOA are associated with postural instability in terms of disruption of sensory-motor coupling (Masui, Hasegawa, Yamaguchi, Kanoh, Ishiguro, & Suzuki, 2006). Impaired balance control may occur because pain inhibits muscle activity and torque and proprioception of the KOA (Takacs, Carpenter, Garland, & Hunt, 2013). Pain sensitivity may disturb the sensory input of information to the central nervous system, which changes the motor function output of balance control (Hirata *et al.*, 2019). Increased knee pain, decreased knee strength, and impaired balance ability may contribute to fear of movement and falls (Hirata *et al.*, 2019; Rätsepsoo *et al.*, 2013; Takacs, Carpenter, Garland, & Hunt, 2013). Thus, appropriate interventions to ameliorate pain and fear of movement, and improve knee muscle strength and balance ability have become matters of great clinical concern.

A Cochrane review suggested that land-based exercise is relatively safe and can provide beneficial effects for KOA (Fransen *et al.*, 2015); however, some strengthening

*Corresponding author
Email address: pattanasin.are@mfu.ac.th

and aerobic exercises are not preferred as treatments for seniors with KOA due to the increment in knee joint impact, discomfort during exercise, and being uninteresting interventions (Chen *et al.*, 2021; Franco *et al.*, 2015). As mentioned, an ideal exercise for older adults with KOA would be one with lower knee joint impact and high motivation to perform. It has been proposed that cultural low-impact dance-based exercise could be an interesting exercise form for KOA patients to improve their physical performance and increase exercise participation (Chen *et al.*, 2021; Ye *et al.*, 2020a).

Dancing is an interesting and elating activity that integrates biopsychosocial elements as a complex sensorimotor rhythmic intervention (An *et al.*, 2013; Chen *et al.*, 2021; Ye *et al.*, 2020a). Baduanjin dance (BD) and Thai boxing dance (TBD) are alternative therapies with low knee joint impacts that have recently received attention from the KOA research community (An *et al.*, 2013; Chen *et al.*, 2021; Franco *et al.*, 2015; Janyacharoen *et al.*, 2018; Ye *et al.*, 2020a). BD, a traditional Chinese martial art of global interest, is a multicomponent mind–body exercise that comprises slow body movement with reciprocal muscle contraction and stretching coordinated with deep breathing, mental concentration, and physical relaxation (Ye *et al.*, 2020a). Several trials reported significantly improved pain, joint stiffness, proprioception, and physical fitness of KOA patients after BD was performed (An *et al.*, 2013; Chen *et al.*, 2021; Ye *et al.*, 2020a; Zeng *et al.*, 2020). TBD, a Thai martial art, allows the use of punches, kicks, and elbow and knee strikes to create multidimensional exercise (Areeudomwong *et al.*, 2019; Janyacharoen *et al.*, 2018). Only one study examined the effects of the ancient TBD in KOA patients and demonstrated that TBD could increase leg muscle strength, balance, and quality of life compared to home exercise (Janyacharoen *et al.*, 2018). Although several studies have shown the beneficial effects of BD (An *et al.*, 2013; Chen *et al.*, 2021; Ye *et al.*, 2020a) and TBD (Janyacharoen *et al.*, 2018) for KOA, to date, a comparative study of BD and TBD on physical functions, symptoms and the fear of movement is still lacking. The findings of the present study are expected to be a guideline for therapists to consider these exercises as alternative interventions for KOA patients in a community setting. This study aimed to compare the impacts of BD and TBD on KOA symptoms, balance ability, knee muscle strength, and fear of movement in KOA patients.

2. Materials and Methods

2.1 Study design and population

This was a single-blinded randomized study approved by the Mae Fah Luang University Ethics Committee (EC 20151-25) based on the Declaration of Helsinki, and registered in the Thai Clinical Trials Registry (TCTR20210123001). All participants gave informed consent before participation. The study was conducted in the community halls of the Nang Lae and Mae Khao Tom subdistricts in Chiang Rai, Thailand, between January and October 2021. KOA patients were screened by a medical doctor who was unaware of the study interventions. Participants were considered eligible if they: 1) were aged 60–70 years; 2) were diagnosed with KOA according to the criteria of the American College of Rheumatology (Altman *et al.*, 1986), with radiographic grading of the severity between 2 and 3, osteophyte formation, crepitus sounds, morning stiffness of the knee, and knee pain of > 2 on the 11-point numerical rating scale; 3) had body mass index of < 30 kg/m^2; 4) had a Mini-Mental State Exam score of ≥ 24 (Limpawattana, Tiamkao, Sawanyawisuth, & Thinkhamrop, 2012); and 5) were able to walk without gait devices. This study excluded patients who: 1) suffered from serious diseases, e.g., cancer, infectious, or autoimmune diseases; 2) had severe pain or inflammation of the knee; 3) had received knee arthroplasty in the previous six months; 4) received a corticosteroid or hyaluronic acid injection to the affected knee within three months prior to participation; and 5) participated in regular BD or TBD.

