Prevalence of chronic patellofemoral pain in Thai university athletes and correlation between pain intensity, psychological features, and physical fitness of leg muscles

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Abstract:

Background: Previous studies have established the prevalence of Patellofemoral pain in the United Kingdom, Australia, United States, China, and Thailand. Other studies have reported that the chronic pain of PFP affects physical, functional, and psychological statuses of patients, which has not been investigated in Thai thus far. Results in this field may be useful for preventing, controlling, and planning treatment for the chronic pain of PFP. Thus, the aim of this study was to investigate the prevalence of chronic PFP in Thai university athletes and the correlation of pain intensity and psychological and physical fitness of leg muscle outcome measurements.

Method: The participants, aged 19 to 25 years, had retropatellar pain for more than 3 months without traumatic onset or swelling and no history of surgery or dislocation of the patella. University athletes completed the Thai language version of the survey instrument for natural history, aetiology, and prevalence of patellofemoral pain studies, and those who scored 6 or more were considered to have PFP. In addition, the diagnosis was confirmed by clinical tests, including tests for vastus medialis coordination, patellar apprehension, eccentric step, and single leg squat, if at least two of the tests returned a positive result. After the diagnosis, data were then collected using Visual Analog Scales, the Philadelphia Mindfulness Scale, Pain Catastrophizing Scale, and the Fear Avoidance Beliefs Questionnaire. The final tests, to assess the physical fitness of leg muscles, included a leg dynamometer and vertical jump test. **Results:** The prevalence of chronic PFP in the overall sample was 6.14%. The proportion of chronic PFP with respect to knee pain was 43.29% in the overall sample and was 48.2% and 36.58% among the male and female participants, respectively. Leg strength and power of the male participants was significantly higher than those of the female participants. Interestingly, the psychological features were significantly correlated with the Visual Analog Scale, and leg power was correlated with leg strength for both genders. **Conclusion:** The prevalence of chronic PFP in Thai university athletes was low; however, chronic PFP had an impact on psychological features and physical fitness of leg muscles. A correlation between pain intensity and psychological features was found with high pain intensity, leading to lower mindfulness, higher pain catastrophizing, and fear avoidance beliefs. Therefore, both psychological and physical treatments should be considered for patients with chronic PFP.

Key Words: chronic patellofemoral pain, visual analog scale, mindfulness, pain catastrophizing, fear avoidance beliefs, physical fitness of leg muscles

Introduction

Patellofemoral pain (PFP) is the most common lower extremity injury in physically active adults and adolescents including the military, high school athletes, physical education students, collegiate athletes and elite athletes (Smith et al., 2018). A common symptom of PFP is pain, especially, when athletes increase physical activity while bearing weight on a flexed knee in such situations as walking up or down stairs, jumping, running, and squatting, which results in irritation of peripatellar soft tissue and pain. The source of pain cannot be adequately explained. It may be from the innervated lateral retinaculum and patellofemoral bone. There is no singular cause of PFP, as impairment and pain levels can vary between patients and the cause of the anterior knee pain can be due to various and multiple reasons. The most common factors that increase the chances of developing PFPs are lower extremity and patella malalignment, lower extremity muscular imbalance, and over-activity (Thomeé et al., 1999). Also, overuse and injuries of muscle and tendon and osteochondral damage may cause anterior knee pain (Petersen et al., 2014). Recreational athletes that were diagnosed with PFP have approximately one third chance of becoming pain free after being diagnosed, and conversely, have about 25% of quitting sports due to the knee pain (Petersen et al., 2017). In fact, 70-90 percent of individuals with PFP still have recurrent or chronic pain (Stathopulu et al., 2003).

All of these symptoms lead to a limitation of functional and sporting activities and will eventually lead to osteoarthritis. Recreational athletes that are diagnosed with PFP have approximately one third of a chance of becoming pain free after being diagnosed, and conversely, are about 25% likely to quit sports due to the knee pain (Petersen et al., 2017). Many physically active people have suffered from knee pain which has contributed to healthcare costs and absence from work due to sickness. Especially, the chronic pain of PFP patients has impacted physically, functionally and psychologically (Smith et al., 2018). Pain is an unpleasant sensory and emotional experience, which can become progressively worse and disturb the usual healing process. It has a negative effect on cognitive performance and attention processes. Pain can be recognized on the brain lead to chronic pain, which may cause abnormal neural network and disturb several area of the brain. Many regions of brain involve in cognitive and emotional and the meta-analysis studies of experimental pain stimuli found that the following brain areas were positively associated with pain such as the primary and secondary somatosensory cortex, thalamus, insula, anterior cingulate cortex (ACC), prefrontal cortex, periaqueductal gray, spinal cord, cerebellum, hippocampus, basal ganglia, and amygdala are brain areas related with pain experience. Patients with prolonged pain may have problems with focus, concentration, regulating body temperature, sleep disturbances and short term memory. Chronic pain also produces fear and relate with the amygdala which lead to less movement (Simons et al., 2014; Ong et al., 2019). Additionally, a systematic review found that patients with PFP had an increase of abnormal psychological problems, such as anxiety, depression, catastrophizing and fear of movement, correlating with pain and reduced physical function (Maclachlan et al., 2018). According to Schütze et al. (2010) found the mindfulness shows significant negative correlation with pain intensity and the relationship of mindfulness was strongly inverse with pain catastrophizing and medium with variables in each of the major categories of the fear-avoidance model in general of musculoskeletal chronic pain but there is no study in chronic PFP. To be able to develop suitable treatment models for PFP requires further study into the physical and psychological role of people with chronic PFP. Therefore, there is a significant need for basic research on the nature or epidemiology and aetiology of PFP. The results may be useful in preventing, controlling and treating this condition (Thomeé et al., 1999).

