Abstract

The current study is aimed at examining the validity of five clinical patellofemoral tests used in the diagnosis of patellofemoral pain syndrome (PFPS). Forty-five knee patients were divided into either the PFPS or the non-PFPS group, based on the fulfillment of the diagnostic criteria for PFPS. An investigator, blinded to the group assignment, performed the vastus medialis coordination test, patellar apprehension test, Waldron’s test, Clarke’s test, and the eccentric step test. The positive likelihood ratio was 2.26 for both the vastus medialis coordination test and the patellar apprehension test. For the eccentric step test, the positive likelihood ratio was 2.34. A positive outcome on either the vastus medialis coordination test, the patellar apprehension test, or the eccentric step test increases the probability of PFPS to a small, but sometimes important, degree. For the remaining tests, the positive likelihood ratios were below the threshold value of 2, indicating that given a positive test result, the probability that the patient has PFPS is altered to a small, and rarely important degree. The negative likelihood ratios for all tests exceeded the threshold value of 0.5, suggestive of clinically irrelevant information. These data question the validity of clinical tests for the diagnosis of PFPS.

Keywords: Diagnosis; Patellofemoral; Patellofemoral pain syndrome; Validity

1. Introduction

In the absence of other pathology, anterior or retropatellar pain which exacerbates during sustained sitting, kneeling, ascending or descending stairs, and squatting is defined as patellofemoral pain syndrome (PFPS). The aetiology of PFPS has not been delineated, but appears to be multifactorial. Abnormal tracking of the patella, possibly inducing pain and abnormal tissue stresses, has frequently been proposed as a contributing factor to PFPS (Baker et al., 2002). A delayed onset of the vastus medialis obliquus in relation to the vastus lateralis, as observed in PFPS subjects (Cowan et al., 2001, 2002, Tang et al., 2001), might account for the abnormal patellar tracking. Apart from a neuromuscular imbalance of the vastii, other theories for the origin of PFPS have been proposed (and are able to explain maltracking of the patella): tightness of the lateral knee retinaculum, hamstrings, iliotibial band, and gastrocnemius; overpronation of the subtalar joint (Tang et al., 2001), reduced proprioceptive information (Baker et al., 2002), and the depth of the trochlear groove (Powers, 2000). Regarding the conservative treatment strategies, Bizzini et al. (2003) concluded from their systematic literature review that quadriceps strengthening, acupuncture, the use of a resistive brace, and the combination of exercises with patellar taping and biofeedback are effective in decreasing pain and improve functioning in PFPS patients. In their review article, Thomée et al. (1999) suggested that standardized information and
adjusted physical activity (i.e., avoiding pain-causing activities etc.) will suffice for many PFPS patients having mild symptoms, while chronic PFPS subjects (knee pain duration of at least six months) require a specific training programme. However, at least three systematic reviews addressing the effectiveness of physical interventions in PFPS indicate that the evidence is limited and that high quality randomized controlled clinical trials are required (Zomerdijk et al., 1998; Crossley et al., 2001; Bizzini et al., 2003).

Physical examination is essential in the diagnosis of any medical condition, especially in musculoskeletal disorders (Malanga et al., 2003). However, in order to draw appropriate conclusions from the findings of the physical examination, it is important that clinicians are aware of the significance of the test results (i.e. the diagnostic value of each test). A positive vastus medialis coordination test has been suggested as an indicator of dysfunction of the vastus medialis obliquus muscle which may result in pain (Souza, 1997), pain or crepitus during Waldron’s test has been proposed as a sign of patellofemoral pain disorders (Martens et al., 1995; Souza, 1997). Likewise, both the patellofemoral grinding test and the eccentric step test have been suggested to be indicative of PFPS (Souza, 1997; Selfe et al., 2001a; Malanga et al., 2003). However, the scientific examinations of several clinical tests of patellar position and mobility have yet to prove them reliable (Watson et al., 2001), and Malanga et al., (2003) concluded from their literature review that studies documenting the sensitivity or specificity of the patellofemoral grinding test in the diagnosis of PFPS are essentially lacking. Apart from one study reporting that the eccentric step test produced knee pain in 57 of 77 PFPS patients (74%) (Selfe et al., 2001a), we are unaware of data addressing the scientific value of clinical tests in the diagnosis of PFPS. A study examining the validity of the vastus medialis coordination test, patellar apprehension test, Waldron’s test, and Clarke’s test in the diagnosis of PFPS in knee pain patients was therefore warranted.

