The Royal London Hospital Test for the clinical diagnosis of patellar tendinopathy

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Summary

Purpose: **To ascertain whether the Royal London Hospital test is reproducible, sensitive, and specific for diagnosis of patellar tendinopathy.**
Methods: **Fifteen consecutive athletes with patellar tendinopathy were prospectively enrolled and compared with a control group of 15 non consecutive athletes with Achilles tendinopathy. Two testers examined separately each patient, using manual palpation and the Royal London Hospital test for diagnosis of patellar tendinopathy. High resolution real time ultrasonography was used as standard for diagnosis of tendinopathy and assessment of tendon thickness.**
Results: **The palpation test presented significantly higher sensitivity compared to the Royal London Hospital test (98 *vs* 88%; P=0.01); specificity was 94% for the palpation test and 98% for the Royal London Hospital test (P>0.05). Positive and negative predictive values were 94 and 98% for palpation test, 98 and 89% for the Royal London Hospital test, respectively. The two tests showed good to very good intra-tester and inter-tester agreement. At ultrasonography, pathological patellar tendons were significantly thicker compared to controlateral healthy tendon (P<0.001).**
Conclusions: **In symptomatic patients with patellar tendinopathy, the Royal London Hospital test showed lower sensitivity and higher specificity than manual palpation. Both tests should be performed for a correct clinical diagnosis of patellar tendinopathy. Imaging assessment should be performed as a confirmatory test.**
Level of Evidence: III.

KEY WORDS: specific, sensitive, PT, test.

Introduction

Patellar tendinopathy (PT) is a chronic overuse condition[1-3] relatively frequent in sports such as volleyball, basketball, soccer, track and field (particularly jumping specialties), tennis and skiing[3,4], with a prevalence in elite volleyball and basketball players of over 40%[3,5]. Recovery may be long and, at times, only partial, up to induce athletes to retire prematurely[6-8].
The main causes of PT are repetitive overloading and microtrauma[9,10] in patients genetically predisposed[1, 11], with histopathological changes typical of tendinopathy[6,12].
Early diagnosis and management are important. Even though imaging is the gold standard for diagnosis, including both high resolution real time ultrasonography (US) and magnetic resonance imaging (MRI)[13], the first suspicion is clinical, based on history and clinical examination[3,13,14].
Cook et al.[13] tested in young basketball players the reproducibility and the clinical utility of manual palpation of the tendon for the diagnosis of PT, reporting that tenderness to palpation presents 68% of sensitivity and 9% of specificity, 52 and 17% of positive and negative predictive values, respectively. On the other hand, in asymptomatic tendons, palpation had 56% sensitivity, 47% specificity, and 22% positive predictive value. Although palpation was a reliable test, it was moderately sensitive, but not specific in symptomatic tendons. Moreover, tenderness on palpation

was not predictive for US changes in asymptomatic patients[14]. To the best of our knowledge, no specific test with high sensitivity and specificity has been developed for the diagnosis of PT. We routinely use the Royal London Hospital test for clinical diagnosis of PT. This test is considered positive when the local tenderness elicited palpating the tendon in a relaxed position (knee extended), decreases or disappears when the tendon is palpated under tension (knee flexion).

Maffulli et al.[15] have already evaluated the reproducibility and the validity of the Royal London Hospital test in patients with Achilles tendinopathy. In this case, the test will be positive if the pain evoked palpating the tendon with the ankle in neutral position disappears or is reduced when the tendon is palpated with the ankle in active dorsiflexion.

In this study, in athletes with clinical features of PT, US was the gold standard for diagnosis of PT, and was compared for sensitivity, specificity, reproducibility, and predictive values to the Royal London Hospital test.

Patients and methods

We conducted a prospective study[16] on PT group included 15 consecutive athletes with clinical and imaging diagnosis of patellar tendinopathy referred to a tertiary centre. All patients gave the informed consent to be enrolled in the study after the local Ethics Committee had approved all procedures. All athletes had chronic PT (more than 6 months) unresponsive to conservative management, including rest, ice, analgesics and/or nonsteroidal anti-inflammatory drugs, and physiotherapy. In the control group, we enrolled athletes with Achilles tendinopathy selected from a population of athletes with Achilles tendon disorders managed in the same tertiary centre without history and symptoms of PT. The two groups of subjects were matched for gender, age, sport activity and side assessed.

Two testers, a fully trained orthopaedic surgeon and a senior trainee, with a special interest in soft tissue and sports injuries, were enrolled. One of the testers was aware of the diagnosis, the other was not.