Thus, the researchers from the United Kingdom, Australia and the United States have been interested in the incidence and prevalence of PFP. PFP was found to be the most common form of knee pain, occurring in 15-45% of cases. The majority of the studies reported that PFP mainly affected adolescents, young active adults, elite athletes and military recruits. Female patients were usually present two to ten times more often than males (Smith et al., 2018). Previous studies have used non-specific measurement instruments or first excluded other knee conditions or clinical assessment. However, there is no clear gold standard method to diagnose PFP. The diagnosis has been based on subjective and objective assessments. In 2016, Dey et al. designed a survey instrument for measuring the natural history, aetiology and prevalence of patellofemoral pain (SNAPPS) to identify those with PFP specifically and discriminate between those that have knee pain with and without patellofemoral pain. A recent self-report questionnaire study by a Chinese researcher found that the prevalence of PFP in the general Chinese adult population was 20.7%, while general knee pain was found in 35.6% of the population (Xu et al., 2018). Previous studies in Thailand also reported the incidence and prevalence of sport injuries in different athletes and found that the knee is a commonly injured area in sport. Poomsalood and Hambly (2019) showed that the overall prevalence of PFP in young Thai athletes (12-18 years) was 6 % (19 out of 310) and that there was a weak correlation between sports training duration and Anterior Knee Pain Scale (AKPS). However, the assessment for PFP diagnosis of the study was limited. They had used just the AKPS questionnaire to identify the knee cap pain and criteria from various studies to diagnose PFP. Other outcome measurements that related to PFP, such as psychological effect or physical fitness were not investigated. The prevalence of chronic PFP still needs to be studied in different populations and evaluated the physical and psychological features.

Thus, the aims of this study was to investigate the prevalence of chronic PFP in Thai university athletes (aged 19-25 years) using a self-report questionnaire and clinical test for diagnosis. Additionally, pain intensity, psychological features and physical fitness of leg muscles were assessed and determined the correlation between all variables examined. The results may be beneficial for planning treatment for chronic PFP.

Material & methods

Participants

Participants were selected from the population of university athletes of Thailand National Sports University (Mahasarakham Campus), Mahasarakham University, and Rajabhat Maha Sarakham University. They were aged between 19 and 25 years old. They had had retropatellar pain without traumatic onset for more than 3 months, no swelling, and no history of dislocation of the patella or knee surgery.

Procedures

The study was approved by the Khon Kaen University ethics committee for human research, based on the declaration of Helsinki and the ICH good clinical practice guidelines (HE 622192; No.4.2.02:30/2019). PFP was diagnosed by the self-report questionnaire, Survey instrument for Natural history, Aetiology and Prevalence of Patellofemoral Pain Studies (SNAPPS V5.1) (Dey et al., 2016). It consists of four sections. The first section is

to identify persons with knee pain or problems. If participants have had knee pain, they are to complete the remaining three sections of the questionnaire. The second section includes clinical features of the knee pain and problem. The third section covers pain or difficulty during many activities related to knee problems. The last section is to identify the location of knee pain using a knee and patella map. The total scores for the questionnaire are calculating by combining the scores of section 2 and 4. Participants with knee problems and a total score of 6 or more were considered to have PFP. The SNAPPS was translated into Thai following the guidelines for the cross cultural adaptation of self-report measures (Beaton et al, 2000). The first step was to request permission from the original study's author and then it was translated into Thai independently by two bilingual translators from different backgrounds. The first translator had no clinical background and the second translator had a medical and clinical background. Then both Thai translated versions were analyzed and synthesized by the two translators together and an expert on orthopedics. A backward translation version was completed by two bilingual translators, with expertise in the English language, but no medical background. The expert committees for this study included health, methodological and language professionals and the translators and they considered all the translations and the equivalence of words, phrases, and sentences between the original and target version. The last process was to pretest the new target language questionnaire and analyze by the intraclass correlation coefficient (ICC) 95% CI for test-retest reliability. The result showed the Thai language version of SNASS had very strong test-retest reliability ($ICC_{1,3} = 0.91$) (Brady et al., 2021a). Other Thai language self-report questionnaires for university students were also determined to have good to excellent test retest reliability. The Visual Analog Scale (VAS) gave results of 1. Usual pain, VAS-U ($ICC_{1,3} = 0.94$); 2. Worst pain, VAS-W ($ICC_{1,3} = 0.94$); and pain during the activities of 3. Ascending stairs: VAS-AS ($ICC_{1,3} = 0.92$); 4. Descending stairs: VAS-DS ($ICC_{1,3} = 0.92$); 5. Jumping: VAS- J ($ICC_{1,3} = 0.94$); 6. Running: VAS- R ($ICC_{1,3} = 0.93$); 7. Squatting: VAS- SQ ($ICC_{1,3} = 0.89$). Other results used were the Philadelphia Mindfulness Scale: PHLM ($ICC_{1,3} = 0.97$), the Pain Catastrophizing Scale: PCS ($ICC_{1,3} = 0.95$) and the Fear Avoidance Beliefs Questionnaire: FABQ ($ICC_{1,3} = 0.86$) (Brady & Boonprakob, 2021b)