A number of self-assessment questionnaires, which are aimed at assessing functionality in PFPS patients, have been reported in the scientific literature, but their psychometric properties have not been addressed adequately (Bennell et al., 2002). Still, Selfe et al. (2001a) constructed the Modified Functional Index Questionnaire (MFIQ), and examined its reliability and clinical sensitivity in PFPS patients (Selfe et al., 2001b). An English questionnaire, however, cannot be applied to subjects having Dutch as their native language (i.e. to PFPS patients in the Flemish part of Belgium or in the Netherlands). We therefore translated the original MFIQ into Dutch, and examined some of the psychometric properties of the Dutch version of the MFIQ.

2. Purpose

The primary aim of the current study was to examine the validity of five clinical patellofemoral tests (the vastus medialis coordination test, patellar apprehension test, Waldron’s test, Clarke’s test, and the eccentric step test) used in the diagnosis of PFPS in knee pain patients. Secondly, this study aimed at translating an existing English self-assessment questionnaire for assessing functionality in PFPS-patients into Dutch, and examining some of the psychometric properties (the disease-specificity, the internal consistency, and the convergent validity) of the scores obtained with this new assessment-tool in PFPS-patients.

3. Methods

3.1. Subjects and study design

A sample of convenience of 45 knee patients was recruited from private practices and outpatient clinics (multicentre trial). Prior to study participation, all patients were given both oral and written information regarding the nature and purpose of the study. All subjects had to give written informed consent in order to be included in the study. The rights of the subjects were protected, implicating that the patient was allowed to withdraw at any time if the pain became unbearable. Subjects were included for the trial if they experienced knee pain, if they were referred by a physician for physical therapy (Ng and Cheng, 2002), if they were independent ambulators in the community (Watson et al., 2001), and if they had not undergone knee surgery (Cowan et al. 2001; Ng and Cheng, 2002; Laprade and Culham, 2002; Brechter and Powers, 2002). Including patients with scars from knee surgery would prohibit a blinded assessment. Next, all included patients were divided into either the PFPS or the non-PFPS group, based on the fulfilment of the diagnostic criteria for PFPS. The criteria used for the diagnosis of PFPS were based on those used in other PFPS studies: patients (1) were diagnosed as a PFPS case by a medical doctor (Bennell et al., 2002; Ng and Cheng, 2002), (2) had anterior or retropatellar knee pain (Bennell et al., 2002; Brechter and Powers, 2002; Cowan et al., 2001; Watson et al., 2001); (3) reported that at least two of the following activities exacerbated their symptoms: prolonged sitting, ascending or descending stairs, squatting, kneeling (Lepällä et al., 1998; Bennell et al., 2002; Cowan et al., 2001; Tang et al., 2001; Watson et al., 2001; Brechter and Powers, 2002; Cowan et al., 2002; Thomée et al., 2002); and (4) were not allowed to show clinical evidence of a current knee condition other than PFPS (Lepällä et al., 1998; Bennell et al., 2002; Cowan et al., 2001; Watson et al., 2001; Cowan et al., 2002;
Laprade and Culham, 2002; Thomée et al., 2002). Subjects not fulfilling all four requirements listed above were assigned to the control group (non-PFPS knee patients), on the premise that they did not fulfill the first three requirements either. Patients fulfilling the first three criteria, and having evidence of a current knee condition other than PFPS were considered ‘co-morbid PFPS-patients’. Since the primary aim of this study was to examine the diagnostic value of patellofemoral tests, co-morbid PFPS patients were excluded from the trial. In occurrence, Malanga et al. (2003) indicated that the pathologic changes in one structure may alter the examination outcome of a different structure. Therefore, prior to data collection, all subjects entering the study underwent a structured and standardized clinical examination, in order to rule out any condition other than PFPS (bursitis, tendonitis, damage to the articular cartilage, tears of the menisci, ligaments or joint capsule, patellar subluxation or dislocation, etc.). The clinical examination comprised of history taking, review of the medical records, inspection, and a set of standard orthopaedic tests (patellar ballottement test, assessment of both active and passive joint range of motion, palpation of the knee joint—including the detection of abnormal temperature, varus/valgus stress tests, Lachman’s test, anterior and posterior drawer test, pivot shift test, McMurray’s test for both the medial and the lateral meniscus, Apley’s test, and muscle testing of the knee) (Winkel and Aufdenkampe, 1994; Reider, 1999). The patellar ballottement test was performed in the following order: the vastus medialis coordination test, patellar apprehension test, Waldron’s test (phase 1 and 2), Clarke’s test, and the eccentric step test.

