

The Effect of Mindful Movement on Pain Intensity, Leg Muscle Fitness and Psychological Features in University Athletes with Chronic Patellofemoral Pain - A Randomized Controlled Trial Pilot Study

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ABSTRACT

Objectives: To evaluate and compare the effects of mindful movement therapy and general exercise therapy on pain intensity, leg muscle fitness, and psychological features in university athletes with chronic patellofemoral pain

Study design: Randomized controlled trial, a pilot study

Setting: Sport laboratory room, Department of Health and Sport Science, Mahasarakham University

Subjects: Thirteen athletes with chronic patellofemoral pain

Methods: The participants were males and females aged 19 to 25 years old who had had anterior knee pain for over three months. The self-report questionnaire and clinical tests diagnosed patellofemoral pain. The thirteen people were divided into two groups by block randomized allocation: the mindful movement group (n=7) and the general exercise therapy group (n=6). They were assessed for pain intensity, leg muscle fitness, and psychological features before and after the eight-week study. Both groups visited the physiotherapist to train three times a week for eight weeks.

Results: After the 8-week intervention, both groups showed significant improvement in pain intensity, pain catastrophizing scale, fear-avoidance beliefs questionnaire, and strength, endurance, and power tests of the legs over baseline ($p < 0.05$), but the acceptance scores of the mindful movement group ($p = 0.286$) and all levels of mindfulness of the general exercise therapy group showed no statistically significant difference ($p = 0.904$). The differences in average outcomes between the two groups at baseline were not statistically significant with the exception of leg power ($p = 0.008$). Moreover, there was no significant difference in the change in all outcomes between the two groups after the 8-week intervention ($p > 0.05$).

Conclusions: Both interventions can reduce pain intensity and improve physical and psychological features, even though the athletes had continued to perform other physical activities in daily life while participating in the program. Future studies with

a larger sample size and a determination of retention time are needed.

Keywords: mindful movement, pain intensity, leg muscle fitness, psychological features, chronic patellofemoral pain

ASEAN J Rehabil Med. 2025; 35(1): 8-19.

Introduction

Chronic patellofemoral pain (chronic PFP) is a local pain around the anterior aspect of a knee which has had knee pathology for more than three months. It has been found to be highly prevalent in physically active adolescents, young adults, elite athletes, and the military.¹ Additionally, previous studies have shown that the prevalence of PFP among young Thai athletes (12-18 years) was 6% (19 of 310)² and 6.14% (42 of 683) in Thai university athletes.³ Pain is a common symptom of PFP, and the long-term prognosis for most patients with PFP is poor.⁴ Pain is also recognized in the brain, leading to chronic pain and poor long-outcomes, which may impact occupational tasks and sports negatively. Twenty-five percent of recreational athletes with PFP quit participating in sports because of knee pain.^{5,6} In fact, 70-90 percent of individuals with PFP still have recurrent or chronic pain.⁷ Interestingly, psychological features play a role in chronic PFP that may limit the potential for improvement with rehabilitation or which may act as barriers to recovery. Those psychological features include pain catastrophizing, which refers to a detrimental cognitive and emotional reaction towards expected or real pain, and kinesiophobia, which is an excessive and irrational fear of movement or physical activity due to the belief that it will result in pain or re-injury. A recent study reported that pain catastrophizing and kinesiophobia may be elevated in patients with PFP and that they are both correlated with pain and reduced physical function.⁸ Past studies have found

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Received: June 12, 2024

Revised: August 1, 2024

Accepted: August 8, 2024

greater kinesiophobia, pain catastrophizing, and poorer objective function in individuals with PFP than pain-free controls. Catastrophizing and kinesiophobia can predict current pain and disability in anterior knee pain patients.^{9,10} In addition, fear-avoidance beliefs (FABs), which refers to the cognitive and emotional factors that contribute to the avoidance of activities or movements due to fear of pain or injury, were the strongest predictor of functional outcome of the PFP patients.¹¹ The PFP patients with elevated FABs also presented with lower limb weakness.¹² Previous studies have reported that patients in the United Kingdom with chronic PFP had pain-related fear avoidance and damaged beliefs.¹³ A study of long-lasting pain showed that the pain catastrophizing is associated with FABs that determine pain in the future, mental problems, and functional disability.¹⁴ Previous studies have found that the Philadelphia mindfulness scale, the pain catastrophizing scale (PCS), and the Fear Avoidance Beliefs Questionnaire were significantly correlated with the visual analog scale, so the researchers suggested that the biopsychosocial targeted interventions should be explored in future research.³ Exercise programming combined with other therapies including stretching and strength training of the lower extremity, hip, and trunk muscles was the most effective treatment for patients with PFP. The current consensus is that best-evidence treatments consisting of hip and knee strengthening may not address the fear and beliefs identified in the study.¹³ However, the optimal clinical approach to treating PFP is not yet clear, as studies have found that 40%-57% of people treated with an evidence-based treatment program did not see long-term improvement.¹⁵ Previous studies have also shown that a physical therapy program, including strengthening, stretching, and patellar taping, reduced pain and improved function significantly, but that FABs were changed only insignificantly.¹⁶ The missing link in current treatment plans may relate to non-physical, psychological factors that affect perceived musculoskeletal pain.⁸ Previous studies have found a significant negative correlation between pain intensity and mindfulness, and that the relationship of mindfulness is highly inversely related with pain catastrophizing and has a medium inverse correlation with the fear-avoidance model of musculoskeletal chronic pain.¹⁷ The treatment aims to reverse these changes in the central nervous system, which can be categorized as a top-down approach, e.g., exercise, education, and/or relaxation training such as mindfulness.¹⁸ Previous studies of mindfulness intervention have been associated with reduced pain and increased physical function as well as better emotional control and quality of life in patients with chronic pain such as cancer, low back pain, and shoulder or upper limb pain.^{19,20} Those studies included both genders, but nearly all participants were middle age or older. Interestingly, the mindful movement technique focuses awareness on the state of the movement at all times. It may disconnect attention from the pain, and repeated training can lead to increased concentration and relearning in the brain, which can lead to changes