At the beginning of the COVID-19 situation, all university athletes had to go back to their hometowns, so all of the self-report questionnaires were provided online. The researcher sent a link of the online questionnaire to the coaches who then sent the link to their athletes. The participants came to the laboratory after the COVID-19 situation improved and signed consent forms. They completed the Thai language version of SNAPPS and those with a total score of 6 or more were considered to have PFP. In addition, participants were confirmed by clinical tests including vastus medialis coordination, patellar apprehension, eccentric step and single leg squat, if at least two gave positive test results. Data was then collected from all tests including pain intensity of anterior knee pain; VAS-U, VAS-W, VAS-AS, VAS-DS, VAS- J, VAS- R and VAS- SQ, PHLM, PCS, FABQ. The last tests, assessed by research assistants, were on physical fitness of leg muscles such as leg strength (leg dynamometer test) and leg power (vertical jump test).

Measurements

Visual Analog Scale (VAS)

Pain intensity was obtained by asking participants to rate their pain by using a line with 2 extremes on each end – no pain and extreme pain. The patient was asked to choose a point along the line to represent their pain level. The scale was 10 cm. long and anchored by the statements “no pain” on the left and “the most intense pain imaginable” on the right. Additionally, the patient was asked about intensity of pain in 7 situations: usual pain, worst pain, and pain during ascending, descending stairs, jumping, running and squatting.

Philadelphia Mindfulness Scale (PHLM)

This tool was designed to assess mindfulness. The Thai language version of the Philadelphia Mindfulness Scale consisted of two subscales, awareness and acceptance, which used a Likert scale of 5 points (1=never, 5=very often) (Silpakit et al, 2011). There were twenty questions, with a total score of 100. Participants indicated the degree of mindfulness. High total score meant high mindfulness.

Pain Catastrophizing Scale (PCS)

This study used the Thai language version of the Pain Catastrophizing Scale from a previous study (Youngcharoen et al., 2018). There are thirteen statements describing different thoughts and feelings that may be associated with pain. Participants indicated the degree to which they have 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 greater negative thoughts and feelings with pain.

Fear Avoidance Beliefs Questionnaire-physical activity (FABQ-PA)

This study used the Thai language version of the Fear Avoidance Beliefs Questionnaire (Hanrungharotorn et al., 2017). There are four statements describing 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 were 0 to 24. Higher scores mean greater pain-related fear.

Leg strength test

The dynamometer tests the maximal isometric force of the legs using Takei analog leg dynamometer (T.K.K.5002), made from Japan. 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 (or 'chest up' position) and bent knees, then gradually applied maximal force upwards while avoiding jerking the handle. The back position should be a little forward of vertical. The neck should be reasonably relaxed and neutrally positioned. The test was repeated after a 15 second break, then the higher of the two scores was recorded in kilograms/ body weight.

Leg power test

The vertical jump test tests the power of the legs using Marathon digital jump test, made from 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 to do a counter movement before jump to the maximum height possible. They jumped from both feet and landed on both feet while keeping the hands on the hips. This was repeated for a total of 3 jumps, with 15 second breaks between, and then the mean was recorded in centimeters.

Data collection and analysis / Statistical analysis

The demographics of the participants were presented as mean and standard deviation and included age, weight and height. Frequencies and percentage described the characteristics of the participants. The Visual Analog Scale, Philadelphia Mindfulness Scale, Pain Catastrophizing Scale, Fear Avoidance Beliefs Questionnaire, and strength and power tests of the legs were also expressed as mean and standard deviation. The prevalence of chronic PFP was calculated as the number and percentage of the overall sample and according to the gender of the athletes. The inter-relationships of Visual Analog Scale, Philadelphia Mindfulness Scale, Pain Catastrophizing Scale, Fear Avoidance Beliefs Questionnaire, and strength and power tests of legs were analyzed by Pearson correlation coefficient which is a number between -1 and +1 that indicates how strongly two variables are associated. The coefficient values of between 0.00-0.29, 0.30-0.49, 0.50-0.69, 0.70-0.89 and 0.90-1.00 are indicative of negligible, low, moderate, high, very high correlation respectively (Hinkle et al, 1998). Prior to statistical analysis, all variables were assessed for normal distribution which was based on the obtainment of $p > 0.05$ in the Shapiro-Wilk test. Some variables were found to be of normal distribution so independent t-tests were performed to compare between male and female participants including height, experience of playing the sport, VAS-U, VAS-AS, VAS-J, VAS-R, VAS-SQ, Awareness, Acceptance, PCS_TH and leg power. Other variables were analyzed by Mann-Whitney U.

