Research Paper

# Patellofemoral Pain Syndrome in Young Adult Women With Low to Moderate Physical Activity Levels

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## ABSTRACT

**Objectives:** To assess the prevalence and associated factors of Patellofemoral Pain Syndrome (PFPS) in young women with low to moderate Physical Activity (PA) levels.

**Methods:** Women with low to moderate PA, aged between 18 and 40 years, were enrolled in this study. A Thai version of the Kujala Patellofemoral Questionnaire (KPQ), history taking, and physical examination were used to screen and confirm the diagnosis of PFPS. Demographic features, including age, Body Mass Index (BMI), PA, knee alignment, and static foot posture, were recorded. Logistic regression analysis was conducted to determine confounding factors associated with PFPS.

**Results:** A total of 1011 women with a Mean±SD age of 25.51±6.79 years participated in this study. The prevalence of PFPS was 15%. Age, BMI, PA, knee alignment, and static foot posture were not significantly associated with PFPS in this population.

**Discussion:** Although the participants were young adults with low to moderate PA, the prevalence of PFPS was in the same range as the highly active groups. None of the factors investigated in this study could predict PFPS occurrence. Based on the findings, the risk factors of PFPS seem to be complex and individualized. The early diagnosis and treatment of PFPS should therefore be considered in this age group.

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## Highlights

- The prevalence of PFPS is 15% in young adult women with low to moderate physical activity levels.

- Age, body mass index, physical activity levels, knee alignment, and static foot posture are not associated with PFPS in this group of population.

## Plain Language Summary

This study surveyed the patellofemoral pain syndrome (PFPS) or the anterior knee pain in young adult women who were not highly active in daily life. The participants' characteristics were recorded, including age, body mass index, physical activity levels, knee alignment, and static foot posture. These characteristics were explored in associations with PFPS. Data collection was performed on 1011 participants. To diagnose PFPS, a specific-health questionnaire, history taking, and physical examination were used. Patellofemoral pain was found in 152 young women (15%). However, there was no association between patellofemoral pain and confounding factors of age, body mass index, physical activity level, knee alignment, and static foot posture. Therefore, the risks of PFPS may be complex and varied among age groups and individuals. An individual suffering from anterior knee pain should immediately seek medical attention for early diagnosis and treatment.

## 1. Introduction

Patellofemoral Pain Syndrome (PFPS) is one of the most common types of knee pain, with varied prevalence from 7.2% to 35.7% reported in different populations [1]. PFPS typically presents with diffuse anterior knee pain around or behind the patella and is usually aggravated by activities that load the joint, including running, squatting, jumping, and stair climbing [2, 3]. The impacts of the PFPS are the reduction of sporting, daily life, and work-related activities [4]. Increasing evidence suggests that PFPS is a refractory condition, persisting for many years [5]. In addition, it has been hypothesized that anterior knee pain in younger adults may progress to subsequent patellofemoral osteoarthritis [3, 6, 7].

Epidemiology data are crucial for clinical decision-making and the allocation of healthcare resources, especially in disease prevention and control. Previous studies have reported that PFPS is common among adolescents [2, 8-12], elite athletes [13-15], and military recruits [16]. Women are reportedly twice more likely to develop PFPS compared to men [16]. However, most previous studies have explored the prevalence of PFPS among adolescents [2, 8-12] and elite athletes [13-15]. Few studies have investigated the prevalence of PFPS in the general population of young adults [17-19]. One study surveyed the PFPS in a specific group of long-distance amateur cyclists [17], while the other two studies did not identify Physical Activity (PA) levels in the studied subjects [18-19].

The prevalence data of PFPS in young adults is warranted, especially those whose lives do not include high levels of PA. Therefore, this study aimed to investigate the prevalence of PFPS in young adult women with low to moderate PA. The factors contributing to PFPS occurrence in this population were also explored.

## 2. Materials and Methods

### Study design

This cross-sectional survey study was carried out in selected communities from August 2020 to February 2021. All study subjects with different careers were recruited from different communities and workplaces, such as hospitals, schools, and universities. The protocol was approved by the Human Research Ethics Committee of Walailak University, Thailand (WUEC-20-179-01).

### Study subjects

The sample size was estimated from the formula for the prevalence study [20]. The calculation based on the expected prevalence of 9.7% from our pilot study resulted in a sample size of 1011. The eligible participants in this study were the women between 18 to 40 years old, doing low to moderate levels of PA, and without confirmed clinical conditions, both systemic and chronic diseases. In this study, the low to moderate levels of PA were identified using the Global Physical Activity Questionnaire (GPAQ), as recorded in the Thai version [21]. The GPAQ divides PA levels into high, moderate, and

low levels based on time spent in PA and the Metabolic Equivalent Of Task (MET)-minutes per week. Involving vigorous-intensity PA for at least 3 d/wk and total MET-minutes of at least 1500 min/wk, or an equivalent combination of moderate- and vigorous-intensity PA for 7 d/wk achieving at least 3000 MET-minutes per week indicates a high level PA. The moderate level is classified as vigorous-intensity PA for at least 3 d/wk and involving more than or equal to 60 min/wk, moderate-intensity PA for at least 5 d/wk and involving more or equal to 150 min/wk, or an equivalent combination of moderate- and vigorous-intensity PA for at least 5 d/wk, achieving at least 600 MET-minutes per week. PA intensity that does not meet the criteria for moderate level is considered low PA [22, 23]. The exclusion criteria were having an inflammatory knee condition, a lower extremity fracture, a previous knee injury, arthroplasty, different features of knee alignments and static foot posture between limbs; or receiving any type of treatment for knee pain. Pregnant women were also excluded. All participants provided written informed consent before the study.

