

Risk factors of the patellofemoral pain syndrome

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ABSTRACT

Background: Patellofemoral pain syndrome (PFPS) is one of the common injuries to the knee that often occur, causing pain when doing physical activities such as squatting, running or going up and down stairs when the knee is bent. As the joint that supports the body the most, this certainly hinders a person's activities. PFPS is caused by various risk factors ranging from intrinsic factors such as muscle strength to extrinsic factors such as type of activity. This study aimed to determine the risk factors related to PFPS as a preventive effort by doing quadriceps muscle strengthening exercises.

Methods: This study used a literature review study design using secondary data from published literature. Literature searches were conducted online through PubMed, ScienceDirect, and Google Scholar, using the keywords "knee injury", "patellofemoral pain", "patellofemoral pain syndrome", and "risk factors", which selected based on inclusion and exclusion criteria.

Results: From the five studies that discussed risk factors related to PFPS, it was found that all journals showed quadriceps muscle strength, type of daily activity, Q-angle, joint laxity, hip tightness, patellar imbalance, overuse, and patellofemoral joint overpressure were associated with PFPS.

Conclusion: Based on the literature that has been reviewed and the discussion, the dominant risk factor associated with PFPS was a decrease in hip muscle strength, especially quadriceps. Besides, several other contributing factors include the type of daily activity, Q-angle, joint laxity, hip tightness, patellar imbalance, overuse, and patellofemoral joint overpressure.

Keywords: knee injury, patellofemoral pain, patellofemoral pain syndrome, risk factors.

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Introduction

The knee is a region that is essential as a large joint with the most weight in the human body. Excessive loading on the knee due to excessive activity can impact the onset of various complaints or injuries in the knee area, including patellofemoral pain syndrome (PFPS).¹ PFPS is pain around the anterior knee when the patella is weight-bearing in the flexed or bent knee state.² The pain will worsen when doing activities such as running, climbing up and down stairs, jumping, and squatting, which will undoubtedly hamper daily activities. One of the risk factors for PFPS is the position and alignment of the patella. When the patella has a different orientation, it will glide to one side of the patellar facies of the femur, which may cause overuse and overpressure on that part of the femur, resulting in pain, discomfort or irritation.³

The prevalence of PFPS based on a systematic review conducted by Smith et al. in the general population in

the UK (2017) was 22.7%, in men as much as 15.5%, and in women, both adolescents and young adults, the highest prevalence of 29.2%.⁴ A retrospective review of the orthopaedic database showed more than 30 million patients in the United States in 2007-2011; 1.75 million patients (about 6%) experienced PFPS, and women accounted for 55% of cases.⁵ PFPS can be experienced by everyone, both men and women, adolescents or adults. The prevalence of PFPS in youth in China was 20.7% out of 1.153 participants in 2018.⁶ People with high physical activity have an increased risk of PFPS. A study on people with increased activity, namely recreational runners in Badung and Denpasar, showed a high prevalence of PFPS in 17 knees out of 45 people or 37.8%.⁷

According to research by Halabchi et al., using systematic review and meta-analysis methods, PFPS is influenced by intrinsic and extrinsic factors. Intrinsic factors are related to individual characteristics, and outside factors

are related to factors outside the human body, such as the type of physical activity.² Other factors that cause PFPS are quadriceps weakness, especially in vastus medialis oblique (VMO), hamstring stiffness, iliopsoas stiffness, iliotibial band stiffness, gastroc soleus stiffness, hip muscle dysfunction, especially abductor and external rotator, foot overpronation, joint laxity, Q-Angle angle, limb length difference, patellar malalignment and patellar hypermobility.⁸ PFPS symptoms usually appear gradually and may occur bilaterally.²

Risk factors associated with the development of PFPS and its incidence in various populations still need to be better evaluated in existing studies due to limited prospective data and the homogeneity of the population studied.⁹ Therefore, this literature review aims to review previous studies on the dominant risk factors and factors contributing to the incidence of PFPS as a first step in determining the prevention of the syndrome, one of which is by performing hip muscle strengthening exercises, especially the quadriceps muscle.