Figure 1 Flow chart of the number of participants in the study.

Results

The total number of athletes from the 3 universities in 2020 was 683. Ninety-seven questionnaires were submitted and forty-six were included, as they had had knee pain for more than 3 months, but no swelling and no history of surgery or dislocation of the patella. They were willing to sign consent forms and completed all the self-report questionnaires, clinical tests and physical fitness of leg muscles tests. Forty-two out of forty-six had chronic PFP. Four participants were excluded: two because they had chronic knee pain without PFP and two had chronic PFP of left knees but one had history with surgery of the right knee joint and the other dislocation of the patella. The prevalence of knee pain and chronic PFP in the overall sample was 14.20 % (97 of 683) and 6.14% (42 of 683) respectively. The proportion overall of chronic PFP with respect to knee pain was 43.29 % (42 of 97). The proportion of chronic PFP with respect to knee pain was 48.2 % (27 of 56) among the male participants and 36.58 % (15 of 41) among the female participants as shown in the figure 1.

Table 1 Characteristics of the participants

Characteristics	Numbers (n)		Percentage (%)
Gender			
Female	15		35.7
Male	27		64.3
Total	42		100
Affected side			
Right knee	16		38.1
Left knee	21		50
Both	5		11.9
Type of sport			
Volleyball	11		26.2
Rugby	7		16.7
Ballroom dance	6		14.3
Basketball	6		14.3
Athletics	6		14.3
Football	2		4.8
Futsal	2		4.8
Swimming	1		2.4
Sepak takraw	1		2.4

It was found that there were more males with chronic PFP than females in the present study. Chronic PFP was found in the right knee of sixteen participants, in the left knee of twenty-one and in both knees of five. The forty-two participants with chronic PFP played nine different sports: volleyball, rugby, ballroom dance, basketball, athletics, football, futsal, swimming and sepak takraw as shown in the Table 1.

Table 2 Demographics of the participants with chronic PFP

Demographics	Mean (SD)		<i>p</i> value	Mean (SD)
	Female (n=15)	Male (n=27)		Total (n=42)
Age (year)	20.26 (0.96)	21.11 (1.62)	0.120	20.80(1.46)
Weight (Kg)	57.86 (8.32)	74.37 (10.57)	<0.001*	68.47 (12.59)
Height (cm)	165.53(7.56)	171.77 (6.04)	<0.001*	171.47 (7.92)
Experience of playing the sport (months)	65.40 (43.83)	73.44 (35.21)	0.520	70.57 (38.25)
Sport training duration (hours/day)	3.06 (0.70)	2.77 (1.05)	0.203	2.88 (0.94)
Frequency of Sport training (days/week)	5.33 (0.48)	5.22 (0.84)	0.942	5.26 (0.73)

**p* <0.05, significant at 0.05

As shown in the table 2, there were no significant difference of age (years), experience of playing the sport (months), sport training duration (hours/day) and frequency of Sport training (days/week) between male and female participants. The mean weight and height of male participants was significantly higher than females.

Table 3 Mean and standard deviation of Self-report questionnaires and Physical fitness of leg muscles in overall sample, male and female participants.

Variables	Mean (SD)		p value	Mean (SD)
	Male (n=27)	Female (n=15)		Total (n=42)
Self-report questionnaires				
SNAPPS (scores)	8.48 (1.25)	9.06 (2.18)	0.243	8.69(1.6)
VAS-U (centimeter)	4.72(1.88)	5.52 (1.38)	0.159	5.00 (1.74)
VAS-W (centimeter)	6.90 (1.82)	7.46 (1.4)	0.437	7.10(1.70)
VAS-AS (centimeter)	3.88 (2.4)	4.50(2.05)	0.410	4.10(2.30)
VAS-DS (centimeter)	4.02 (2.58)	4.35 (2.09)	0.581	4.10(2.3)
VAS-J (centimeter)	5.93 (2.83)	5.36 (2.24)	0.408	5.73 (2.62)
VAS-R (centimeter)	5.02 (2.92)	5.49 (1.64)	0.575	5.19 (2.52)
VAS-SQ (centimeter)	4.7 (2.58)	5.79 (1.42)	0.155	5.11 (2.27)

PHLM_TH (scores)	65.88 (8.01)	64.86 (10.24)	0.958	65.52 (8.76)
Awareness	34.55 (4.32)	32.60 (6.20)	0.238	33.85 (5.09)
Acceptance	31.44 (5.69)	32.33 (6.12)	0.640	31.76 (5.79)
PCS_TH	24.40 (9.43)	23.53 (10.27)	0.782	24.09 (9.62)
FABQ-PA_TH	14.88 (4.33)	16.66 (2.84)	0.375	15.52 (3.92)
Physical fitness of leg muscles				
Leg strength (kilograms/ body weight)	1.90 (0.68)	1.54 (0.73)	0.031*	1.77 (0.71)
Leg power (centimeter)	33.42 (9.88)	24.42 (6.08)	0.003*	30.20 (9.67)