## Study procedure

The participants' characteristics, including age, Body Mass Index (BMI), and PA levels, were recorded. A physical therapist with 10 years' experience in treating patients with musculoskeletal disorders, especially knee disorders, performed an observational analysis of knee alignment and static foot posture for all participants. During the study, physical examinations, including palpation and physical tests (e.g., patellar compression, patellar gliding, and resisted isometric quadriceps muscle contraction) were thoroughly investigated in participants with anterior knee pain. While history taking and health-specific questionnaires assessment were also recorded for statistical validation.

Knee alignments in both frontal and sagittal planes were assessed in a standing position barefoot. In the frontal plane, the knee alignment was classified into three categories: normal, genu valgum, and genu varum. The participants were asked to stand with their feet together. Genu valgum was classified when the medial surface of both knees was knocked together while both ankles were still apart [24, 25]. Genu varum was classified as two or more fingers would fit between the knees when the ankles were together [24, 26]. In the sagittal plane, knee alignment was classified into two categories: normal and genu recurvatum. A hyperextended knee in a weight-bearing position was indicated as genu recurvatum [24]. Also, a static foot posture was classified into three categories: normal foot position, excessive foot pronation, and excessive foot supination. Excessive foot pronation was indicated when heel eversion and inward rotation, abduction of the forefoot, and or medial longitudinal arch decrease were observed. Excessive foot supination was indicated when inversion and outward rotation of the heel, adduction of the forefoot, and or medial longitudinal arch increase were observed [24, 27].

All participants were asked to complete a Thai version of the Kujala Patellofemoral Questionnaire (KPQ), which consisted of 13 questions, with a total score of 100 points [28]. In this study, this health-specific questionnaire was used to screen for anterior knee pain and the first step of PFPS diagnosis. If the KPQ score was less than 100 for at least one site, history taking and clinical tests would be in order. In cases of participants with bilateral knee pain (KPQ<100 of both knees), the KPQ score of the most affected/suffered side of lower extremities was used in data analysis.

Then, we identified the retropatellar pain aggravated during activities. A physical examination, consisting of palpation around the patella and anterior knee and compression of the patella, was conducted to confirm PFPS. The diagnostic criteria for patellofemoral pain in this study consisted of a KPQ score<100; retropatellar pain occurred with at least two of the following activities: prolonged sitting with flexed knees, ascending/descending stairs, hopping/jogging, squatting, and kneeling; and occurring pain during the compression of the patella and on the palpation of one of the following areas: medial or lateral patellar facets, or the anterior portion of the medial or lateral femoral condyles [2, 10, 16]. We also performed other physical tests, including patellar medial-lateral and superior-inferior translations, as well as resisted isometric quadriceps muscle contraction to confirm patellofemoral pain diagnosis [29]. Pain characteristics, including severity, duration, and affected sides, were also recorded.

Participants with PFPS were also asked to complete a Thai version of the International Knee Documentation Committee (IKDC) [30] form to evaluate the severity and limitation of knee symptoms. This specific instrument consists of 18 items, with a total score of 87. The score was then transformed into scales ranging from 0 to 100, indicating the level of knee symptoms and limitations of daily living or sporting activities [31]. In the case of bilateral PFPS, the IKDC score was determined according to the most affected/suffered side of the lower extremities. The overall study procedures are shown in Figure 1.