Both palpation and Royal London Hospital tests were performed with the patient supine and the knee extended. Palpation was performed gently, at the attachment site of the patellar tendon, over the inferior pole of the patella, and along its whole length, from proximal to distal. Patients were asked about tenderness on palpation.

Regarding the Royal London Hospital test, once local tenderness had been elicited palpating the tendon with the knee extended, the tender portion of the tendon was palpated again with the knee flexed to 90°. The test was considered positive if the pain was markedly reduced or absent in knee flexion. In asymptomatic tendons, the test was performed with the knee extended, selecting an area of the tendon 1 cm distal to the patellar insertion.

Design of the study

Both testers examined separately all patients and controls. In the PT group, we examined only the involved tendon; in the matched controls, we examined the ipsilateral tendon to the tendon involved of the corresponding patient.

The 2 testers performed the tests in the same day, separately, without communicating each other. After two weeks, the entire assessment was repeated (Fig. 1).

Diagnostic Imaging

All patients in both groups underwent high resolution US assessment. The maximum tendon thickness was measured; US changes were recorded. At US, typical features of tendinopathy were a hypoechogenic area within the tendon, loss of the normal ribbon-like intratendinous echostructure, increased anteroposterior diameter greater than 50% compared to the asymptomatic controlateral tendon[15]. Color/Power Ultrasound was used for assessment of the neovascularisation within the tendon[17]. The testers and the patients were not aware of US findings.

Data collection

Demographic data regarding gender, age and sport activity, clinical information, results of Royal London Hospital test and manual palpation, coded as binary items (positive/negative), and imaging data were all recorded in a computer database. Sensitivity, specificity, reproducibility, positive predictive value (PPV), and negative predictive value (NPV), were calculated for both Royal London Hospital test and manual palpation[18,19].

US was used as standard method for the imaging diagnosis of tendinopathy[13]. To estimate sensitivity and specificity of both tests, we compared the clinical results with the imaging findings. In this context, sensitivity was obtained from the number of positive clinical examinations for both tests in patients with a PT confirmed at US. On the other hand, the specificity was obtained from the number of negative clinical examinations for both tests in patients with a healthy tendon confirmed at US. We do not know the population prevalence of patellar tendinopathy in the current setting (indeed, sensitivity was obtained from the number of positive clinical examinations for both tests in patients with tendinopathy at US; specificity was obtained from the number of negative clinical examinations for both tests in patients with healthy tendon at US). Since the population prevalence of patellar tendinopathy in the current setting was not known, PPV and NPV were expressed as range of prevalences (0.25, 0.50, 0.75).

Clinical evaluations at day 1 and day 14 were used to calculate the kappa value (intratester agreement); the measures at day 1 and day 14 were pooled to estimate the inter-tester agreement. Descriptive statistics were calculated. Sensitivity and specificity of the two tests were assessed with Pearson's chi-squared test with Yates correction. In patients with US signs of PT, the Wilcoxon signed rank test[20] was used to compare thickness measures of affected patellar tendons re-

