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Effects of strength training on the treatment of patellofemoral pain syndrome – a meta-analysis of randomized controlled trials

Efeitos do treinamento de força no tratamento da síndrome da dor femoropatelar – uma metanálise de ensaios clínicos randomizados

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Abstract

Introduction: Palletofemoral pain syndrome (PFPS) is anterior knee pain that affects around 25% of the population at some point in their lives. Muscle weakness is one of the main causal factors related to PFPS. **Objective**: Conduct a quantitative analysis on the effectiveness of strength training at reducing pain in PFPS sufferers. **Methods**: An electronic search was conducted on the MEDLINE, Pubmed, EMBASE, Lilacs and Scielo databases for studies published between January 2005 and September 2014. The following descriptors were used: "*patellofemoral pain syndrome*", "*patellofemoral pain*", "*retropatellar pain*", "*exercise*", "*exercise therapy*", "*strength*", "*rehabilitation*". Only randomized controlled trials (RCTs) that compared the effects of strength training to no exercise in terms of reducing pain among PFPS sufferers were included. Data were extracted by two independent authors using predefined quality indicators. **Results**: A total of 39 RCTs were initially identified in the search. However, only five met the inclusion criteria. Strength training exhibited a positive effect on PFPS (SMD = 0.85, CI: 0.45-1.25). However, high heterogeneity was observed between the studies ($p < 0.05$; $I^2 = 68.3\%$). **Conclusion**: Strength training showed a statistically positive response in the treatment of PFPS.

Keywords: Knee. Strength Training. Patella.

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Resumo

Introdução: *A síndrome da dor femoropatelar (SDF) é uma patologia da região anterior do joelho que atinge cerca de 25% da população em algum momento da vida. Dentre os fatores causais relacionados com a SDF, destaca-se o enfraquecimento muscular.* ***Objetivo****: Realizar uma análise quantitativa da eficácia do exercício de força na redução da dor em portadores de SDF.* ***Métodos****: Foi realizada uma busca eletrônica nas bases de dados MEDLINE, Pubmed, EMBASE, Lilacs e Scielo, limitada entre o período de janeiro de 2005 e setembro de 2014. Os seguintes descritores foram usados, em língua inglesa: "patellofemoral pain syndrome", "patellofemoral pain", "retropatellar pain", "exercise", "exercise therapy", "strength", "rehabilitation". Apenas ensaios clínicos randomizados que comparassem os efeitos do treinamento de força ao não exercício na redução da dor de portadores de SDF foram incluídos. A extração de dados foi realizada por dois autores de forma independente, utilizando indicadores de qualidade pré-definidos.* ***Resultados****: Total de 39 ECR's foi identificado inicialmente na pesquisa. No entanto, apenas cinco estudos contemplaram os critérios de inclusão. O treinamento de força apresentou efeito positivo sobre a SDF (SMD = 0,85, IC: 0,45-1,25). Contudo, foi encontrada alta heterogeneidade entre os estudos (p < 0,05; I2 = 68,3%).* ***Conclusão****: Evidenciou-se resposta estatisticamente positiva do treinamento de força no tratamento da SDF.*

Palavras-chave: *Joelho. Treinamento de Resistência. Patela.*

Introduction

Palletofemoral pain syndrome (PFPS), characterized by anterior knee pain with no definitive cause or diagnosis (1), can be defined as pain around the kneecap (patella) resulting from physical and biomechanical changes in this joint (2). Other commonly used terms include anterior knee pain, chondromalacia patella, palletofemoral arthralgia and palletofemoral pain (3). The condition can be exacerbated by activities such as going up and down stairs, sitting for prolonged periods, running and squatting (4).

PFPS affects around 7% of active young adults and about 25% of people at some stage in their lives, but is most common among the former (5). Incidence rates are even more pronounced among sports enthusiasts, accounting for up to 40% of injuries in sports medicine (6).

Dye et al. (7) suggested that the onset of PFPS is likely the result of a complex pathophysiological process, which may include peripatellar synovitis, increased pressure and internal bone remodeling.

Despite the lack of consensus on the causes of this condition, several factors are believed to contribute to its development, such as weakness in the quadriceps (8), changes in the posture alignment of the lower limbs (9), abnormal leg biomechanics, (10), smaller knee flexion angle (11), weak hip muscles (12), excessive adduction and internal rotation of the hip (13) and, primarily, kneecap misalignment (8).

