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Review Article

Diagnostic Test Accuracy of Physical Examination Tests in Suspected Patellofemoral Osteoarthritis: A Systematic Review

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SUMMARY

This study aimed to perform a systematic review of the diagnostic test accuracy of physical examination tests, including crepitus of the knee, pain during functional activities, and manual tests of the patella in suspected patellofemoral osteoarthritis (PF OA) cases. The searched languages were English, Chinese, Korean, and Japanese. The PubMed, Cumulative Index to Nursing and Allied Health Literature, Web of Science, Korea Studies Information Service System, China National Knowledge Infrastructure, and Ichushi databases were searched electronically. The inclusion criteria of this systematic review were: (1) original articles; (2) prospective cohort or cross-sectional studies with isolated PF OA; (3) magnetic resonance imaging and/or orthopedic procedures used as the reference standard; and (4) odds ratio and/or test accuracy reported. The risk of bias was evaluated using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS)-2 tool. Seven citations were included in the systematic review. Overall, the risk of bias was favorable. Among the included studies, four reported the odds ratio of the physical examination tests, while three reported the sensitivity and specificity for test accuracy. The odds ratio of crepitus to identify cartilage lesions of the patella was between 1.74 and 5.49. Additionally, the odds ratio of pain during activities including walking and descending stairs was between 1.01 and 1.6 (original data = 0.60). The odds ratio of the manual tests of the patella was between 1.9 (original data = 0.52) and 2.7. Thus, crepitus was possibly the least efficient parameter for diagnosing PF OA among the three physical examination tests.

1. Introduction

Osteoarthritis (OA) of the knee is a known degenerative joint disease affecting older adults. It is estimated that knee OA occurs in approximately 19% of Americans aged 45 years and above, and it is believed to be highly prevalent in developed nations due to the recently increased life expectancy.[1,2] The degenerative changes of knee OA present not only in the femorotibial joint but also the patellofemoral (PF) joint. A previous study[3] indicated that knee OA is a commonly diagnosed condition, with approximately 25% of patients showing signs of PF OA, and about 40% of them have isolated PF OA. Furthermore, the radiographic signs of PF OA are related to symptoms such as pain, stiffness, and disabilities in older adults.[4,5]

Although standardized international diagnostic criteria have not been established, diagnostic imaging modalities, radiography, and magnetic resonance imaging (MRI) are used for its diagnosis. Qiu et al.[6] attempted to establish a definition for the diagnosis of PF OA in the Asian population using radiographic changes such as osteophyte and joint space narrowing. Additionally, a systematic review was performed to identify the diagnostic test accuracy (DTA) of the chondral defects in the PF in PF OA cases using MRI, which revealed a sensitivity of 87% and specificity of 86% in the detection of patellar defects. The review concluded that MRI is a highly sensitive, specific, and accurate noninvasive diagnostic modality for the detection of chondral defects in the PF compartment of the knee, using arthroscopy as the reference gold standard.[7] However, MRI and radiography are expensive, and the economic burden on patients is high. Moreover, the MRI equipment may not be adequate in some countries and regions. Therefore, diagnostic imaging modalities may not always be appropriate and convenient tools for diagnosing patients with suspected PF OA.

Conversely, physical examination tests are cost effective and can be performed without the use of specific equipment. Based on previous studies,[8–13] physical examination tests for diagnosing PF OA can be roughly categorized as crepitus of the knee, pain during functional activities, and manual tests of the patella. A previous study[8] indicated that the sign of crepitus of the knee presented high sensitivity (89%) and specificity (83%) in the diagnosis of PF OA. Previous studies[9–11] have indicated that pain during functional activities such as squatting, stair climbing, and kneeling were useful indicative tools in clinical practice, with pain during squatting showing a sensitivity of 91% in diagnosing PF OA. Moreover, manual tests of the patella,

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such as compression, gliding, grinding, and tenderness, are often used in clinical practice because they are easy to perform and their test accuracies have been examined.[12,13] These findings indicate that they are useful in clinically diagnosing PF OA. Whereas, there are previous studies[11,12] showed contradictive result, Nijs[12] et al. suggested that some physical examinations were not good diagnostic test. To conclude these contradictive results, systematic review in the same setting gives certain conclusion. However, in the literature, there is no systematic review on the DTA of physical examination tests in PF OA yet.