Section and Topic	Item #		On page #
TITLE/ABSTRACT/ KEYWORDS	1	Identify the article as a study of diagnostic accuracy (recommend MeSH heading 'sensitivity and specificity').	1-4
INTRODUCTION	2	State the research questions or study aims, such as estimating diagnostic accuracy or comparing accuracy between tests or across participant groups.	4
METHODS			
Participants	3	The study population: The inclusion and exclusion criteria, setting and locations where data were collected.	5
	4	Participant recruitment: Was recruitment based on presenting symptoms, results from previous tests, or the fact that the participants had received the index tests or the reference standard?	5
	5	Participant sampling: Was the study population a consecutive series of participants defined by the selection criteria in item 3 and 4? If not, specify how participants were further selected.	5
	6	Data collection: Was data collection planned before the index test and reference standard were performed (prospective study) or after (retrospective study)?	5
Test methods	7	The reference standard and its rationale.	
	8	Technical specifications of material and methods involved including how and when measurements were taken, and/or cite references for index tests and reference standard.	5,6
	9	Definition of and rationale for the units, cut-offs and/or categories of the results of the index tests and the reference standard.	5,6
	10	The number, training and expertise of the persons executing and reading the index tests and the reference standard.	5,6
	11	Whether or not the readers of the index tests and reference standard were blind (masked) to the results of the other test and describe any other clinical information available to the readers.	5,6
Statistical methods	12	Methods for calculating or comparing measures of diagnostic accuracy, and the statistical methods used to quantify uncertainty (e.g. 95% confidence intervals).	7
	13	Methods for calculating test reproducibility, if done.	7
RESULTS			
Participants	14	When study was performed, including beginning and end dates of recruitment.	5
	15	Clinical and demographic characteristics of the study population (at least information on age, gender, spectrum of presenting symptoms).	8
	16	The number of participants satisfying the criteria for inclusion who did or did not undergo the index tests and/or the reference standard; describe why participants failed to undergo either test (a flow diagram is strongly recommended).	8
Test results	17	Time-interval between the index tests and the reference standard, and any treatment administered in between.	5
	18	Distribution of severity of disease (define criteria) in those with the target condition; other diagnoses in participants without the target condition.	5
	19	A cross tabulation of the results of the index tests (including indeterminate and missing results) by the results of the reference standard; for continuous results, the distribution of the test results by the results of the reference standard.	10
	20	Any adverse events from performing the index tests or the reference standard.	Not applicable
Estimates	21	Estimates of diagnostic accuracy and measures of statistical uncertainty (e.g. 95% confidence intervals).	8-11
	22	How indeterminate results, missing data and outliers of the index tests were handled.	Not applicable
	23	Estimates of variability of diagnostic accuracy between subgroups of participants, readers or centers, if done.	11,12
	24	Estimates of test reproducibility, if done.	11,12
DISCUSSION	25	Discuss the clinical applicability of the study findings.	13-15

Figure 1. Time of the clinical examination.

spect to those of healthy contra-lateral tendons and to compare age data of patients enrolled in the two groups. After assessment for normal distribution, non-parametric statistical tests were selected. A P value <0.05 was considered statistically significant. When appropriate, 95% confidence interval (CI) was calculated. The kappa coefficient[21] was used to assess the intra- and intertester agreement. All statistical analyses were performed using SPSS for Mac (version 16.0).

Results

Patients and Controls

Between March and September 2010, 15 consecutive elite athletes (11 males; 4 females) with patellar tendinopathy and 15 non-consecutive control patients (11 males; 4 females) extracted from a population of athletes with achilles tendinopathy were prospectively enrolled. The median age was 28 years (95% CI, 25.81 to 30.99) for the PT Group, and 27 years (95% CI, 25.56 to 30.43) for the control group (P>0.05). The 2 groups were comparable for sport activity. Recruitment criteria are reported in Figures 2 and 3.

Diagnostic Imaging

In the PT group, US assessment showed pathological thickness of the patellar tendon in all patients and a hypoechogenic area within the tendon in 13 of 15 patients. In the control group, a single tendon was pathologically thick and another showed intra-tendinous dishomogeneity. At Color/Power US, all patients in the PT group presented neovascularisation within the tendon. 7 patients were graded as 2+, 4 as 3+, and 4 as 4. In the control group, 2 patients were graded as 2+ and 1 as grade 1+.

The median thickness of tendinopathic patellar tendons was 7 mm (95% CI, 6.87 to 8.54), and 4 mm (95% CI, 3.73 to 4.38) for healthy controlateral tendons (P<0.001).

At the 5% level, no statistically significant differences were found between the findings of the investigators recorded at the day 1 and day 14 for both the tests. Therefore, these covariates were dropped from the calculation of specificity, sensitivity, PPV and NPV.

The Royal London Hospital test was positive in 13 of 15 (88%) patients in the PT group and in 53 of 60 (88%) observations performed in patients with PT. In 7 observations, the test was negative, despite the