The treatment of PFPS is still a challenge in the scientific literature. There is no standard recommended treatment, although it is believed that conservative non-surgical approaches produce good results, with a resolution rate of up to 87% (5). Conventional treatment generally includes physiotherapy (14), strengthening the quadriceps, using a knee brace and taping, as well as soft tissue mobilization and stretching (15, 16). In this respect, muscle strengthening aims to combat neuromuscular deficits, which include the quadriceps, vastus medialis oblique muscle, proximal muscle strength deficits, soft tissue tightness or abnormal knee alignment (17). A variety of exercises are used in different combinations, including open and closed kinetic chain exercises and stretching (18).

In a study of PFPS sufferers, van Linschoten et al. (19) concluded that exercise improves pain and functionality in the knee joint in the short and long term. Similar results were found by Song et al. (20), who observed an improvement in these parameters regardless of the resistance exercise used. As such, the primary aim of this study was to conduct a quantitative analysis of the effectiveness of strength training at reducing pain in PFPS sufferers.

Methods

Search strategysong

In the literature review, only randomized controlled trials (RCTs) that aimed to assess the effectiveness of strength training in PFPS treatment were selected. An electronic search was conducted on the MEDLINE, Pubmed, EMBASE, Lilacs and Scielo databases for studies published between January 2005 and September 2014.

The descriptors used during the review process were chosen after consulting Medical Subject Headings (MeSH), as follows: "*patellofemoral pain syndrome*", "*patellofemoral pain*", "*retropatellar pain*", "*exercise*", "*exercise therapy*", "*strength*", "*rehabilitation*". The Boolean operators "AND" and "OR" were used to combine the search terms.

Study eligibility and selection criteria

Studies included were RCTs; articles published in English or Portuguese; papers that measured the variable "pain"; and those that provided means and their respective standard deviations on a pain scale for each group. Abstracts and studies whose sample contained only adolescents were not included.

Based on the PRISMA diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) (21), two authors independently evaluated the methodological quality of all the selected studies. Disagreements between the authors were resolved by consulting a third reviewer. The decision to include or exclude studies was initially made by analyzing its title, followed by the abstract and, finally, the entire manuscript. The flow chart considered 52 studies at the start of the search and finished with five (Figure I).

Data Collection

Information was extracted from each study based on: 1) population – characteristics of study participants – age and diagnostic method; 2) intervention – characteristics of the intervention protocol – duration, frequency, intensity, volume and types of exercises, compared to a control group, and; 3) result – type of outcome measured – pain intensity.

Statistical analysis

Data were analyzed using the Stata 12.1 program. Cochran's Q test was applied to evaluate inter-study heterogeneity. The level of inconsistency between the trials was estimated using the I^2 statistic, where an I^2 value close to 75% indicates high heterogeneity, according to Higgins et al. (22).

As suggested by DerSimonian & Laird (23), the primary outcome of the studies (pain) was pooled using a random effects model.

Results

A total of 39 RCTs were initially identified in the search. Of these, 25 were considered for assessment based on their titles. Four were excluded as duplicates, leaving 21 studies eligible for analysis of the full text. A total of five studies met all the selection criteria (Figure 1).

Most of the studies used the visual analog scale (VAS) to measure pain intensity, while only one (24) used the Numerical Pain Rating Scale (NPRS). Two studies included only women (24, 25) and two investigated adolescents (19, 26). Since two of the studies contained three groups (20, 24), two of which performed exercises, the five articles reported a total of seven results, given that these were included in the meta-analysis twice, with each intervention compared to the control. Table I shows the five studies on physical exercise and PFPS included in the meta-analysis.

Five articles (377 participants) analyzed the effect of strength training (219 participants) compared to a control group (158 participants) on PFPS (19, 20, 24, 25, 26). Five of the seven results included in the meta-analysis exhibited a significant difference in relation to the baseline, indicating a positive effect on PFPS ($p < 0.001$) (Figure 2). However, the results demonstrated high heterogeneity ($p < 0.05$; $I^2 = 68.3\%$), but within the tolerance limit.