*P<0.05, significant at 0.05

Overall, the mean of SNAPPS scores was more than 6 in athletes with chronic PFP. The mean of the visual analog scales ranged from 4.10 (2.30) - 7.10 (1.70). The mean of PHLM_TH was 65.52 (8.76); 65% of the total score (100 scores) and subscales awareness and acceptance were 33.85 (5.09) and 31.76 (5.79) respectively. The means of PCS_TH and FABQ-PA_TH were 24.09 (9.62); 46.32% of the total score (52 scores) and 15.52 (3.92); 64.66% of the total score (24 scores) respectively. In addition, there was no significant difference in the results of the male and female participants for pain intensity from the visual analog scales, psychological features and physical fitness of leg muscles. The exception was in the mean of leg strength and power which the male participants were significantly higher than the female as shown in the Table 3.

Table 4 Correlation coefficient matrix for the different visual analog scales (VASs) (n=42)

Variables	Correlations					
	VAS-U	VAS-W	VAS-AS	VAS-DS	VAS- J	VAS- R
VAS-AS	0.318*	-	-	-	-	-
VAS-DS	-	-	0.898**	-	-	-
VAS- J	0.416**	0.516**	0.426**	0.513**	-	-
VAS- R	0.461*	-	-	0.323*	0.627**	-
VAS- SQ	-	0.312*	0.726**	0.675**	0.563**	0.400**

*Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

As shown in the table 4, the relationship of each visual analog scales (VASs) was low to high, Pearson's r values ranging from -0.339-0.318. The best relationship was between VAS-AS and VAS-DS (r=0.898**) significantly at the 0.01 level, while the poorest relationship was between VAS-U and VAS-AS (r=0.318*) significantly at the 0.05 level.

Table 5 Correlation coefficient matrix between different visual analog scales (VASs) and Pain Catastrophizing Scale, Fear Avoidance Beliefs Questionnaire (n=42)

Variables	Correlations						
	VAS-U	VAS-W	VAS-AS	VAS-DS	VAS- J	VAS- R	VAS- SQ
PCS_TH	-	0.480**	0.447**	0.423**	0.530**	-	0.475**
FABQ-PA_TH	0.311*	0.541**	0.457**	0.430**	0.522**	0.408**	0.503**

*Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

Interestingly, as shown in table 5, the psychological features were related with visual analog scales (VASs) and significant levels were set at the 0.01 and 0.05 levels. The PCS_TH had correlation with VAS-DS (r=0.423**), VAS-AS (0.447**), VAS-SQ (r=0.475**), VAS-W (0.480**) and VAS-J (r=0.530**). The FABQ_TH was correlative with VAS- SQ (r= 0.503**), VAS- J (r=0.522**) and, VAS-W (r=0.541**), VAS- R (r= 0.408**), VAS- DS (r= 0.430**), VAS-AS (r=0.457**) and VAS-U (r= r=0.311*). Moreover, the PHLM_TH had negative correlation with VAS-AS (r= -0.334*).

Table 6 Correlation coefficient matrix between different visual analog scales (VASs) and Philadelphia Mindfulness Scale, between leg strength and leg power (n=42)

Variables	Correlations			
	VAS-AS	VAS- J	VAS- SQ	Leg strength
PHLM_TH	-0.334*	-	-	-
Awareness	-0.339*	-0.323*	-0.471**	-
Leg power	-	-	-	0.490**

*Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

The correlation of awareness was negative with VAS- J, VAS-AS, VAS- SQ; $r=-0.323$, -0.339 , -0.471 respectively. The negative direction of relationships indicates the opposite scoring of questionnaires such as high scores of mindfulness level indicating less symptoms. In addition, the leg strength and leg power had correlation positively ($r=0.490^{**}$) as shown in the table 6

Discussion

The overall prevalence of Chronic PFP in university athletes from 3 universities in Maharakham province, Thailand was 6.14% (42 of 683), whereas the prevalence of chronic PFP with respect to knee pain was 48.2% in male, 36.58% in female participants and 43.29 % in overall (fig. 1). The prevalence in this study was lower than previous studies, for example, in Europe, USA and Australia a prevalence of 25% was reported for general or sporting populations (Callaghan & Selfe, 2007). The prevalence of PFP in the general population of Chinese young adults was 20.7% (Xu et al., 2018). As Smith et al. (2018) have reported, a systematic review and meta-analysis of 23 studies showed that an annual prevalence of PFP for mixed gender in the military, general population and adolescents were 13.5%, 22.7% and 28.9% respectively. However, the current study has found the overall prevalence of PFP similar to previous studies in young Thai athletes (12-18 years), young individuals in Israel (16.5-19.3 years) and young students in Denmark (16-18 years), which were reported as 6%, 5.7% and 4.15% respectively (Poomsalood & Hambly, 2019; Molgaard, 2011; Lakstein et al., 2010). The pooled estimate for point prevalence of two studies was 7.2% on mixed gender adolescents (Smith et al., 2018). The participants were still at the beginning level of sport training and they may have had fewer competition events or their training schedule and intensity of training may not have been as high as military or elite athletes. The possible reasons for the low prevalence in the present study were a different personal sample structure, diagnosis method, specific group and small population. The prevalence of this study was calculated from those who reported suffering from PFP for more than 3 months and completed all of the tests including self-report questionnaires, clinical tests and physical fitness of leg muscles tests, so if participants had PFP for less than 3 months or not completed the tests, they wouldn't be included in the calculation of prevalence. Moreover, coronavirus disease (COVID-19) created difficult conditions for participants because each university had to be closed and locked down for 3 months and university athletes went back to their hometowns. They could do the self-report questionnaires but could not visit a laboratory and complete the tests. Some athletes had already graduated when the researcher started in the laboratory again.