By performing a systematic review and examining the DTA of physical examination tests for PF OA, it is possible to clarify the physical examination that health-care providers should prioritize in clinical practice. The aim of this study was to perform a systematic review of original research studies on the DTA of physical examination tests in suspected PF OA cases.

2. Methods

2.1. Design

This study is registered in the UMIN (University Hospital Medical Information Network) to avoid duplication and reduce reporting bias (approval number: UMIN000044723). This systematic review was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-analysis of Diagnostic Test Accuracy guidelines.[14]

2.2. Eligibility criteria

This review included studies evaluating the accuracy of three physical examination tests (crepitus of the knee, pain during functional activity, and manual tests of the patella) in diagnosing PF OA. The inclusion criteria were: (1) original articles; (2) prospective cohort or cross-sectional studies with isolated PF OA; (3) MRI and/or orthopedic procedures (e.g., arthroscopy) used as the reference standard; and (4) odds ratio and/or test accuracy (e.g., sensitivity and specificity) reported. Although odds ratio is not a measure of diagnostic test accuracy, it is statistic that can be used to determine whether it is a significant factor that can discriminate between the presence and absence of PF OA, and therefore odds ratio was addressed in this review. No limits regarding the date of publication were established; however, studies in which subjects had undergone surgery in knee joints affected by OA, subjects had other associated diseases (e.g., anterior cruciate ligament injury and meniscus injury), or the diagnosis was determined using questionnaires were excluded.

2.3. Search strategy

The searched languages included English, Chinese, Korean, and Japanese to avoid mixing language bias. The electronic search was conducted in the following databases: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science, Korea Studies Information Service System (KISS), China National Knowledge Infrastructure (CNKI), and Ichushi (Japanese database). The most recent search was conducted on June 29, 2021. The search strategies are presented in Table 1. The same approach was used for all searches and was adapted as necessary according to the specifics of each database.

2.4. Selection of the studies

One evaluator (ST) read the titles and abstracts of the identified articles and excluded the irrelevant studies after searching the aforementioned databases. The full text of the selected studies was evaluated and the suitability for inclusion was determined by two independent evaluators (ST and YI). Disagreements between the evaluators were resolved by consensus. In cases where no consensus was reached, a third evaluator (RT) was consulted to decide the eligibility.

2.5. Risk of bias

The methodological quality of the diagnostic studies was evaluated using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS)-2 tool.[15,16] This tool comprises four domains: patient selection, index test, reference standard, and flow and timing. Each domain of QUADAS-2 was assessed in terms of the risk of bias and classified accordingly as low, high, or unclear by ST and RT. This tool allows for an objective and transparent rating of the bias and applicability of primary diagnostic accuracy studies. Any applicability concerns of three domains of the QUADAS-2 such as patient selection, index test, and reference standard were assessed by ST and RT.

3. Results

The PubMed, CINAHL, Web of Science, KISS, and Ichushi searches provided 170 citations, 65 citations, and 226 citations, 3 citations, and 44 citations, respectively. There were no eligible citations found in the CNKI search. Among these 508 citations, 7 were included in this review (Figure 1). The characteristics of the included studies are summarized in Table 2.

The risk of bias of the included studies was evaluated using QUADAS-2 tool (Figure 2 and 3). Among the included studies, two studies presented a low risk of bias. For the patient selection domain, only one study showed a high risk of bias, as it used the case-control method. Additionally, applicability concerns of patient selection in the two studies were considered high, because they included patients with rheumatoid arthritis and those of young age. For the index test domain, no studies specified the threshold of the index tests because the physical examinations of this review were qualitative. For the reference standard domain, all studies used diagnostic imaging modalities or arthroscopy, and the diagnosis of PF OA was clear. However, some studies did not state whether the reference standard results were interpreted without knowledge of the results

Table 1
Search strategy.