in attitudes and acceptance of pain. Current studies in sports psychology have also reported that mindfulness enhances general well-being and athletic performance in the pediatric, adolescent, and young adult populations. However, there has been no attention specifically on chronic pain. It may be useful to focus on rehabilitation exercises to ensure correct movement performance and to gain maximum benefits from physical interventions.²¹ Mindfulness-based interventions (MBIs) can improve athletic performance, mindfulness levels, and mindfulness-related psychological components in athletes. Research findings also indicate that more high-quality studies utilizing a rigorous empirical design (e.g., RCT) will be necessary in the future, especially in athletes' mental health domains.²²

To date, no studies have investigated the efficacy of mindful movement therapy in athletes with chronic patellofemoral pain. Therefore, this study was designed to evaluate and compare the effects of mindful movement therapy and general exercise therapy on various outcomes in university athletes with chronic patellofemoral pain. Outcomes evaluated include pain intensity, strength, endurance, power of leg muscles, mindfulness level, pain catastrophizing, and fear-avoidance beliefs in university athletes with chronic patellofemoral pain based on assessment before and following an eight-week intervention.

Methods

Participants and design

The study was a randomized comparative trial. The sample size was calculated following the formula for sample size calculation and using a power of 0.80, the standard deviation from the previous study, which was 1.4²³ and a clinically meaningful improvement of 2 cm on a 10 cm visual analog scale (VAS)²⁴ and an alpha level of 5%, with at least eight individuals with PFP in each group. To account for a possible 15% withdrawal, there were 10 participants per group. The participants were divided by block randomized allocation with block size 4, 6, and 8, and stratification factors male and female with assignment to either mindful movement or general exercise therapy groups.

Study procedures

The Khon Kaen University Ethics Committee for Human Research approved the study based on the declaration of Helsinki and the ICH good clinical practice guidelines (HE 622192; No.4.2.02:30/2019). The research assistant explained the details of the study to the participants before they signed the consent forms. The participants ranged in age from 19 to 25 years and were university athletes at Thailand National Sports University (Mahasarakham Campus), Mahasarakham University, or Rajabhat Mahasarakham University. The inclusion criteria were fluent Thai speakers with retro patellar pain for more than three months without traumatic onset and elevated pain during three of the following four tasks: walking

up or down stairs, jumping, running, and squatting. PFP was diagnosed by the self-report questionnaire, the Thai version of the Survey Instrument for Natural History, Aetiology and Prevalence of Patellofemoral Pain Studies (SNAPPS).²⁵ Participants with a total score of 6 or more were considered to have PFP. They were also clinically diagnosed with PFP by a physiotherapist using tests including vastus medialis coordination, patellar apprehension, eccentric step, and single leg squat. The diagnosis was considered to be confirmed if at least two tests were positive. Participants had a moderate intensity of usual pain assessed using the VAS with scores ranging from 4 to 6 out of 10 in unilateral symptomatic PFP, medium mindfulness level measured by a total score of 50 to 80 on the Philadelphia Mindfulness Scale (PHLM), kinesiophobia indicated by scores greater than 15 on the Fear Avoidance Beliefs Questionnaire-Physical Activity (FABQ-PA) and low to medium level of leg strength measured by a leg dynamometer. Results were associated with gender and age. The exclusion criteria were knee swelling from any disease, a history of dislocation of the patella or knee surgery, and any use of non-steroidal anti-inflammatory or corticosteroids. Data was then collected before and after the eight weeks of exercise programs, including VASs, PHLM, PCS, and FABQ-PA, which are self-report questionnaires. The final tests assessed leg muscle fitness, including the leg dynamometer test, single leg wall sit test, and vertical jump test. All assessments were conducted in the same order and by the same research assistant.

Mindful movement intervention and General Exercise Program

Five experts approved the programs for appropriateness. The participants of both groups visited a physiotherapist to train three times a week for 8 weeks. The physiotherapist was responsible for administering the rehabilitation protocol and demonstrating all exercises to each patient. Both groups performed the same 7 exercises, but in the mindful movement group, participants also had the addition of mindful focus on the movement during exercise led by the instructor using physical cues to direct the participants' attention to how their bodies felt and moved and discouraging comparison to other participants. The participants were encouraged to take a nonjudgmental view of their progress. The instructor questioned the participants often to help ensure they were still

focused on the program.

