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Prognosis of Patellofemoral Pain: A Systematic Review With Evidence- and Gap-Map

OBJECTIVE: To systematically appraise current prognostic factor literature for patellofemoral pain (PFP).

DESIGN: Systematic review with evidence- and gap-map.

LITERATURE SEARCH: PubMed, CINAHL complete, PEDro, Scopus, SPORTDiscus, Embase, Cochrane Database of Systematic Reviews, and Web of Science (from inception to April 2024).

STUDY SELECTION CRITERIA: Included participants were those with symptoms consistent with PFP and an average age ≤45 years. Eligible studies were longitudinal cohort studies and randomized controlled trials with a true "wait-and-see" group that measured at least 1 outcome variable at 2 time points and at least 1 potential prognostic factor at baseline.

DATA SYNTHESIS: Prognostic factors were iteratively grouped relative to 7 categories and mapped by population and follow-up.

RESULTS: Ten longitudinal cohort studies and 12 randomized controlled trials were included. The most frequently evaluated prognostic factors were sociodemographic (n = 21), anthropometric (n = 21), and symptoms and function (n = 19). Fewer studies evaluated biomechanics (n = 12), behavioral (n = 11), psychological (n = 6), and neurobiological (n = 4) factors. Most studies examined the general population (n = 13), with fewer studies in specific populations (adolescents, n = 4; military, n = 2; runners, n = 2; university athletes, n = 1). Most studies evaluated short-term (≤3 months; n = 9) or long-term (>1 year; n = 11) follow-up, with only 2 studies evaluating medium-term follow-up (3 months to 1 year).

CONCLUSION: Sociodemographic, anthropometric, and symptoms and function factors were the most studied prognostic factors for PFP. Neurobiological, psychological, biomechanical, and behavioral factors were understudied. Additional studies are needed to identify prognostic factors in specific populations with high incidence of PFP. A comprehensive understanding of prognostic factors may inform development and implementation of evidence-based interventions. *J Orthop Sports Phys Ther 2025;55(10):661-670. Epub 8 September 2025. doi:10.2519/jospt.2025.13491*

KEY WORDS: *evidence and gap map, knee, patellofemoral pain, systematic review*

Patellofemoral pain (PFP) is a common musculoskeletal problem.[28,35] People with PFP report pain at, around, or behind their patella during activities that involve loading on a flexed knee.[8] PFP typically develops in adolescence and frequently continues throughout adulthood.[31,35] Although originally believed to be a self-limiting problem, PFP is now considered a persistent condition that may precede both patellofemoral and tibiofemoral osteoarthritis.[6,7] Despite an evolving understanding of effective treatment approaches,[26,27,42] individual outcomes remain variable, and over half of people with PFP remain symptomatic 5 to 8 years after diagnosis.[21]

While longer duration and higher severity of symptoms are consistently identified as prognostic for people with PFP,[4,5,10,21] uncertainty persists. Understanding prognostic factors can assist clinicians with explaining the clinical course of PFP and allows them to set realistic expectations for people experiencing PFP.[4] Greater understanding of prognostic factors may also guide developing and implementing evidence-based treatment strategies by confirming what can be expected from natural history as an intervention control and identifying prognostic factors that may be amenable to change. To guide further research, it is

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important to understand which factors have been studied for their prognostic utility in people with PFP (ie, evidence) and factors that have been explored less frequently (or not explored at all) in this population (ie, gaps).

The purpose of this review was to provide a systematic overview[23] of the current literature on prognostic factors for PFP to create an evidence and gap map.

METHODS

We registered our protocol a priori with the Open Science Framework in February 2024 (https://doi.org/10.17605/OSF.IO/GCBKS) guided by the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) checklist,[34] and produced our evidence and gap map guided by the PRISMA checklist.[25] There was 1 deviation from the protocol, with the Quality in Prognostic Studies (QUIPS) Risk of Bias Instrument for prognostic factor studies[14] used instead of the Risk Of Bias In Non-randomized Studies of Exposures (ROBINS-E) tool.

Equity, Diversity, and Inclusion Statement

We are a broad author group comprising 10 men and 7 women from 8 different high-income countries. We are diverse across the academic career spectrum, spanning from PhD students to tenured professors.

Patient and Public Involvement

This project was designed as a time-limited initiative during the 2023 International Patellofemoral Pain Research Retreat in Bologna, Italy, with no direct patient and public involvement.

Search Strategy

We codeveloped our search with an experienced medical research librarian and conducted it with no language or date restrictions. We searched PubMed, CINAHL complete, PEDro, Scopus, SPORTDiscus, Embase, the Cochrane Database of Systematic Reviews, and Web of Science from inception to April 2024 with terms translated for each database (see **SUPPLEMENTAL FILE 1**). We examined the reference lists of all subsequently eligible articles and completed a citing reference search using Google Scholar.

Eligibility Criteria and Selection Process

We sought longitudinal cohort studies or randomized controlled trials (RCTs) with a true "wait-and-see" group (ie, no intervention of any kind) that included at least 1 outcome variable collected at 2 time points (ie, baseline and follow-up) and a prognostic factor collected at baseline. Eligible studies were required to involve participants with symptoms consistent with PFP, which we defined according to the 2016 consensus statement,[8] and a mean/median age of ≤45 years old.

Titles and abstracts identified using the search strategies were imported into Covidence (Veritas Health Innovation, Melbourne, Australia), with duplicates deleted using automatic detection. Titles and abstracts were independently screened by 10 review authors, with conflicts resolved by 4 authors working in pairs. Full texts were independently assessed for eligibility by 6 review authors, with conflicts resolved by 4 authors working in pairs.