3.2. Self-assessment tools

Visual analogue scales (VAS—100 mm) for pain at rest, pain during movement, and pain at night, were used. The pain scores obtained with the VAS are believed to be reliable (Jensen et al., 1986; Harms-Ringdahl et al., 1986) and sensitive to change (Jensen et al., 1986). Using a time interval of 2 days in a sample of 24 PFPS patients, the test-retest reliability coefficients (intraclass correlation coefficients) ranged between 0.77 and 0.79 (Bennell et al., 2002).

Selfe et al. (2001a) constructed the MFIQ. The Cronbach Alpha coefficient for internal consistency was 0.83 in a sample of 77 patients with PFPS (Selfe et al. 2001a). Assessing the test-retest reliability of the MFIQ total scores it was found that the 95% confidence interval (CI) was $\pm 11.2$ (SD $\pm 4.57$) (Selfe et al., 2001b). A change of 10 points in the overall score on the MFIQ was considered clinically sensitive (Selfe et al., 2001b). In order to make the MFIQ an appropriate questionnaire for the assessment of functionality in Dutch-language PFPS patients, the first and the third author independently translated the English version of the MFIQ into Dutch. Afterwards, both translations were compared and combined into one version (the Modified Functional Index Questionnaire-Dutch Version or MFIQ-DV1). The MFIQ-DV contains ten closed-ended questions, using both three-point (the first two questions) and four-point (questions three–ten) Likert scales. For counting the total scores obtained with the MFIQ-DV, the scoring system as described by Selfe et al. (2001a) was used. This scoring system indicates that higher scores are suggestive of more severe problems. In order to exclude investigator bias, all study subjects were asked to complete the questionnaire independently. Patients with bilateral symptoms were asked to complete the questionnaires for their most symptomatic leg only.

3.3. Clinical tests

3.3.1. Vastus medialis coordination test

The vastus medialis coordination test was performed and interpreted as described by Souza (1997). The patient lay supine, and the examiner placed his/her fist under the subject’s knee and asked the patient to extend the knee slowly without pressing down or lifting away from the examiner’s fist (Fig. 1). The patients were instructed to achieve full extension. The test was considered positive when a lack of coordinated full extension was evident, i.e. when the patient either had difficulty smoothly accomplishing extension or recruited

$^1$The MFIQ-DV can be obtained from the corresponding author.
either the extensors or flexors of the hip to accomplish extension. Souza (1997) suggested that a positive test may be an indicator of dysfunction of the vastus medialis obliquus muscle which may result in patellar pain.

3.3.2. Patellar apprehension test
The patellar apprehension test, also referred to as the Fairbanks apprehension test, was performed with the patient lying supine and relaxed (Reider, 1999). The examiner used one hand to push the patient’s patella as lateral as possible, in order to obtain a lateral patellar glide (Fig. 2). Starting with the knee flexed at 30°, the examiner grasped the leg at the ankle/heel with the other hand and performed a slow, combined flexion in the knee and hip (Reider, 1999; Malanga, et al., 2003). This lateral glide was sustained throughout the test. The test was considered positive when it reproduced the patient’s pain or when apprehension was present. The apprehension can manifest itself in a number of ways, ranging from verbal expressions of anxiety over grabbing the knee to involuntary quadriceps muscle contractions (to prevent further knee flexion) (Reider, 1999; Souza, 1997; Malanga, et al., 2003).

3.3.3. Waldron’s test (phase I and II)
For phase I of Waldron’s test, with the patient lying supine and the examiner pressed the patella against the femur while simultaneously performing a passive knee flexion with the other hand (Reider, 1999), Crepitus and pain during a particular part of the range of motion are considered signs of patellofemoral pain disorders (Souza, 1997; Martens et al., 1995). For phase II, the standing patient was asked to perform a slow, full squat, again with the examiner performing a gentle compression of the patella against the femur. As was the case in Waldron’s test phase I, pain and crepitus were of interest for interpreting the test.