They were also reminded to focus by the bell of the mindfulness application which rang 3 times after every 5 minutes. Initially, a physiotherapist demonstrated and taught the correct breathing technique to the participants, putting one hand on the stomach while the other was on the chest and breathing in slowly through the nose. This caused the belly to expand and the lungs to fill with air, after which the belly relaxed and the individual breathed slowly through the nose or pursed lips. Practicing this technique continued until the participants could breathe in and out without the chest moving and felt relaxed and comfortable. Before and at the end of the exercise program, participants were instructed to perform static stretching of the quadriceps, hip flexor, hamstrings, tensor fascia latae, iliotibial band, and gastrocnemius muscles, with each position held for 20 seconds, for 1 set of 3 repetitions.

The first two weeks of the program started with non-weight, partial weight, and weight-bearing muscle stabilization and strengthening exercises focused on activating the core, hip, and leg musculature. There were seven positions, including an abdominal draw-in exercise (hold 10 seconds, repeat 10 times, 3 sets), static quadriceps muscle contractions (hold 10 seconds, repeat 10 times, 3 sets), supine with straight leg raises (12 times/side, 3 sets), supine arm/leg extensions (12 times/side, 3 sets), hip adduction side-lying (12 times/side, 3 sets), side-lying clamshells with an elastic band (12 times/side, 3 sets) and side-lying straight leg raises with elastic band with each position held for 15 seconds of rest/set (Figure 1).

The first two weeks of the program begin with no non-weight and weight bearing (open-closed chain exercise) of muscle stabilization and strengthening exercise that focus on stimulating core, hip and leg muscles. Exercise positions of 3-5 weeks progressed to partial weight and weight bearing but still focused on muscle stabilization and strengthening of the core, hip, and leg. There were seven positions, including a 90/90 breathing position (hold 10 seconds, 10 times, 3 sets), bridging (20 times/side, 3 sets), single leg bridging (12 times/side, 3 sets), prone plank (hold 30 seconds, 5 times, 2 sets) and quadruped arm/leg extensions (12 times/side, 3 sets), with each position followed by 15 seconds/set of rest. For the side plank (hold 10 seconds, 10 times, 2 sets) and the isometric hip abduction against the wall while standing (hold



Figure 1. Example of weeks 1-2 of the exercise program



Figure 2. Example of weeks 3-5 of the exercise program

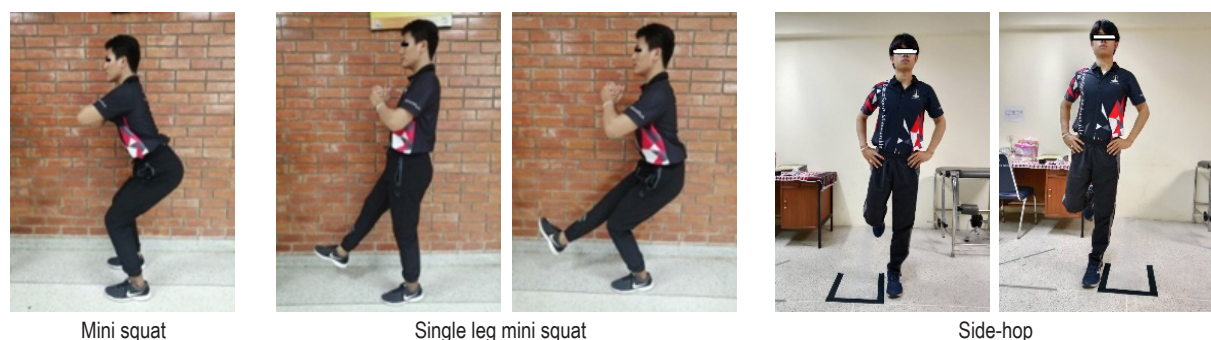


Figure 3. Example of weeks 6-8 of the exercise program

10 seconds, 10 times, 2 sets), each position was followed by 30 seconds/set of rest (Figure 2).

The program's final three weeks focused on functional movement and weight bearing. There were seven positions, including the mini squat (hold 10 seconds, 10 times, 3 sets), mini lunge (hold 10 second, 10 times, 3 sets), lateral lunge (hold 10 seconds, 10 times, 3 sets), single leg mini squat (10 times, 3 sets), step-ups and down (10 times, 3 sets), step-ups and down, lateral (10 times, 3 sets), and side-hop (6 times/side, 3 sets), with each position including a minute of rest between each set (Figure 3). Moreover, all positions were performed while breathing smoothly and continuously. If a participant felt pain with some movement or position, they were allowed to adapt or change the angle of movement to be more comfortable.

Instruments

VASs were used to assess pain intensity of patellofemoral pain, including usual pain (VAS-U), worst pain (VAS-W), and pain during activities such as ascending (VAS-AS) and descending stairs (VAS-DS), jumping (VAS-J), running (VAS-R) and squatting (VAS-SQ). Participants had to mark their VASs on 10 cm. lines of a visual analog scale (0 cm, no pain-10 cm, extremely intensive pain). The reliability of VASs was 0.89-0.94.²⁶

The Thai version of the PHLM) was designed to assess mindfulness. It consists of two subscales, awareness and acceptance, which use a 5-point Likert scaleS (1=never, 5=very often).²⁷ There are twenty questions, with a maximum score of 100. Participants indicated their degree of mindfulness level. A high total score meant high mindfulness. In this study, the reliability of PHLMS_TH was 0.97.