Additionally, the present study found that the proportion of chronic PFP with respect to knee pain was higher among the male participants than the female, which was similar to the study in Israel on defense force recruits (Lakstein et al., 2010). According to Boling et al (2010) females tended to have an increased prevalence of PFPS compared with males but there was no significant association between genders. On the other hand, a previous study showed that across varied populations and age groups, females have a higher prevalence, being two times higher than males (Rathleff et al., 2015). There was found to be a steady increase of cases in the United States during the 2007-2011 examination periods. The incidence rate of PFP was approximately 7.3% of all orthopedic visits and there were differences in age and gender. The frequency of PFP in the 10-19 year and 20-29 year age group was 13.5% and 10% respectively. Females experienced PFP more often than males (Glaviano et al., 2015). The different activity levels or difference in pain tolerance between genders may be partially influencing factors to explain these findings (Dawson, 2009).

Overall, all of Visual analog scales were range from 4.10 (2.30) - 7.10 (1.70) (Table 3). Pain is a common symptom of patellofemoral pain, especially present as aggressive pain during activities that load the patella, such as sitting with flexed knee, kneeling, jumping, running, squatting and stair ambulation. These activities increase patellofemoral joint compression and produce mechanical force in the peripatellar soft tissue, resulting in irritation and pain. The source of pain cannot be sufficiently explained. It may be from innervated lateral retinaculum and subchondral bone. The most common factors increasing the chances of developing PFPS are lower extremity and patella malalignment, lower extremity muscular imbalance and over-activity or overuse (Thomeé et al., 1999; Crossley et al, 2016). The mean of VAS- J, VAS- R and VAS- SQ was higher than VAS-U, VAS-AS, VAS-DS because of the different biomechanics of the patellofemoral joint. All of the activities are

weight-bearing knee flexion but there are differences in joint angle, ground reaction and muscle activation. Patellofemoral joint reaction force (PFJRF) is the resulting compression force acting on the joint and is dependent on knee joint angle and muscle tension. A high PFJRF combined with a small contact area results in high patellofemoral joint stress, which appears to be the cause of PFP and may be harmful to the joint cartilage and elevate pain (Loudon et al., 2016).

Another new finding of our study concerned the mindfulness level of the participants with chronic PFP, which was 65.52 % of the total score. Also subscales of PHLM including awareness and acceptance were 33.85 (5.09) and 31.76 (5.79) respectively. There is no previous study on mindfulness level of chronic PFP. The past studies showed that patients with general chronic pain had PHLM awareness and acceptance scores averaging 33.75 (6.1) and 29.9 (7.9) respectively (Ussher et al., 2014). Also, in patients with fibromyalgia these were 36.48 (5.94) and 25.31(6.60) (Taylor et al., 2015). Those studies have showed mindfulness level similarly in athletes with chronic pain PFP in this study.

Additionally, the PCS and FABQ-PA in the present study were 46.32% and 64.66% of total scores respectively. The PCS of the present study (24.09 (9.62)) was higher than a previous study (19.3 (13.0)) of mixed gender with anterior knee pain (Domenech et al., 2013). A systematic review has reported that catastrophizing and fear of movement may be elevated in individuals with PFP (MacLachlan et al., 2017) and PCS was higher in women with PFP (14.23(9.01)) than those who were pain-free (0.83(2.09)) (Priore et al., 2019). Also, the study of the experience of living with chronic PFP in the UK showed that patients demonstrated pain-related fear avoidance, damage beliefs, difficulty with making sense of their pain, low self-efficacy and fear of the future (Smith et al., 2018). Chronic pain has a negative effect on cognitive performance and attention processes. The meta-analysis studies of experimental pain stimuli found that the following brain areas were positively associated with pain: primary and secondary somatosensory cortex, thalamus, insula, anterior cingulate cortex (ACC), prefrontal cortex, periaqueductal gray, spinal cord, cerebellum, hippocampus, basal ganglia, and amygdala, for example, pain affects the amygdala, which also produces fear, which leads to less movement (Simons et al., 2014; Ong et al., 2019).