3.3.4. Clarke’s test (or patellofemoral grinding test)
Clarke’s test was performed with the patient lying supine with both knees supported by a knee pad, in order to create a sufficient amount of knee flexion and consequent articulation of the patella in the patellofemoral joint. Performing the test in full extension might even cause false-positive findings, due to pinching of the suprapatellar pouch (Souza, 1997). While the patient was relaxed, the examiner pressed the patella distally (with the hand on the superior border of the patella) and then asked the patient to contract the quadriceps muscle (Souza, 1997; Malanga et al., 2003). If the patient’s pain was reproduced during test performance, then the test was considered positive. A positive Clarke’s test has been suggested to be indicative for patellofemoral disorders (Souza, 1997; Malanga et al., 2003).

3.3.5. Eccentric step test
For the eccentric step test, the patients wore shorts and performed the testing in bare feet (Fig. 3). The step was made of a stool 15 cm high. Selfe et al. (2001a), in an attempt to standardize the height of the step against the anthropometric differences between study participants, adjusted the step height to 50% of the length of the tibia. Selfe et al., (2001a) found that the eccentric step test produced knee pain in 57 of 77 PFPS patients (74%). The step was manufactured by wood, and a layer of non-slip rubber was placed on top of the wood to prevent slipping of the subjects while performing the test. Selfe et al. (2001ab) used video equipment to quantify the eccentric step test. Due to the time consuming and expensive nature of this procedure, the video equipment was deemed inappropriate for clinical purposes and consequently not used in the present investigation. Apart from the step height and the video analysis, the eccentric step test was performed as described by Selfe et al. (2001a). Briefly, each study
The participant was given a standard demonstration of the test followed by standardized verbal instructions: ‘stand on the step, put your hands on your hips, and step down from the step as slowly and as smoothly as you can’. Patients were asked to keep their hands on their hips throughout the test performance. After each patient performed the test with one leg, the procedure was repeated using the other leg. A warm-up or practice attempt was not allowed. The eccentric step test was considered positive when the patients reported knee pain during the test performance.

3.4. Statistics

All data were analysed using SPSS 11.0 for Windows (SPSS Inc. Headquarters, 233 S. Wacker Drive, 11th floor, Chicago, Illinois 60606, USA). The following descriptive statistics were obtained: mean and standard deviation (SD) for age and knee pain duration, frequencies and percentages for gender distribution and the number of left knees affected, and median and interquartile range for the total scores obtained with the MFIQ-DV. To examine the differences between the PFPS and the non-PFPS group, both the Fisher exact test (for gender distribution) and the Mann–Whitney U test (knee pain duration, age, and the visual analogue scales) were used.

The disease specificity of the MFIQ-DV scores was assessed by examining the differences in both the total and the item scores between the PFPS and the non-PFPS groups (Mann–Whitney U test). Cronbach’s alpha reliability coefficients were calculated as a measure for estimating the internal consistency of the item scores of the MFIQ-DV. Spearman Rank correlation coefficients were calculated for the convergent validity analysis (the total scores obtained with the MFIQ-DV versus the visual analogue scales). The level of significance was set at 0.05.

To examine the diagnostic value of the patellofemoral tests, the positive and negative likelihood ratios were calculated and interpreted as described by Fritz and Wainner (2001). Likelihood ratios are considered the best statistics for summarizing the usefulness of a diagnostic test; sensitivity and specificity work in the opposite direction of clinical decision making, while predictive values are highly dependent on the prevalence of the condition of interest in the sample (Fritz and Wainner, 2001). Since likelihood ratios are ratios of probabilities, they can be treated as risk ratios for the purposes of calculating CI (Deeks and Altman, 2004). The 95% CI for the likelihood ratios were calculated as described by Kirkwood and Sterne (2003, p. 155–156).