The Thai version of the PCS was used²⁸ which includes thirteen statements describing different thoughts and feelings that may be associated with pain. Participants indicated the degree to which they had these thoughts and feelings when experiencing pain. For each statement, participants chose from a scale of 0 to 4. Possible scores of PCS were 0 to 52. Higher scores mean more negative thoughts and feelings about pain. In this study, the reliability of PCS_TH was 0.95.

The Thai version of the FABQ-PA was used.²⁹ Four statements describe how much physical activity would affect knee pain. Participants chose from a scale of 0 to 6 for each statement. Possible scores of FABQ-PA ranged from 0 to 24. Higher scores mean greater pain-related fear. In this study, the reliability of FABQ-PA_TH was 0.86.

Leg strength used a dynamometer to measure the maximal isometric force of the legs. The participants stood upright on the dynamometer, facing the handle with feet spread apart on the plate. They gripped the handle with an overhand grip, straight arms, straight back, and bent knees, then gradually applied maximal force upwards while avoiding jerking the handle. The position of the back should be forward or vertical. The neck should be reasonably relaxed and neutrally positioned. The test was repeated after a 15-second break, and the higher scores were recorded in kilograms/body weight. In this study, the reliability was 0.93, demonstrating good reliability (Figure 4).

Leg endurance using the single-leg wall sit tests the strength and endurance of the quadriceps. The participants stood with their backs against a wall, then slid down it, shuffling their feet forward until their knee and hip angles reached 90 degrees. The participants lifted the pain-free leg 5 cm off the ground and then started recording their time. They balanced

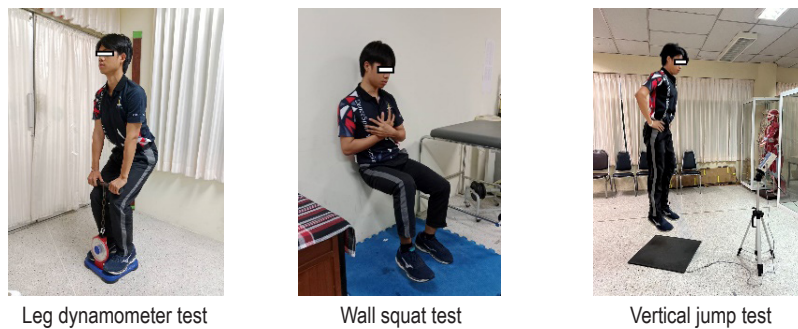


Figure 4. Tests of leg muscle fitness

and held the position for as long as possible, then stopped recording when they put their foot down again, repeating the test after a 15-second break, then recorded the higher score in seconds. In this study, the reliability was 0.92, demonstrating good reliability (Figure 4).

Leg power using the vertical jump measures the power of the legs using the Marathon digital jump equipment, which was developed in Thailand. The participants stood with feet shoulder-width apart on a jump mat with hands on hips. They were instructed to bend at the hips and knees and then do a counter-movement vertical jump to the maximum height possible. They jumped with both feet and landed on both feet while keeping their hands on their hips. This exercise was repeated for 3 jumps with 15-second breaks between jumps, and the mean height was recorded in centimeters. In this study, the reliability was 0.91, demonstrating good reliability (Figure 4).

Statistical analyses

The participants were of both genders, including individuals with either left or right sides affected, and participating in a variety of sports. Age, weight, and height are presented as mean and standard deviation. The visual analog scale, Philadelphia mindfulness scale, PCS, fear-avoidance beliefs questionnaire, physical activity, strength, endurance, and power tests of the leg muscles are also expressed as mean and standard deviation. Prior to statistical analysis, all variables were assessed for distribution based on the Shapiro-Wilk test. For those with a normal distribution, paired t-tests and independent t-tests were performed to compare within the group and between groups. The Wilcoxon sign rank test analyzed variables that were not normally distributed, and Mann-Whitney U. Group comparisons were adjusted for confounding variables using an analysis of covariance (ANCOVA) model when pre-assessment results were different across groups. All of the statistical analyses used SPSS.

Results

Forty-two university athletes with chronic knee pain were willing to complete all the self-report questionnaires, clinical tests, and physical performance tests. Nineteen university athletes fulfilled the eligibility criteria and signed consent

forms to participate in the exercise program. They were randomized into two groups. Six participants dropped out of the study before the 8th week. Thirteen participants completed the eight weeks of the program, of whom seven participants were in the mindful movement and six were in the general exercise therapy group (Figure 5). The power of analysis was 0.76.

Assessment of baseline comparability showed no significant difference between participants in the mindful movement and the general exercise therapy groups for gender, affected side, sports, age, weight, height, experience of playing the sport, sport training duration, or frequency of sport training ($p > 0.05$) (Table 1). The baseline of the study outcome measures did not differ between groups with the exception of leg power which was significantly different ($p = 0.008$) (Table 2).