Risk of Bias

Pairs of authors independently applied an appropriate risk-of-bias tool for each study type before reaching consensus in an online meeting. Longitudinal cohorts

TABLE 1 Variable Categories and Descriptions

Category	Description
Symptoms and function	Refers to the subjective experiences and physical capabilities reported by an individual with PFP. This includes the severity and characteristics of symptoms (eg, pain intensity) as well as functional limitations (eg, limitations in recreational activities).
Sociodemographic	Covers characteristics related to an individual's social and demographic context, such as age, sex, income level, education, occupation, and ethnicity. These factors often influence access to resources, lifestyle, and health care.
Neurobiological	Pertains to the biological and neurological mechanisms underlying pain, including nervous system functioning, brain activity, neurotransmitter levels, and genetic predispositions. This category addresses the physiological basis of pain processing and modulation.
Anthropometric	Relates to the physical dimensions and composition of the human body, including measurements such as height, weight, body mass index (BMI), limb lengths, and body fat percentage. These variables are structural rather than functional.
Psychological	Encompasses cognitive and emotional factors that influence pain perception and response. Key aspects include anxiety, depression, coping mechanisms, fear-avoidance behaviors, and pain catastrophizing.
Biomechanics	Refers to the study of physical forces and their effects on the body, focusing on movement, posture, and mechanical stress on tissues. Key variables include joint angles, muscle forces, range of motion, and loading patterns.
Behavioral	Focuses on observable actions or patterns of activity that may influence pain, such as exercise habits, sleep quality, physical activity levels, smoking, or adherence to treatment protocols. These are external actions rather than internal processes.

Abbreviation: PFP, patellofemoral pain.

were appraised using the QUIPS Risk of Bias Instrument for prognostic factor studies,[14] and RCTs were appraised using the Cochrane Risk of Bias 2 (RoB 2) tool.[36] Eligible studies were subsequently classified as having low, some, or high risk of bias.

Data Extraction

Pairs of authors independently extracted data from eligible studies, using a custom designed data extraction tool housed in Qualtrics (Qualtrics, Seattle, WA). Extracted data included the following: author and year, journal of publication, country of origin, source of funding and conflicts of interest, study design and follow-up length, participant characteristics, and any potential outcome variables/prognostic factors. Agreement was reached in an online meeting.

Data Synthesis and Evidence/ Gap Mapping

Data analysis was completed using EPPI-Mapper (Social Science Research Unit at the Institute of Education, University of London, London, United Kingdom). All prognostic factors were grouped by 5 authors working collaboratively (B.N., N.C., S.L., L.B., and M.V.M.) relative to one of 7 categories: symptoms and function, sociodemographic, neurobiological, anthropometric, psychological, biomechanics, and behavioral. These categories were decided iteratively once all potential outcome variables/prognostic factors had been extracted. Where variables/factors could have been placed in more than 1 category, we reached consensus on the final categorization. Details of how the categories were defined are in **TABLE 1**. Using a narrative synthesis, the quantity and quality of the available evidence in each category was then visually mapped to reflect evidence and gaps (ie, factors not explored or less frequently explored).[23] Subanalyses were conducted for specific populations and study follow-up length, given the expectation that prognosis would differ in specific people and over a time course.

RESULTS

Our systematic search identified 24 818 titles and abstracts, with 17 835 remaining after duplicates were removed (see **FIGURE 1**). We screened 111 full texts , and after 89 were removed, 22 eligible studies remained: 10 longitudinal cohorts[3,11,17,19–21,30,31,39,43] and 12 RCTs.[2,9,12,15,16,18,22,24,32,37,38,44] These eligible studies included a total of 75 284 people with PFP, 74 408 of whom came from a single cohort study conducted in the United States of America military health system.[43] Extracted data from the included studies are provided in **TABLE 2**.

Risk of Bias

For the 10 longitudinal cohorts, four were classed as at low risk of bias,[1,11,20,31] five were at some risk of bias,[3,19,21,30,39] and one was at high risk of bias.[17] For the 12 RCTs with a true "wait-and-see" group, one was classed at low risk of bias,[9] seven were classed as at some risk of bias,[12,15,18,32,37,38,44] and four were classed as at high risk of bias.[2,16,22,24]

Evidence and Gaps

Thirteen studies involved participants from the general population, 4 studies involved adolescents, 2 studies involved military recruits, 2 studies involved runners,