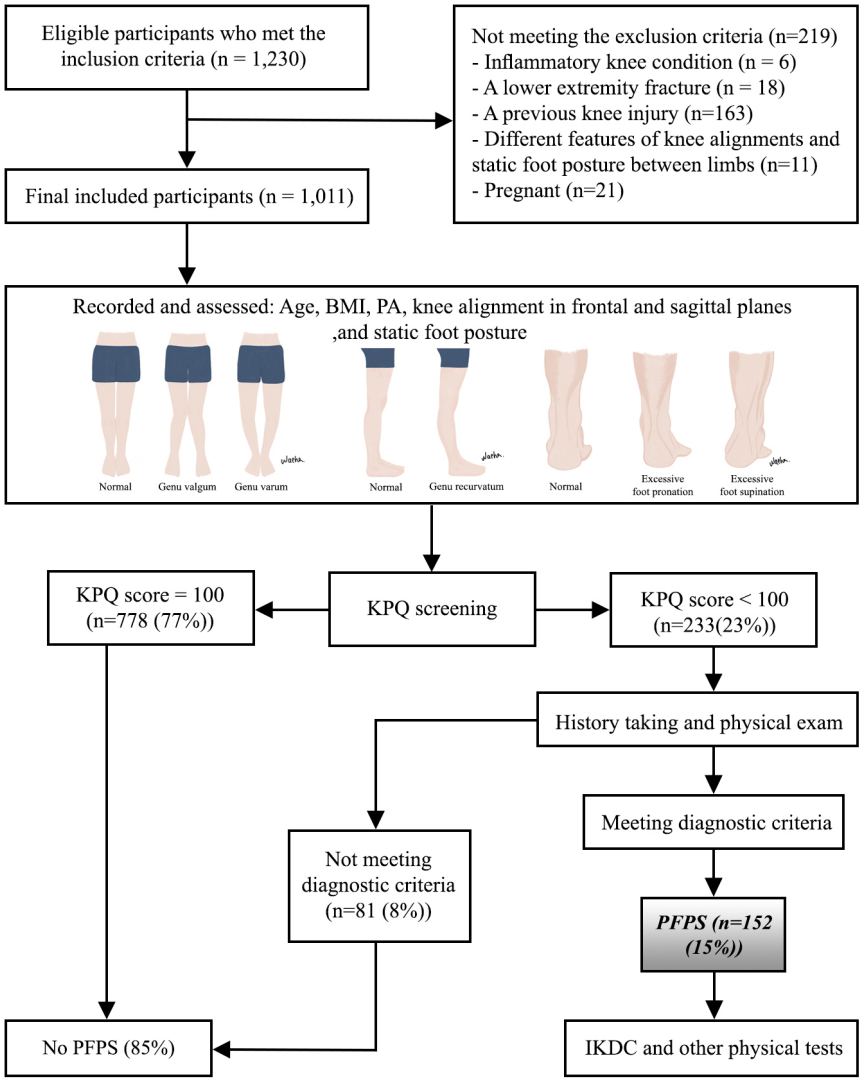


**Figure 1.** Overall study procedure

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## Statistical analysis

The statistical analysis was performed using SPSS for Windows version 18 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov goodness-of-fit test was used to test the distribution of data consisting of age, BMI, KPQ score, IKDC score, VAS, and duration of knee pain. All variables were not normally distributed. The descriptive statistics, including frequency, median (interquartile range, $25^{th}$–$75^{th}$ percentile), Mean±SD, and range, were used to describe variables.

Predictors of PFPS occurrence were analyzed by using logistic regression in two steps. In the first step, each factor was analyzed to obtain crude OR. All variables with a p value of less than 0.25 were included in the final model to obtain adjusted OR [32]. The backward selection procedure was performed to allocate the most predictive variables for PFPS in young women adults with low to moderate PA. A P value of less than 0.05 was considered statistically significant.

## 3. Results

Of 1011 young adult women, 23.7% were overweight (BMI: 23.0-27.5 kg/m$^2$), and 16.4% were obese (BMI>27.5 kg/m$^2$) according to the body mass index based on Asian criteria [33]. Most participants reported low physical activities (71.3%). Table 1 presents the descriptive characteristics of the study population. More than 10% of participants had knee and foot misalignments, including genu valgum, genu recurvatum, and excessive foot pronation. Knee alignments and static foot posture are shown in Figure 2.

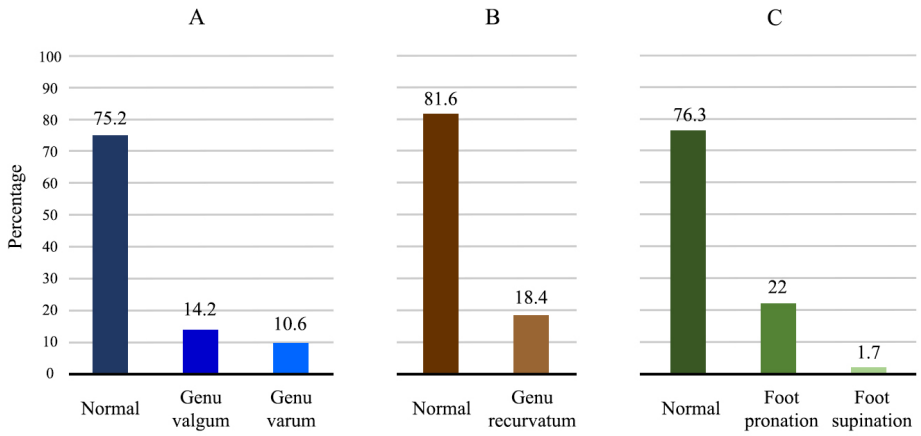




**Figure 2.** Distribution of knee alignment and static foot posture in 1011 participants

A: Knee Alignment in Frontal Plane (Normal: Genu Valgum, Genu Varum); B: Knee Alignment in Sagittal Plane (Normal, Genu Recurvatum); C: Static Foot Posture (Normal, Excessive Foot Pronation, Excessive Foot Supination).

In this study, we further found that 152 participants (15%) had PFPS. There were 31 participants (20.39%) with bilateral PFPS and 121 (79.61%) with unilateral PFPS. Also, 81 participants (8%) suffered from other types of knee pain. The Mean±SD duration of knee pain in individuals with PFPS was 2.0±1.97 years. The Mean±SD KPQ and IKDC scores were 83.22±4.79 and 78.96±12.03, respectively.