After the 8-week intervention, the mindful movement group showed that visual analog scales, the Philadelphia mindfulness scale, total scores, awareness subscale, PCS, fear-avoidance beliefs questionnaire, and strength, endurance, and power tests of the legs improved significantly compared with baseline. The acceptance subscale of PHLM_TH was improved, but the difference was not statistically significant. Similarly, the general exercise therapy group demonstrated no significant difference in total scores on the Philadelphia mindfulness scale or any of the subscales. However, other outcomes in the general exercise therapy group showed significant improvement compared to the baseline. There was no difference in change in all outcomes ($p > 0.05$) between the two groups. However, the mindful movement group tended to improve the mindfulness level and physical fitness of leg muscles more than the general exercise therapy group (Table 2).

Discussion

We determined the effect of mindful movement on pain intensity, physical performance, and psychological features in university athletes with chronic patellofemoral pain. The study was specific regarding diagnosis and other inclusion criteria, so obtaining a large sample size was challenging. 19 participants met the inclusion criteria, which resulted in unequal group sizes. This research was conducted from August 2023 through March 2024. Some participants in the

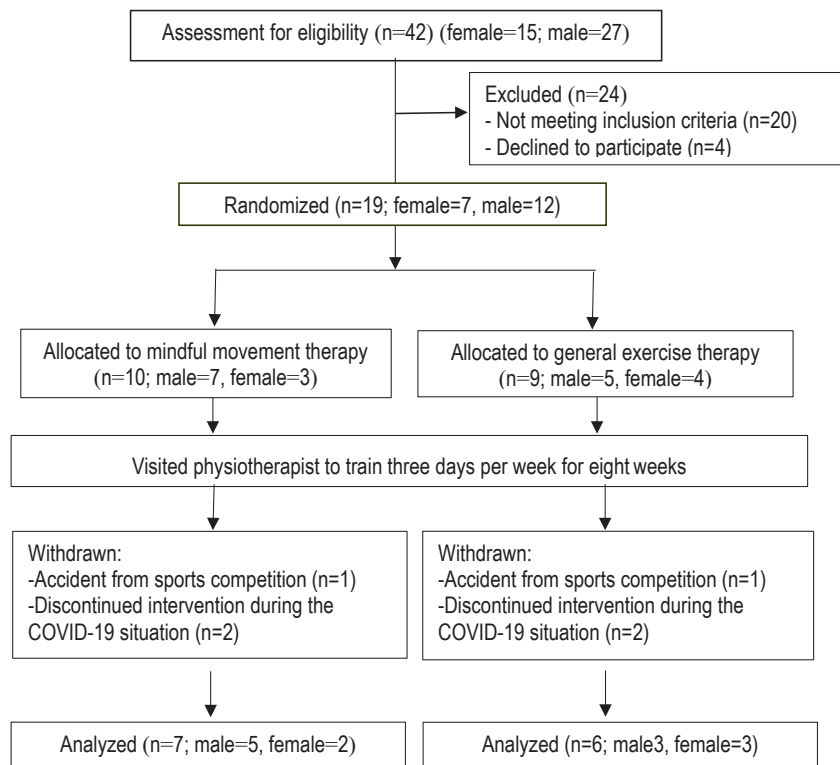


Figure 5. Flow chart describing the progression of participants

Table 1. Basic characteristics of participants

Characteristics	Mindful movement (n=7)	General exercise therapy (n=6)	p-value
Gender ¹			0.429
Male	5	3	
Female	2	3	
Affected side 1 ¹			0.391
Right	4	2	
Left	3	4	
Affected side 2 ¹			0.797
Dominant leg	3	3	
Non-dominant leg	4	3	
Sports ¹			0.639
Ballroom dance	2	2	
Futsal	0	1	
Volleyball	2	1	
Sepak takraw	1	0	
Rugby	1	0	
Athletics	1	1	
Swimming	0	1	
SNAPPS ²	8.85 (0.69)	8.66 (0.81)	0.657
Age (years) ²	21.57 (1.61)	20.83 (2.31)	0.514
Weight (Kg) ²	73.85 (16.17)	69 (14.58)	0.636
Height (cm) ²	174.00 (11.60)	174.66 (7.20)	0.905
Experience of playing the sport (months) ²	63.85 (31.68)	71.16 (39.79)	0.719
Sport training duration (hours/day) ²	3.28 (1.11)	3.33 (0.81)	0.933
Frequency of sport training (days/week) ²	5.42 (0.78)	4.83 (0.98)	0.215

¹number, ²Mean (SD)

The survey instrument for natural history, aetiology, and prevalence of patellofemoral pain studies (SNAPPS), kilogram (kg), centimeter (cm), $p < 0.05$, significant at 0.05

Table 2. Comparative effects on pain intensity, leg muscle fitness and psychological features within and between groups

