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Conservative treatment of patellofemoral pain: effectiveness of strength exercises compared to other treatments. a systematic review with meta-analysis

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Abstract

Objective The aim of the study was to investigate the effectiveness of strengthening exercise compared to other conservative treatment methods to reduce pain and improve functional abilities for patellofemoral pain.

Methods MEDLINE, Physiotherapy Evidence Database, Scopus, Cochrane Central Register of Controlled Trials and Embase were the databases consulted from inception until June 2024. Randomised controlled trials (RCTs) were included with patients diagnosed with patellofemoral pain, adolescents over 16 years of age and adults up to 44 years of age, athletes and non-athletes, regardless of gender, and in which pain recorded at 4–6 weeks or 8–12 weeks follow-up was the primary outcome. Functional evaluation scales of the knee as the Anterior Knee Pain Scale, with a follow-up of 8–12 weeks or 6 months were secondary outcome.

Results Database search yielded a total of 1,654 papers and 12 papers were included. The meta-analysis on the change in pre- and post-treatment pain at 4–6 weeks and 8–12 weeks showed an average reduction of -1.44 (CI. -2.20; -0.67) for 601 patients included and -0.8 (CI -1.23; -0.37) in favour of the intervention group with exercises for 719 patients. In subgroup analysis performed for woman population, the mean difference in pain reduction was -2.81 (CI -4.39; -1.23). At 8–12 weeks, standardized mean difference for functional outcomes, in pre-post treatment variation between the two groups was 0.08 (CI -0.07; 0.24) in favour of the intervention for 685 patients included. A very low and low level of certainty of the evidence was recorded based on Risk of Bias analysis and GRADE method.

Conclusion A positive effect in the use of muscle strengthening strategies in the treatment of patellofemoral pain was highlighted, albeit with a low level of certainty of the results. Women benefit most from treatment with strengthening exercises.

Keywords Patellofemoral pain, Exercises, Conservative treatment, Systematic review, Meta-analysis

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Introduction

Patellofemoral pain (PFP) is a common condition with an annual prevalence of 22.7% in the general population and 28.9% among adolescents. In particular adolescent female athletes are affected by this condition [1]. Pain appears mainly in the anterior aspect of the knee and retropatellar or peripatellar pain appears during activities of daily living, such as walking, running or kneeling [2, 3]. The persistent or recurrent nature of PFP can limit social, sports and work activity and therefore reduce the quality of life in patients who suffer from it [4].

Diagnosis is made mainly by clinical evaluation using patellar grinding, apprehension tests and palpation of patellar edges, knee resisted isometric tests and by excluding other pathologies such as iliotibial band syndrome, tendinitis and knee arthritis [3, 5, 6]. Treatment is mainly conservative not surgical [7]. The literature shows beneficial treatment for the management of PFP can be achieved by orthotic devises for the correction of movement mechanics, taping, educational therapy and exercise [2–4, 8–10]. In a systematic review, supported by weak but coherent evidence, Van der Hejden et al. [11] showed that exercise had a significantly positive effect on the reduction of pain and improvement in the patient's mobility. Their results were mainly based on comparing exercise therapy and placebo or wait and see. The same findings were supported by the systematic review by Neal et al. [12] in which different exercise programs were compared with each other, while the comparison between treatment with strengthening exercises and other types of conservative treatment was poor. Only a few recent studies have made comparisons with other types of treatment. After reviewing the available guidelines on PFP treatment, Winters et al. [13] concluded that the evidence to indicate the best type of conservative treatment was insufficient. The evaluation of the efficacy of therapeutic strengthening exercise for patients with PFP must take into account three fundamental factors: pain as a subjective outcome, impossibility of using a placebo treatment and the difficulty of differentiating exercise programmes. It is important to keep in mind that, due to the nature of the conservative treatments proposed, studies cannot be blinded with respect to the patient allocation group. At the same time, pain is an outcome that could be strongly influenced by the patient's knowledge of the study group they belong to. These considerations reinforce the idea of the need that treatment with exercise cannot simply be compared with no treatment or wait and see treatment but must be compared with another type of conservative treatment. Recent systematic reviews have taken into consideration the comparison between different types of strengthening exercises, differentiating according to the target muscle groups of the exercise such as proximal muscle groups, hip muscle groups and knee muscle groups [12, 14–17]. In clinical practice, the activation of a target muscle group during a therapeutic exercise very often involves the simultaneous activation and strengthening of other related muscle structures. Achieving complete selectivity in targeting a single muscle group is therefore challenging. For this reason, the present review did not differentiate between exercise programs focused exclusively on strengthening the quadriceps and those aimed at the proximal or hip muscles. Furthermore, this approach was in line with the results of previous reviews, which did not demonstrate the superiority of one type of strengthening over another.

The aim of the present systematic review was to investigate the effectiveness of strengthening exercise compared to other conservative treatment methods to reduce pain and improve functional abilities in patients diagnosed with PFP.