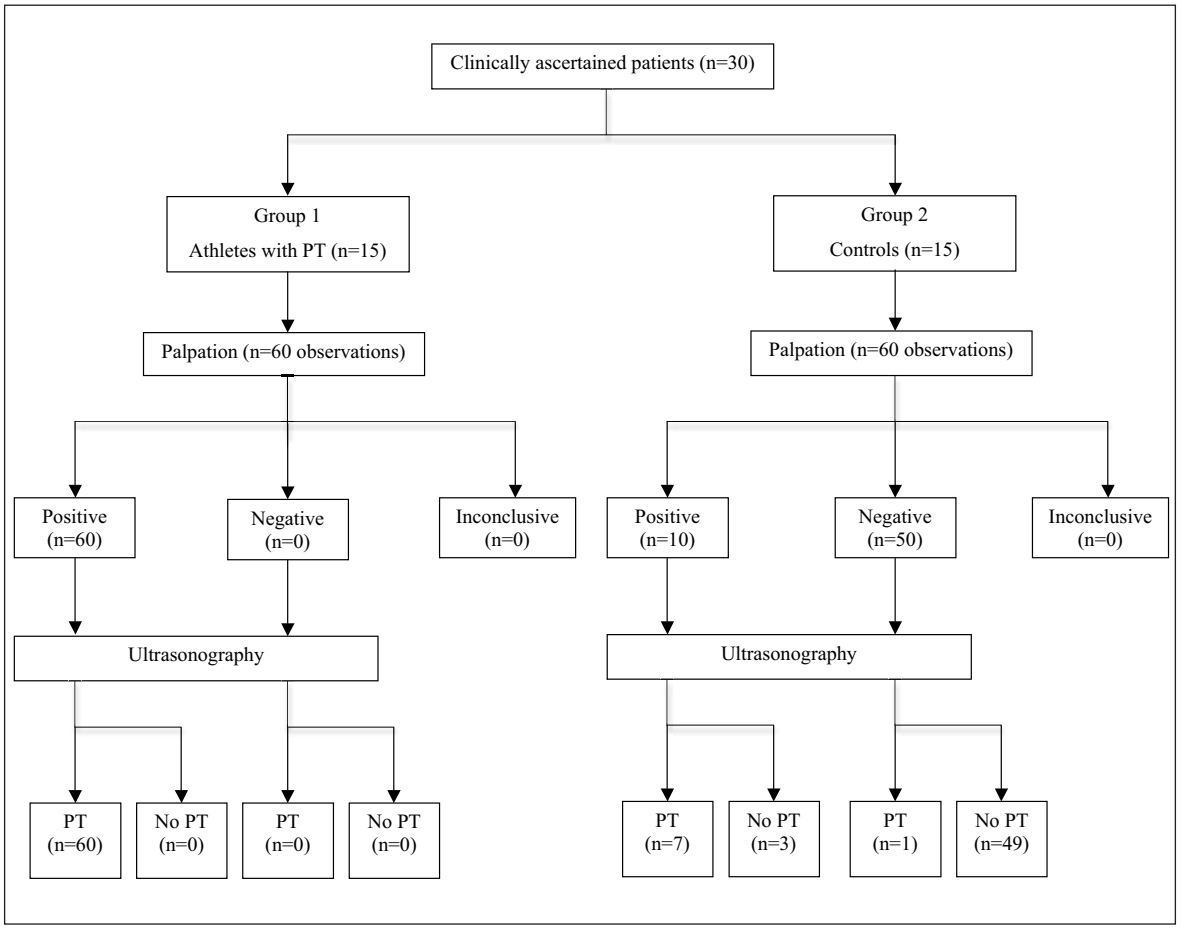

Figure 2. STARD flow diagram for recruitment of patients for palpation.