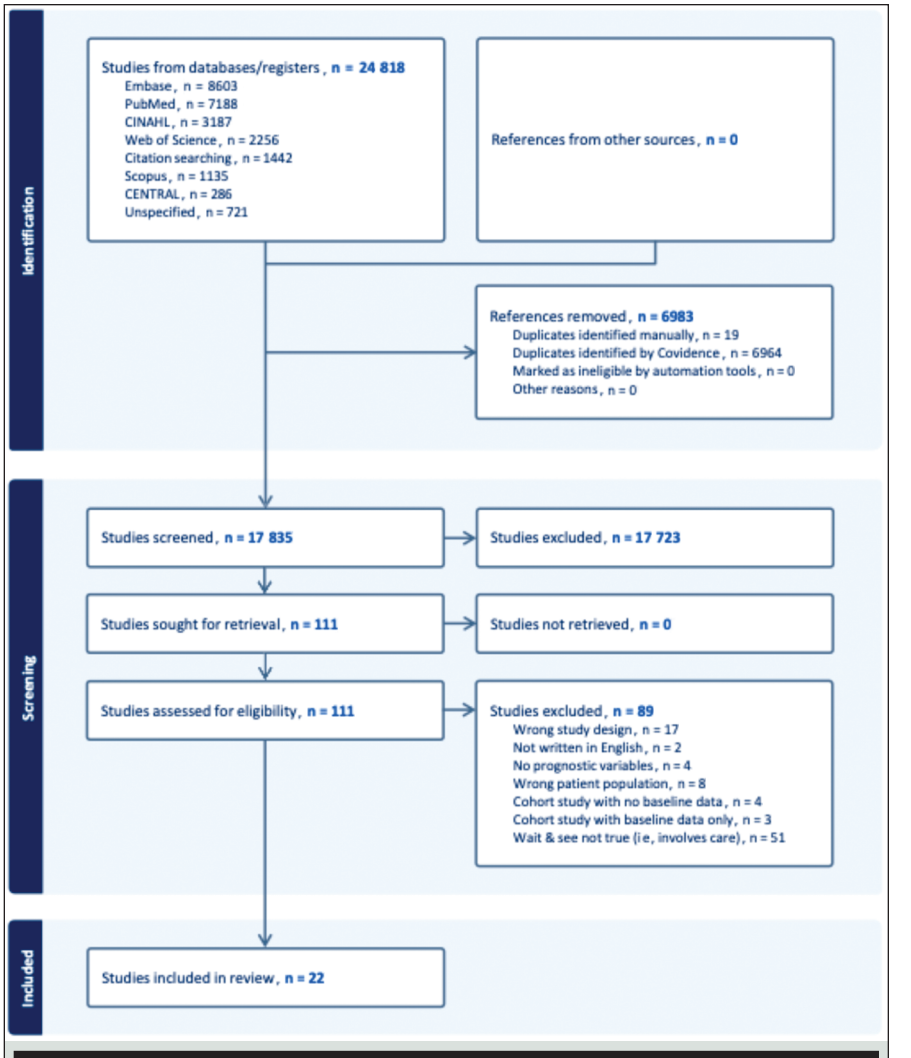

FIGURE 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

TABLE 2 Participant Characteristics

Author, Year	Study Design	Population	Sample Size (F:M)	Age in Years (Mean ± or Range) Height in cm (Mean ±) Mass in kg (Mean ±) BMI in kg/m² (Mean ±)	Baseline Symptom Duration in Months (Mean ± or Range)	Follow-up Length (Range)
Arslan, 2023[2]	RCT	General population	20 (20:0)	30.7 ± 7.6 161.7 ± 5.6 69.9 ± 13.5 NR	>3	6 weeks
Carlson, 2017[3]	Cohort	Adolescents	6 (6:0)	14.0 ± 1.3 156.9 ± 6.3 52.4 ± 5.7 21.3 ± 2.5	NR	4-5 years
de Souza Junior, 2024[9]	RCT	Runners	10 (4:6)	29.0 ± 4.4 172.0 ± 10.0 NR 27.0 ± 4.8	NR	4 weeks
Drew, 2019[11]	Cohort	General population	70 (43:27)	31.0 ± 5.3 171.0 ± 9.0 76.7 ± 18.6 26.3 ± 5.5	18-74	1 year
Fukuda, 2010[12]	RCT	General population	25 (25:0)	24.0 ± 7.0 160.0 ± 5.0 57.8 ± 6.2 NR	>3	4 weeks
Herrington, 2007[15]	RCT	Military recruits	15 (0:15)	NR NR NR NR	>1	6 weeks
Honarpishe, 2015[16]	RCT	General population	18 (NR)	26.6 ± 1.1 NR NR 23.8 ± 0.6	>3	4 weeks
Hvid, 1981[17]	Cohort	General population	22 (12:10)	27.1 ± 9.4 NR NR NR	48-192	3-8 years
Jensen, 1999[18]	RCT	General population	34 (21:33)	33.4 ± NR NR NR 24.0 ± NR	NR	1 year
Karlsson, 1996[19]	Cohort	General population	48 (34:14)	20.5 (16-35) NR NR NR	6-72	10-12 years
Kastelein, 2015[20]	Cohort	Adolescents	74 (35:39)	23.7 ± 7.9 NR NR NR	NR	1-6 years
Lankhorst, 2016[21]	Cohort	General population	60 (45:15)	26.2 ± 8.1 NR NR 23.0 ± 3.9	1-12	6-9 years

(Table continues on next page.)

TABLE 2 Participant Characteristics (continued)

Author, Year	Study Design	Population	Sample Size (F:M)	Age in Years (Mean ± or Range) Height in cm (Mean ±) Mass in kg (Mean ±) BMI in kg/m² (Mean ±)	Baseline Symptom Duration in Months (Mean ± or Range)	Follow-up Length (Range)
Loudon, 2004[22]	RCT	General population	11 (8:3)	27.9 ± 6.0 154.6 ± 34.4 66.8 ± 3.1 NR	>2	8 weeks
Mills, 2012[24]	RCT	General population	20 (14:6)	28.5 ± 5.9 172.6 ± 9.0 70.5 ± 10.9 23.6 ± 2.7	48 (24-97.5)	6 weeks
Rathleff, 2016[31]	Cohort	Adolescents	153 (124:29)	17 (16-18) 171.9 ± 8.9 64.2 ± 11.9 21.7 ± 3.0	37.5 (20-63)	2 years
Rathleff, 2019[30]	Cohort	Adolescents	504 (363:141)	17 (17-18) 172.1 ± 9.2 65.2 ± 11.5 22.0 ± 3.1	24 (12-42)	5 years
Saad, 2018[32]	RCT	University athletes	10 (10:0)	23.2 ± 1.0 161.0 ± 6.0 55.4 ± 2.0 21.3 ± 1.3	>3	8 weeks
Syme, 2009[37]	RCT	General population	23 (15:8)	28.5 ± 6.4 169.0 ± 8.7 74.5 ± 1.2 26.2 ± 1.2	50.5 ± 41.3	8 weeks
Timm, 1998[38]	RCT	General population	50 (21:29)	29.1 ± 6.4 NR NR NR	12.6 ± 4.3 w	4 weeks
van Middelkoop, 2017[39]	Cohort	General population	44 (21:23)	26.8 ± 5.8 NR NR 24.9 ± 3.7	11.0 ±6.4	1 year
van Middelkoop, 2017[39]	Cohort	Adolescents	20 (14:6)	15.9 ± 1.2 NR NR 20.7 ± 2.2	14.2 ±8.3	1 year
Young, 2021[43]	Cohort	Military recruits	74 408 (22 640:51 768)	32.1 ± 7.7 NR NR NR	NR	2 years
Zago, 2020[44]	RCT	Runners	24 (13:11)	32.9 ± 8.8 172.3 ± 7.0 71.6 ± 10.2 24.1 ± 2.2	>3	4 weeks