#1	patellofemoral
#2	osteoarthritis
#3	#1 and #2
#4	crepitus
#5	squatting
#6	“stair climbing”
#7	kneeling
#8	#5 or #6 or #7
#9	compression
#10	grinding
#11	gliding
#12	“Clarke's test”
#13	#9 or #10 or #11 or #12
#14	tenderness
#15	#3 and #4
#16	#3 and #8
#17	#3 and #13
#18	#3 and #14
#19	#15 or #16 or #17 or #18

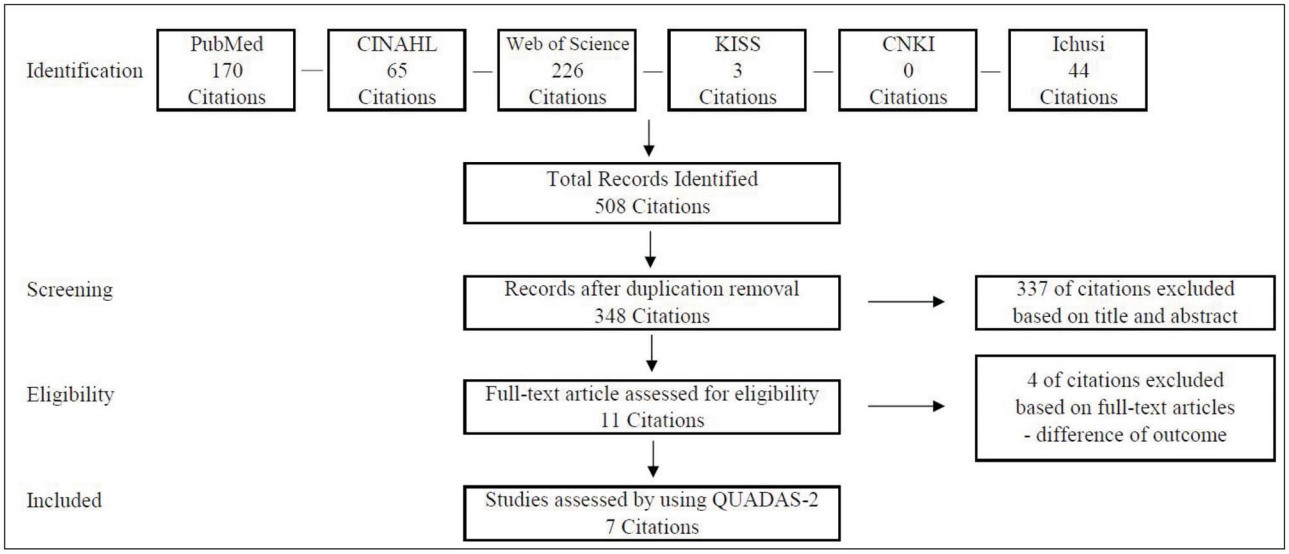

Figure 1. Flow chart of the search process. CINAHL, Cumulative Index to Nursing and Allied Health Literature; CNKI, China National Knowledge Infrastructure; KISS, Korea Studies Information Service System; QUADAS-2, Qualitative Assessment of Diagnostic Accuracy Studies.

of the index test. For the flow and timing domain, almost all studies analyzed all the patients, and the patients were subjected to the same reference standard.

In the included studies, four presented the odds ratio of the physical examination tests, while three presented test accuracies. The odds ratio of crepitus to identify symptoms of PF OA was between 1.74 and 5.49 and that of pain during activities including walking and descending stairs was between 1.01 and 1.6 (original data = 0.60). Moreover, the odds ratio of manual tests of the patella was between 1.9 (original data = 0.52) and 2.7.

4. Discussion

Based on the inclusion and exclusion criteria, seven citations were included in this review. The risk of bias of the included studies was evaluated using the QUADAS-2 tool and was found to be favorable. There were few studies showed test accuracies in the included studies, and outcomes were various. Although it is not possible to compare each odds ratio due to the difference in the outcomes, the odds ratio of the sign of crepitus for PF OA was relatively high. Crepitus sign was possibly the least efficient tool in diagnosing PF OA among the three types of physical examination tests used commonly by healthcare providers. The result of this study supports to priority use crepitus for diagnosing PF OA in clinical practice.