Materials and methods

Information sources and search strategy

This paper was drafted following PRISMA 2020 guidelines and the "Cochrane Handbook for Systematic Reviews of Interventions" [18]. The protocol was registered in the PROSPERO database under code CRD42023444137. MEDLINE, Physiotherapy Evidence Database (PEDro), Scopus, Cochrane Central Register of Controlled Trials (CENTRAL), and Embase were the databases consulted to search for papers. The research had no limits in relation to language and year of publication but was conducted from inception until in June 2024. The search strings were constructed according to the PICO methodology by combining free search terms with Mesh terms and adapting the different strings to the specific characteristics of the databases. The main terms agreed through a consultation of experts in this field and used for the research were "patellofemoral pain syndrome" and "anterior knee pain syndrome" for population identification and "muscle strength", "exercise", "muscle strengthening" and "resistance training" for the definition of the intervention. A summary of the research strings is shown in supplementary materials (Tab. S1).

Eligibility criteria

Randomised controlled trials (RCTs) were included to evaluate the benefits obtained with strengthening exercises compared to other conservative treatments. According to the structuring of the PICO, the eligibility criteria included the following elements.

- Population: participants in the studies were patients with a medical diagnosis of patellofemoral pain, adolescents older than 16 years and adults up to 44 years of age, athletes and non-athletes regardless of gender. Patellofemoral pain was to be defined

as characterized by retropatellar or peripatellar pain following a biomechanical alteration of the patellofemoral joint and persisting at least for more than 4 weeks. Pain had to be exacerbated by the activity of climbing or descending stairs, squatting, or sitting with bent knees. Studies that included patients diagnosed with chondromalacia, osteoarthritis, or other knee pathologies such as trauma and ligament injuries were excluded from the analysis.

- Intervention: the intervention treatment was defined as a program of exercises aimed at muscle strengthening which might involve one or more body areas such as the trunk, pelvis or lower limbs. Exercises were carried out with or without the use aids and the different training programs were recorded to evaluate their similarities and differences.
- Control: the intervention treatment had to be compared with other conservative treatments such as exercises not aimed at muscle strengthening, re-education, orthotics, taping, or patellar mobilization techniques. Comparison with no treatment, such as wait and see or the presence of forms of muscle strengthening exercise also in the comparison treatment were reasons for exclusion.
- Outcome: Pain was the primary outcome of the study. Papers were examined that assessed pain directly through the use of a pain intensity measurement scale, such as the Visual Analogue Scale (VAS) or the Numeric Rating Scale (NRS) which have been indicated with a range from 0 to 10 to facilitate comparison. Pain at rest, usual pain or worst pain were all included. Pain had to be recorded at 4–6 weeks or 8–12 weeks follow-up. As a secondary outcome, functional evaluation scales of the knee with a follow-up of 8–12 weeks or 6 months, such as the Anterior Knee Pain Scale (AKPS), were considered [19]. The Kujala AKPS is a 13-item self-report questionnaire that assesses subjective reactions to particular activities and symptoms that are known to correlate with anterior knee pain. It is a scale designed for this pathology and commonly used in studies [20]. It is graded on a scale of 0 to 100, with 100 being the highest possible score, signifying normal physical abilities with no evidence of disease.

Selection and data collection process

The Rayyan Intelligent Review application (https://www.rayyan.ai/) [21] was used for screening and was carried out by two reviewers (EV, CG) blind to each other, by progressively analysing titles, abstracts and text of the papers. When the two reviewers could not reach an agreement, a third reviewer (RR) was asked to make a decision. A structured checklist, planned before the beginning of the study and agreed upon by all reviewers, was used to retrieve data from the studies included. Two reviewers were involved in the data extraction process (AC, EV) and a third reviewer checked the collected data (MM).

Data on the general characteristics of the studies were: name of the first author and year of publication, country where the study was carried out, sample size, age and sex of the population involved, inclusion and exclusion criteria, follow-up times, outcome measures (pain and/or function) and study drop-out rates. The description of treatment and control involved the collection of some specific data as far as possible set out in line with TIDIeR – Reporting [22], such as the exercise plan, training duration length, training program duration, the setting in which the treatment was carried out (at home or in the clinic) and the method of execution (supervised or independent). Extracting quantitative data for meta-analysis involved collecting the following data for the intervention group and control group: mean and standard deviation pre- and post-treatment, mean difference pre- and post-treatment and relative standard deviation, mean difference control group – intervention group and relative confidence intervals and p-value of the statistical test used.

Study risk of bias (ROB) assessment

Two authors (VP; RR) separately performed the Risk of Bias (RoB) analysis for each study included in the review, using the RoB2 tool. The Cochrane Handbook for Systematic Reviews of Interventions was taken as reference for the analysis [21]. The following domains were considered: randomisation process, deviations from the intended intervention, handling of missing data, outcome measurement methods, data return methods. When discrepancies in evaluation emerged, these were discussed by the two reviewers and, if necessary, a third reviewer (MM) was involved.

It should be remembered that pain was an outcome evaluated by the patient who was not blinded to its administration or their group of allocation (intervention vs. control). Therefore, the reviewers agreed to attributing a Risk of Bais to all the studies. This risk varied from some concerns to high risk with regard to the domain related to the outcome used. This aspect was considered in the summary evaluation of the quality of the studies and for this reason the reviewers decided not to report the overall RoB score of the individual studies. The RoB graph was created through RobVis visualization tool [21, 23].