2.2 Sample size calculation

A formula of analysis of covariance (ANCOVA) was used for calculation with a 90% power of test and an alpha level of 0.05. A pooled variance of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) overall of 112.67 scores and mean difference of such parameter between groups of 9 scores from the previous study (Ye *et al.*, 2020b) were taken in the formula. Thus, a sample size of 56 was required.

2.3 Interventions

Participants were randomly assigned to either the BD (n = 28) or the TBD (n = 28) group using block randomization with block sizes of two and four by a research assistant who was unaware of the screening and intervention procedures. The randomization results were concealed in sealed and opaque envelopes with consecutive numbering.

Both BD and TBD were conducted as group dance exercises, with a maximum of 10 participants in each group. The participants in each BD and TBD group were trained by five certified instructors with at least four years of teaching experience in BD and TBD, respectively. The familiarization session of each exercise was provided to the participants one day before the experiment. The intensity of BD and TBD estimated from our pilot study were 54% and 60% of predicted maximal heart rate, respectively.

2.3.1 BD group

The participants performed each BD pattern six times over the course of six weeks in 40 min sessions (10 min for warm-up and cool-down and 30 min for the BD session), three times per week. The BD protocol was in accordance with the recommendation of the Health-Qigong Management Center of the General Administration of Sport of China (2007). BD included eight patterns with deep breathing as a mind–body exercise, including 1) holding the hands high with palms up, 2) posing as an archer shooting, 3) holding one arm aloft, 4) looking backwards, 5) swinging the head and lowering the body, 6) moving the hands down the back and legs and touching the feet, 7) thrusting the fists and making the eyes glare, and 8) raising and lowering the heels. Each pattern was repeated six times, following a BD song.

2.3.2 TBD group

A six-week TBD was modified from previous studies (Areeudomwong *et al.*, 2019; Janyacharoen *et al.*, 2018). The participants performed each TBD pattern 10 times, in 30 min sessions with 10 min for warm-up and cool-down, three times per week. Specific patterns of TBD comprised 1) straight punch to the face, 2) hook to the face, 3) uppercut to the chin, 4) long uppercut to the chin, 5) downward elbow to the face, 6) side hook elbow to the chin, 7) uppercut elbow to the chin, 8) upward elbow to the chin, 9) reverse elbow to the chin, and 10) low kick to the outside of the thigh. The participants stepped in a square-like direction, following a Thai boxing song while performing each pattern. The progression of the dance was provided to them from the choreography at a slow pace at weeks one and three to a faster pace at weeks four and six.

To enhance the adherence rate, the participants were called via telephone to participate in the class regularly over the study period and were given an appointment book. They were asked to describe any adverse effects of the intervention upon completion of the six-week intervention. Additionally, they were asked to avoid any other therapies throughout the study period.

2.4 Outcome measures

Outcomes were measured at baseline, at six weeks postintervention, and at a three-month follow-up by a blinded assessor. The primary outcome measure was a modified Thai version of WOMAC overall that is widely employed to evaluate KOA symptoms. It comprises 22 items across three dimensions and has high validity and reliability (Kuptniratsaikul & Rattanachaiyanont, 2007). The overall score is composed of pain level, joint stiffness, and physical function, with a higher score indicating a worsened function of the knee, while a lower score indicates improved function.

Secondary outcome measures were static and dynamic balance ability, knee muscle strength, and fear of movement. For static balance assessment, the participants wore comfortable footwear and performed the sharpened Romberg (SR) test (Gras, Pohl, Epidy, Godin, & Hoessle, 2017) by standing with the dominant foot directly behind the non-dominant foot with the toe of the dominant foot touching the heel of the non-dominant foot, and then crossing arms at the chest. The conditions were the length of time to maintain this position for a maximum of 60 sec each with open and closed eyes; the results were recorded. The test was performed three times under each condition, and the average of the three tests was analyzed.

To assess dynamic balance ability, the participants performed the functional reach test (FRT) by standing on both feet and flexing the shoulder at 90° with elbow extension, and reaching the arm as far forward as possible in the horizontal plane, while maintaining both heels in contact with the ground. The distance of reaching was measured as the distance between the fingertip of the middle finger in the starting and ending positions. The test was performed three times, and the average value of the test was recorded (Uzunkulaoğlu, Yıldırım, Aytekin, & Ay, 2019).

The strengths of knee flexors and extensors of the affected leg were quantified using a push–pull dynamometer (Baseline® Hydrolic Dynamometer 100 lb/45 kg, USA) as previously described (Areeudomwong *et al.*, 2019). Three measurements were performed for each muscle with 30 sec rest, and the average value was recorded.

The reliable Thai version of the Tampa Scale of Kinesiophobia-17 (TSK-17) was employed to evaluate fear of movement. The TSK-17 comprises 17 items on a 4-point Likert scale, and the total score ranges from 17 to 68. A higher score indicates a higher level of fear of movement (Areeudomwong & Buttagat, 2017).