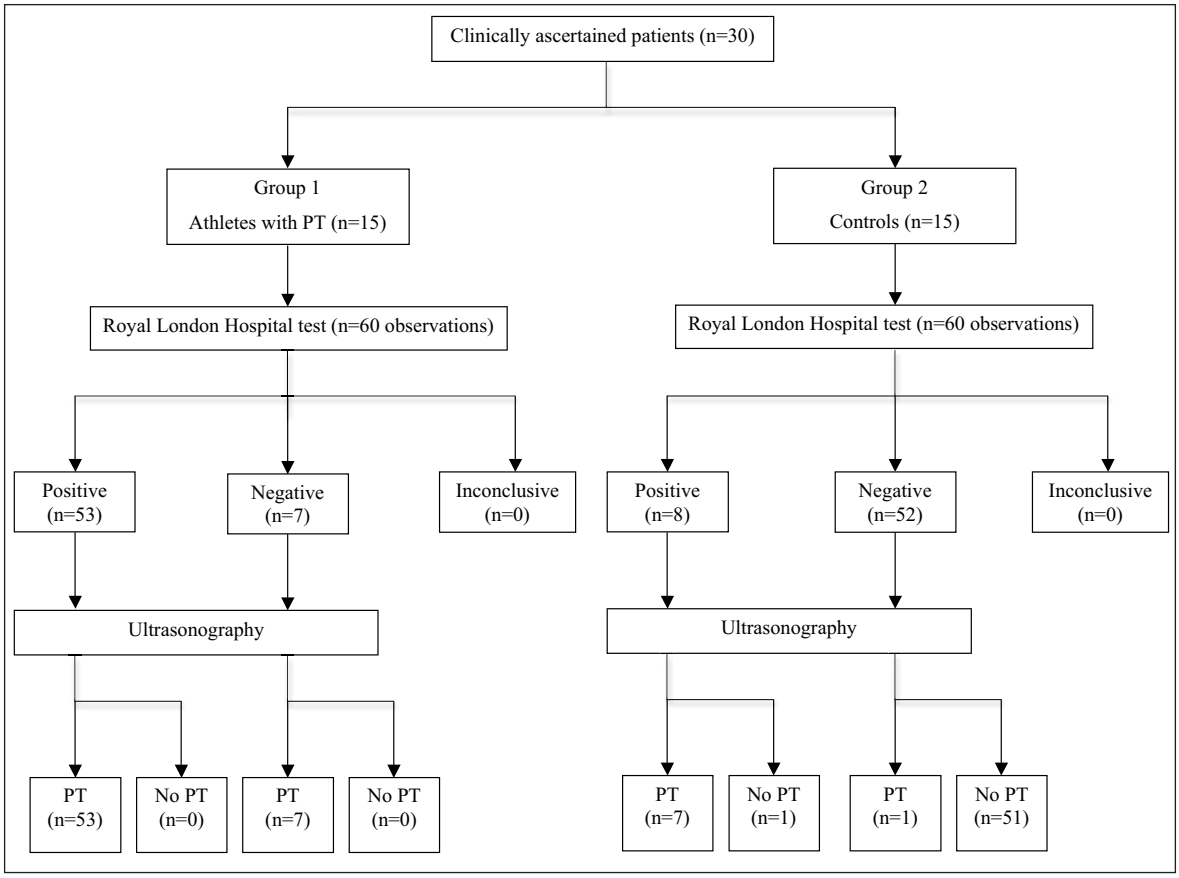

Figure 3. STARD flow diagram for recruitment of patients for Royal London Hospital test.

presence of PT at US (false negative). The test was positive in 2 of 15 (13%) patients in the control group, and in 8 of 60 (13%) observations performed on asymptomatic tendons in the control group. Seven of 8 observations were found in 2 control patients with intratendinous changes at US. The single positive observation found in a patient without US evidence of tendinopathy was considered as false positive (Tab. I).
Palpation was positive in 15 patients in the PT group and 60 observations performed in patients with PT, in 3 of 15 (20%) control patients and in 10 of 60 (20%) observations performed on asymptomatic tendons in the control group. Of these 10 positive observations, 7 were in patients with US evidence of tendinopathy (true positive), 3 were positive in patients with no evidence of tendinopathy (false positive) (Tab. I).

Table I. Results of clinical tests in two different observations.

	OBSERVATIONS	
	Day 1	**Day 14**
Palpation		
Tenderness present	34	35
Tenderness absent	26	25
Royal London Hospital test		
Positive	30	31
Negative	30	29

Sensitivity, specificity, and predictive rates
The palpation test presented significantly higher sensitivity (88 *vs* 98%, P=0.01); the Royal London Hospital test presented higher, not significantly, specificity (98 *vs* 94%, P>0.05) (Tabs. II-IV). The Royal London Hospital test reported slightly higher PPV for all estimated prevalences of PT compared to the palpation test; the palpation test reported slightly higher NPV for all estimated prevalences of PT compared to the Royal London Hospital test (Tab. V).
The two tests have good to very good intra-tester and inter-tester agreement (Tabs. VI, VII). One investigator was more consistent in his findings than the other. The inter-tester agreement was graded as very good for the palpation test and good for the Royal London Hospital test.

Discussion

The main finding of the present study is that both palpation and Royal London Hospital tests have good and very good reproducibility (Kappa 0.94 and 0.70

Table II. Sensitivity and specificity.

Test	Sensitivity	Specificity		
	Estimate	95% CI	Estimate	95% CI
Palpation	0.98	0.79 – 1.17	0.94	0.7 – 1.17
Royal London Hospital test	0.88	0.5 – 1.26	0.98	0.73 – 1.23

Table III. Results of Royal London Hospital test.

		Ultrasound		
		Tendinopathy	Normal	N of observations
Test	Positive	60	1	61
	Negative	8	51	59
	N of observations	68	52	120

Table IV. Results of palpation.

		Ultrasound		
		Tendinopathy	Normal	N of observations
Test	Positive	67	3	70
	Negative	1	49	50
	N of observations	68	52	120

Table V. Predictive values.