Abbreviations: BMI, body mass index; F, female; M; male; RCT, randomized controlled trial; NR, not reported.

and 1 study involved university athletes. Fifteen studies involved participants from both sexes, 4 studies involved only female participants, 2 studies did not report the sex or gender of their participants, and 1 study involved only male participants. Length of follow-up ranged from 6 weeks to 11 years. Nine included studies involved short-term follow-up only (≤3 months),

2 studies involved medium-term follow-up (3 months to 1 year), and 11 studies involved long-term follow-up (>1 year).

When mapping prognostic factors (**FIGURE 2**), sociodemographic (n = 21) and anthropometric (n = 21) were the most represented categories, followed by symptoms and function (n = 19), biomechanics (n = 12), behavioral (n = 11), psychological (n = 6), and neurobiological (n = 4). A breakdown of individual factors within each category is provided in **SUPPLEMENTAL FILE 2**.

When mapping prognostic factors by population (**FIGURE 3**), factor categories for the general population in order of prevalence were sociodemographic (n = 12), symptoms and function (n = 11), anthropometric (n = 9), biomechanics (n = 7), behavioral (n = 5), neurobiological (n = 3), and psychological (n = 3). Prognostic factor categories for the adolescent population in order of prevalence were symptoms and function (n = 4), sociodemographic (n = 4), anthropometric (n = 4), psychological (n = 3), behavioral (n = 3), neurobiological (n = 2), and biomechanics (n = 2). Prognostic factor categories for the military population in order of prevalence were sociodemographic (n = 2), symptoms and function (n = 1), anthropometric (n = 1), biomechanics (n = 1), and behavioral (n = 1). Two studies that included runners reported symptoms and function, sociodemographic, anthropometric, biomechanics, and behavioral factors. One study investigated a university athlete population and reported symptoms and function, sociodemographic, anthropometric, and biomechanics factors.

When mapped by follow-up (see **FIGURE 4**), prognostic factor categories for short-term follow-up (≤3 months) in order of prevalence were sociodemographic (n = 9), anthropometric (n = 9), symptoms and function (n = 8), biomechanics (n = 6), psychological (n = 2), and behavioral (n = 1). Prognostic factor categories for medium-term follow-up (3 months to 1 year) were symptoms and function, sociodemographic, anthropometric, biomechanics, and behavioral; each was reported by 2 studies. Prognostic factor categories for long-term follow-up (>1 year) in order of prevalence were: sociodemographic (n = 10), anthropometric (n = 10), symptoms and function (n = 9), behavioral (n = 8), neurobiological (n = 4), psychological (n = 4), and biomechanics (n = 4).

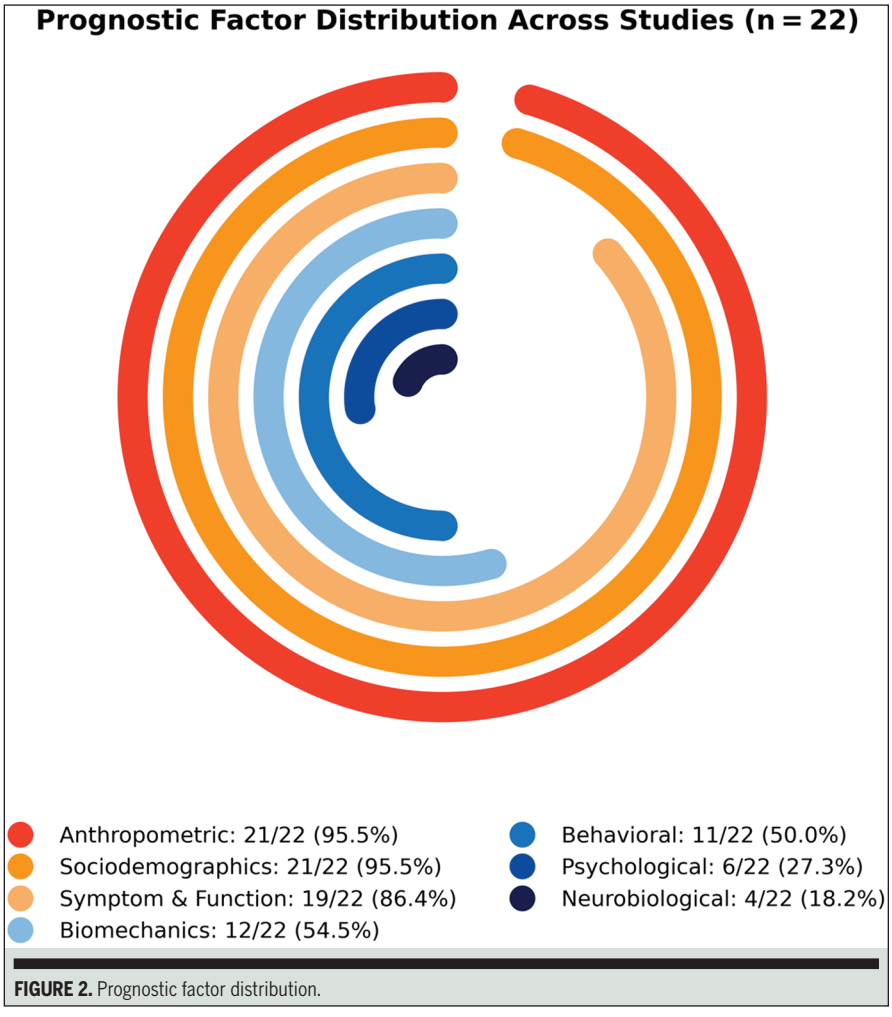

FIGURE 2. Prognostic factor distribution.