However, Visual Analog Scales and the psychological features of this present study showed no significant differences between the male and female participants. The fact, the review literature has been confirmed that females display a greater sensitivity to pain than males. Although biological, hormonal, genetic have been proposed, the causes of this gender difference remain unclear (Riley et al., 1998; Pickering et al., 2002; Fillingim et al., 2009). Previous study reported that females had a higher level of PCS than males (Sullivan et al., 2000). A systematic literature review indicated that the catastrophizing thinking may partially contribute to gender-related differences in pain responses in healthy women and men but biological and physiological factors may not mediate gender differences in pain perception and past individual history may be influential in female pain response (Racine et al., 2012). While, the result of a past study showed that FABQ-PA was not significantly related to gender in chronic low back pain (Waddell et al., 1993). In the present study, none of the self-report questionnaires have shown any significant differences between the male and female participants. The possible reasons may be explained by methodology, including age group, number and gender ratio of samples, and the method of investigation. For example, this study used subjective assessments for subjects to indicate their feelings of knee pain, but some previous studies used stimuli such as pressure pain thresholds (PPT) or heat pain thresholds (HT).

The total of mean leg power in this study was 30.20 (9.67) cm. which lower than the result of previous study that indicated a significant difference between the groups only in vertical jump performance. The group with patellofemoral pain showed a statistically significantly lower explosive strength capacity [52.63(3.63) cm.] compared with the control subjects [56.02(6.28) cm.] and lower performance on vertical jump was associated with the development of PFPS (Witvrouw et al., 2000). According to leg strength dynamometer test norms of Thai population, participants were medium level [1.90 (0.68) kg/BW] and good level [1.54 (0.73)] kg/BW] in male and female athletes respectively. The mean leg strength and power of the male participants was significantly higher than the female. It is a commonly acknowledged finding that males have higher physical fitness or performance capacity than females. Difference of physical fitness and performance may be explained by energy metabolism, fiber type composition, and contractile speed. Generally, male muscles are faster and have a higher capacity for anaerobic metabolism and generate a higher maximum power output than female muscles (Glenmark et al., 2004). Accordingly, Busko & Gajewski (2011) demonstrate that male swimmers had much more muscle torque and power than female swimmers. A previous study found the prevalence of the slower-twitch fibers in females compared with males that parallel the lower contractile velocity in females (Haizlip, 2015). In this present study, the mean weight and height of male participants was also significantly higher than females which is an important factor in leg strength and leg power.

The present study also investigated the correlation of all variables (Table 4,5,6). These results can assist the clinician in deciding which variables or questionnaires are appropriate and adequate to evaluate the chronic PFP. For example, if there is high correlation between variables or questionnaires, this suggests that the variables or questionnaires are measuring similar constructs and administering any one of the variables or questionnaires would provide similar information about the patient and could predict other results even using only one tool. If

they were not correlated or weakly related, the clinician could not administer any one of these variables or questionnaires.

This current study showed that worst pain (VAS-W) had correlation with pain when subjects were jumping (VAS-J) and squatting (VAS-SQ). According to the biomechanical theory of the knee joint, Patellofemoral joint reaction force (PJRF) is the resultant compression force acting on the joint and is dependent on knee angle and muscle tension. PJRF and patellofemoral joint stress (PFJS) can significantly increase during daily activities, sports and recreational activities (Loudon, et al., 2016). While weight-bearing knee flexion increases, the ground reaction force through the center of gravity of the body produces an increase in the moment arm of the femur and tibia, resulting in increasing PJRF (Andrish, 2015). Studies have demonstrated that the highest PJRF is 20 times bodyweight during jumping, follow by up to 7.8 times bodyweight during squatting, 5.6 times bodyweight during running and 3.3 times bodyweight during stair ambulation. The increase in the PFJRF with knee flexion offers an explanation for the aggravation of patellofemoral symptoms experienced by individuals during flex knee activities (Schindler, 2011). Bennell et al. (2000) reported that the VAS-W and VAS-U was moderately correlated ($r=0.63$) but this wasn't found in this present study. There is a lack of study establishing the correlation between different Visual Analog Scales.

The psychological features were related to the Visual Analog Scale (VAS) and significant levels were set at the 0.01 and 0.05 levels. The PCS_TH had correlation with VAS-DS ($r=0.423^{**}$), VAS-AS ($r=0.447^{**}$), VAS-SQ ($r=0.475^{**}$), VAS-W ($r=0.480^{**}$) and VAS-J ($r=0.530^{**}$). The FABQ_TH was correlative with VAS-SQ ($r=0.503^{**}$), VAS-J ($r=0.522^{**}$), VAS-W ($r=0.541^{**}$), VAS-U ($r=0.311^{*}$), VAS-R ($r=0.408^{**}$), VAS-DS ($r=0.430^{**}$) and VAS-AS ($r=0.457^{**}$). Pain is a multidimensional phenomenon consisting of sensitive, cognitive-evaluative and affective-motivational domains. The results were similar as the past study; pain was significantly associated with PCS ($r=0.34$) and FABQ-PA ($r=0.33$) in adolescents with PFP (Selhorst et al., 2020) but the study hasn't determined pain intensity when subjects were doing physical activities. Previous studies found that the PCS was related with pain perception positively in healthy subjects (Sullivan et al., 2001), as well as in acute and chronic pain conditions (Sullivan et al., 1995; Sullivan et al., 2005) so the PCS may have an important role in predicting acute and chronic pain states (Weissman-Fogel et al., 2008). According to Domenech et al. (2013) the PCS correlated with pain (VAS) ($r=0.43$) in anterior knee pain patients. Additionally, the PCS had correlation with pain severity before ($r=0.47^{**}$) and after treatment ($r=0.59^{**}$). Patients who decreased the PCS after treatment showed a greater improvement in pain (VAS) and disability (Domenech et al., 2014). The PCS can lead to pain related fear and cause disuse, depression, and disability (Schütze et al., 2010). According to Piva et al. (2009a) pain intensity correlated with FABQ-PA ($r=0.31$) and FABQ-W ($r=0.37$) and the results of forward regression showed that pain was associated with FABQ-W ($p=0.007$) and FABQ-PA ($p=0.037$), indicating that patients with PFP who reported higher levels of pain also scored higher in FABQ. Another study reported that changes in FABQ-PA were associated with outcome of pain ($r=0.51$) and physical function ($r=0.57$) significantly at the 0.01 level. The FABQ-PA was the strongest predictor of function and pain outcomes in patients with PFP (Piva et al., 2009b). Also, physical activity such as steps per day, was significant correlation with FABQ ($p=0.002$) in the PFP population (Glaviano et al., 2017).