2.5 Statistical analysis

SPSS version 20 (IBM Corporation, Armonk, NY, USA) was used to analyze the data based on the intention-to-treat method. The mean, standard deviation, and 95% confidence intervals were shown for each parameter. All data were normally distributed, as confirmed by the Shapiro–Wilk test. To determine between-group differences in the parameters at each follow-up testing, ANCOVA was used. The intervention group and baseline values of the outcome variable were set as fixed factor and covariates, respectively. A one-way repeated measures analysis of variance was employed to test for within-group differences in all outcomes.

3. Results and Discussion

One hundred twenty-five KOA patients were enrolled for eligibility screening, out of which 56 eligible participants were identified. Sixty-nine of these were excluded because they did not meet the inclusion criteria (n = 63) or declined to participate (n = 6). Four participants were lost to follow-up in each group (Figure 1). The baseline demographic and characteristic data of the participants are shown in Table 1; all are similar between the groups. The compliance rate of participation of each group was 100%, and no adverse effects from the interventions were reported.

Table 1. Baseline demographic and characteristics of the participants

Baseline demographic and characteristics	Baduanjin dance group (n = 28)	Thai boxing dance group (n = 28)
Age (year), mean ± SD	67.07 ± 0.60	66.36 ± 0.92
Gender, n (% female)	26 (92.86)	26 (92.86)
Height (cm), mean ± SD	153.25 ± 1.70	154.11 ± 1.22
Weight (kg), mean ± SD	59.79 ± 1.41	59.61 ± 1.25
Pain duration (year), mean ± SD	3.52 ± 0.64	2.77 ± 0.44
0-10 numerical pain score (score)	5.93 ± 0.31	5.54 ± 0.40

Note: SD, standard deviation

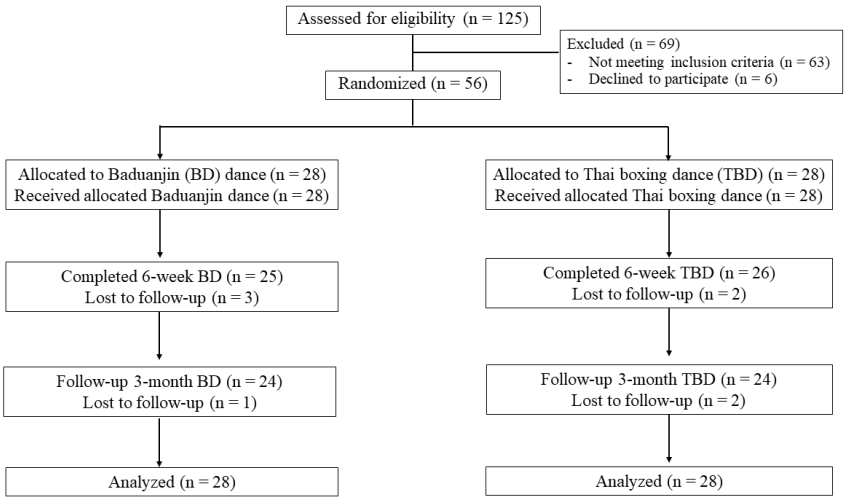

Figure 1. Flow of the participants

3.1 Comparing outcome measures in each group over time

Table 2 shows the results of the within-group comparison over three-time measurement periods in all outcomes. For the BD group, the overall WOMAC representing KOA symptoms showed statistically significant improvements from the baseline to the two follow-ups ($F_{2,46}$ = 31.70, $p < 0.001$). Similarly, the TBD group demonstrated significant improvements in symptoms through the follow-up periods ($F_{2,46}$ = 91.41, $p < 0.001$).

The SR test with eyes closed also increased significantly from the baseline to all follow-ups in both BD ($F_{2,46}$ = 11.41, $p < 0.001$) and TBD ($F_{2,46}$ = 25.75, $p < 0.001$). The SR test with eyes open increased significantly at six weeks only in BD ($F_{2,46}$ = 4.58, p = 0.02); no enhancement was seen in TBD ($p > 0.05$).

Only TBD showed significant improvement in FRT at six weeks ($F_{2,46}$ = 6.17, p = 0.004); however, BD did not have a significant effect on this outcome over time ($p > 0.05$). Significant improvements in knee flexor and extensor strength were observed in BD ($F_{2,46}$ = 14.20, $p < 0.001$ for knee flexors and $F_{2,46}$ = 23.49, $p < 0.001$ for knee extensors) and TBD ($F_{2,46}$ = 50.75, $p < 0.001$ for knee flexors and $F_{2,46}$ = 33.54, $p < 0.001$ for knee extensors). BD showed a significant increase in both knee flexor and extensor strength ($p < 0.01$) in all follow-ups, whereas a significant increase in knee flexor strength was seen in TBD at six weeks only ($p < 0.001$). However, knee extensor strength was gained at both follow-ups after participating in TBD ($p < 0.05$).