Crepitus is a crackling or popping sound in the joint due to tissue abnormalities and is often a result of arthritis or previous joint injury. In fact, a previous study[24] indicated that crepitus is more common in women with PF pain than in those without. This study suggested that the crepitus sign is a useful test for diagnosing PF OA. However, several previous studies[25–27] have indicated that knee crepitus has no relationship with the physical activity level, physical function, biomechanics of stair ascent, and quality of life (QOL). Moreover, Pazzinatto et al.[27] investigated whether the presence of knee crepitus is associated with the occurrence of total knee arthroplasty (TKA) and found that it did not predict the occurrence of TKA at 36 months in older adults. These findings suggest that caution should be exercised when using the sign of crepitus to evaluate the functional ability, limitation of QOL, and necessity of orthopedic intervention.

In contrast, this study revealed that pain during activities including walking and descending stairs was not good diagnosing test. In clinical practice, knee pain is a common complaint in patients with knee OA, and is caused capsulitis, cartilage loss, malalignment of the knee, and mechanical stress such as knee adduction moment.[28] Additionally, knee pain is caused not only PF joint but also femorotibial joint. Thus, knee pain occurs in various causes and joints. Since this study focused on PF OA only, the DTA of knee pain during activities may be low. However, odds ratio of pain during activities including walking and descending stairs was between 1.01 and 1.6, this result means that positive of pain during activities suggests presence of PF OA. Cook et al.[11] suggested that combinations of assessment tests were useful for diagnosing PF OA. Therefore, it may be important to combine physical examination tests including crepitus in the diagnosis of PF OA.

The QUADAS-2 tool was used to evaluate the risk of bias in this review. The applicability concerns in almost all the studies were assessed as low. This means that the patient selection, index test, and reference standard of the included studies showed almost no difference. However, there were many unclear assessments in each signaling question, especially in few studies that described the flow and timing between the reference test and index test. Therefore, further research on more strictly controlled diagnostic studies is required.

This systematic review has some limitations. First, this study could not conduct a meta-analysis because the included studies did not have findings that enabled the calculation of the number of true positives, true negatives, false positives, and false negatives. Therefore, this study did not indicate any statistical conclusions regarding the DTA of the physical examination tests. Second, because this systematic review included English, Japanese, Chinese, and Korean language articles, it could not use EMBASE, a database used frequently in other systematic reviews. Only seven studies were included in this study, and there may be a difference in the studies included in other systematic reviews and this review. Third, this study did not include patients with rheumatoid arthritis or femorotibial OA, nor did it consider the severity of PF OA. These limitations may affect the generalization. Finally, our systematic review included studies that reported odds ratio. The odds ratios are useful for examining whether a particular variable is a factor in suspecting the presence of PF OA, but

Table 2
Characteristics of the included studies.