	PPV			NPV		
Prevalence	**0.25**	**0.50**	**0.75**	**0.25**	**0.50**	**0.75**
Palpation	0.84	0.94	0.98	0.99	0.98	0.94
Royal London Hospital test	0.94	0.98	0.99	0.96	0.89	0.73

Abbreviation: PPV, positive predictive value; NPV, negative predictive value.

Table VI. Kappa values for intra-tester agreement.

Investigators	Palpation		Royal London Hospital test	
	Kappa	*P value*	*Kappa*	*P value*
1	1.000	<0.0001	0.886	<0.0001
2	0.834	<0.0001	0.677	<0.0001

Table VII. Kappa values for inter-tester reliability.

Investigators	Palpation		Royal London Hospital test	
	Kappa	*P value*	*Kappa*	*P value*
1 and 2	0.943	<0.0001	0.694	<0.0001

respectively for intertester agreement), and that some clinical experience is required to improve intra-tester reliability, mostly for the Royal London Hospital test.

Palpation was superior for sensitivity to the Royal London Hospital test, but it may be positive also in patients with other disorders to the knee. On the other hand, when the Royal London Hospital test is positive, given its high specificity, it is possible to diagnose PT more confidently compared to a condition in which only tenderness to palpation is present. Therefore, both tests are recommended for a correct clinical diagnosis of PT. Since positive findings in clinical tests are strongly associated with US signs of tendinopathy, we now point out that clinical examination is the first diagnostic step in patients with PT, whereas imaging assessment should only be used to confirm the diagnosis.

To the best of our knowledge, this is the first study which assesses sensitivity, specificity, predictive value, and reliability of the Royal London Hospital test for the diagnosis of PT in symptomatic patients. The reason why pain decreases or disappears when the patellar tendon is palpated under tension is unknown. Maffulli et al. previously evaluated the reproducibility and validity of the Royal London Hospital test for diagnosis of Achilles tendinopathy[15]. In that instance, the Achilles tendon is under tension when the ankle is in active dorsiflexion.

In this study, the validity of manual palpation has been also assessed, showing greater sensitivity and specificity than those reported by Cook et al.[13] (98 *vs* 68% and 94 *vs* 9% respectively) in a study on athletes with symptomatic PT. In addition, both palpation and Royal London Hospital test presented higher PPV (94 and 98% respectively) than those reported by Cook et al.[13] for palpation (52%). This probably reflects the different selection criteria of the study population. Specifically, all our patients were tertiary referrals to our clinics, all with an already well established diagnosis of PT. In the other study[13] 16 of 27 symptomatic patients had tendon changes at US. Moreover, we considered US evidence of PT when a hypoechogenic area was present within the tendon or the thickness was increased of 50% at least. On the contrary, Cook et al.[13] considered as diagnostic criterion only the presence of tendon lesion at US.

The strength of our study are that we enrolled only athletes with unilateral PT diagnosed on clinical and/or imaging findings, they were consecutive patients enrolled prospectively, and the 2 groups were well matched for gender, age, sport activity and side assessed.

As potential bias, the fact that all symptomatic patients had been referred to a tertiary centre, could induce to suppose that the PT group could not be representative of the population of athletes with tendinopathic changes to the patellar tendon.

Even though one of the two testers was not blind to the patients' pathology, we tried to minimize this bias not allowing the testers to communicate with each other. Another bias could be that, at the second evaluation, both the tester and patients could remember the findings of the first evalation. To minimize this bias, the second testing session was performed two weeks following the first one.

We used US as diagnostic standard[13], given its excellent reliability for the diagnosis of patellar tendon disorders in volleyball[22] and basketball[23] players.

We are aware that the definitive diagnosis is histological, but it is difficult to perform in a clinical setting, as this would require invasive biopsies.

Further research is necessary to improve the clinical diagnosis of PT. In the future, larger studies should be undertaken to better evaluate the validity of the Royal London Hospital test in patients with anterior knee pain and rule out other conditions of anterior knee pain such as patellofemoral pain syndrome and Hoffa body syndrome[9].

Conclusions

In symptomatic patients with PT, the Royal London Hospital test showed lower sensitivity and higher specificity than manual palpation. Both tests should be performed for a correct clinical diagnosis of PT. A positive palpation test alone may not be necessarily associated with patellar tendinopathy, whereas the positivity of both clinical tests is strongly associated with US appearance of patellar tendinopathy. Imaging assessment should be performed only as a confirmatory additional test.

Conflict of interest

The Authors have no conflict of interest.

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