Accounting for 31 participants with bilateral PFPS, a total of 183 knees suffered from PFPS. Their Mean±SD pain intensity was 4.66±1.50 (range 3.00-8.40) using the Visual Analog Scale (VAS). The most location of tenderness was medial patellar facets (39.30%). Moreover, patellar translation medially was the highest aggravated pain in PFPS (75.40%). The location of tenderness and

**Table 1.** Demographic characteristics of study population (n=1011)

| Variables | Mean±SD | Median (Q1, Q3) | No. (%) |
|---|---|---|---|
| Age (y) | 25.51 ± 6.79 | 22(20,31) | - |
| BMI (Kg/m$^2$) | 23.02 ± 4.87 | 23.04(19.52,25.44) | - |
| Physical activity levels | | | |
| Low | - | - | 721(71.30) |
| Moderate | - | - | 290(28.70) |



**Table 2.** Location of tenderness in individuals with patellofemoral pain (n=183)

| Location | No. (%) |
|---|---|
| Medial patellar facets | 72(39.30) |
| Lateral patellar facets | 70(38.30) |
| The anterior portion of the medial femoral condyles | 24(13.10) |
| The anterior portion of the lateral femoral condyles | 31(16.90) |
| Quadriceps tendon | 35(19.10) |
| Patellar tendon | 71(38.80) |

**Table 3.** Physical test in individuals with patellofemoral pain (n=183)

| Physical test | | No. (%) |
|---|---|---|
| Patellar translation medial-laterally | Translation medially | 138(75.40) |
| | Translation laterally | 104(56.80) |
| Patellar translation superior-inferiorly | Translation superiorly | 71(38.80) |
| | Translation inferiorly | 72(39.30) |
| Resisted isometric quadriceps muscle contraction | | 93(50.80) |

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the results of the physical tests are presented in Tables 2 and 3, respectively.

The logistic regression analysis was used to predict PFPS occurrence with the demographic variables, including age, BMI, PA levels, knee, and foot misalignment variables. However, the analysis showed no significant confounding factors for the occurrence of PFPS (Table 4).

## 4. Discussion

The results of this study provided baseline information on the prevalence of PFPS in women with low to moderate levels of physical activity. A PEPS prevalence of 15% was observed in this young adult female population. This rate agrees with the range of prevalence of 7.2%-35.7% reported in previous studies [1, 2, 14, 16, 18]. The prevalence of PFPS reported in the literature is inconsistent due to the different diagnostic procedures and the populations involved [2, 10, 14, 16-19]. Similar to this study, Roush et al. reported a prevalence of 12%-13% PFPS in the adult population [18], whereby their average age (25.51 years) and BMI (23.93 kg/m$^2$) were also similar to our study. However, their population's physical activity levels were not determined, and participants were divided according to age and pregnancy history. Another survey, using only one questionnaire in young Chinese adults, reported a higher prevalence of 21.2% [19]. The history taking and physical tests in our study may have resulted in a smaller number of participants with confirmed PFPS.

The demographic and clinical features, including age, BMI, PA, knee alignment, and static foot posture, were included in the logistic regression analysis to determine the predictors of having PFPS in the general women

**Table 4.** Logistic regression analysis to determine associated factors with the prevalence of Patellofemoral Pain Syndrome (PFPS)

| Variables | Mean±SD/No. (%) | | Crude Odds Ratio (95%CI) | P | Adjusted Odds Ratio (95%CI) | P |
|---|---|---|---|---|---|---|
| | PFPS (n=152) | Non-PFPS (n=859) | | | | |
| Age (y) | 25.38±7.08 | 25.53±6.75 | 0.997(0.972-1.022) | 0.797 | - | - |
| BMI (kg/m$^2$) | 22.91±4.73 | 23.06±4.90 | 0.993(0.958-1.030) | 0.719 | - | - |
| PA-moderate levels | 38(25.0) | 252(29.3) | 1.245(0.839-1.850) | 0.277 | - | - |
| Knee alignment in the frontal plane | - | - | - | 0.403 | - | - |
| Genu valgum | 27(17.80) | 117(13.60) | 1.038(.580-1.857) | 0.900 | - | - |
| Genu varum | 15(9.90) | 92(10.70) | 1.415(.712-2.815) | 0.322 | - | - |
| Genu recurvatum | 34(22.40) | 152(17.70) | 0.746(.490-1.135) | 0.172 | 0.788(0.515-1.204) | 0.271 |
| Static Foot posture | - | - | - | 0.078 | - | 0.078 |
| Excessive foot pronation | 44(28.9) | 178(20.70) | 1.191(0.269-5.294) | 0.816 | 1.194(0.269-5.294) | 0.816 |
| Excessive foot supination | 2(1.3) | 15(1.7) | 1.854(.409-8.408) | 0.424 | 1.854(0.409-8.408) | 0.424 |

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adult population. The results illustrated that none of these factors was a significant predictor of PFPS in this population. Similar to previous reports, age [19] and BMI [34, 35] were not significant predictors of PFPS development. In contrast, lower extremity malalignment was reportedly an important etiologic factor in PFPS [36, 37]. Lower extremity alignment factors associated with PFPS were femoral neck anteversion, genu valgum, genu recurvatum, Q angle, tibia varum, and excessive foot pronation [36]. In addition, genu varum was found to be an associated factor of PFPS in men workers in an automobile manufacturing factory [38]. Thijs et al. [39] stated that static foot posture does not contribute to PFPS. However, excessive foot pronation may be related to the development of PFPS [37, 40-42]. Overall, the risk factors of PFPS are quite complex and individualized. Although three major contributing factors to PFPS, i.e., lower extremity malalignment, lower extremity muscle imbalance, and hyperactivity, have been identified [36, 42], more recent work has, however, demonstrated no consensus regarding the contributing factors of PFPS occurrences [43, 44].