Synthesis methods

A descriptive summary of the data extracted from the studies was provided. The data on the difference in usual/rest pain between pre- and post-treatment recorded at 4–6 weeks and 8–12 weeks of follow-up and the data on the difference in knee functional assessment pre- and post-treatment measured at 8–12 weeks and 24 weeks were used to perform the respective meta-analyses. Given the continuous nature of the outcomes considered, we used the mean difference (MD) or standardised mean difference (SMD) where necessary. Data were analyzed with Review Manager (RevMan; The Cochrane Collaboration, London, UK) software. Clinical relevance was judged according to the minimal difference reported by Crossley [24]: for AKPS it was 10 (out of 100) points and for VAS 2 cm (out of 10 cm). The random-effects meta-analysis model, a more conservative approach than the fixed-effects model, was used to combine the results. It was assumed that clinical and methodological heterogeneity existed between the different studies. The characteristics of physiotherapy treatments, which inherently vary in their application, and patient characteristics, which differ in duration of pain, activity levels and underlying biomechanical factors contributing to their condition, are likely to have an impact on the results. Data heterogeneity was analysed using the I2 test. Heterogeneity was considered substantial when the I2 exceeded 50%. To explain possible study heterogeneity, a sensitivity analysis was planned, considering articles where the study population was composed of only women or only athletes. A further analysis was performed on the basis of the methodological quality of the studies according to the Risk of Bias assessment, considering only articles with low risk of Bias. The decision was made to analyse publication bias using the Funnel Plot if the meta-analysis included at least 10 studies [25].

The GRADE method was applied to evaluate and summarise the evidence, whereas the GradePRO programme was used to construct the "Summary of findings" table (https://www.gradepro.org/) [26]. The table shows the data for the primary outcomes taken into account in the review, and reported the overall quality of the evidence from the selected studies and the magnitude of the effect produced by the intervention examined. The authors downgraded the evidence from 'high quality' by one level for severe (or by two for very severe) study limitations (risk of bias), indirectness of evidence, severe inconsistency, imprecision of effect estimates or potential publication bias.

Results

Study selection and characteristics

The database search yielded a total of 1,654 papers, of which 878 were discarded because they were duplicates. The remaining 776 papers were subjected to the screening process that allowed 12 papers to be included in the qualitative and quantitative analysis [27–38] (Fig. 1). The list of papers excluded after reading the full-text and the reason for exclusion is presented in the supplementary file (Tab.S2).

The baseline characteristics of the included articles are summarised in Tables 1 and 2 (Appendix). Pain assessment was performed in 9 studies [27, 29–34, 36, 37] using the VAS scale and in three studies [28, 35, 38] using the NRS, whereas in 4 studies [30–32, 34] usual pain or pain during daily activities was differentiated from the worst perceived pain or pain during physical activity (Table 3). In this systematic review, usual pain or pain during daily activities was used as the outcome measure.

Functional assessment was not measured in three studies [25,29,32], whereas in two other studies [24,27] it was done with a 6-week follow-up, a timeframe that was not considered in the present study. The AKPS was the most widely used scale for assessing function, being present in 6 studies [28, 31, 32, 35, 37, 38].

The mean age of the enrolled patients ranged from 22 to 34 years and in three studies [28, 29, 37] only women were enrolled. The sample sizes of the studies ranged from 30 to 218 patients in the study by Matthews [35]. In 4 studies [29, 30, 33, 37] enrolment consisted of a population of athletes.

Ten papers [28–31, 33–38] reported intervention by exercise treatment under the supervision of a physiotherapist, whereas the remaining two papers [27, 32] reported a mixed method of intervention. Five papers [29, 32, 35–37], reported types of exercises with a specific focus on strengthening the knee or hip muscles. The treatment was carried out in 4 studies [30, 31, 34, 38] at the patient's home, in 2 studies [27, 32] in a mixed manner (home and clinic) and in the remaining studies [28, 29, 33, 35–37] at a clinic. The most common treatment plan was 3 physiotherapy sessions per week with a heterogeneous duration from 20 to 60 min for 6 to 12 weeks. The most commonly used control treatment was re-education combined or not with other types of treatment such as taping, the use of orthoses and stretching exercises. Five papers [32–35, 38] reported unsupervised control treatment.

Risk of bias in studies

The randomization domain had a low level of risk in most studies. The risk of bias was moderate only in 3 studies [27, 30, 33] due to the lack of specific information on the conciliation procedures implemented. The domain relating to the evaluation of the outcome measured in the studies was assessed with a moderate level of risk for all papers in accordance with the considerations reported in the methods of the present review. A high risk of bias was found in only two studies [35, 38] in a single domain