DISCUSSION

We mapped the evidence and gaps in the PFP prognostic literature. There was a greater volume of literature exploring sociodemographic, anthropometric, and symptoms and function factors in the general population, and in the short term (≤3 months) and long term (>1 year). Neurobiological, psychological, biomechanical, and behavioral prognostic factors were understudied. Few studies captured prognostic factors in the medium-term (3 months to 1 year), and there were fewer studies exploring prognostic factors in specific populations with high incidence of PFP, including adolescents, military recruits, and recreational runners.[28,35]

Neurobiological and psychological prognostic factors were reported with the lowest frequency, irrespective of study population or follow-up length. This is likely explained by the fact that understanding of the relationship between PFP prognosis and neurobiological/psychological factors is in its infancy, compared to other musculoskeletal

FIGURE 3. Evidence and gap map by population. The increasing size of a bubble reflects a larger number of studies, and the color represents the risk of bias (red = high; yellow = some; green = low).

conditions such as low back pain where the relationship is already more established.[40] The same is true for behavioral factors, where the link between lifestyle factors and conditions such as osteoarthritis is much better understood than in PFP.[13] Given the inherent similarities between PFP and other nontraumatic musculoskeletal conditions (ie, highly persistent and recalcitrant nature, significant negative effect on function), future prognostic studies should prioritize neurobiological, psychological, and behavioral factors. Such factors may also be more amenable to interventions, opening potential opportunities to improve prognosis in people with PFP.

Biomechanics is one of the most investigated domains in the overall PFP literature, linked to the historic hypothesis that symptoms arise from overload of subchondral bone secondary to altered arthrokinematics.[29] From a prognostic perspective, most biomechanics studies have short-term follow-up (6/12), half have some or high risk of bias (6/12), and most evaluate the general population (7/12). The included studies that collected biomechanics data reported multiple factors from a small sample, representing an absence of clearly defined research questions that are built on specific hypotheses based on existing knowledge. While there was some consistent data at a macro level (eg, strength, kinematics), there was substantial heterogeneity at a micro level (eg, contraction type, segment/plane of motion). This limits data pooling and the transfer of knowledge into clinical practice. We recommend that future prognostic studies define specific hypotheses for evaluating biomechanics factors, underpinned by existing understanding of the plausibility of the relationship between each factor and PFP prognosis.

Having evaluated the risk of bias of the included studies, only 5 of 22 were at low risk of bias, studies that involved adolescents (n = 2), the general population (n = 1), military recruits (n = 1), and runners (n = 1). There were no studies at low risk of bias that also evaluated short-term prognosis of PFP, and just 1 study at low risk of bias that evaluated the medium-term prognosis. The methods of included studies (longitudinal cohorts and RCTs with a true "wait-and-see" group) affected the risk of bias, with more RCTs demonstrating high risk of bias (n = 4) compared to longitudinal cohorts (n = 1). This was expected given the greater potential for bias in RCTs designed to investigate treatment effects (rather than the association between exposure and outcome).[41] Further studies with low risk of bias are required to provide greater certainty of factors associated with PFP prognosis.

Future Research Priorities

A greater volume of prognostic studies with a low risk of bias are needed at all follow-up points. It is also imperative that studies are designed a priori relative to specific prognostic questions, as opposed to relying on secondary analyses that explore the prognostic potential of any collected factor(s). Priority areas include reducing risk of bias in studies with short-term follow-up and exploring the prognostic value of neurobiological, psychological, and behavioral factors. Exploring prognosis at medium-term follow-up is also important as this period (3 months to 1 year) is likely