There was no significant within-group difference in the fear of movement parameter at all measurement periods in both BD ($F_{2,46}$ = 3.36, $p > 0.05$) and TBD ($F_{2,46}$ = 6.88, $p > 0.05$).

3.2 Comparing outcomes between BD and TBD

After adjustment for baseline data, TBD provided statistically significantly better results in KOA symptoms (p = 0.031), fear of movement (p = 0.045), and knee flexor strength (p = 0.004) than BD at six weeks. BD showed a superior effect on knee flexor strength at the three-month follow-up (p = 0.004) (Table 3).

3.3 Discussion

The present study compared the clinical effects of BD and TBD in the treatment of KOA patients. A six-week course of BD provided significant improvements in symptoms, static balance ability with eyes open and closed, knee muscle strength, and retention effect of those outcomes, except static balance ability with eyes open. Practicing TBD for six weeks showed significant improvements in symptoms, static balance ability with eyes closed, dynamic balance ability, and knee strength; a positive effect on static balance ability with eyes closed was maintained. When the groups were compared, the TBD group demonstrated greater improvements in symptoms, fear of movement, and strength of the knee flexors at six weeks than those of the BD group. High compliance in the BD and TBD programs was found because each intervention was designed as a group-based exercise under supervision, resulting in fun and feeling safe. In addition, it was attractive and related to their familiarized cultural context and interpersonal interactions. To the best of our knowledge, this is the first randomized comparative study to reveal the effectiveness of BD and TBD on clinical-related outcomes and balance ability in KOA patients.

KOA patients have several problems, not only knee pain but also knee muscle weakness related to disruption of sensory-motor coupling (Masui *et al.*, 2006). Pain can inhibit the proprioceptive sense and knee muscle function, resulting in changes in motor function output of balance control (Hirata, *et al.*, 2019; Takacs, Carpenter, Garland, & Hunt, 2013). Thus, impaired balance ability, and increased fear of movement and risk of falling may be found in KOA (Hirata *et al.*, 2019; Rätsepsoo *et al.*, 2013; Takacs, Carpenter, Garland, & Hunt, 2013). Although numerous therapeutic programs for KOA patients have been proposed, there is currently a lack of conclusive evidence about the best practice for this condition. So far, cultural low-impact dance-based therapy may be a choice for improving KOA problems because it may promote a complex sensorimotor rhythmic intervention, improve

Table 2. Comparison of WOMAC measured KOA symptoms, balance ability, and knee muscle strength over time in both groups analyzed by one-way repeated measures ANOVA

Variable	Baseline	6 weeks	3 months	Δ mean Baseline vs 6 weeks (95% CI)	Δ mean Baseline vs 3 months (95% CI)
Baduanjin dance group (n = 28)					
WOMAC (score)	86.38 ± 13.40	45.13 ± 23.42	55.29 ± 26.41	-41.75 ± 5.83*** (-56.81 to -26.69)	-31.58 ± 6.58*** (-48.57 to -14.59)
Sharpened Romberg test with eyes open (sec)	51.50 ± 15.57	59.59 ± 1.44	57.30 ± 7.31	8.09 ± 3.03* (0.28 to 15.90)	5.80 ± 3.35 (-2.85 to 14.46)
Sharpened Romberg test with eyes closed (sec)	26.89 ± 20.42	49.03 ± 16.36	45.06 ± 17.23	22.14 ± 4.74*** (9.91 to 34.37)	18.16 ± 5.42*** (4.18 to 32.15)
Functional reach test (cm)	20.82 ± 7.82	22.16 ± 5.82	21.45 ± 6.20	1.34 ± 1.39 (-2.24 to 4.92)	0.63 ± 1.25 (-2.61 to 3.86)
Knee flexor strength (kg)	2.57 ± 1.71	5.14 ± 2.03	4.18 ± 1.31	2.56 ± 0.55*** (1.16 to 3.97)	1.61 ± 0.29*** (0.85 to 2.36)
Knee extensor strength (kg)	3.75 ± 2.20	9.06 ± 3.25	6.10 ± 2.21	5.31 ± 0.95*** (2.86 to 7.75)	2.35 ± 0.55*** (0.94 to 3.77)
Thai version of TSK-17 (score)	44.71 ± 6.56	45.38 ± 6.15	48.04 ± 4.67	0.67 ± 1.50 (-3.21 to 4.55)	3.33 ± 1.31 (-0.04 to 6.71)
Thai boxing dance group (n = 28)					
WOMAC (score)	108.04 ± 26.07	33.25 ± 18.27	44.25 ± 20.54	-74.79 ± 5.23*** (-88.29 to 61.30)	-63.79 ± 6.52*** -(80.62 to 46.96)
Sharpened Romberg test with eyes open (sec)	56.57 ± 6.97	58.00 ± 7.18	59.01 ± 2.95	1.43 ± 1.55 (-2.58 to 5.45)	2.45 ± 1.53 (-1.51 to 6.40)
Sharpened Romberg test with eyes closed (sec)	27.41 ± 20.22	52.35 ± 12.39	51.28 ± 12.56	24.94 ± 4.40*** (13.57 to 36.31)	23.87 ± 4.35*** (12.65 to 35.09)
Functional reach test (cm)	18.49 ± 6.03	23.36 ± 8.35	20.63 ± 5.22	4.87 ± 1.56* (0.84 to 8.90)	2.13 ± 1.39 (-1.46 to 5.72)
Knee flexor strength (kg)	3.19 ± 2.50	7.59 ± 3.15	3.33 ± 1.59	4.40 ± 0.44*** (3.25 to 5.54)	0.13 ± 0.44 (-0.99 to 1.26)
Knee extensor strength (kg)	3.64 ± 2.01	8.56 ± 3.99	5.42 ± 2.96	4.92 ± 0.61*** (3.53 to 6.48)	1.78 ± 0.57 (0.31 to 3.24)
Thai version of TSK-17 (score)	45.00 ± 3.76	40.50 ± 10.30	46.88 ± 5.15	-4.50 ± 2.11 (-9.94 to 0.94)	1.88 ± 1.23 (-1.30 to 5.50)