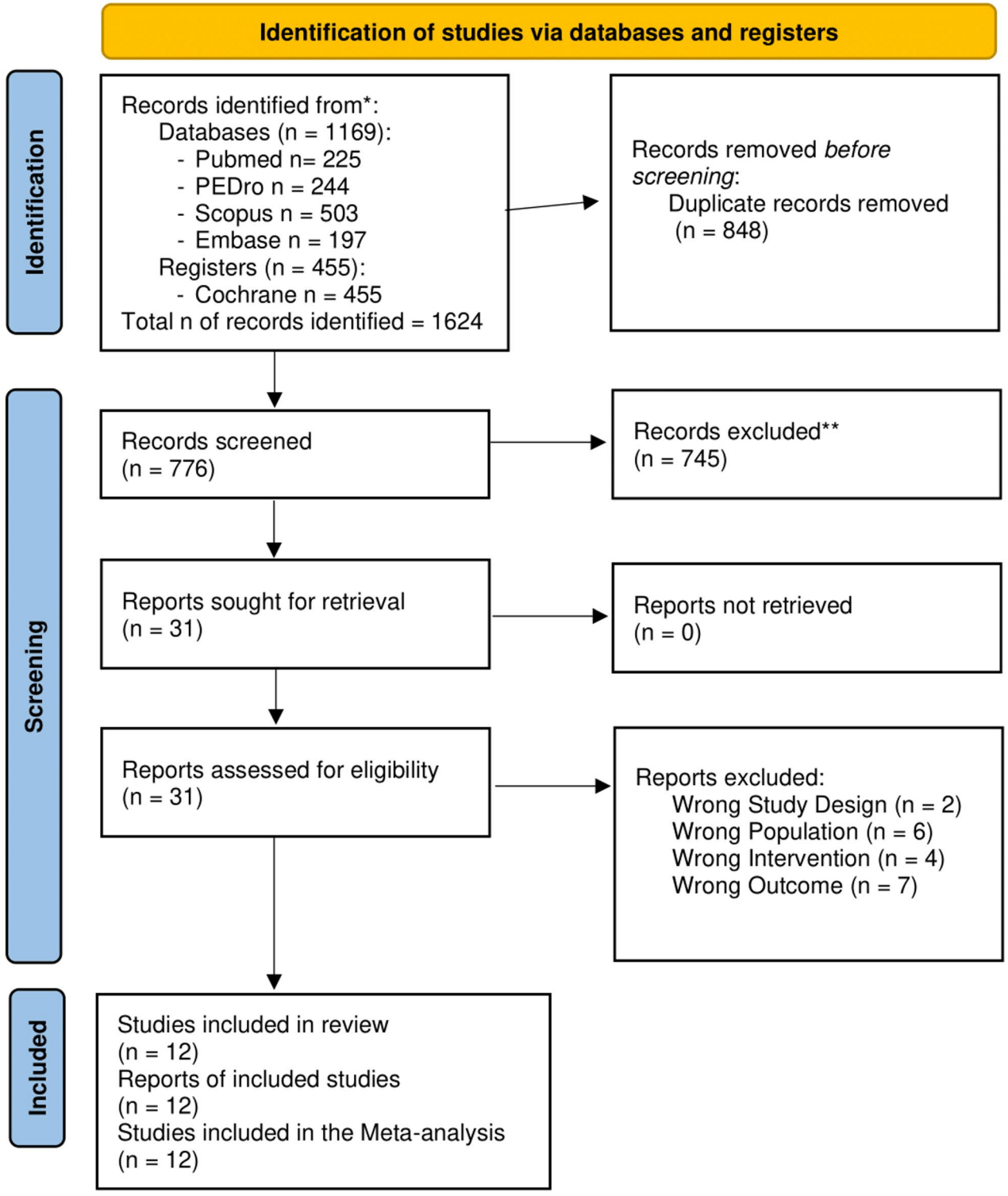


Fig. 1 PRISMA 2020 flow diagram

for both relating to data management and reporting. The summary of the RoB assessment is presented in Fig. 2 (Fig. 2).

Results of syntheses

Results of individual studies are shown in Tables 4a and 4b (Appendix). Overall, 12 studies were included in the meta-analysis. With the exception of the study by Matthews [35] in relation to functional recovery, all studies reported both pre- and post-treatment values for pain and function. Therefore, rather than a precise estimate of the post-treatment average, an estimate of the pre-post treatment difference of the different outcomes and the different follow-ups (4–6 and 8–12 weeks) could be used as an outcome in the meta-analyses. The meta-analysis on the change in pre- and post-treatment pain at 4–6 weeks and 8–12 weeks showed an average reduction of -1.44 (CI. -2.20; -0.67) and -0.8 (CI -1.23; -0.37) in favour of the intervention group with exercises (Fig. 3). The number of patients involved was 601 and 719 respectively. Heterogeneity was 87% in the meta-analysis relating to the first follow-up and 0% in the case of the second follow-up. The sensitivity analysis on the female population was not able to explain the heterogeneity of the meta-analysis of pain at 4–6 weeks (Fig. 4). In this case the mean difference in pain reduction was -2.81 (CI -4.39; -1.23) and the pain outcome was measured with a follow-up that varied from 4 to 8 weeks to allow 3 papers to be used within the same meta-analysis. The sensitivity analysis for pain at 4–6 weeks, with respect to the quality of the studies, was performed by examining the studies that presented a low level of risk for all domains except