Methods

The method used for the study was a literature review employing secondary data from published literature. An online literature search was conducted through *Majalah Ilmiah Fisioterapi Indonesia* (MIFI), PubMed, ScienceDirect and Google Scholar, using the keywords “knee injury”, “patellofemoral pain”, “patellofemoral pain syndrome”, and “risk factors”. The literature selection was based on inclusion and exclusion criteria. The inclusion criteria for this literature review were as follows: publications from reputable organisations, literature reviews of printed books from the last ten years, content addressing two or more variables such as patellofemoral pain, patellofemoral pain syndrome, and risk factors, and inclusion of pain measurement in the literature. The exclusion criteria for this literature review were publications not from credible institutions, published more than ten years ago, focusing on only one variable, and lacking appropriate measurements. The literature included in the review met the criteria established by the author.

Results

From the results of the literature that the author has found, five journals are relevant to the title of this research, which have been included in Table 1.

A study by Bradley S Neal et al. (2018) showed that from 18 selected studies involving 4,818 participants, 483 experienced PFPS. It consisted of 3 different subgroups: seven studies on military recruits, six on adolescents and five on recreational runners. Quadriceps weakness was a risk factor for PFPS in the military population measured with an isokinetic dynamometer concentrically at 60°/s ($I^2=0\%$, moderate SMD -0.66, CI -0.99,-0.32) concentrically at 240°/s ($I^2=17\%$, small SMD -0.49, CI -0.85 to -0.12). In adolescents, hip abduction strength is a risk factor for PFPS due to high levels of physical activity, which is common in this age group—Increased lower limb muscle strength due to high physical activity levels. It is possible that lower limb muscle

strength correlates with symptom duration in adolescents, with strength deficits appearing later in life when symptoms persist and if activity levels are subsequently reduced.¹⁰

The risk of injury occurs when there is a muscle imbalance in the trunk and hip or changes in the foot and ankle kinetic movement. This aligns with Pablo Monteiro Pereira et al. (2022) research. Two main risk factors cause PFPS: anterior knee translation with the anterior tibial line in front of the ipsilateral toe line when squatting. The second is imbalance and weakness of the thigh muscles, such as the gluteus medius and quadriceps, especially the VMO. Muscle imbalance of the thigh, posteroanterior, and stabiliser muscles such as the gluteus medius and the VMO demonstrated through EMG with contracting ability is the most significant cause of pain in PFPS patients compared to people without the syndrome. Therefore, it is considered as one of the aggravating factors.¹¹

Biomechanically, a person with knee complaints is often found to have problems in the waist as well. This area can be examined at the quadriceps angle, often known as the Q angle. In research conducted by Naufal et al. (2020), 15 respondents were measured with Clarke's test to determine the presence of PFPS and the amount of Q-angle angle measured with a goniometer. It shows a p-value of 0.043 and a correlation value of 0.528, which offers a strong relationship between the degree of quadricep angle and grade patella fetal pain syndrome. Excessive Q-angle will increase the occurrence of PFPS. This is based on the fact that there is an increase in compressive force between the lateral side of the patella and the lateral femoral condyle. A knee that has a valgus shape is a condition of abnormality in neuromuscular control of the lower extremity. Lower extremity. This creates a force vector to the lateral on the patella bone, thus increasing the load on the lateral surface of the patella. Force between the lateral surface of the patella and the lateral femoral condyle. Lateral femoral condyle.¹²

Research conducted by Papadopoulos et al. (2016) found that out of 251 screened studies, 18 were selected, 6 of which were about risk factors for PFPS. Decreased quadriceps or knee extensor muscle strength was the dominant risk factor for PFPS, followed by dynamic misalignment of the lower extremities.¹³

Xie et al. (2022) showed moderate evidence that increased peak hip adduction was found in the PFPS group during single-leg running and squatting activities. Excessive adduction and excessive internal rotation of the femur during movement can lead to lateral patellar tracking and increased contact pressure on the lateral aspect of the patella. Consequently, patellar realignment may increase the incidence of PFPS development. The two groups had no difference in the activation level of GMed and GMax in functional activities. The activation level of GMed was the same level of GMed activation between the health and PFPS groups in the operational activities of running, jumping, falling, and descending, concluding that there is a