4. Results

Of the 45 knee patients enrolled, one had undergone knee surgery and was therefore excluded. Five additional patients (seven knees) were classified as co-morbid PFPS patients and were consequently excluded. Of the remaining 39 study participants (59 symptomatic knees), 20 patients were classified in the PFPS group (31 knees), and the remaining 19 in the control group (non-PFPS sample—28 knees). The control group comprised of four patients with a grade II injury of the medial collateral ligament (one of which had a comorbid shin splints or periostitis), one patient with a iliotibial band friction syndrome, one with osteoarthritis of the knee, two with an injury of the anterior cruciate ligament, three with a meniscus tear (two of the medial meniscus and one of the lateral meniscus), one with a stress fracture, one with severe knee instability, one with severe overloading of the muscles of the lower extremities, two with tendinitis of the Quadriceps tendon, one with a contusion of the knee, one with an injury of the M. Popliteus, and one with both an injured joint capsule and several injured knee ligaments. The demographic features of both the PFPS and the non-PFPS group are presented in Table 1. No statistically significant differences in age (Mann–Whitney $U = 185.5; p = 0.899$), knee pain duration ($U = 121; p = 0.052$), or gender distribution ($p = 0.320$) were found between the two groups.
Regarding the self-reported measures, both the descriptive statistics and the comparisons between the PFPS and the non-PFPS group are presented in Table 2. No statistically significant differences in pain intensity at night (VAS night: Mann–Whitney \( U = 175; p = 0.595 \)), at rest (VAS rest: \( U = 154; p = 0.271 \)), or during movement (VAS movement: \( U = 178.5; p = 0.746 \)) were found between the PFPS and the non-PFPS group. Regarding the disease specificity for the scores obtained with the MFIQ-DV, neither the total scores (Mann–Whitney \( U = 159; p = 0.382 \)), nor any of the individual item scores (data not shown) showed a statistically significant difference between the two groups. The Cronbach Alpha coefficient was 0.71 for the PFPS patients and 0.80 for the non-PFPS subjects. Furthermore, the convergent validity analysis revealed statistically significant associations between the total scores obtained with the MFIQ-DV and the visual analogue scales for pain during movement in both the PFPS patients (\( \rho = 0.41; p = 0.020 \)) and the non-PFPS subjects (\( \rho = 0.50; p = 0.007 \)). In the latter group, there was a statistically significant correlation between the pain intensity at rest and the MFIQ-DV overall scores (\( \rho = 0.422; p = 0.025 \)). All Spearman Rank correlation coefficients and corresponding p-values are displayed in Table 3.

The outcome of the clinical tests for both groups is presented in Table 4. The positive likelihood ratio was 2.26 for both the vastus medialis coordination test and the patellar apprehension test, and 2.34 for the eccentric step test. A likelihood ratio of 1 indicates that the test result does nothing to change the odds favouring the condition of interest. A positive likelihood ratio indicates a shift in odds favouring the condition of interest (i.e. PFPS) when the test is positive. A larger positive likelihood ratio is therefore desirable. A positive likelihood ratio within the range of \( 2–5 \), as is the case for the vastus medialis coordination test, the patellar apprehension test, and the eccentric step test, is considered to generate small, but sometimes important, shifts in probability (Jaeschke et al., 1994). Thus, a positive outcome on either the vastus medialis coordination test, the patellar apprehension test, or the eccentric step test in a knee pain patient increases the probability of PFPS to a small, but sometimes important degree. Still, the intraobserver and the interobserver reliability of these tests remain to be established. Given the subjective interpretation of the vastus medialis coordination test, the examination of the intraobserver and interobserver reliability of this test is highly recommended. For the remaining tests, the positive likelihood ratios were below the threshold value of 2, indicating that given a positive test result, the probability that the knee pain patient has PFPS is altered to a small, and rarely important degree. Negative likelihood ratios indicate a change in odds favouring the condition given a negative test result. Consequently, a small negative likelihood ratio will identify the test that is useful for ruling out PFPS when negative (Fritz and Wainner, 2001). The negative likelihood ratios for all tests exceeded the threshold value of 0.5 (Jaeschke et al., 1994), suggestive of clinically irrelevant information. Indeed, negative likelihood ratios within the range of the threshold value of 2 (Table 5). For all five tests, the negative likelihood ratios were above the threshold value of 0.5.

### 5. Discussion

This study provided new insight into the scientific value of five clinical tests for the diagnosis of PFPS in knee pain patients. It was shown that the positive likelihood ratio was 2.26 for both the vastus medialis coordination test and the patellar apprehension test, and 2.34 for the eccentric step test. A likelihood ratio of 1 indicates that the test result does nothing to change the odds favouring the condition of interest (i.e. PFPS) when the test is positive. A larger positive likelihood ratio is therefore desirable. A positive likelihood ratio within the range of \( 2–5 \), as is the case for the vastus medialis coordination test, the patellar apprehension test, and the eccentric step test, is considered to generate small, but sometimes important, shifts in probability (Jaeschke et al., 1994). Thus, a positive outcome on either the vastus medialis coordination test, the patellar apprehension test, or the eccentric step test in a knee pain patient increases the probability of PFPS to a small, but sometimes important degree. Still, the intraobserver and the interobserver reliability of these tests remain to be established. Given the subjective interpretation of the vastus medialis coordination test, the examination of the intraobserver and interobserver reliability of this test is highly recommended. For the remaining tests, the positive likelihood ratios were below the threshold value of 2, indicating that given a positive test result, the probability that the knee pain patient has PFPS is altered to a small, and rarely important degree. Negative likelihood ratios indicate a change in odds favouring the condition given a negative test result. Consequently, a small negative likelihood ratio will identify the test that is useful for ruling out PFPS when negative (Fritz and Wainner, 2001). The negative likelihood ratios for all tests exceeded the threshold value of 0.5 (Jaeschke et al., 1994), suggestive of clinically irrelevant information. Indeed, negative likelihood ratios within the range of