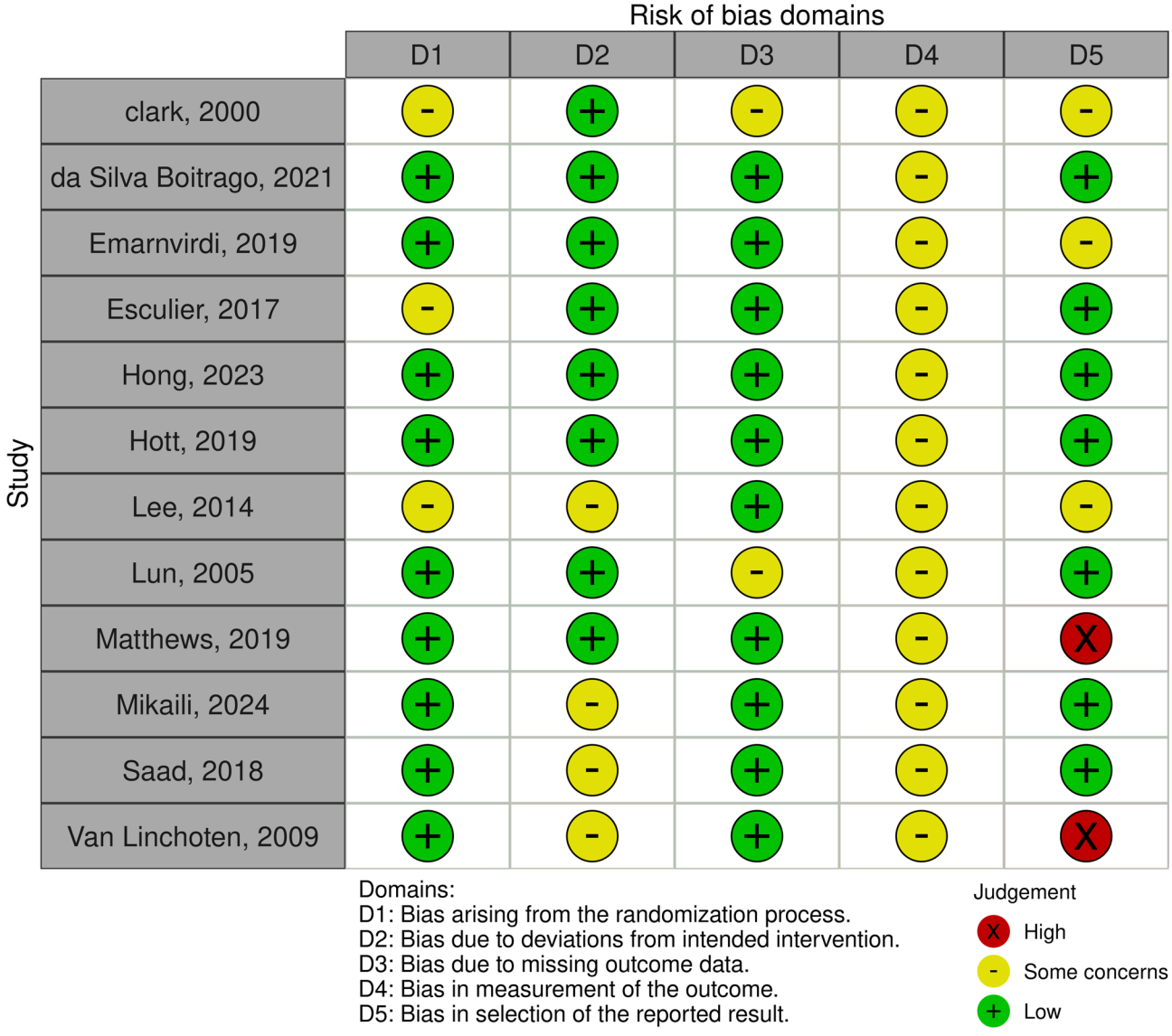
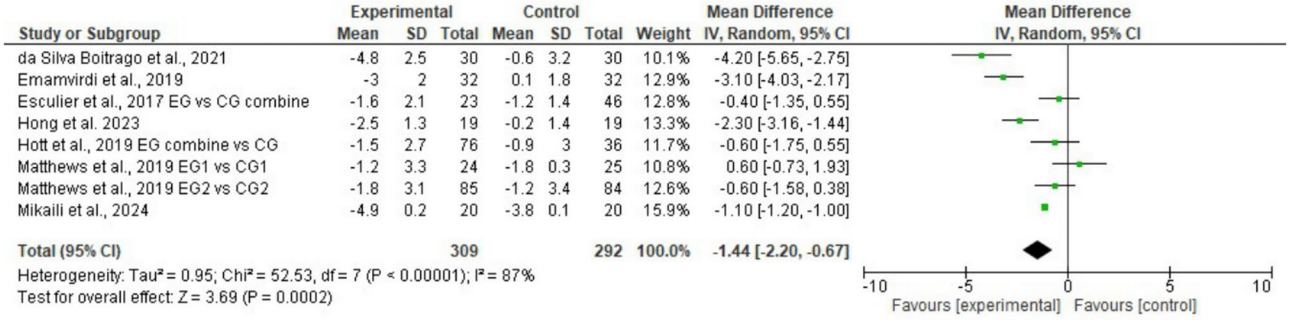
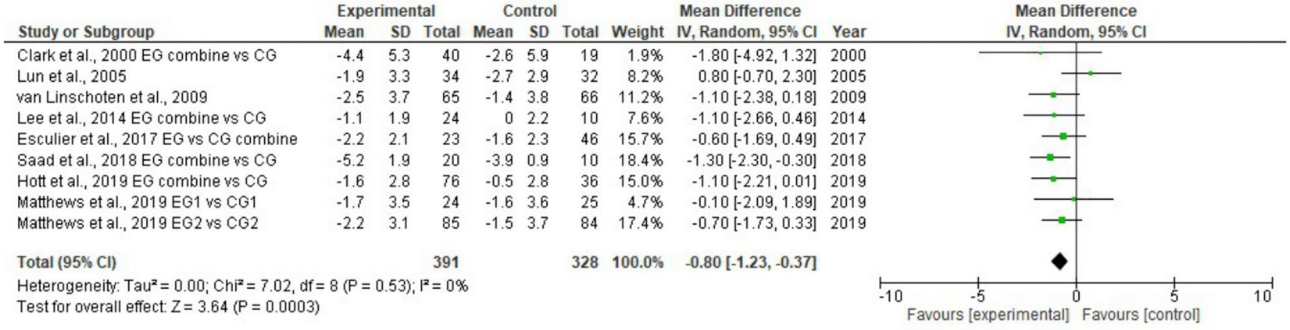