The Mean±SD pain intensity (VAS) of the knee PFPS was 4.66±1.50. The pain intensity might not be mild so the participants disregard medical attention from health professionals. A previous study has shown a greater pain intensity, that is, VAS of 6 in 10 among individuals with PFPS, of those who were referred to physiotherapy [45]. Moreover, the evidence supported that women with PFPS who maintained a high level of PA have severe pain compared to those with a moderate level of PA [46]. In this study, 72% and 70% of individuals with PFPS demonstrated tenderness at the medial and lateral borders of the patella, respectively. The results were consistent with a previous study that reported tenderness to palpation of the patellar edges in 71%-75% of people with PFPS [47]. In addition, the patellofemoral pain consensus statement recommended that the tenderness on patellar facet palpation was an additional criterion to define PFPS [48].

Other physical tests used as diagnostic criteria in some previous studies consisting of patellar gliding and the resisted isometric quadriceps contraction tests, were examined in this study. A tight knee with decreased patellar mobility was postulated as a contributor to PFPS. The finding of diminished patellar mobility in individuals with PFPS remained unclear of clinical importance. The previous study suggested that the patellar mobility test could not be used alone to confirm PFPS. This opinion was because the diagnostic accuracy of patellar translation medial-laterally was moderate, and for patellar translation, superior-inferiorly was fair to moderate [49]. Therefore, in this study, this test was used as supporting clinical results for individuals with PFPS. The results revealed that approximately two of three PFPS knees had positive tests of translation medially, while approximately 39% had positive tests of patellar translation superior-inferiorly. This study found that approximately 50% of individuals with PFPS demonstrated pain in resisted isometric quadriceps muscle contraction. In this study, the resisted isometric quadriceps muscle contraction was used as supporting clinical results of individuals with PFPS as well, while some previous studies used it to diagnose in combination with other criteria [10, 50]. Cook et al. (2010) reported the specificity and sensitivity of the resisted isometric quadriceps muscle contraction as 82% and 39%, respectively. However, they suggested that the combination of tests could improve the diagnostic accuracy of the PFPS; two of three positive findings of resisted isometric quadriceps contraction, pain during squatting, and pain during palpation [51].

The next assessment in individuals diagnosed with PFPS was the severity of knee symptoms and dysfunction by using the IKDC as well as reported in previous studies [2, 52]. The IKDC score in female athletes with PFPS at diagnosis (85.6±7.7) was higher than our participants [2]. It is implied that the knee symptoms and functions of our population were more severe than in female athletes. However, the volunteers with PFPS who enrolled in the study of Tsai et al. (2016) demonstrated an IKDC score of 59.9±14.2 before training, reflecting a higher severity than participants in our study [52]. Remarkably, there has been a poor long-term prognosis in the adult population, as more than 50% of participants still reported pain and functional limitation at 5 to 8 years of follow-up after six weeks of treatments [5]. The level of activity limitation was significantly increased, especially among participants involved in impact activities [53]. Accordingly, PFPS presents a poor prognosis which requires more attention from health professionals. However, exercise therapy could relieve PFPS and improve function in the medium and long term in these affected individuals [54].

The present study had some limitations. It was an observational study conducted in various communities. Some confounding factors, such as muscle strength of lower extremities and kinetic foot variables, were not included. Moreover, a longitudinal study should be further investigated for the prognosis in individuals with PFPS and follow-up participants without PFPS symptoms to identify significant risk factors.

## 5. Conclusion

Based on these preliminary results, PFPS was found in 15% of the young adult women population with low to moderate PA. Age, BMI, PA level, knee alignment, and static foot posture were not associated factors with the occurrence of PFPS. Therefore, the risk factors of PFPS seem to be complex and individualized. A more comprehensive study is recommended to investigate further unknown but existing risks associated with PFPS in the future. This finding can be used as a guideline strategic plan to curve the incidence of PFPS not only in active women but also in the general population.

## Ethical Considerations

### Compliance with ethical guidelines

The protocol for this study was approved by the Human Research Ethics Committee of Walailak University, Thailand (WUEC-20-179-01). Each participant also provided written informed consent to this study.

### Funding

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### Authors' contributions

Conceptualization: Patcharin Nilmart and Mantana Vongsirinavarat; Resources, methodology, writing, review, and editing: All authors; Funding acquisition and investigation: Patcharin Nilmart and Wantanee Yodchaisarn; Writing: Patcharin Nilmart, Mantana Vongsirinavarat; Supervision: Mantana Vongsirinavarat.

### Conflict of interest

The authors declared no conflict of interest.