Table 1. Five articles on risk factors of patellofemoral pain syndrome

Authors	Title	Methods	Results
Neal et al. (2018) ¹⁰	Risk factors for patellofemoral pain: a systematic review and meta-analysis	Research method: systematic review & meta-analysis by PRISMA. Inclusion criteria: studies involving women & men who have symptoms of PFP, sample >20 people with at least one variable studied as a risk factor, study design prospective study design, journals in English	Eighteen studies on Patellofemoral Pain (PFP) involving 4,818 participants found that factors like age, weight, Q-angle, and BMI are not significant risk factors. However, quadriceps weakness is a moderate risk factor in military populations, and hip abduction strength is a risk factor in adolescents.
Pereira et al. (2022) ¹¹	Patellofemoral Pain Syndrome Risk Associated with Squats: A Systematic Review	Research method: systematic review & meta-analysis. A literature search was conducted from 2014-2021 Inclusion criteria: articles, case reports, cohort and cross-sectional studies published in indexed journals, journals written in English,	Out of 6,570 articles screened, 37 were included and reviewed. The main risk factors for Patellofemoral Pain Syndrome (PFPS) are anterior knee translation during squats, with the knee positioned in front of the toes, and weakness in thigh muscles, particularly the gluteus medius and quadriceps, especially the Vastus Medialis Obliquus (VMO).
Naufal, et al. (2020) ¹²	Derajat Quadriceps Angle Mempengaruhi Patellofemoral Pain Syndrome	Research method: Cross-sectional. Sample technique: Randomized Controlled Trial. n=15, Sample: members of the Basketball Unit of Universitas Muhammadiyah Surakarta with female gender. Q-angle measuring instrument: goniometer, PFPS measuring instrument: Kujala score	I-value = 0.043 in the relationship between PFPS grade and Q-angle degree correlation value = 0.528, which means that there is a strong relationship between PFPS and the degree of Q-angle
Papadopoulos et al. (2015) ¹³	A Systematic Review of Reviews in Patellofemoral Pain Syndrome Exploring the Risk Factors, Diagnostic Tests, Outcome Measurements and Exercise Treatment	Research method: systematic review Inclusion criteria: journals in English, precise research methods with detailed references, adult research population, study design in the form of RCT, case-control, and cohort.	Two hundred fifty-one studies were screened, and 18 studies were selected, 6 of which were about risk factors for PFPS. Decreased quadriceps or knee extensor muscle strength is the dominant risk factor leading to PFPS, followed by dynamic malalignment of the lower extremities.
Xie et al. (2022) ¹⁴	The Relationship between Patellofemoral Pain Syndrome and Hip Biomechanics: A Systematic Review with Meta-Analysis	Research methods: Systematic review & meta-analysis The database was searched through Medline, Embase, Google Scholar, and Scopus. 846 articles were identified and then selected based on inclusion criteria for 12 articles	Moderate evidence suggests increased peak hip adduction was found in the PFPS group during running and single-leg squat activities. The two groups had no difference in the activation levels of GMed and GMax in functional activities. Strong evidence suggests hip strength is weaker in individuals with PFPS than in the control group.

BMI, body mass index; GMed, gluteus medius; GMax, gluteus maximus; n, total; PFP, patellofemoral pain; PFPS, patellofemoral pain syndrome; RCT, randomized controlled trials; VMO, vastus medialis oblique

Compensatory strategy in PFPS patients whose trunk is leaning on the ipsilateral hip may minimise gluteus muscle strength to stabilise the Strong evidence suggests that hip strength is weaker in individuals with PFPS compared to the control group.¹⁵

Discussion

PFPS is one of the most common conditions. PFPS can cause severe pain and develop into progressive functional loss, which can lead to difficulty performing daily activities such as walking, climbing up and down stairs or squatting. PFPS can be caused by patellar trauma but is more often a combination of several multifactors, such as overuse of the patellofemoral joint, anatomical or biomechanical abnormalities, muscle weakness, imbalance, or dysfunction.¹⁵ Conversely, irregularity in sports activities, environmental conditions, surfaces, and equipment can be considered extrinsic factors. Intrinsic risk factors include individual characteristics, such as malalignment of the lower extremity or joint or abnormal pressure on the patella.¹⁶ Based on the results of the review of journals that raised the topic of risk factors associated with PFPS, five journals stated that there were risk factors associated with patellofemoral pain syndrome.