Source (year)	No. of subjects	Male	Female	Age (years) Mean (range)	Reference	Examination maneuver		Result
Eijkenboom, 2019[17]	64	29	35	23.4 (14–40)	MRI	Presence of crepitus	Odds ratio	Osteophytes patella, 1.74 (95% CI, 0.52 to 5.83) Marrow lesions in the patella, 1.36 (95% CI, 0.47 to 3.94) Minor cartilage defects in the patella, 11.95 (95% CI, 2.25 to 63.61) Patellar tendon abnormalities, 1.20 (95% CI, 0.41 to 3.54) Hoffa synovitis, 0.38 (95% CI, 0.12 to 1.26)
						Pain during activity	Odds ratio	Osteophytes patella, 1.04 (95% CI, 0.79 to 1.36) Marrow lesions in the patella, 1.13 (95% CI, 0.88 to 1.44) Minor cartilage defects in the patella, 1.01 (95% CI, 0.73 to 1.38) Patellar tendon abnormalities, 1.04 (95% CI, 0.81 to 1.34) Hoffa synovitis, 1.05 (95% CI, 0.79 to 1.38)
						Pain during walking stairs (severe pain or unable to walk stairs)	Odds ratio	Osteophytes patella, 0.33 (95% CI, 0.88 to 1.29) Marrow lesions in the patella, 0.86 (95% CI, 0.29 to 2.54) Minor cartilage defects in the patella, 0.87 (95% CI, 0.24 to 3.19) Patellar tendon abnormalities, 0.45 (95% CI, 0.15 to 1.37) Hoffa synovitis, 0.69 (95% CI, 0.21 to 2.22)
Peat, 2012[18]	745	335	410	65.2 (NA)	Radiography	Coarse crepitus	Odds ratio	0.64 (95% CI, 0.40 to 1.02)
						Difficulty descending stairs	Odds ratio	0.45 (95% CI, 0.27 to 0.73)
						Coarse crepitus	Odds ratio	0.37 (95% CI, 0.22 to 0.63)
						Difficulty descending stairs	Odds ratio	0.60 (95% CI, 0.35 to 1.05)
						PF joint compression test	Odds ratio	0.52 (95% CI, 0.29 to 0.92)
Ike, 1995[19]	20	8	12	49.9 (20–82)	Needle arthroscopy	Patellofemoral crepitus	Sensitivity, Specificity	Sn = 69, Sp = 50
Parsons, 2018[20]	409 (775 knees)	207	202		Radiography	Crepitus	Odds ratio	NS
						Tenderness	Odds ratio	2.7 (95% CI, 1.1 to 7.1)
Schiphof, 2014[21]	888 (1776 knees)	0	888	55.1 (NA)	MRI	Present of crepitus	Odds ratio	Cartilage lesions in PF joint, 5.49 (3.79 to 7.94) Osteophytes in PF joint, 2.61 (2.00 to 3.40) Cysts in PF joint, 2.82 (2.00 to 3.98) Bone marrow lesions in PF joint, 3.70 (2.71 to 5.04)
						Compression test pain	Odds ratio	Cartilage lesions in PF joint, 1.60 (1.10 to 2.31) Osteophytes in PF joint, 1.18 (0.86 to 1.61) Cysts in PF joint, 1.18 (0.80 to 1.75) Bone marrow lesions in PF joint, 0.97 (0.67 to 1.40)
Stefanik, 2014[22]	728	229	499	66.5 (NA)	MRI	Maximum pain with stairs (up or down)	Sensitivity, Specificity	(≥ min) Sn = 74, Sp = 33 (≥ mod) Sn = 40, Sp = 70
						Pain going up stairs	Sensitivity, Specificity	(≥ min) Sn = 72, Sp = 34 (≥ mod) Sn = 35, Sp = 74
						Pain going down stairs	Sensitivity, Specificity	(≥ min) Sn = 64, Sp = 40 (≥ mod) Sn = 32, Sp = 80
						Absence of pain walking on level ground	Sensitivity, Specificity	(≥ min) Sn = 58, Sp = 44 (≥ mod) Sn = 93, Sp = 13

Table 2
Continued.

Source (year)	No. of subjects	Male	Female	Age (years) Mean (range)	Reference	Examination maneuver	Result	
Stefanik, 2017[23]	745	335	410	65.2 (NA)	Radiography	Definite crepitus	Sensitivity, Specificity	Sn = 24, Sp = 82
						Pain with stairs	Sensitivity, Specificity	Sn = 90, Sp = 15
						No pain with walking	Sensitivity, Specificity	Sn = 26, Sp =69
						Pain with PF joint compression	Sensitivity, Specificity	Sn = 56, Sp = 53
						Definite crepitus	Sensitivity, Specificity	Sn = 33, Sp = 83
						Pain with stairs	Sensitivity, Specificity	Sn = 92, Sp = 14
						No pain with walking	Sensitivity, Specificity	Sn = 24, Sp = 69
						Pain with PF joint compression	Sensitivity, Specificity	Sn = 70, Sp = 54

CI, confidence interval; min, minimum; mod, moderate; MRI, magnetic resonance imaging; NA, not applicable; NS, not significant; PF joint, patellofemoral joint; Sn, sensitivity; Sp, specificity.