Note: WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; KOA, knee osteoarthritis; TSK-17, Tampa Scale of Kinesiophobia-17; CI, confidence interval; Δ, difference value; ANOVA, Analysis of variance. $^{*}p < 0.05$; $^{***}p < 0.05$

Table 3. Comparison of mean post-test measures at each assessment time point between Baduanjin dance (BD) (n = 28) and Thai boxing dance (TBD) (n = 28) groups after differences in baseline values analyzed by ANCOVA

Variable	Time	BD group	TBD group	Adjusted Δ mean (95% CI)	*p*-value
WOMAC (score)	6 weeks	46.78	31.59	-15.19 (-28.95 to -1.43)	0.03
	3 months	54.80	44.74	-10.06 (-25.73 to 5.61)	0.20
Sharpened Romberg test with eyes open (sec)	6 weeks	59.88	57.71	-2.17 (-5.17 to 0.83)	0.15
	3 months	57.42	58.89	1.47 (-1.86 to 4.80)	0.38
Sharpened Romberg test with eyes closed (sec)	6 weeks	49.07	52.31	3.24 (-5.11 to 11.58)	0.44
	3 months	45.07	51.26	6.19 (-2.63 to 15.01)	0.17
Functional reach test (cm)	6 weeks	21.59	23.94	2.35 (-1.41 to 6.11)	0.22
	3 months	20.98	21.10	0.12 (-2.85 to 3.09)	0.93
Knee flexor strength (kg)	6 weeks	5.33	7.40	2.40 (0.71 to 3.43	0.004
	3 months	4.29	3.21	-1.08 (-1.79 to -0.37)	0.004
Knee extensor strength (kg)	6 weeks	9.05	8.56	-0.50 (-2.45 to 1.46)	0.49
	3 months	6.08	5.44	-0.64 (-2.08 to 0.80)	0.38
Thai version of TSK-17 (score)	6 weeks	45.43	40.45	-4.98 (-9.84 to -0.11)	0.04
	3 months	48.04	46.86	-1.24 (-4.02 to 1.55)	0.38

Note: WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; KOA, knee osteoarthritis; TSK-17, Tampa Scale of Kinesiophobia-17; CI, confidence interval; Δ, difference value; ANCOVA, analysis of covariance

physical performance and balance ability, and enhance the exercise adherence of KOA patients (An *et al.*, 2013; Areeudomwong *et al.*, 2019; Chen *et al.*, 2021; Janyacharoen *et al.*, 2018; Ye *et al.*, 2020a; Zeng *et al.*, 2020).

In the present study, improved KOA symptoms, measured using WOMAC from a baseline for BD and TBD, reached a minimally clinically important difference (effects larger than 12% of baseline score) (Angst F, Aeschlimann A,

& Stucki, 2001). BD had 48% and 36% improvements in the overall WOMAC score at the six-week intervention and the three-month follow-up, respectively, over baseline. Similarly, TBD showed 70% and 59% improvements in such outcomes at each follow-up. Therefore, our study revealed that both BD and TBD provide more than minimally perceptible improvements for KOA.