Fig. 2 Risk of bias

A. pain at 4-6weeks;



B. pain at 8-12 weeks;



C. function at 8-12 weeks

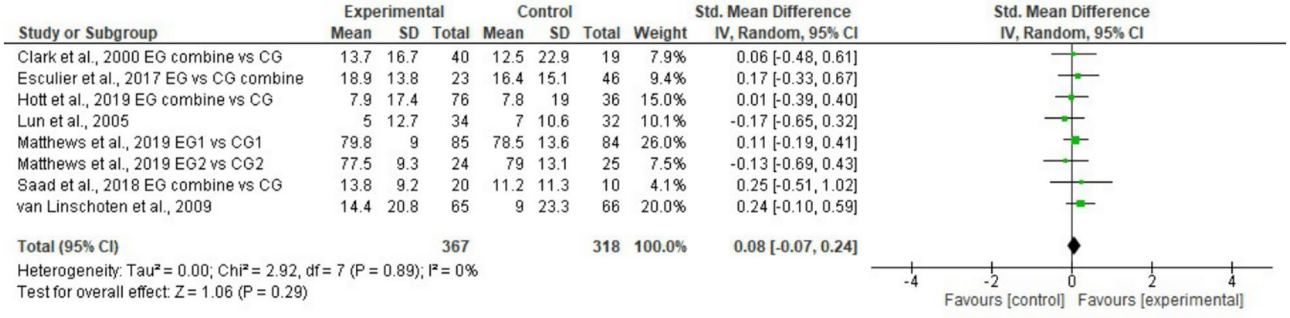
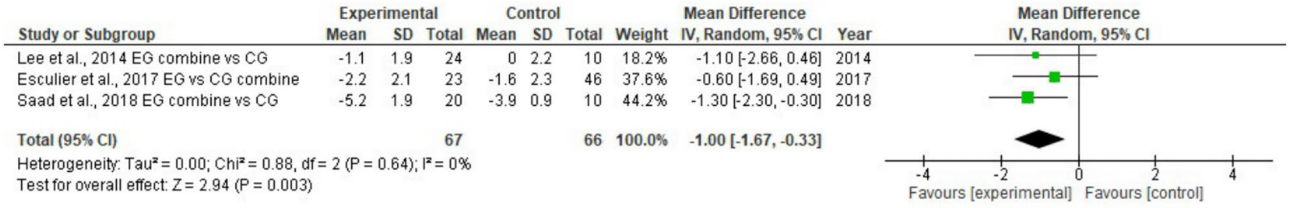


Fig. 3 Primary meta-analysis performed

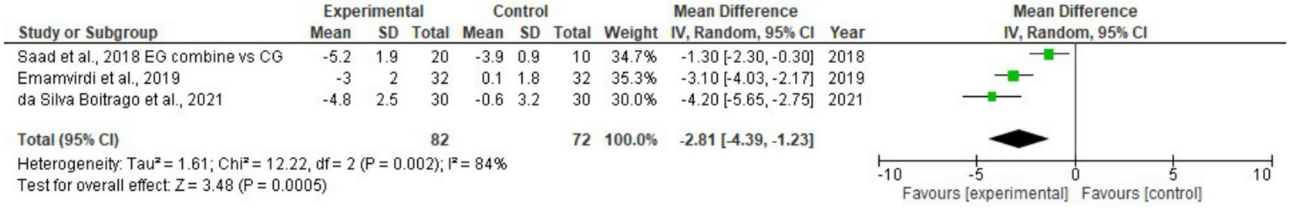
for domain 4 which was not considered. The meta-analysis did not provide an explanation for the increased heterogeneity (Fig. 4). With regards to the population of athletes, the analysis of pain at 8–12 weeks confirmed a heterogeneity of 0% with an average reduction of -1.0 (CI -1.67; -0.33) (Fig. 4) which was in line with the analysis carried out on all types of patients. In relation to this outcome, it was not possible to perform a meta-analysis on studies with low risk of bias as only one of the studies included in the meta-analysis fell within the hypothesized quality criteria.