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## References

[1] Smith BE, Selfe J, Thacker D, Hendrick P, Bateman M, Moffatt F, et al. Incidence and prevalence of patellofemoral pain: A systematic review and meta-analysis. PLoS One. 2018; 13(1):e0190892. [DOI:10.1371/journal.pone.0190892] [PMID] [PMCID]

[2] Myer GD, Ford KR, Barber Foss KD, Goodman A, Ceasar A, Rauh MJ, et al. The incidence and potential pathomechanics of patellofemoral pain in female athletes. Clinical Biomechanics. 2010; 25(7):700-7. [DOI:10.1016/j.clinbiomech.2010.04.001] [PMID] [PMCID]

[3] Willy RW, Hoglund LT, Barton CJ, Bolgla LA, Scalzitti DA, Logerstedt DS, et al. Patellofemoral Pain. Journal of Orthopaedic & Sports Physical Therapy. 2019; 49(9):CPG1-95. [DOI:10.2519/jospt.2019.0302] [PMID]

[4] Rothermich MA, Glaviano NR, Li J, Hart JM. Patellofemoral pain: Epidemiology, pathophysiology, and treatment options. Clinical Journal of Sport Medicine. 2015; 34(2):313-27. [DOI:10.1016/j.csm.2014.12.011] [PMID]

[5] Lankhorst NE, van Middelkoop M, Crossley KM, Bierma-Zeinstra SM, Oei EH, Vicenzino B, et al. Factors that predict a poor outcome 5-8 years after the diagnosis of patellofemoral pain: A multicentre observational analysis. British Journal of Sports Medicine. 2016; 50(14):881-6. [DOI:10.1136/bjsports-2015-094664] [PMID]

[6] Thomas MJ, Wood L, Selfe J, Peat G. Anterior knee pain in younger adults as a precursor to subsequent patellofemoral osteoarthritis: A systematic review. BMC Musculoskeletal Disorders. 2010; 11:201. [DOI:10.1186/1471-2474-11-201] [PMID] [PMCID]

[7] Wyndow N, Collins N, Vicenzino B, Tucker K, Crossley K. Is there a biomechanical link between patellofemoral pain and osteoarthritis? A narrative review. Sports Medicine. 2016; 46(12):1797-808. [DOI:10.1007/s40279-016-0545-6] [PMID]

[8] Fairbank JC, Pynsent PB, van Poortvliet JA, Phillips H. Mechanical factors in the incidence of knee pain in adolescents and young adults. The Journal of Bone and Joint Surgery. British Volume. 1984; 66(5):685-93. [DOI:10.1302/0301-620X.66B5.6501361] [PMID]

[9] Hall R, Barber Foss K, Hewett TE, Myer GD. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. Journal of Sport Rehabilitation. 2015; 24(1):31-5. [DOI:10.1123/jsr.2013-0101] [PMID] [PMCID]

[10] Molgaard C, Rathleff MS, Simonsen O. Patellofemoral pain syndrome and its association with hip, ankle, and foot function in 16- to 18-year-old high school students: A single-blind case-control study. Journal of the American Podiatric Medical Association. 2011; 101(3):215-22. [DOI:10.7547/1010215] [PMID]

[11] Steinberg N, Siev-Ner I, Peleg S, Dar G, Masharawi Y, Zeev A, et al. Joint range of motion and patellofemoral pain in dancers. International Journal of Sports Medicine. 2012; 33(7):561-6. [DOI:10.1055/s-0031-1301330] [PMID]

[12] Rathleff MS, Roos EM, Olesen JL, Rasmussen S. Exercise during school hours when added to patient education improves outcome for 2 years in adolescent patellofemoral pain: A cluster randomised trial. British Journal of Sports Medicine. 2015; 49(6):406-12. [DOI:10.1136/bjsports-2014-093929] [PMID]

[13] Nejati P, Forogh B, Moeineddin R, Baradaran HR, Nejati M. Patellofemoral pain syndrome in Iranian female athletes. Acta Medica Iranica. 2011; 49(3):169-72. [PMID]

[14] Clarsen B, Krosshaug T, Bahr R. Overuse injuries in professional road cyclists. American Journal of Sports Medi-

cine. 2010; 38(12):2494-501. [DOI:10.1177/0363546510376816] [PMID]

[15] Winslow J, Yoder E. Patellofemoral pain in female ballet dancers: Correlation with iliotibial band tightness and tibial external rotation. Journal of Orthopaedic & Sports Physical Therapy. 1995; 22(1):18-21. [DOI:10.2519/jospt.1995.22.1.18] [PMID]

[16] Boling M, Padua D, Marshall S, Guskiewicz K, Pyne S, Beutler A. Gender differences in the incidence and prevalence of patellofemoral pain syndrome. Scandinavian Journal of Medicine & Science in Sports. 2010; 20(5):725-30. [DOI:10.1111/j.1600-0838.2009.00996.x] [PMID] [PMCID]

[17] Weiss BD. Nontraumatic injuries in amateur long distance bicyclists. American Journal of Sports Medicine. 1985; 13(3):187-92. [DOI:10.1177/036354658501300308] [PMID]

[18] Roush JR, Curtis Bay R. Prevalence of anterior knee pain in 18-35 year-old females. International Journal of Sports Physical Therapy. 2012; 7(4):396-401. [PMCID]

[19] Xu X, Yao C, Wu R, Yan W, Yao Y, Song K, et al. Prevalence of patellofemoral pain and knee pain in the general population of Chinese young adults: A community-based questionnaire survey. BMC Musculoskeletal Disorders. 2018; 19(1):165. [DOI:10.1186/s12891-018-2083-x] [PMID] [PMCID]