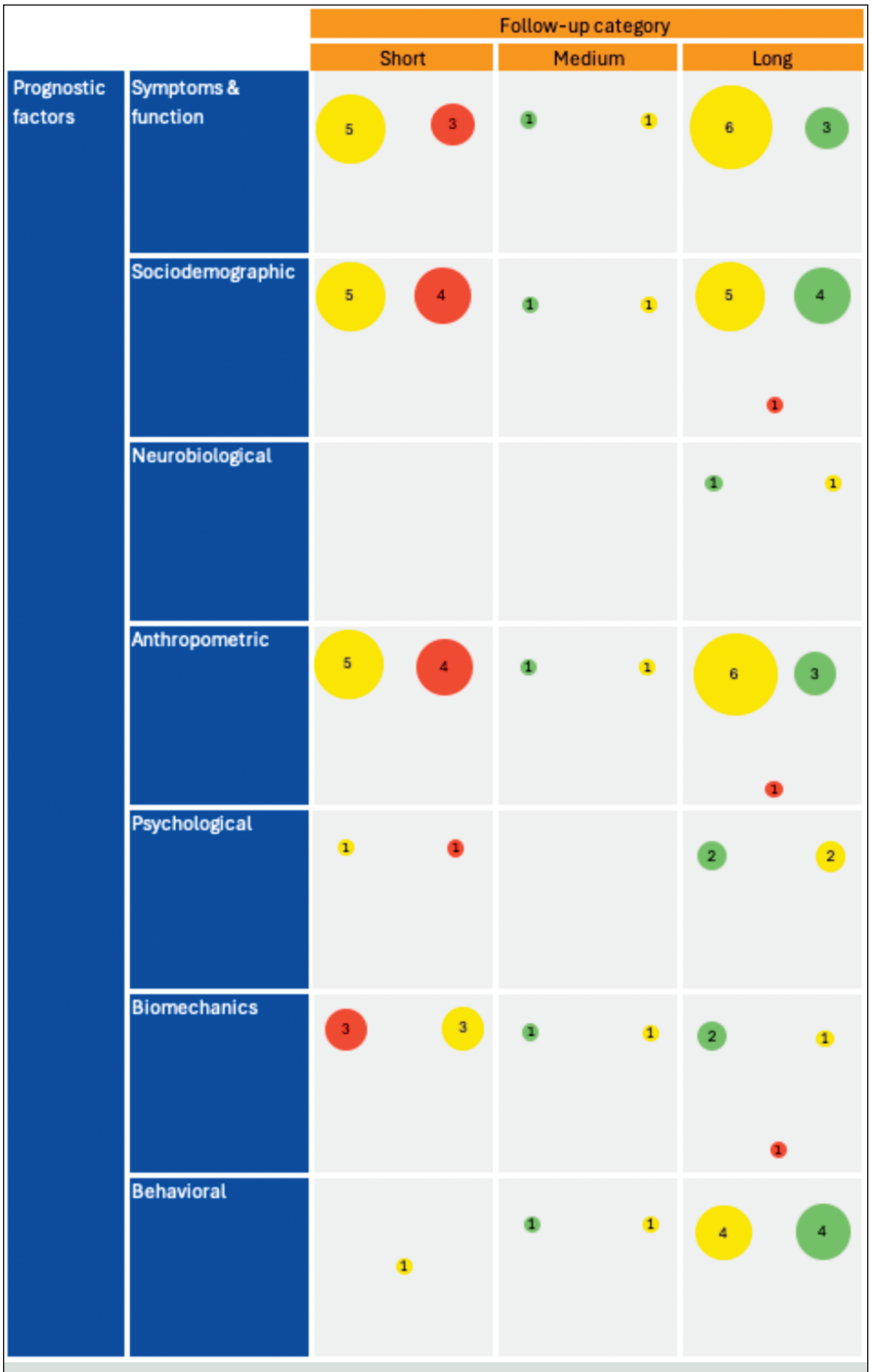

FIGURE 4. Evidence and gap map by follow-up. The increasing size of a bubble reflects a larger number of studies, and the color represents the risk of bias (red = high; yellow = some; green = low).

to reflect the shift from a more acute or primary nociceptive pain presentation to persistent pain that may have features consistent with nociplastic pain.

Strengths and Limitations

Strengths include our large and diverse author team, the breadth of our search, and our novel use of RCTs with a true "wait-and-see" group to explore prognostic factors. Limitations include conducting this project with a large team of authors for efficiency, leading to greater potential for variability in decision making (eg, title and abstract screening). We mitigated this by having authors work in pairs at each stage of the screening process and having separate pairs of authors for resolving conflicts. We did not search unpublished or grey literature, but the exclusion of such literature may have a small to no effect on systematic review outcomes.[33]

CONCLUSION

Sociodemographic, anthropometric, and symptoms and function were the most examined prognostic factors in PFP. Neurobiological, psychological, biomechanical, and behavioral factors were understudied, and important to explore in future prognostic studies. Additional studies are needed to identify prognostic factors in specific populations with high incidence of PFP, such as adolescents, military recruits, and recreational runners.

KEY POINTS

FINDINGS: Sociodemographic, anthropometric, and symptoms and function prognostic factors were most frequently evaluated in patellofemoral pain, especially in the general population. Neurobiological, psychological, biomechanical, and behavioral prognostic factors were understudied in patellofemoral pain. Most studies examined the general population and evaluated short-term (≤3 months) or long-term (>1 year) follow-up. There were clear gaps in the literature regarding prognostic factors for specific populations with a high prevalence of patellofemoral pain (eg, adolescents, military recruits, runners) and prognostic factors for medium-term outcome (3 months to 1 year).

IMPLICATIONS: Future prognostic studies must target a broader range of factors, in specific populations commonly affected by PFP, and across short-, medium-, and

long-term follow-up. This will provide a more comprehensive understanding of prognostic factors for PFP and inform further research to determine the extent that these factors are amenable to change.

CAUTION: These findings come from 22 included studies, of which only five were at low risk of bias.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: All authors contributed to the design of the study at the International Patellofemoral Pain Research Retreat in Bologna, Italy, 2023. L.B., S.K., H.R., B.E., R.v.P., G.v.L., C.P., S.C., and J.R. contributed to title and abstract screening. S.L., S.K., M.B., C.P., S.C., and J.R. contributed to full-text screening. B.N., D.B.J., N.C., and M.v.M. handled conflict resolution. L.B., M.B., R.v.P., and M.F. contributed to quality appraisal. L.B., B.E., C.Y., H.R., and C.P. contributed to data extraction. B.N., S.L., N.C., L.B., D.B.J., and M.v.M. contributed to data mapping and visualization. B.N., S.L., N.C., L.B., and M.v.M. drafted the manuscript.

DATA SHARING: All relevant data are included in the article or are available as supplemental files.

PATIENT AND PUBLIC INVOLVEMENT: Not applicable.