The meta-analysis on functional outcomes was performed only on the 8-12 week follow-up (Fig. 3), since none of the included studies reported an outcome with a 24-week follow-up. The standardized mean difference in pre-post treatment variation between the two groups was 0.08 (CI -0.07; 0.24) in favour of the intervention with a statistical heterogeneity of 0% and an overall number of 685 patients. It was not possible to carry out

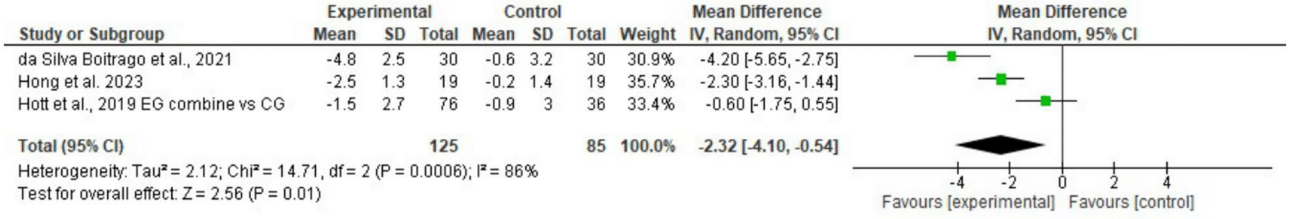
A. Pain at 8-12 weeks for athletes



B. Pain at 4-8 weeks for female



C. Pain at 4-6 weeks for studies with low ROB



D. Function at 8-12 weeks for AKPS scale

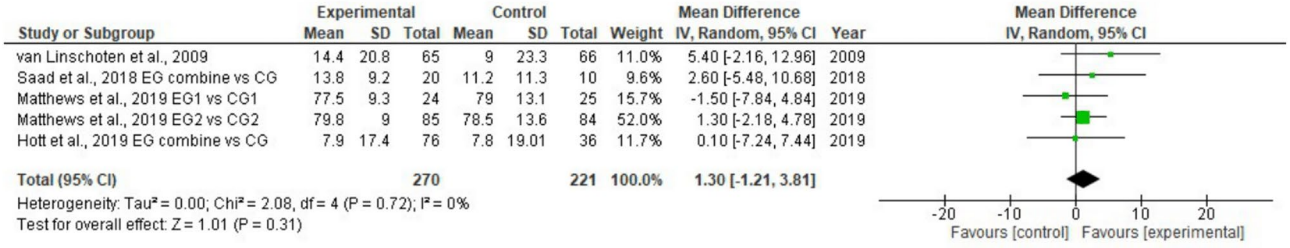


Fig. 4 Sensitivity and sub-groups meta-analysis

further sub-analyses in relation to the specific populations formed by women or athletes or in relation to the methodological quality of the studies. The sub-analysis which included the 4 studies,[28,31,33,34] which used the same assessment scale, i.e. the AKPS at 8–12 weeks, presented a mean difference in change in the scale score of 1.30 (CI: -1.21; 3.81) with a p value of 0.31 (Fig. 4).

Reporting bias

A funnel plot was calculated for all primary meta-analyses. In the case of the meta-analysis of pain at 4–6 weeks there is a more uncertain result which does not allow us to reach a definitive conclusion. The funnel plot relating to the meta-analysis of pain and function at 8–12 weeks, also involving a greater number of studies, helps the authors to exclude the risk of publication bias with

greater certainty. Based on these findings, risk of publication bias is limited although it cannot be completely excluded.

Certainty of evidence

The results of the present analyses are summarized in the "Summary of Findings" (Table 5). with regard to pain measured at 4–6 weeks, there was a very low level of certainty of the evidence with a downgrade by one level attributed for three domains by GRADE: the quality of the studies, the high level of heterogeneity and the imprecision of the estimated effect. For pain and functional recovery at 8–12 weeks the level of certainty was low with a downgrade by one level for the domains related to the quality of evidence and the imprecision of the estimated effect.

Discussion

The aim of this systematic review was to compare the effectiveness of physiotherapy programs focused on strengthening exercises with other types of conservative treatment with regards to reducing pain and improving function in patients with PFP. This meta-analysis showed, for both outcomes considered, an efficacy in favour of the experimental treatment. Despite the number of papers included and large sample size, the extent of the improvement measured and the characteristics of the studies included imply a certain caution in the interpretation of the results and relative choices in clinical practice. The level of certainty of the evidence for these findings ranged from very low to low, indicating the need for further studies to determine which conservative treatment is truly most effective.

The improvement in pain in favour of treatment with therapeutic strengthening exercises was more marked in the first follow-up period at 4–6 weeks. The reduction in pain pre-post treatment was equal to 1.4 points on the VAS/NRS scale with a statistical significance ($p < 0.001$) and a very low level of certainty. This reduction from a clinical point of view is lower than the cut-off identified in the literature, which is 2 points [24], and is in line with the network meta-analysis of Winters et al. [13] where no certainty was possible regarding the superiority of one type of conservative treatment compared to another. For these reasons the reported efficacy results must be interpreted with caution.

In the systematic review of Neal et al. [12], conducted with regard to conservative treatments for patients with PFP, strengthening exercises showed efficacy in relation to pain in a follow-up short-term compared to the wait and see treatment with a moderate level of certainty considering exercise as a single treatment and a low level of certainty considering multiple treatments combined. Both meta-analyses were based on the aggregate estimate of only 2 high-quality RCTs. When authors compared the strength exercises with another type of conservative treatment, the only analyses carried out were based on a comparison between groups that performed exercise programs which differed only for the target muscles to be strengthened. The present review allows to deepen the efficacy of therapeutic exercise of strengthening by highlighting how it can bring a greater benefit compared to other types of conservative treatment.