Research conducted by Neal et al. shows that the risk factor associated with the incidence of PFPS is quadriceps muscle weakness in the military population. Quadriceps muscle weakness in the military population occurs due to overuse or excessive use and emphasis on the muscle. The quadriceps muscle plays an essential role in the stability of the patella, allowing it to remain in a physiological position when the knee moves. If the quadriceps muscle is weakened, the patella will move abnormally, resulting in excessive friction between the femur and patella.⁸ This can cause irritation and inflammation of the patellofemoral surface, eventually leading to PFPS. This is in line with a systematic review study conducted by Lankhorst et al. in 2013, which showed that quadriceps weakness, in particular, significantly influences the incidence of PFPS in the military population in the UK. In the adolescent population, the risk factor associated is the strength of the hip abductor muscle. Vital to moderate evidence suggests that age, weight, Q-angle, and BMI are not risk factors for PFPS. Based on reasonable evidence in the military population, two HQ studies proved that quadricep weakness is a risk factor for developing PFPS when measured by a concentric isokinetic dynamometer. From the results of this study, it can be concluded that anthropometry, demographics and biomechanics are not risk factors for PFPS. At the same time, hip strength, especially quadriceps, is a risk factor for PFPS. Weakness of one of the muscle components in the quadriceps will cause patellar imbalance, affecting abnormal knee movements.⁸

According to Pereira et al., two main factors influence PFPS. The first is an anterior translation of the knee with the anterior tibial line in front of the ipsilateral toe line during the squat. This can occur because, during squats,

significant pressure will appear on the patellofemoral when the knee is flexed, triggering symptoms of PFPS, namely pain in the front of the knee. The second is the imbalance and weakness of hip muscles, such as the gluteus medius and quadriceps, especially the vastus medialis oblique (VMO). Suppose there is an imbalance between the strength of the vastus medial oblique and the other muscles. In that case, the patella will experience pressure to be unbalanced during movement, which can cause irritation and pain on the patellofemoral surface.² Additionally, muscle imbalance can be caused by excessive Q-angle pulling the knee outward due to lateral solid pull of the quadriceps and tight ilio tibial band (ITB).⁸ Muscle weakness and imbalance are shown through EMG through the ability to contract. This is the most significant cause of pain in patients with PFPS compared to those without PFPS. Therefore, it is considered one of the main factors that increase the risk of PFPS. This is in line with research conducted by Chen et al. in China in 2018, which showed that quadricep weakness and imbalance, especially VMO, were found to be the most significant cause of pain in patients with PFPS compared to people without PFPS.¹⁶

Based on research, Naufal et al. obtained the results of the univariate analysis that those who experience PFPS are dominant at 19-20 years with a Q-angle of 15-16 degrees and grade two. The results of bivariate analysis through the Spearman Rho test between grade patellofemoral pain syndrome and Quadricep Angle showed that there is a relationship between grade patellofemoral pain syndrome and degree of Quadricep Angle with a p-value of 0.043. The Spearman Rho test also shows a correlation value of 0.528, indicating a strong relationship between the grade of PFPS and the degree of Quadricep Angle. So, the degree of Q-angle is one of the risk factors for the incidence of PFPS. In excessive Q-angle, there is a dominant muscle activation of the adductor group muscles, VL, ITB, Hamstring, and Gastrocnemius, so it will usually cause the knee to be pushed in when doing squats or lunges without control from the physiotherapist with specific instructions or stimulation.⁸ This study's results are similar to those of research conducted by Vora et al., which show evidence of a relationship between grade pain in PFPS to Q-angle and pain in female professional athletes to their functional capacity.¹⁷ This is based on an increase in the compressive force of the lateral side of the patella and femoral condylus lateralis. The Q-angle is the angle formed by the intersection of two imaginary lines measured between the axial tendon of the M. quadriceps femoris that divides the patellar ligament in half to the tibial tubercle and a line drawn from the superior anterior spina iliaca (SIAS) to the centre. -The patella when the knee is in extension.¹⁸ Excessive Q-angle often leads to injury.⁸ The Q-angle measures the Q-angle of the quadriceps femoris, and an increase in this angle affects the mechanical impact of the force generated by the quadriceps femoris.¹⁹ Muscle imbalance and weakness of the muscles in the hip and knee region are closely related to Q-angle.⁸ A larger Q-angle can lead to an imbalance of the quadriceps muscles, especially the vastus medialis oblique (VMO). Suppose the