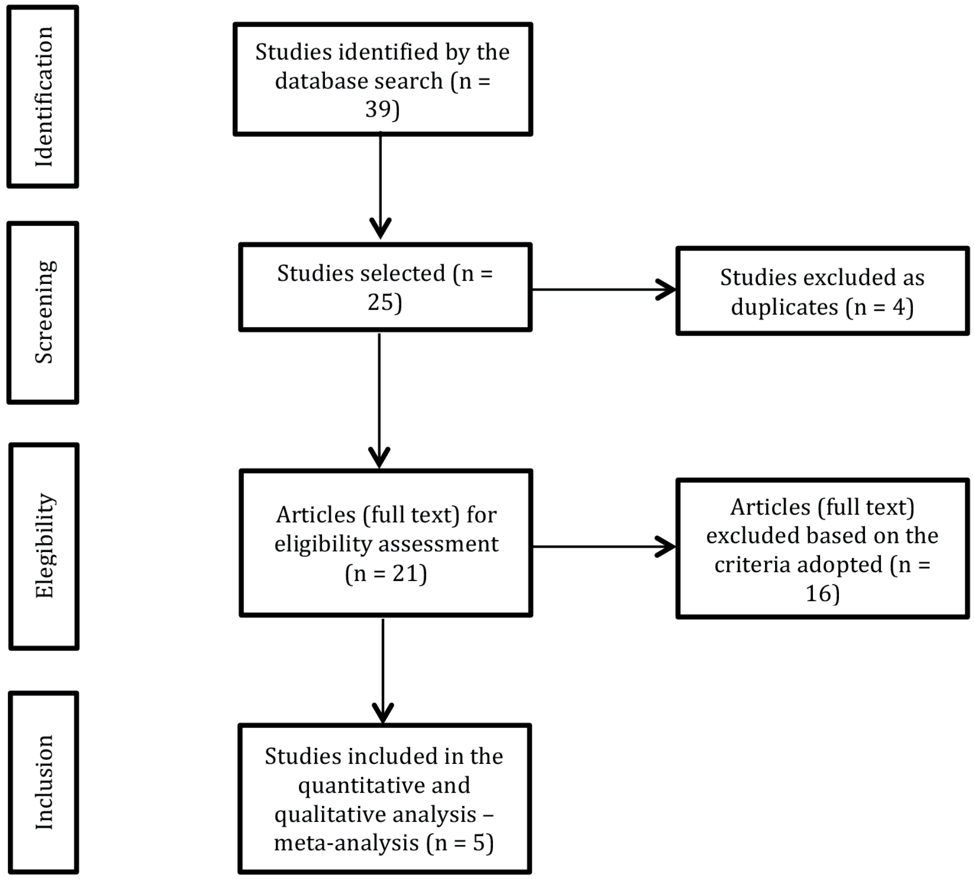

Figure 1 - Flow chart of the search process

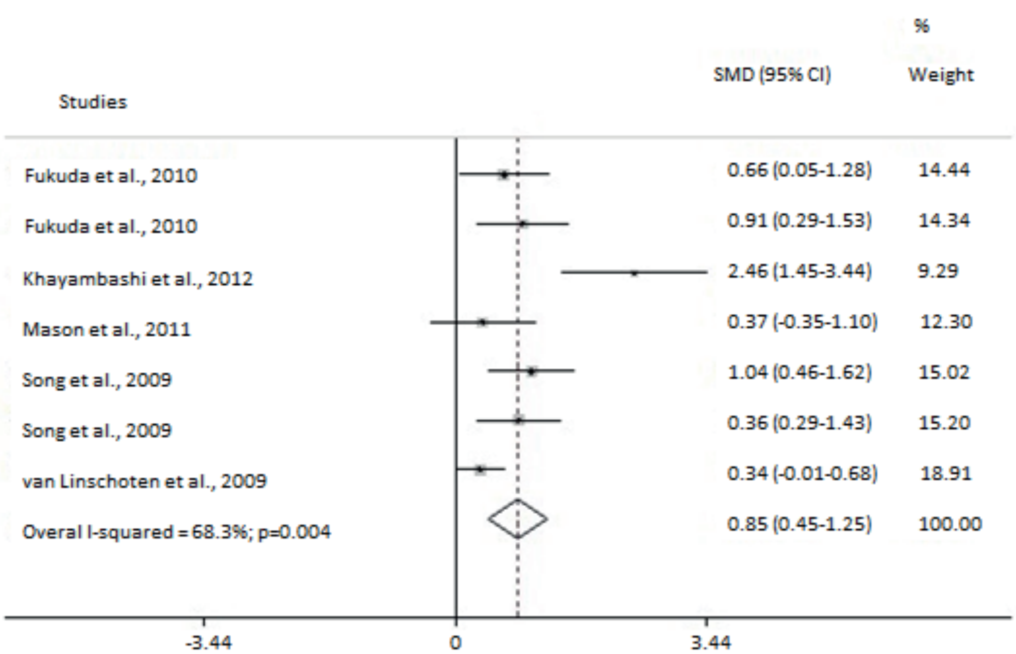

Figure 2 - Forest plot of the effect of exercise on PFPS

Table 1 - Description of the studies included

Study, year	Sample				Intervention			Results
	Size (n)	Distribution (n)	Age (years)	Sex	Description	Duration (weeks)	Frequency (per week)	
Fukuda et al. 2010	64	CG = 23 KG = 20 KHG = 21	20 - 40 years	Women	CG – received conventional treatment that emphasized stretching and strengthening knee muscles; KHG – carried out exercises to strengthen abductors and external rotators in addition to the same exercises performed by the KG; CG – did not receive any treatment.	4	3 sessions	CG = 64.5 ± 11.1 KG = 80.6 ± 13.9 KHG = 78.9 ± 16.0
Herrington et al., 2007	45	CG = 15 KEG = 15 LPG = 15	18 - 35 years	Men	KEG – performed knee extension exercises; GEJ – performed seated leg press exercises; CG – did not receive any treatment.	6	3 sessions	CG = 8.2 KEG = 4.8 LPG = 3.9
Khayambashi et al., 2012	28	CG = 14 EG = 14	Average age of 30 years	Women	EG – performed hip adductor and abductor exercises; CG – did not receive any treatment.	8	3 sessions	CG = 6.7 ± 2.4 EG = 1.4 ± 1.9
Mason et al., 2011	30	CG = 15 EG = 15	13 - 82 years	Men and women	EG – carried out hip strengthening exercises at homes without loads; CG – did not receive any treatment.	1		CG = 2.26 (1.5) EG = 1.74 (1.7)
Song et al., 2009	79	CG = 25 KG = 27 KHG = 27	Average age of 38.6 years	Men and women	KG – performed only leg press exercises; KHG – performed the leg press combined with hip adductor exercises; CG – did not receive any treatment.	8	3 sessions	CG = 4.81 (2.55) KG = 2.26 (2.20) KGH = 2.62 (2.51)
van Linschoten et al., 2009	131	CG = 66 EG = 65	14 - 40 years	Men and women	EG – carried out static and dynamic muscle exercises for the quadriceps, adductors and gluteus at home; CG – did not receive any treatment.	12		CG = 3.22 (2.8) EG = 2.30 (2.5)

Note: CG: Control group; KG: Knee group; KHG: Knee and hip group; KEG: Knee extension group; LPG: Legg press group; EG Exercise group.

Discussion

Our study aimed to assess the effectiveness of strength training on PFPS treatment and the overall result indicated a positive effect for this type of intervention on the outcome studied. Despite the lack of meta-analyses on this subject, literature reviews on the issue corroborate the findings of the present study (16, 27, 28).