Outcomes	Mindful movement (n=7)		<i>p</i> -value within group	General exercise therapy (n=6)		<i>p</i> -value within group	<i>p</i> -value Pre- assessments	<i>p</i> -value Between groups
	Pre-test Mean (SD)	Post-test Mean (SD)		Pre-test Mean (SD)	Post-test Mean (SD)			
Pain intensity								
VAS-U (cm)	6.35 (1.01)	1.61 (1.03)	<0.001*	5.13 (1.27)	1.61 (1.74)	0.002*	0.081	0.998
VAS-W (cm)	7.58 (0.74)	3.30 (2.45)	0.004*	7.90 (1.43)	2.96 (2.01)	0.001*	0.622	0.796
VAS-AS (cm)	4.84 (1.55)	1.02 (0.66)	<0.001*	4.30 (2.70)	1.40 (1.04)	0.032*	0.659	0.453
VAS-DS (cm)	5.24 (2.03)	1.27 (1.17)	0.006*	4.41 (2.69)	1.38 (0.79)	0.026*	0.542	0.848
VAS-J (cm)	6.71 (2.20)	1.48 (1.15)	0.001*	6.86 (2.68)	2.43 (1.52)	0.002*	0.912	0.230
VAS-R (cm)	6.45 (1.54)	1.35 (0.79)	0.001*	6.50 (2.39)	1.46 (0.56)	0.007*	0.970	0.785
VAS-SQ (cm)	6.85 (1.67)	2.28 (1.64)	0.001*	5.78 (1.34)	2.1 (1.49)	0.001*	0.234	0.880
Leg muscles fitness								
Leg strength (kg/BW)	1.76 (0.41)	2.61 (0.44)	0.018*	1.36 (0.34)	2.09 (0.71)	0.039*	0.090	0.141
Leg endurance (sec)	3.11 (3.25)	16.97 (6.38)	0.018c*	5.38 (4.67)	14.84 (5.40)	<0.001*	0.317 ^a	0.533
Leg power (cm)	32.69 (4.88)	38.14 (7.06)	0.008*	24.72 (3.82)	29.32 (5.04)	0.020*	0.008*	0.880 ^b
Psychological features								
PHLM_TH	65.57 (8.56)	71.42 (9.94)	0.045*	65.50 (7.66)	65.83 (6.04)	0.904	0.988	0.256
Awareness	32.71 (5.12)	36.00 (6.55)	0.048 c*	33.28 (5.70)	33.00 (6.57)	0.859	0.942 ^a	0.429
Acceptance	33.28 (5.70)	35.42 (3.77)	0.286	32.16 (5.70)	32.83 (3.43)	0.709	0.731	0.225
PCS_TH	27.28 (9.10)	14.42 (7.11)	0.012*	23.66 (6.68)	11.33 (7.81)	0.011*	0.439	0.470
FABQ-PA_TH	18.14 (1.95)	11.50 (4.72)	0.005*	16.83 (1.32)	11.16 (2.71)	0.002 ^c	0.175 ^a	0.884

Usual pain (VAS-U), worst pain VAS-W, ascending (VAS-AS), and descending stairs (VAS-DS), jumping (VAS-J), VAS-SQ, running (VAS-R) and squatting; PHLM_TH The Thai version of the Philadelphia Mindfulness Scale; PCS; The Thai version of Pain Catastrophizing Scale; FABQ-PA, The Thai version of Fear Avoidance Beliefs Questionnaire-physical activity; Sec, second; kg/BW; kilogram/body weight, centimeter (cm)

^a, using an analysis of Mann-Whitney U; ^b, using an analysis of covariance (ANCOVA) model; ^c, using an analysis of the Wilcoxon sign rank test,

**p* < 0.05, significant at 0.05.

local area joined the program during the COVID-19 situation, where the university had to be closed and locked down for one month during December and January 2024. Four participants dropped out, and two participants had an accident in a sports competition. Finally, 13 participants completed the programs. We analyzed per protocol before the experiment, and this study was assessor-blinded. The general exercise group was an active control group in which participants performed 7 exercises without a mindful focus on the movement during exercise using only physical cues by the instructor and the bell of the mindfulness application.

The results of both groups showed that all of the visual analog scales, PCS, fear-avoidance beliefs questionnaire, and strength, endurance, and power tests improved significantly after participating for eight weeks. Almost all variables of both groups improved, possibly due to the appropriate exercise posture design, suitable exercise dosage, adherence of the participants, and other factors. Exercise postures were designed to include muscles related to the pathomechanics of PFP. The program gradually progressed from easy positions to a more difficult ones, such as wide to narrow base support, high to low center of gravity, and increasing load on body weight. In the first two weeks of the program, the participants started with non-weight, partial weight, and weight-bearing muscle stabilization and strengthening exercises that focused on activating the core, hip, and leg musculatures with low central gravity and wide base support.

Exercise positions over the next three weeks progressed to more weight-bearing. The last three weeks of the program focused on close-chain exercise and functional movement. Previous studies have shown strong evidence that exercise therapy is the only intervention that has received such a high recommendation for patients with PFP.⁵ Exercise reduced pain and improved function in the short-medium and long term, which is strongly recommended for treatment of PFP because of its influence on the biomechanics of these muscles, and on femur alignment as well as the potential effect of exercise in improving altered biomechanics of the knee and that it is better than no treatment. Moreover, regular exercise can promote pain relief, by increasing opioids and serotonin levels in central inhibitory pathways, including the periaqueductal gray (PAG) and the rostral ventromedial medulla (RVM). Exercise uses endogenous inhibitory systems to reduce pain.³⁰ Strengthening exercises of the hip external rotators, the abductor muscles, and the trunk provided more pain relief than strengthening exercises of the quadriceps in patients with PFP.³¹ According to Ferber et al.³², the hip, core, and knee rehabilitation protocols improved the function of movement and strength over six weeks. Also, the hip and core strengthening protocol could decrease pain and increase strength better than the knee-focused protocol. At the beginning of the knee treatment group, non-weight-bearing exercises, including quadriceps strengthening, were performed, then the program progressed to weight-bearing