VMO is optimally weakened during flexion. In that case, the patella will tend to slide laterally, causing excessive patellofemoral friction and pressure, leading to irritation and pain as a symptom of PFPS. The increase in Q-angle on the stability index and, thus, on the risk of falls may be due to the inability to elicit an adequate muscular response by affecting quadriceps strength.⁸

Research by Papadopoulos et al. found that an increase in the Q-angle, decreased thigh muscle strength and flexibility, as well as joint and patellar laxity, contribute to PFPS. Another study highlighted quadriceps tightness and reduced patient function as risk factors. Additionally, high-quality studies identified significant Q-angle, large patellar tilt angle, hip abduction muscle weakness, and decreased knee extension strength as risk factors for PFPS, with a larger Q-angle leading to patellofemoral instability.¹⁹ Biomechanically, this causes the patella to move in an unstable or uncontrollable manner during knee flexion and extension, causing abnormal friction and pressure on the patellofemoral and being one of the factors for the development of PFPS. Various factors cause excessive Q-angle. Genu valgum, femoral and tibial torsion, and inward rotation of the tibia during knee flexion and extension. Q-angle depends on the patella's position and the tibia tubercle.⁸ This aligns with the RCT study conducted by Lankhorst et al., who reported that decreased knee extensor muscle strength can be considered a significant risk factor for PFPS.²⁰ People with increased Q angle experience excessive adduction and internal rotation caused by knee and hip flexion, decreasing patellofemoral joint contact. Functionally, the knee extensor muscle plays a role in controlling the movement and stability of the patella during physical activity.¹⁹ If the muscle is weakened, the patella may experience abnormal movement during knee movement, causing over-pressure on the patella, leading to PFPS.

According to Xie et al., the risk factor for PFPS with solid evidence is hip muscle weakness, especially the external rotator and abductor. The study evidence shows that patients with PFPS have weaker hip strength than the control group. At the same time, moderate evidence shows an increase in the angle in hip adduction is found in the PFPS population during running or squatting activities. This is supported by research conducted by Glaviano et al. in 2022, where excessive hip adduction in female runners can be considered an essential contribution to increasing knee joint stress during running with repeated exposure to high loads.²¹ When the hip muscles experience a decrease in strength, there will be an imbalance in strength between the supporting muscles and the prime mover, which can lead to increased hip adduction. Biomechanical factors may also play a role in increased hip adduction in PFPS.² Lack of stability and control at the hip also results in uncoordinated movements during the squat, leading to increased hip adduction.^{22,23}

The results of the reviewed literature found multifactorial risks associated with PFPS. Based on the

literature reviewed, the most dominant risk factor is decreased hip muscle strength, especially quadriceps. This is because reduced muscle strength in the hip affects patellofemoral instability, muscle imbalance and uneven load distribution. The type of daily activity, Q-angle, joint laxity, hip tightness, patella imbalance, overuse and overpressure of the patellofemoral joint are also associated with PFPS. However, the Q-angle factor still needs consistent results between one study and another. By knowing the risk factors associated with PFPS, prevention efforts can be made against the incidence of PFPS. One of them is strengthening hip exercises, especially the quadriceps muscle, increasing activity and duration gradually, doing physical activity with the correct technique and posture, and getting enough rest not to overuse the patella. This aligns with the results of research conducted by Singh et al. in 2018, which found that strengthening the quadriceps muscles, especially the vastus medial oblique, is done to prevent further PFPS.²⁴

The limitations of this study include the reliance on a literature review design that utilises secondary data from published literature. Additionally, limitations may arise from variations in methodology among the studies included in this literature review. The retrospective nature of literature research also limits the ability to control for confounding factors or to draw conclusions about cause-and-effect relationships. Furthermore, there is a possibility of publication bias that may influence the selection of studies included in the analysis. Therefore, this study's findings should be interpreted considering these limitations.

Conclusion

Based on the literature that has been reviewed and the discussion, the dominant risk factor for PFPS is a decrease in hip muscle strength, especially quadriceps. Besides, there are several other causative factors, such as the type of daily activity, joint laxity, Q-angle, hip tightness, patellar imbalance, overuse and overpressure of the patellofemoral joint.

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Conflict of interest

The author states no potential conflict of interest with this article's research, authorship and publication.

Author contributions

NKEW conceived the study design and data collection and drafted the manuscript; MW and IMJ collected and revised the data.

Ethical consideration

This review study used published articles that are accessible. Thus, this study did not require any informed consent or ethical consideration.

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