[20] Pourhoseingholi MA, Vahedi M, Rahimzadeh M. Sample size calculation in medical studies. Gastroenterology and Hepatology from Bed to Bench. 2013; 6(1):14-7. [PMCID]

[21] Visuthipanich V. Psychometric Testing of GPAQ among the Thai Population. Thai Pharmaceutical and Health Science Journal. 2016; 11(4):144-52. http://ejournals.swu.ac.th/index.php/pharm/article/view/8792

[22] Abu Saad H, Low PK, Jamaluddin R, Chee HP. Level of physical activity and its associated factors among primary healthcare workers in Perak, Malaysia. International Journal of Environmental Research and Public Health. 2020; 17(16):5947. [DOI:10.3390/ijerph17165947] [PMID] [PMCID]

[23] World Health Organization. Global Physical Activity Questionnaire (GPAQ). Geneva: World Health Organization. https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf

[24] Magee DJ. Orthopedic physical assessment. 6th ed. St. London: Elsevier Health Sciences; 2014. https://books.google.com/books/about/Orthopedic_Physical_Assessment.html?id=_wcyAgAAQBAJ

[25] Jankowicz-Szymanska A, Mikolajczyk E. Genu valgum and flat feet in children with healthy and excessive body weight. Pediatric Physical Therapy. 2016; 28(2):200-6. [DOI:10.1097/PEP.0000000000000246] [PMID]

[26] Isin A, Melekoglu T. Genu varum and football participation: Does football participation affect lower extremity alignment in adolescents? The Knee. 2020; 27(6):1801-10. [DOI:10.1016/j.knee.2020.10.007] [PMID]

[27] Ghanem I, Massaad A, Assi A, Rizkallah M, Bizdikian AJ, El Abiad R, et al. Understanding the foot's functional anatomy in physiological and pathological conditions: The calcaneopedal unit concept. Journal of Children's Orthopaedics. 2019; 13(2):134-46. [DOI:10.1302/1863-2548.13.180022] [PMID] [PMCID]

[28] Sakunkaruna S, Sakunkaruna Y, Sakulsriprasert P. Thai version of the kujala patellofemoral questionnaire in knee pain patients: Cross-cultural validation and test-retest reliability. Journal of the Medical Association of Thailand. 2015; 98(S 5):S81-5. [PMID]

[29] Nunes GS, Stapait EL, Kirsten MH, de Noronha M, Santos GM. Clinical test for diagnosis of patellofemoral pain syndrome: Systematic review with meta-analysis. Physical Therapy in Sport. 2013; 14(1):54-9. [DOI:10.1016/j.ptsp.2012.11.003] [PMID]

[30] Lertwanich P, Praphruetkit T, Keyurapan E, Lamsam C, Kulthanan T. Validity and reliability of Thai version of the international knee documentation committee subjective knee form. Journal of the Medical Association of Thailand. 2008; 91(8):1218-25. [PMID]

[31] Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) subjective knee evaluation form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). Arthritis Care & Research. 2011; 63(S 11):S208-28. [DOI:10.1002/acr.20632] [PMID] [PMCID]

[32] Essien SK, Bath B, Koehncke N, Trask C, Saskatchewan Farm Injury Cohort Study T. Association between farm machinery operation and low back disorder in farmers: A retrospective cohort study. Journal of Occupational and Environmental Medicine. 2016; 58(6):e212-7. [DOI:10.1097/JOM.0000000000000746] [PMID]

[33] WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004; 363(9403):157-63. [DOI:10.1016/S0140-6736(03)15268-3]

[34] Hart HF, Barton CJ, Khan KM, Riel H, Crossley KM. Is body mass index associated with patellofemoral pain and patellofemoral osteoarthritis? A systematic review and meta-regression and analysis. British Journal of Sports Medicine. 2017; 51(10):781-90. [DOI:10.1136/bjsports-2016-096768] [PMID]

[35] Barber Foss KD, Hornsby M, Edwards NM, Myer GD, Hewett TE. Is body composition associated with an increased risk of developing anterior knee pain in adolescent female athletes? The Physician and Sportsmedicine. 2012; 40(1):13-9. [DOI:10.3810/psm.2012.02.1947] [PMID] [PMCID]

[36] Thomee R, Augustsson J, Karlsson J. Patellofemoral pain syndrome: A review of current issues. Sports Medicine. 1999; 28(4):245-62. [DOI:10.2165/00007256-199928040-00003] [PMID]

[37] Duffey MJ, Martin DF, Cannon DW, Craven T, Messier SP. Etiologic factors associated with anterior knee pain in distance runners. Medicine & Science in Sports & Exercise. 2000; 32(11):1825-32. [DOI:10.1097/00005768-200011000-00003] [PMID]

[38] Sharifian SA, Chinichian M, HalimiMilani A, Mehrdad R. Prevalence and risk factors of patellofemoral pain in an automobile manufacturing factory. Malaysian Journal Of Medicine And Health Sciences. 2020; 16(2):193-7. https://medic.upm.edu.my/upload/dokumen/2020042010303627_MJMHS_0160.pdf

[39] Thijs Y, De Clercq D, Roosen P, Witvrouw E. Gait-related intrinsic risk factors for patellofemoral pain in novice recreational runners. British Journal of Sports Medicine. 2008; 42(6):466-71. [DOI:10.1136/bjsm.2008.046649] [PMID]