A positive result of symptoms in the BD group was consistent with previous studies, which reported that KOA patients practicing BD showed better symptoms (An *et al.*, 2013; Ye *et al.*, 2020a, 2020b). Static balance ability with eyes open and closed was improved after six weeks of BD training, and the effect on static balance ability with eyes closed was maintained. It is possible that an increase in knee extensor and flexor strength could be attributed to improved proprioception of the knee (Hafez *et al.*, 2013; Ye *et al.*, 2020a), which may decrease KOA symptoms. Previous research reported that regular BD training considerably improved quadriceps strength (An *et al.*, 2008, 2013). Better knee muscle strength may be elucidated by the nature of BD, which focuses on precise control of knee flexion and extension to maintain center of gravity while performing upper body movements (Ye *et al.*, 2020a). Positive effects on balance control ability after practicing BD may be linked to an increase in the local control of co-contraction of the knee flexors and extensors while the upper body is moved in multiple directions, and takes weight off the heels. Concurrently, higher central nervous system control may also contribute to improvement in balance ability, even though it is beyond the scope of the present study. Ye and colleagues (2020b) supported our result of improvement in static balance ability after practicing BD, although there is different static balance testing between studies. Interestingly, the present study demonstrated better static balance ability with eyes closed following the BD program. We speculated that increased neuromuscular control and proprioception may influence such an outcome after six weeks of BD training. As BD is a multicomponent mind–body exercise, synergy between its physical and psychological components possibly plays an important role in alleviating symptoms (Ye *et al.*, 2020a). Future studies are encouraged to assess the influences of local and central control on balance ability and psychological effects in KOA patients after practicing BD.

The six-week TBD training showed positive effects on symptoms and knee flexor and extensor strength. This result was in line with Janyacharoen *et al.* (2018) who proposed that the ancient Thai boxing exercise relieved symptoms and increased knee extensor strength, although there are different methodologies and outcomes evaluating KOA symptoms between studies. Although there is a limited study to evaluate the effects of TBD in KOA, Areeudomwong *et al.* (2019) found that four-week TBD training could improve knee flexor and extensor strength and static and dynamic balance in older adults at risk of falling. The participants in this study stepped in a square-like direction while performing each TBD pattern, which may effectively activate knee flexor and extensor strength. Our notion, supported by Shigematsu *et al.* (2008), was that a multidirectional step exercise in the forward, backward, and lateral directions could improve agonist and synergistic leg muscles. Furthermore, specific dynamic patterns of TBD during square stepping may significantly improve both static and dynamic balance abilities. Additionally, TBD practice requires a body transition from double standing to alternate feet standing or one leg standing and shifts to the limit of stability. Changes in the base of support may challenge the postural-control system to maintain equilibrium when the center of gravity is shifted to the limit of stability (Areeudomwong *et al.*, 2019). Dance with free movements in different planes and axes, with rotational movements of the head and the body, may promote intense vestibular stimulation and joint proprioception to provide effective balance control while being less dependent on visual output (Pichierri, Murer, & de Bruin, 2012).

TBD showed superior effects on symptoms, knee flexor strength, and fear of movement at six weeks compared to BD. The TBD intervention promoted more participants to step and move their bodies in more multidirectional ways than BD. The specifically designed TBD program may relate to actual physical activities, including regular and recreational activities in the daily social lives of seniors (Areeudomwong *et al.*, 2019; Janyacharoen *et al.*, 2018). In addition, greater improvements in balance control and knee flexor strength in TBD may contribute to encouraging normal functioning and lessening pain in KOA participants compared to BD. Although we found a significantly greater improvement in fear of movement at six weeks in TBD compared to BD, it was noted that neither group showed a significant difference in such outcome at the baseline or the follow-up periods. This should be interpreted with caution. BD had a retention effect on knee flexor strength at the three-month follow-up, which may be caused by an accumulative effect received from continuing BD training.

Some limitations should be noted. First, there was no control group with minimal intervention or other standard care as a comparator with BD and TBD. Second, the findings of this study cannot be inferred to other conditions, such as patellofemoral joint pain or knee ligament injury, or to other age ranges. Third, it focused only on the effectiveness of BD and TBD programs on physical outcomes. Further studies should include analysis of cognitive functions, postural sway, and body center of mass kinematics measurements using a force platform and a motion capture system, respectively, which may provide an in-depth understanding of balance ability. Finally, 92.86% of the present study sample consisted of females; future studies recruiting a large proportion of males are required to balance the population sex ratio.

4. Conclusions

Six weeks of BD and TBD improved KOA symptoms, static balance ability with eyes closed, and knee muscle strength in KOA patients. Both interventions also provided positive long-term effects on symptoms, especially static balance ability with eyes closed. Retention effects of knee muscle strength were observed in BD group. The TBD program provided a greater reduction in symptoms and improves fear of movement and knee flexor strength more than the BD program at six weeks. High levels of attendance in BD and TBD and no adverse effects during participation in BD and TBD indicated that both danced-based exercises may be pleasant and stimulating ways to exercise. Although both

exercises are cheap and practical exercise interventions, BD might be a recommended exercise for KOA patients due to a superior retention effect on knee muscle strength.

Acknowledgements

We thank all participants for their good cooperation and the primary hospitals of Nang Lae Sub-district and Mae Kao Tom Sub-district, Chiang Rai, Thailand for recruiting the participants. This study was funded by the Mae Fah Luang University, Thailand.