quadriceps-strengthening exercises. In addition, the proximal stability program focused on neuromuscular control of the hip and core musculature showed that an 8-week rehabilitation program improved the hip and core muscle strength and reduced knee abduction moment, which is associated with developing PFP. Then, dynamic exercises were added at the beginning of the program. Participants had to control and correct lower extremity alignment, such as maintaining the knee over the second toe, maintaining a level pelvis during exercise, and not letting the knee move medially to the foot during a single-legged stance. The end of the program was a more complex functional task, and the maintenance of position and alignment became automatic.³³ The rehabilitation program should begin with performing open kinetic chain exercises in deeper ranges of knee flexion, e.g., 50°-90°, and closed kinetic chain exercises in lower ranges, e.g., 0°-45° because of the lower patellofemoral contact force.³⁴

Exercise dosage is also an essential factor that affects changes in variables, e.g., intensity, frequency, and adherence to exercise programs. The present study used 10-12 repetitions per exercise and three sessions per week for 8 weeks. Current research on PFP rehabilitation often follows the exercise dosage described by the American College of Sports Medicine.³⁵ The most intense exercise programs for PFP include ten repetitions per exercise session conducted two to four times per week for a total of six weeks for reducing pain and improving muscle function properties. However, kinesiophobia typically requires more than three to eight weeks of rehabilitation intervention. Thus, patients would need to continue an exercise program for the long term, i.e., more than six months to achieve these treatment goals.³⁶ Runners with PFP performed a home exercise program and education component three times a week for eight weeks. The symptom and functional outcomes significantly improved mean scores at four weeks, eight weeks, and 20 weeks compared with baseline, but only the exercise group increased knee extension strength.³⁷ A systematic review of three trials that explored 8-12 weeks of hip and knee strengthening to provide strength measures found that the results were significantly higher.³⁸ However, exercise dosage should be determined and prescribed based on an individual's deficits or specific assessments. In addition, adherence to participation in the program is also essential. In this study, all subjects had greater than 80% adherence to the program. A pilot study reported that adolescents (12-16 years) with PFP had poor adherence to the exercise program, so self-reported outcomes were only slightly improved. There were no significant changes in knee strength after three months of intervention.³⁹ With other strategies, the participants were encouraged to perform exercises and functional movement without pain, and if they felt pain with some movement or position, they were allowed to adapt or change the angle of movement to make it more comfortable. It is essential to gradually increase the intensity and frequency of training while providing ade-

quate rest periods between sessions. This method helps to reduce the risk of suffering severe pain or injury.

Only the mindful movement group showed significantly improved Philadelphia Mindfulness Scale, total scores and awareness subscale compared with baseline. This study used a questionnaire to determine mindfulness indirectly. It could be explained by based on theories and previous studies that determined brain activity when participants did mindfulness therapy or meditation. The aim of mindfulness in the treatment of chronic pain is to cultivate a quality of openness and experiential acceptance of pain rather than rejecting or avoiding the pain.⁴⁰ Neuropsychological research has found that individuals with greater trait mindfulness have higher prefrontal cortical activation during affect labeling, that trait mindfulness is also associated with reduced bilateral amygdala activation when responding to fear, and that high mindfulness is indicative of an inverse relationship between the prefrontal cortex and right amygdala responses. Thus, mindful individuals may better regulate emotional responses via the prefrontal cortex and inhibition of the amygdala.⁴¹ Additionally, Marie et al.⁴² have reported that alleviation of pain is associated with increased neuronal connectivity between the anterior insular cortex and the dorsal anterior mid-cingulate cortex, so long-term mindfulness practice may affect cortical thickness in pain-related brain areas and result in changes in pain sensitivity. Additionally, mindfulness techniques can modulate neural brain processes; for example, less activity in the amygdala has been associated with less fear of pain and increased activity in the anterior insular and anterior cingulate, two areas involved in the emotional regulation of pain processing. Mindfulness decreases basal sympathetic tone, leading to reduced chronic pain and increased blood flow in the frontal-lobe region, which plays a role in reframing the contextual evaluation of an event. This suggests that increasing blood flow is related to the re-evaluation and awareness of changes in emotional state.