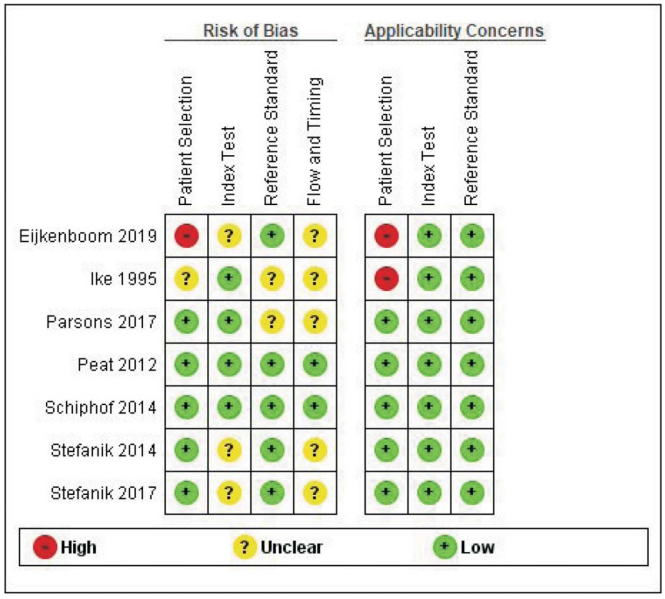

Figure 2. Methodological quality summary (QUADAS-2).

Figure 3. Methodological quality graph (QUADAS-2).

are not the best indicator for assessing test accuracy. The reader should interpret our results with the cation that the strength of the odds ratio does not reflect high accuracy.

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Declaration of any potential financial/non-financial conflicts of interest

The authors declare no conflicts of interest associated with this manuscript.

References

1. Lawrence RC, Felson DT, Helmick CG, et al. Estimate of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis Rheum*. 2008;58(1):26–35.
2. Wallace IJ, Worthington S, Felson DT, et al. Knee osteoarthritis has doubled in prevalence since the mid-20th century. *Proc Natl Acad Sci U S A*. 2017;114(35):9332–9336.
3. Lankhorst NE, Damen J, Oei EH, et al. Incidence, prevalence, natural course and prognosis of patellofemoral osteoarthritis: the Cohort Hip and Cohort Knee study. *Osteoarthritis Cartilage*. 2017;25(5):647–653.
4. Kornaat PR, Bloem JL, Ceulemans RY, et al. Osteoarthritis of the knee: association between clinical features and MR imaging findings. *Radiology*. 2006;239(3):811–817.
5. Hunter DJ, March L, Sambrook PN. The association of cartilage volume with knee pain. *Osteoarthritis Cartilage*. 2003;11(10):725–729.
6. Qiu Y, Lin C, Liu Q, et al. Imaging features in incident radiographic patellofemoral osteoarthritis: the Beijing Shunyi osteoarthritis (BJS) study. *BMC Musculoskelet Disord*. 2019;20:359.
7. Harris JD, Brophy RH, Jia G, et al. Sensitivity of magnetic resonance imaging for detection of patellofemoral articular cartilage defects. *Arthroscopy*. 2012;28(11):1728–1737.
8. Bhattacharya R, Kumar V, Safawi E, et al. The knee skyline radiograph: its usefulness in the diagnosis of patello-femoral osteoarthritis. *Int Orthop*. 2007;31(2):247–252.
9. Wenham CY, Grainger AJ, Conaghan PG. The role of imaging modalities in the diagnosis, differential diagnosis and clinical assessment of peripheral joint osteoarthritis. *Osteoarthritis Cartilage*. 2014;22(10):1692–1702.
10. Kim YM, Joo YB. Patellofemoral osteoarthritis. *Knee Surg Relat Res*. 2012;24(4):193–200.
11. Cook C, Hegedus E, Hawkins R, et al. Diagnostic accuracy and association to disability of clinical test findings associated with patellofemoral pain syndrome. *Physiother Can*. 2010;62(1):17–24.
12. Nijs J, Van Geel C, Van der auwera C, et al. Diagnostic value of five clinical tests in patellofemoral pain syndrome. *Man Ther*. 2006;11(1):69–77.
13. Näslund J, Näslund UB, Odenbring S, et al. Comparison of symptoms and clinical findings in subgroups of individuals with patellofemoral pain. *Physiother Theory Pract*. 2006;22(3):105–118.
14. McInnes MDF, Moher D, Thombs BD, et al. Preferred reporting items for a systematic review and meta-analysis of diagnostic test accuracy studies:

the PRISMA-DTA statement. *JAMA*. 2018;319(4):388–396.
15. Whiting PF, Rutjes AW, Westwood ME, et al. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. *Ann Intern Med*. 2011;155(8):529–536.
16. Devillé WL, Buntinx F, Bouter LM, et al. Conducting systematic reviews of diagnostic studies: didactic guidelines. *BMC Med Res Methodol*. 2002; 2:9.
17. Eijkenboom JFA, Timmer ER, van der Heijden RA, et al. Association between self-reported measures, physical examination, and early magnetic resonance imaging signs of osteoarthritis in patients with patellofemoral pain. *J Orthop Sports Phys Ther.* 2019;49(9):634–639.
18. Peat G, Duncan RC, Wood LR, et al. Clinical features of symptomatic patellofemoral joint osteoarthritis. *Arthritis Res Ther.* 2012;14(2):R63.
19. Ike R, O'Rourke KS. Compartment-directed physical examination of the knee can predict articular cartilage abnormalities disclosed by needle arthroscopy. *Arthritis Rheum*. 1995;38(7):917–925.
20. Parsons C, Fuggle NR, Edwards MH, et al. Concordance between clinical and radiographic evaluations of knee osteoarthritis. *Aging Clin Exp Res*. 2018;30(1):17–25.
21. Schiphof D, van Middelkoop M, de Klerk BM, et al. Crepitus is a first indication of patellofemoral osteoarthritis (and not of tibiofemoral osteoarthritis). *Osteoarthritis Cartilage*. 2014;22(5):631–638.
22. Stefanik JJ, Neogi T, Niu J, et al. The diagnostic performance of anterior knee pain and activity-related pain in identifying knees with structural damage in the patellofemoral joint: the multicenter osteoarthritis study. *J Rheumatol*. 2014;41(8):1695–1702.
23. Stefanik JJ, Duncan R, Felson DT, et al. Use of diagnostic performance of clinical examination measures and pain presentation to identify patellofemoral joint osteoarthritis. *Arthritis Care Res (Hoboken)*. 2018;70(1): 157–161.
24. de Oliveira Silva D, Barton C, Crossley K, et al. Implications of knee crepitus to the overall clinical presentation of women with and without patellofemoral pain. *Phys Ther Sport*. 2018;33:89–95.
25. de Oliveira Silva D, Pazzinatto MF, Priore LBD, et al. Knee crepitus is prevalent in women with patellofemoral pain, but is not related with function, physical activity and pain. *Phys Ther Sport*. 2018;33:7–11.
26. Waiteman MC, de Oliveira Silva D, Azevedo FM, et al. Women with patellofemoral pain and knee crepitus have reduced knee flexion angle during stair ascent. *Phys Ther Sport*. 2021;48:60–66.
27. Pazzinatto MF, de Oliveira Silva D, Azevedo FM, et al. Knee crepitus is not associated with the occurrence of total knee replacement in knee osteoarthritis — a longitudinal study with data from the osteoarthritis initiative. *Braz J Phys Ther.* 2019;23(4):329–336.
28. Yamagata M, Taniguchi M, Tateuchi H, et al. The effects of knee pain on knee contact force and external knee adduction moment in patients with knee osteoarthritis. *J Biomech*. 2021;123:110538.