Moreover, the PHLM_TH had negative correlation with VAS-AS ($r=-0.334^{*}$). The correlation of PHLM_TH subscales of awareness was negative with VAS-J ($r=-0.323^{*}$), VAS-AS ($r=-0.339^{*}$) and VAS-SQ ($r=-0.471^{**}$). The negative direction of relationships indicates the opposite scoring of questionnaires such as high scores of PHLM_TH indicating less symptom. Recently, mindfulness has become increasingly important because the majority of research shows that mindfulness has correlation with physical function, pain intensity and such other psychological features as emotional, cognitive, behavioral and social function in patients with chronic pain (McCracken et al., 2009). There were studies of mindfulness in patients with general chronic pain (Ussher et al., 2014) and fibromyalgia (Taylor et al., 2015) using PHLMS but There has been no previous study of correlation between mindfulness and chronic pain outcomes. The PHLMS was administered to assess trait-like qualities of acceptance (10 items) and awareness (10 items) that are manifest in daily life. The PHLMS asks respondents to indicate how often they have had various mindful experiences in the past week and significant differences were found between the nonclinical and clinical samples and have used in clinical and research settings (Cardaciotto et al., 2008; Tejedor et al., 2014). The PHLMS can detect change in mindfulness that is associated with health-related symptoms and satisfaction with life in healthy subjects (Klein et al., 2015).

According to Schütze et al. (2010) found the Mindful Attention Awareness Scale (MAAS) shows significant negative correlation with pain intensity (BPI - the Brief Pain Inventory) and the relationship of mindfulness was strongly inverse with pain catastrophizing and medium with variables in each of the major categories of the fear-avoidance model in general of musculoskeletal chronic pain. Also, Poulin et al. (2016) reported that the Five Facets Mindfulness Questionnaire (FFMQ) was negatively correlated with pain intensity and also demonstrated that mindfulness was a negative predictor of pain intensity in patients with chronic neuropathic pain. The overall mindfulness score of FFMQ was correlated with the pain intensity numerical rating scale in patients with upper extremity illness (Beks et al., 2018).

In addition, the leg strength had correlation positively ($r=0.490^{**}$) with leg power. A systematic review established that leg strength and power of populations with PFP were lower than in controls; moreover, less knee extension strength is significantly associated with a higher risk for future PFPS. Muscle strength is defined as the

ability of muscles to exert force, while muscle power is defined as the ability to generate muscular work per unit of time or the product of force and velocity (power = work/time) so muscle strength is a related but different attribute to muscle power (Bean et al., 2002). Lower extremity weakness might be associated with altered mechanics during weight bearing in subjects with patellofemoral pain syndrome (Wilson & Davis, 2009).

The current study has some limitations. The main complication was the time during the coronavirus disease (COVID-19) situation when subjects could not complete all tests in time so some information about the population was lost. Also, data collection was started after the 47th University Games of Thailand, resulting in some athletes still being injured and unable to participate in this research. The study also lacked numbers of each gender in the total population, so it was not possible to report the prevalence of chronic PFP in each gender of the total population. However, there are several instruments for assessing mindfulness and pain. Therefore, future studies need to determine the correlation between chronic pain assessments and various mindfulness instruments, and comparing with control group.

Conclusions

The prevalence of PFP in Thai university athletes was found to be lower than reported by previous studies in other countries. However, the chronic PFP had still an impact on psychological features and physical fitness of leg muscles in Thai university athletes. A correlation between pain intensity and psychological features was found with high pain intensity, leading to higher pain catastrophizing, and fear avoidance beliefs. Psychological features play a role in chronic PFP, which may barrier to recovery and limit the effectiveness of rehabilitation. Moreover, we have found that athletes with high pain intensity had lower mindfulness in this study. Therefore, the co-intervention is necessary to apply physical and psychological treatments for young adult athletes with chronic PFP.

Conflicts of interest

The author(s) have no conflicts of interest relevant to this article.

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