Strength training is effective in the treatment of PFPS. Previous research demonstrates the importance of strengthening hip adductor muscles and lateral rotators, as well as the quadriceps, since these also exhibit weakness, particularly in women with the condition (29, 30). The weakening of these muscles can trigger internal rotation or adduction of the hip, causing an increase in the quadriceps (Q) angle formed by the intersection of two imaginary lines, one from the ASIS (anterior superior iliac spine) to the central patella and the other from the tibial tubercle to the central patella. This increased Q angle leads to patella subluxation, which intensifies the patellofemoral peak pressure, one of the causes of PFPS (31, 32, 33). In addition, weakness in these muscles may cause patellar facet overload (13, 34).

Recent evidence indicates that increased strength and better hip flexibility have become essential in treating PFPS (35). This factor is justified in that adequate dynamic control of the pelvis helps patients improve the mechanics of the patellofemoral joint (15).

In addition to demonstrating the importance of improving the strength and flexibility of hip muscles (20, 24), the studies included in this meta-analysis largely applied intervention protocols targeting the quadriceps, using both open and closed kinetic chain exercises (19, 25, 26, 34, 36). Mason et al. (26) studied the effect of hip strengthening exercises on PFPS treatment and concluded that this type of intervention is effective in reducing pain and improving functional capacity. This clearly demonstrates the effectiveness of strengthening the anterior thigh muscles, particularly the vastus medialis, in terms of reducing pain in PFPS sufferers, which corroborates the findings of Harvie et al. in their literature review on the theme (34).

Our results exhibited high heterogeneity (68.3%). This finding can be attributed to the fact that the effect of the exercise reported by Khayambashi et al. (25) was far greater than that observed in the other studies included in the meta-analysis.

Conclusion

The main outcome of this investigation suggests a positive effect of strength training on PFPS treatment. From a clinical perspective, these findings indicate the importance of muscle strengthening, especially the anterior thigh muscles, in the treatment of PFPS.

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