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REFERENCES

1. Albers IS, Zwerver J, Diercks RL, Dekker JH, Van den Akker-Scheek I. Incidence and prevalence of lower extremity tendinopathy in a Dutch general practice population: a cross sectional study. *BMC Musculoskelet Disord.* 2016;17:16. https://doi.org/10.1186/s12891-016-0885-2
2. Arslan T, Gultekin MZ. The effect of a supervised online group exercise program on symptoms associated with patellofemoral pain syndrome in women. *Technol Health Care.* 2023;31:771–782. https://doi.org/10.3233/THC-220533
3. Carlson VR, Boden BP, Shen A, Jackson JN, Alter KE, Sheehan FT. Patellar maltracking persists in adolescent females with patellofemoral pain: a longitudinal study. *Orthop J Sports Med.* 2017;5. https://doi.org/10.1177/2325967116686774
4. Collins NJ, Bierma-Zeinstra SMA, Crossley KM, van Linschoten RL, Vicenzino B, van Middelkoop M. Prognostic factors for patellofemoral pain: a multicentre observational analysis. *Br J Sports Med.* 2013;47:227–233. https://doi.org/10.1136/bjsports-2012-091696
5. Collins NJ, Crossley KM, Darnell R, Vicenzino B. Predictors of short and long term outcome in patellofemoral pain syndrome: a prospective longitudinal study. *BMC Musculoskelet Disord.* 2010;11:11. https://doi.org/10.1186/1471-2474-11-11
6. Collins NJ, Oei EHG, de Kanter JL, Vicenzino B, Crossley KM. Prevalence of radiographic and magnetic resonance imaging features of patellofemoral osteoarthritis in young and middle-aged adults with persistent patellofemoral pain. *Arthritis Care Res (Hoboken).* 2019;71:1068–1073. https://doi.org/10.1002/acr.23726
7. Crossley KM. Is patellofemoral osteoarthritis a common sequela of patellofemoral pain? *Br J Sports Med.* 2014;48:409–410. https://doi.org/10.1136/bjsports-2014-093445
8. Crossley KM, Stefanik JJ, Selfe J, 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. *Br J Sports Med.* 2016;50:839–843. https://doi.org/10.1136/bjsports-2016-096384
9. de Souza JR Jr, Rabelo PHR, Lemos TV, Esculier J-F, Barbosa GMP, Matheus JPC. Effects of two gait retraining programs on pain, function, and lower limb kinematics in runners with patellofemoral pain: a randomized controlled trial. *PLOS ONE.* 2024;19:e0295645. https://doi.org/10.1371/journal.pone.0295645
10. Deng F, Razaviasfali SM, Birn-Jeffery A, Cortes N, Neal BS. What prognostic indicators and treatment mechanisms exist for efficacious treatments in people with patellofemoral pain? A secondary meta-regression with an updated search. *JOSPT Open.* 2024;3:193–209. https://doi.org/10.2519/josptopen.2025.0119
11. Drew BT, Conaghan PG, Smith TO, et al. Toward the development of data-driven diagnostic subgroups for people with patellofemoral pain using modifiable clinical, biomechanical, and imaging features. *J Orthop Sports Phys Ther.* 2019;49:536–547. https://doi.org/10.2519/jospt.2019.8607
12. Fukuda TY, Rossetto FM, Magalhães E, Bryk FF, Lucareli PRG, de Almeida Carvalho NA. Short-term effects of hip abductors and lateral rotators strengthening in females with patellofemoral pain syndrome: a randomized controlled clinical trial. *J Orthop Sports Phys Ther.* 2010;40:736–742. https://doi.org/10.2519/jospt.2010.3246
13. Georgiev T, Angelov AK. Modifiable risk factors in knee osteoarthritis: treatment implications. *Rheumatol Int.* 2019;39:1145–1157. https://doi.org/10.1007/s00296-019-04290-z
14. Hayden JA, Côté P, Bombardier C. Evaluation of the quality of prognosis studies in systematic reviews. *Ann Intern Med.* 2006;144:427–437. https://doi.org/10.7326/0003-4819-144-6-200603210-00010
15. Herrington L, Al-Sherhi A. A controlled trial of weight-bearing versus non—weight-bearing exercises for patellofemoral pain. *J Orthop Sports Phys Ther.* 2007;37:155–160. https://doi.org/10.2519/jospt.2007.2433
16. Honarpishe R, Bakhtiary AH, Olyaei G. Effect of quadriceps exercise training on muscle fiber angle in patients with patellofemoral pain syndrome. *Middle East J Rehabil Health.* 2015;2:e32216. https://doi.org/10.17795/mejrh-32216
17. Hvid I, Andersen LI, Schmidt H. Chondromalacia patellae: the relation to abnormal patellofemoral joint mechanics. *Acta Orthop Scand.* 1981;52:661–666. https://doi.org/10.3109/17453678108992164
18. Jensen R, Gøthesen Ø, Liseth K, Baerheim A. Acupuncture treatment of patellofemoral pain syndrome. *J Altern Complement Med.* 1999;5:7. https://doi.org/10.1089/acm.1999.5.521
19. Karlsson J, Thomeé R, Swärd L. Eleven year follow-up of patello-femoral pain syndrome. *Clin J Sport Med.* 1996;6:22–26. https://doi.org/10.1097/00042752-199601000-00006
20. Kastelein M, Luijsterburg PA, Heintjes EM, et al. The 6-year trajectory of non-traumatic knee symptoms (including patellofemoral pain) in adolescents and young adults in general practice: a study of clinical predictors. *Br J Sports Med.* 2015;49:400–405. https://doi.org/10.1136/bjsports-2014-093557
21. Lankhorst NE, van Middelkoop M, Crossley KM, et al. Factors that predict a poor outcome 5–8 years after the diagnosis of patellofemoral pain: a multicentre observational analysis. *Br J Sports Med.* 2016;50:881–886. https://doi.org/10.1136/bjsports-2015-094664
22. Loudon JK, Gajewski B, Gioist-Foley HL, Loudon KL. The effectiveness of exercise in treating patellofemoral-pain syndrome. *J Sport Rehabil.* 2004;13:323–342. https://doi.org/10.1123/jsr.13.4.323
23. Lyng KD, Djurtoft C, Bruun MK, et al. What is known and what is still unknown within chronic musculoskeletal pain? A systematic evidence and gap map. *PAIN.* 2023;164:1406–1415. https://doi.org/10.1097/j.pain.0000000000002855
24. Mills K, Blanch P, Dev P, Martin M, Vicenzino B. A randomised control trial of short term efficacy of in-shoe foot orthoses compared with a wait and see policy for anterior knee pain and the role of foot mobility. *Br J Sports Med.* 2012;46:247–252. https://doi.org/10.1136/bjsports-2011-090204
25. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *Ann Intern Med.* 2009;151:4. https://doi.