[40] Powers CM, Chen PY, Reischl SF, Perry J. Comparison of foot pronation and lower extremity rotation in persons with and without patellofemoral pain. Foot & Ankle International. 2002; 23(7):634-40. [DOI:10.1177/107110070202300709] [PMID]

[41] Hetsroni I, Finestone A, Milgrom C, Sira DB, Nyska M, Radeva-Petrova D, et al. A prospective biomechanical study of the association between foot pronation and the incidence of anterior knee pain among military recruits. The Journal of Bone and Joint Surgery. British Volume. 2006; 88(7):905-8. [DOI:10.1302/0301-620X.88B7.17826] [PMID]

[42] Dutton RA, Khadavi MJ, Fredericson M. Patellofemoral pain. Physical Medicine and Rehabilitation Clinics of North America. 2016; 27(1):31-52. [DOI:10.1016/j.pmr.2015.08.002] [PMID]

[43] Neal BS, Lack SD, Lankhorst NE, Raye A, Morrissey D, van Middelkoop M. Risk factors for patellofemoral pain: A systematic review and meta-analysis. British Journal of Sports Medicine. 2019; 53(5):270-81. [DOI:10.1136/bjsports-2017-098890] [PMID]

[44] Lankhorst NE, Bierma-Zeinstra SM, van Middelkoop M. Risk factors for patellofemoral pain syndrome: A systematic review. The Journal of Orthopaedic and Sports Physical Therapy. 2012; 42(2):81-94. [DOI:10.2519/jospt.2012.3803] [PMID]

[45] Miri Abyaneh H, Mosallanezhad Z, Mohammadalizade H, Bakhshi E, Vahedi G, Nourbakhsh MR. Physiotherapy with and without superficial dry needling affects pain and muscle strength in patients with patellofemoral pain syndrome. Iranian Rehabilitation Journal. 2016; 14(1):23-30. [DOI:10.15412/J.IRJ.08140104]

[46] Briani RV, Pazzinatto MF, De Oliveira Silva D, Azevedo FM. Different pain responses to distinct levels of physical activity in women with patellofemoral pain. Brazilian Journal of Physical Therapy. 2017; 21(2):138-43. [DOI:10.1016/j.bjpt.2017.03.009] [PMID] [PMCID]

[47] Naslund J, Naslund UB, Odenbring S, Lundeberg T. Comparison of symptoms and clinical findings in subgroups of individuals with patellofemoral pain. Physiotherapy Theory and Practice. 2006; 22(3):105-18. [DOI:10.1080/09593980600724246] [PMID]

[48] Crossley KM, Stefanik JJ, Selfe J, Collins NJ, Davis IS, Powers CM, et al. 2016 Patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester. Part 1: Terminology, definitions, clinical examination, natural history, patellofemoral osteoarthritis and patient-reported outcome measures. British Journal of Sports Medicine. 2016; 50(14):839-43. [DOI:10.1136/bjsports-2016-096384] [PMID] [PMCID]

[49] Sweitzer BA, Cook C, Steadman JR, Hawkins RJ, Wyland DJ. The inter-rater reliability and diagnostic accuracy of patellar mobility tests in patients with anterior knee pain. The Physician and Sportsmedicine. 2010; 38(3):90-6. [DOI:10.3810/psm.2010.10.1813] [PMID]

[50] Thijs Y, Van Tiggelen D, Roosen P, De Clercq D, Witvrouw E. A prospective study on gait-related intrinsic risk factors for patellofemoral pain. Clinical Journal of Sport Medicine. 2007; 17(6):437-45. [DOI:10.1097/JSM.0b013e31815ac44f] [PMID]

[51] Cook C, Hegedus E, Hawkins R, Scovell F, Wyland D. Diagnostic accuracy and association to disability of clinical test findings associated with patellofemoral pain syndrome. Physiotherapy Canada. 2010; 62(1):17-24. [DOI:10.3138/physio.62.1.17] [PMID] [PMCID]

[52] Tsai LC, Lee SJ, Yang AJ, Ren Y, Press JM, Zhang LQ. Effects of off-axis elliptical training on reducing pain and improving knee function in individuals with patellofemoral pain. Clinical Journal of Sport Medicine. 2015; 25(6):487-93. [DOI:10.1097/JSM.0000000000000164] [PMID] [PMCID]

[53] Carlson VR, Boden BP, Shen A, Jackson JN, Alter KE, Sheehan FT. Patellar maltracking persists in adolescent females with patellofemoral pain: A longitudinal study. Orthopaedic Journal of Sports Medicine. 2017; 5(2):2325967116686774. [DOI:10.1177/2325967116686774] [PMID] [PMCID]

[54] Collins NJ, Barton CJ, van Middelkoop M, Callaghan MJ, Rathleff MS, Vicenzino BT, et al. 2018 Consensus statement on exercise therapy and physical interventions (orthoses, taping and manual therapy) to treat patellofemoral pain: Recommendations from the 5th International Patellofemoral Pain Research Retreat, Gold Coast, Australia, 2017. British Journal of Sports Medicine. 2018; 52. [DOI:10.1136/bjsports-2018-099397] [PMID]