In addition, mindful movement may help to concentrate the participants' focus to ensure the correct movement, performance and control of muscles to gain maximum benefits from the physical intervention. The mindful movement technique focuses on sensory information from movement of the body and breathing. It tends to go slowly, along with mental training that involves the sense of muscles and movement, rhythmic diaphragmatic breathing, and meditation. All of these trainings involve light to moderate intensity physical activities and are useful for symptomatic management in many musculoskeletal diseases, for example, knee osteoarthritis, fibromyalgia, and chronic lower back pain. Systematic reviews have reported that mindfulness exercises may help reduce pain and increase physical function in adults with knee osteoarthritis; however, sample sizes were small.^{43,44} Mills et al.⁴⁵ reported that the mindfulness of movement intervention also involves developing a moment-to-moment awareness of the quality of postures, including whether the posture is

aligned or misaligned; breathing, including whether breathing is inhale or exhale and movement; and whether movements are integrated with mental preparation or whether there is a sense of mind-body disconnection. In addition, mindfulness training, movement therapy, and relaxation strategies may be effective for improving physical function, pain, and low mood for adults with fibromyalgia compared to usual care controls. However, the quality of the evidence could have been higher because the sample size was small and the use of outcome measures was not consistent in analysis-restricted studies.⁴⁶

Moreover, the mindful movement used the bell of mindfulness application, and the researcher gave physical cues to direct participants' attention to how their bodies felt and moved and discouraged comparison with others. Participants were encouraged to take a nonjudgmental view of their progress. The instructor had to ask participants often to check that they were focused on the program, and to remind them to focus their movement, a bell rang 3 times every five minutes. A previous study reported that sound healing had been used for religious and spiritual ceremonies, including bells, singing bowls, and gongs, and that sound healing was beneficial to emotional healing, psychological and psychosocial factors which have been used in psychotherapy in addition to breathing, relaxation and meditation.⁴⁷ Previous studies have demonstrated the potential effect of sound healing on pain perception, decreasing blood pressure and heart rate more than silence alone.⁴⁸ According to Goldby et al.⁴⁹, a singing bowl meditation significantly improved mood, reduced tension, anxiety, physical pain, and increased spiritual well-being. Even though the reasons for the beneficial effect of sound healing are not clear, theories have suggested that different sound beats or frequencies drive into the brain and propel brainwave states such as beta, alpha, theta, and delta waves, which indicate an ordinary waking consciousness, relaxing, meditation and deep, dreamless sleep. There is a need for further study to reveal brain wave states during mindful movement training combined with the bell of mindfulness.

This study also found no difference in improvement in all outcomes between the two groups. However, the mindful movement group tended to improve mindfulness levels more than the exercise therapy group. Possible reasons for these results include that the sample size was small, the mindful movement intervention period was not long enough to change all outcomes compared to an active control group in patients with chronic PFP, and that both groups included relaxation techniques such as breathing techniques during movement. Participants could still do other activities in daily life while participating in the program, in which each person had different activities and stresses, which may have been confounding. Systematic review and meta-analysis research on the effectiveness of mindfulness-based interventions for chronic pain has revealed that most effects were not significant when compared with controls, and that the effect of mindfulness was generally found to be equivalent to the active comparator. Mindfulness improved significantly in only two of the four

studies, in the intervention group compared to the control group. Limitations of those studies include small sample sizes, recruitment methods, and participation rates, all of which may have resulted in a self-selected sample. Additionally, and the frequency of practice may have affected outcomes.⁵⁰ The mindful movement intervention was as effective at reducing chronic neck pain as an equivalent duration of exercise intervention.⁵¹

In contrast, mindful exercises for chronic lower back pain have shown significantly reduced pain intensity and disability compared to the control group. Mindful exercises have also shown significantly reduced pain intensity compared with active control alone, including conventional exercises, core training, and physical therapy programs.⁴⁴ Pathological musculoskeletal-related muscle impairments can cause this chronic pain, but exercise therapy can improve symptoms of muscle impairment. However, prolonged pain may cause abnormal neural networks (neuro matrix) and disturb several areas of the brain related to emotional and cognitive performance, factors that can change a person's behavior and physiological responses to pain. Treatment plans may include non-physical treatment as well. Longer pain duration is a poor and inconsistent prognostic indicator. A duration of more than two months was significantly associated with poor reduction of pain severity at 3-12 months, so sports medicine practitioners should try to increase efficacy in reducing PFP and should promote early intervention.⁴ In addition, some participants in the present study explained in their diary that after eight weeks of mindful movement, that they experienced not only decreased pain and improved physical function in daily life, but that they also felt relaxed, calmed down, less anxiety and fearfulness, and could control their emotions better. Both programs can be performed even if the individual has to participated in other physical activities such as playing sports, exercising, and studying in physical classes. However, this study has some limitations, including a small sample size, no control group, varied types of athletes in each group, and data collection during the coronavirus disease (COVID-19) situation.

Conclusions

Both groups had similar results: decreased pain intensity as well as improved psychological features and leg muscle fitness. However, only the mindful movement group improved mindfulness levels significantly compared with baseline after eight weeks and they tended to improve in terms of decreased pain intensity more than the general exercise therapy group. Future studies are needed with large sample sizes and similar types of sports. Sports training schedules should be planned that are compatible with the program as well. Athletes with chronic PFP may need more extended periods of treatment, and it should consider stress and anxiety in their lives.

Acknowledgments

The authors would like to acknowledge the participants in this study and thank the Research Institute for Human High Performance and Health Promotion (HHPHP), Khon Kaen University, for funding this research. We are also grateful to Associate Professor Dr. Tanida Julvanichpong, Associate Professor Dr. Parinya Lertsinthalai, Assistant Professor Dr. Chairat Choosakul, and Dr. Amporn Sriyaphai for their kind, useful comments and suggestions regarding the mindful movement intervention.

Conflicts of Interest

The authors declare that they have no competing interests.

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