org/10.7326/0003-4819-151-4-200908180-00135
26. Neal BS, Bartholomew C, Barton CJ, Morrissey D, Lack SD. Six treatments have positive effects at 3 months for people with patellofemoral pain: a systematic review with meta-analysis. *J Orthop Sports Phys Ther.* 2022;52:750–768. https://doi.org/10.2519/jospt.2022.11359
27. Neal BS, Lack SD, Bartholomew C, Morrissey D. Best practice guide for patellofemoral pain based on synthesis of a systematic review, the patient voice and expert clinical reasoning. *Br J Sports Med.* 2024;58:1486–1495. https://doi.org/10.1136/bjsports-2024-108110
28. Neal BS, Lack SD, Lankhorst NE, Raye A, Morrissey D, van Middelkoop M. Risk factors for patellofemoral pain: a systematic review and meta-analysis. *Br J Sports Med.* 2019;53:270–281. https://doi.org/10.1136/bjsports-2017-098890
29. Powers CM, Witvrouw E, Davies IS, Crossley KM. Evidence-based framework for a pathomechanical model of patellofemoral pain: 2017 patellofemoral pain consensus statement from the 4th International Patellofemoral Pain Research Retreat, Manchester, UK: part 3. *Br J Sports Med.* 2017;51:1713–1723. https://doi.org/10.1136/bjsports-2017-098717
30. Rathleff MS, Holden S, Straszek CL, Olesen JL, Jensen MB, Roos EM. Five-year prognosis and impact of adolescent knee pain: a prospective population-based cohort study of 504 adolescents in Denmark. *BMJ Open.* 2019;9:e024113. https://doi.org/10.1136/bmjopen-2018-024113
31. Rathleff MS, Rathleff CR, Olesen JL, Rasmussen S, Roos EM. Is knee pain during adolescence a self-limiting condition?: prognosis of patellofemoral pain and other types of knee pain. *Am J Sports Med.* 2016;44:1165–1171. https://doi.org/10.1177/0363546515622456
32. Saad MC, de Vasconcelos RA, de Oliveira Mancinelli LV, de Barros Munno MS, Liporaci RF, Grossi DB. Is hip strengthening the best treatment option for females with patellofemoral pain? A randomized controlled trial of three different types of exercises. *Braz J Phys Ther.* 2018;22:408–416. https://doi.org/10.1016/j.bjpt.2018.03.009
33. Schmucker C, Blümle A, Schell LK, et al. Systematic review finds that study data not published in full text articles have unclear impact on meta-analyses results in medical research. *PLOS ONE.* 2017;12:e0176210. https://doi.org/10.1371/journal.pone.0176210
34. Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. *BMJ.* 2015;349:g7647. https://doi.org/10.1136/bmj.g7647
35. Smith BE, Selfe J, Thacker D, et al. Incidence and prevalence of patellofemoral pain: a systematic review and meta-analysis. *PLOS ONE.* 2018;13:e0190892. https://doi.org/10.1371/journal.pone.0190892
36. Sterne J, Savović J, Page M, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ.* 2019;366:l4898. https://doi.org/10.1136/bmj.l4898
37. Syme G, Rowe P, Martin D, Daly G. Disability in patients with chronic patellofemoral pain syndrome: a randomised controlled trial of VMO selective training versus general quadriceps strengthening. *Man Ther.* 2009;14:252–263. https://doi.org/10.1016/j.math.2008.02.007
38. Timm KE. Randomized controlled trial of Protonics on patellar pain, position, and function. *Med Sci Sports Exerc.* 1998;30:665–670. https://doi.org/10.1097/00005768-199805000-00004
39. van Middelkoop M, van der Heijden RA, Bierma-Zeinstra SMA. Characteristics and outcome of patellofemoral pain in adolescents: do they differ from adults? *J Orthop Sports Phys Ther.* 2017;47:801–805. https://doi.org/10.2519/jospt.2017.7326
40. Vicenzino BT, Rathleff MS, Holden S, et al. Developing clinical and research priorities for pain and psychological features in people with patellofemoral pain: an international consensus process with health care professionals. *J Orthop Sports Phys Ther.* 2022;52:29–39. https://doi.org/10.2519/jospt.2022.10647
41. Viswanathan M, Patnode CD, Berkman ND, et al. Recommendations for assessing the risk of bias in systematic reviews of health-care interventions. *J Clin Epidemiol.* 2018;97:26–34. https://doi.org/10.1016/j.jclinepi.2017.12.004
42. Winters M, Holden S, Lura CB, et al. Comparative effectiveness of treatments for patellofemoral pain: a living systematic review with network meta-analysis. *Br J Sports Med.* 2020;55:369–377. https://doi.org/10.1136/bjsports-2020-102819
43. Young JL, Snodgrass SJ, Cleland JA, Rhon DI. Timing of physical therapy for individuals with patellofemoral pain and the influence on healthcare use, costs and recurrence rates: an observational study. *BMC Health Serv Res.* 2021;21:751. https://doi.org/10.1186/s12913-021-06768-8
44. Zago J, Amatuzzi F, Rondinel T, Matheus JP. Osteopathic manipulative treatment versus exercise program in runners with patellofemoral pain syndrome: a randomized controlled trial. *J Sport Rehabil.* 2020;30:609–618. https://doi.org/10.1123/jsr.2020-0108