References

Altman, R., Asch, E., Bloch, D., Bole, G., Borenstein, D., Brandt, K., . . . Howell, D. (1986). Development of criteria for the classification and reporting of osteoarthritis: classification of osteoarthritis of the knee. *Arthritis and Rheumatism*, *29*, 1039-1049. doi:10.1002/art.1780290816.

An, B., Dai, K., Zhu, Z., Wang, Y., Hao, Y., Tang, T., & Yan, H. (2008). Baduanjin alleviates the symptoms of knee osteoarthritis. *The Journal of Alternative and Complementary Medicine*, *14*, 167-174. doi: 10.1089/acm.2007.0600.

An, B. C., Wang, Y., Jiang, X., Lu, H. S., Fang, Z. Y., Wang, Y., & Dai, K. R. (2013). Effects of Baduanjin exercise on knee osteoarthritis: a one-year study. *Chinese Journal of Integrative Medicine*, *19*, 143-148. doi:10.1007/s11655-012-1211-y.

Angst, F., Aeschlimann, A., & Stucki, G. (2001). Smallest detectable and minimal clinically important differences of rehabilitation intervention with their implications for required sample sizes using WOMAC and SF-36 quality of life measurement instruments in patients with osteoarthritis of the lower extremities. *Arthritis Care and Research*, *45*, 384-391. doi:10.1002/1529-0131(200108)45:4<384: :AID-ART352>3.0.CO;2-0.

Areeudomwong, P., & Buttagat, V. (2017). Reliability and validity of the cross-culturallyadapted thai version of the tampa scale for kinesiophobia in knee osteoarthritis patients. *The Malaysian Journal of Medical Sciences*, *24*(2), 61-67. doi:10.21315/ mjms2017.24.2.8.

Areeudomwong, P., Saysalum, S., Phuttanurattana, N., Sripoom, P., Buttagat, V., & Keawduangdee, P. (2019). Balance and functional fitness benefits of a Thai boxing dance program among community-dwelling older adults at risk of falling: A randomized controlled study. *Archives of Gerontology and Geriatrics*, *83*, 231-238. doi:10.1016/j.archger.2019.04.010.

Chen, P. Y., Song, C. Y., Yen, H. Y., Lin, P. C., Chen, S. R., Lu, L. H., . . . Lin, C.H. (2021). Impacts of tai chi exercise on functional fitness in community-dwelling older adults with mild degenerative knee osteoarthritis: A randomized controlled clinical trial. *BMC Geriatrics*, *21*, 449. doi:10.1186/s12877-021-02390-9.

Franco, M. R., Tong, A., Howard, K., Sherrington, C., Ferreira, P. H., Pinto, R. Z., & Ferreira, M. L. (2015). Older people's perspectives on participation in physical activity: A systematic review and thematic synthesis of qualitative literature. *British Journal of Sports Medicine*, *49*, 1268-1276. doi:10.1136/bjsports-2014-094015.

Fransen, M., McConnell, S., Harmer, A. R., Van der Esch, M., Simic, M., & Bennell, K. L. (2015). Exercise for osteoarthritis of the knee: A Cochrane systematic review. *British Journal of Sports Medicine*, *49*, 1554-1557. doi:10.1136/bjsports-2015-095424.

Gras, L. Z., Pohl, P. S., Epidy, J., Godin, B., & Hoessle, N. (2017). Use of the Sharpened Romberg as a screening for fall risk: A pilot study. *Topics in Geriatric Rehabilitation*, *33*, 113-117. doi:10.1097/ TGR.0000000000000145.

Hafez, A. R., Al-Johani, A. H., Zakaria, A. R., Al-Ahaideb, A., Buragadda, S., Melam, G. R., & Kachanathu, S.J. (2013). Treatment of knee osteoarthritis in relation to hamstring and quadriceps strength. *Journal of Physical Therapy Science*, *25*(11), 1401-1405. doi:10.1589/jpts.25.1401.

Health Qigong Management Center of General Administration of Sport of China. (2007). *Chinese Health Qigong: Ba DuanJin*. Beijing, China: Foreign Languages Press.

Hirata, R. P., Skou, S. T., Simonsen, O., Rasmussen, S., Laursen, M., & Graven-Nielsen, T. (2019). Increased postural stiffness during challenging postural tasks in patients with knee osteoarthritis with high pain sensitization. *Clinical Biomechanics*, *61*, 129-135. doi:10.1016/j.clinbiomech.2018.12. 004.

Janyacharoen, T., Yonglitthipagon, P., Nakmareong, S., Katiyajan, N., Auvichayapat, P., & Sawanyawisuth, K. (2018). Effects of the applied ancient boxing exercise on leg strength and quality of life in patients with osteoarthritis. *Journal of Exercise Rehabilitation*, *14*, 1059-1066. doi:10.12965/jer. 1836392.196.