Furthermore, if we consider a population composed only of women, the improvement recorded by the relevant meta-analysis at 4–8 weeks was 2.81 with an improvement that became significant from both a statistical and clinical point of view. A reduction in the force produced by the abductor muscles of the hip and an increase in the valgus attitude of the knee have been found to be significant elements in the onset of pain and arthritis in women [39, 40] and might provide an explanation for the best response to strengthening treatment muscle in the case of PFP for women.

Statistical heterogeneity of the meta-analysis was significant with the I2 score above 80% and showed the need to read the results with caution. From a clinical point of view, another aspect that might play a role in determining this level of heterogeneity was linked to the type of exercise program used, which differed among various papers and which would require greater standardization. Starting from common aspects found among the studies (Appendix, Table 2), the intervention treatment that might be envisaged in clinical practice and as the subject of further studies might be based on 3 weekly sessions lasting 30–40 min for a period of 6 weeks. From a quality point of view of the studies, the meta-analysis supported an improvement in favour of the intervention group but did not provide useful elements to explain the statistical heterogeneity.

The mean difference in pre-post treatment pain in favour of the intervention was 0.8 VAS/NRS points at 8–12 weeks with statistical significance albeit with a decreasing trend compared to the first evaluation at 4–6 weeks. This aspect highlights the need for further studies with long-term follow-ups to test the ability of treatment with strengthening exercises to maintain the improvement obtained initially and also underlines the possibility of envisaging treatment plans repeated over time. There was no statistical heterogeneity in this analysis and it was not possible to perform a sensitivity analysis with respect to the female population alone as there was only one study available. The analysis performed on the population of athletes highlighted very similar results to the overall analysis with a reduction in symptoms of 1.0 VAS/NRS points with a statistical significance and heterogeneity of 0%. The reviewers attributed a low level of certainty to the estimates made. In addition to the limited

quality of the studies, the relevant meta-analysis shows how almost all the studies included crossed the line of no effect, making it difficult to have certainties regarding the effectiveness of treatment (Fig. 3).

The meta-analysis on recovery of function was only possible for the 8-12-week follow-up, and not for longer follow-up periods. The standard mean pre-post treatment difference between the intervention group and the control group was estimated at 0.08 with a p value of 0.29 and a low level of certainty attributed to the estimate. All the studies taken into consideration crossed the line of no effect, resulting in a high imprecision of the estimate. The included studies used 4 different assessment scales: the AKPS, the KOS-ADL, the WOMAC and the Modified Knee Function Scale.

Considering only those studies that used the AKPS (Fig. 4) as an evaluation tool, the meta-analysis gave an average difference in the pre-post treatment change in function of 1.31 points. From a clinical point of view, the minimum difference reported in the literature for AKPS was 10 points, essentially highlighting a similar effect between the strengthening exercise and the other conservative treatments used.

Strength and limitations

This systematic review has some limits. The studies included in the review did not allow to all the planned aggregate analyses to be carried out, such as the functional recovery evaluation at 6 months and all the hypothesized sensitivity analyses. This also contributed to the impossibility of fully investigating the statistical heterogeneity that emerged in the meta-analysis of pain at 4–6 weeks. Finally, the literature search did not involve grey literature, although it is believed that this procedure has resulted in a limited risk in the failure to include relevant studies.

The present systematic review has enabled clarification about the role of treatment with strengthening exercises compared to other types of conservative treatment. First of all, this choice obviates overestimating the effect of exercise that might occur in a comparison with no treatment and secondly limits any distortion of the effect linked to the evaluation of a symptom closely linked to the experience of the patient such as pain and at the same time the impossibility of carrying out a real placebo treatment.

Suggestions for future research

For the construction of future study protocols in this area, it is important to consider different populations by sex, standardized exercise programs and provide for prolonged follow-ups over time. The proposed exercise programs should be well described, the authors should also provide elements in relation to the possible tailoring and adherence of the exercises.

Conclusion

Among conservative approaches of PFP patients, the present systematic review highlighted a positive effect in the use of muscle strengthening strategies in the treatment, albeit with a low level of certainty of the results due to methodological weakness of the studies. Women with PFP are the population that may benefit more from treatment with strengthening exercises in improving short-term pain symptoms.

Abbreviations

RCTs	Randomised controlled trials
PFP	Patellofemoral pain
PEDro	Physiotherapy evidence database
VAS	Visual analogue scale
NRS	Numeric rating scale
AKPS	Anterior knee pain scale
ROB	Risk of bias
RevMan	Review manager

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13102-025-01297-x.

Supplementary Material 1

Supplementary Material 2

Author contributions

M.M., E.V., C.G., I.B., R.R. designed the study. E.V., C.G. and I.B. performed screening process. V.P. and R.R. performed assessment of quality. M.M. and R.R. provided certainty of evidence. M.M. and A.C. performed data analysis and prepared tables and figures. M.M. wrote the main manuscript text. All authors reviewed the manuscript.

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Data availability

All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

not applicable. Systematic review protocol was registered in the PROSPERO database under code CRD42023444137 on 06/08/2023.

Consent for publication

not applicable.

Competing interests

The authors declare no competing interests.

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