Koedwan, C., Bunin, J., & Teerasimbut, C. (2016). The prevalence of knee OA in community-based elders. *Thai Journal of Physical Therapy*, *38*, 59-70. Retrieved from https://he02.tci-thaijo.org/index.php/ tjpt/article/view/113654

Kuptniratsaikul, V., & Rattanachaiyanont, M. (2007). Validation of a modified Thai version of the Western Ontario and McMaster (WOMAC) osteoarthritis index for knee osteoarthritis. *Clinical Rheumatology*, *26*, 1641-1645. doi:10.1007/s10067-007-0560-y.

Limpawattana, P., Tiamkao, S., Sawanyawisuth, K., & Thinkhamrop, B. (2012). Can Rowland Universal Dementia Assessment Scale (RUDAS) replace Mini-mental State Examination (MMSE) for dementia screening in a Thai geriatric outpatient setting? *American Journal of Alzheimer's Disease and Other Dementias*, *27*, 254-259. doi:10.1177/1533317512447886.

Masui, T., Hasegawa, Y., Yamaguchi, J., Kanoh, T., Ishiguro, N., & Suzuki, S. (2006). Increasing postural sway in rural-community-dwelling elderly persons with knee osteoarthritis. *Journal of Orthopaedic Science*, *11*, 353-358. doi:10.1007/s00776-006-1034-9.

Neogi, T. (2013). The epidemiology and impact of pain in osteoarthritis. *Osteoarthritis and Cartilage*, 21, 1145-1153. doi:10.1016/j.joca.2013.03.018.

Pichierri, G., Murer, K., & de Bruin, E. D. (2012). A cognitive-motor intervention using a dance video game to enhance foot placement accuracy and gait under dual task conditions in older adults: a randomized controlled trial. *BMC Geriatrics*, *12*, 1-14. doi:10.1186/1471-2318-12-74.

Rätsepsoo, M., Gapeyeva, H., Sokk, J., Ereline, J., Haviko, T., & Päsuke, M. (2013). Leg extensor muscle strength, postural stability, and fear of falling after a 2-month home exercise program in women with severe knee joint osteoarthritis. *Medicina*, *49*, 347-353.

Shigematsu, R., Okura, T., Nakagaichi, M., Tanaka, K., Sakai, T., Kitazumi, S., & Rantanen, T. (2008). Square-stepping exercise and fall risk factors in older adults: a single-blind, randomized controlled trial. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *63*, 76-82. doi:10.1093/gerona/63.1.76.

Takacs, J., Carpenter, M. G., Garland, S. J., & Hunt, M. A. (2013). The role of neuromuscular changes in aging and knee osteoarthritis on dynamic postural control. *Aging and Disease*, *4*, 84-99.

Uzunkulaoğlu, A., Yıldırım, İ. B., Aytekin, M. G., & Ay, S. (2019). Effect of flamingo exercises on balance in patients with balance impairment due to senile osteoarthritis. *Archives of Gerontology and Geriatrics*, *81*, 48-52. doi:10.1016/j.archger.2018.10.012.

Vitaloni, M., Botto-van Bemden, A., Contreras, R. M., Scotton, D., Bibas, M., Quintero, M., . . . Cabot, M. R. (2019). Global management of patients with knee osteoarthritis begins with quality of life assessment: a systematic review. *BMC Musculoskeletal Disorders*, *20*, 493. doi:10.1186/s12891-019-2895-3.

Vos, T., Allen, C., Arora, M., Barber, R.M., Bhutta, Z.A., Brown, A., . . . Coggeshall, M. (2016). Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: A systematic analysis for the Global Burden of Disease Study 2015. *Lancet*, *388*, 1545-1602. doi:https://doi.org/10.1016/S0140-6736(16)31678-6.

Ye, J., Simpson, M. W., Liu, Y., Lin, W., Zhong, W., Cai, S., & Zou, L. (2020). The effects of Baduanjin qigong on postural stability, proprioception, and symptoms of patients with knee osteoarthritis: a randomized controlled trial. *Frontiers in Medicine*, *6*, 307. doi:10.3389/fmed.2019.00307.

Ye, J., Zheng, Q., Zou, L., Yu, Q., Veronese, N., Grabovac, I., . . . Yu, J. J. (2020). Mindful exercise (Baduanjin) as an adjuvant treatment for older adults (60 years old and over) of knee osteoarthritis: a randomized controlled trial. *Evidence-Based Complementary and Alternative Medicine*, *2020*, 9869161. doi:10.1155/2020/9869161.

Zeng, Z. P., Liu, Y. B., Fang, J., Liu, Y., Luo, J., & Yang, M. (2020). Effects of Baduanjin exercise for knee osteoarthritis: A systematic review and meta-analysis. *Complementary Therapies in Medicine*, *48*, 102279. doi: 10.1016/j.ctim.2019.102279.