### Table 1
Demographic features of both the PFPS (n = 20) and the non-PFPS group (n = 19)

<table>
<thead>
<tr>
<th></th>
<th>number of females (%)</th>
<th>knee pain duration (months ± SD)</th>
<th>number of left knees affected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFPS</td>
<td>9 (45.0)</td>
<td>45.1 ± 55.2</td>
<td>17 (54.8)</td>
</tr>
<tr>
<td>Non-PFPS</td>
<td>5 (26.3)</td>
<td>35.1 ± 58.9</td>
<td>14 (50.0)</td>
</tr>
</tbody>
</table>

*a* standard deviation.

### Table 2
Descriptive statistics of the self-reported measures taken from 20 PFPS and 19 non-PFPS patients

<table>
<thead>
<tr>
<th></th>
<th>VAS* rest Mean ± SD; [range]</th>
<th>VAS* movement Mean ± SD; [range]</th>
<th>VAS* night Mean ± SD; [range]</th>
<th>MFIQ-DV Median; IQR* [range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PFPS</td>
<td>20.5 ± 28.2 [0.0; 83.0]</td>
<td>51.2 ± 23.9 [8.0; 98.0]</td>
<td>8.6 ± 20.5 [0.0; 77.0]</td>
<td>32.5; 23.8 [15.65]</td>
</tr>
<tr>
<td>Non-PFPS</td>
<td>18.4 ± 27.9 [0.0; 87.0]</td>
<td>51.2 ± 32.5 [0.0; 100.0]</td>
<td>12.6 ± 24.5 [0.0; 94.0]</td>
<td>35.0; 11.3 [5.55]</td>
</tr>
</tbody>
</table>

*a* visual analogue scale for pain at rest, during movement, and at night,

*b* standard deviation,

*c* interquartile range.
0.5–1 alter the probability to a small, and rarely important degree (Jaeschke et al., 1994).

Selfe et al. (2001a) reported that the eccentric step test produced knee pain in 57 of 77 PFPS patients (74%). In the present study, we were unable to confirm these results: the eccentric step test provoked pain in 13 of 31 PFPS knees (41%). The eccentric step test was performed in the same way as described by Selfe et al. (2001a), subject to a different step height (15 cm in our study versus an adjusted step height to 50% of the length of the tibia in the Selfe et al. trial). The mean step height used in the Selfe et al. (2001a) was not reported. In another study by Selfe (2000) using identical methodology to adjust the height of the step, a modal step height of 22 cm (range 20–26) was reported. Despite the fact that the latter study addressed healthy subjects, it can be assumed that the step height used in the Selfe et al. (2001a) study on PFPS subjects was higher compared to our fixed step height. This might explain the discrepancy between the present data and those reported by Selfe et al. (2001a), and suggests a relationship between step height and painful responses.

The patellar apprehension test is performed primarily to test the knee for patellar dislocation (Malanga et al. 2003; Reider, 1999; Souza, 1997) and not for diagnosing PFPS. It should be noted, therefore, that the high amount of patients presenting with a positive patellar apprehension sign, as seen in our sample, was not due to the classical apprehension sign but due to pain provocation during test performance. One study reported a sensitivity of 39% of the patellar apprehension test for the diagnosis of patellar dislocation (Sallay et al., 1996). From their literature review, Malange et al. (2003) concluded that no studies document the validity of Clarke’s test for the diagnosis of PFPS. In addition, we are unaware of data documenting the validity of the vastus medialis coordination test, Waldron’s test, and the patellar apprehension test for the diagnosis of PFPS in knee pain patients. Consequently, we claim these data to be the first documenting the validity of these clinical tests for the diagnosis of PFPS in knee pain patients.

This study provided preliminary evidence supporting the internal consistency and validity of the Dutch version of the MFIQ, a self-assessment tool for evaluating functionality in PFPS patients. The Cronbach Alpha coefficient was 0.71 for the PFPS patients and 0.80 for the non-PFPS subjects. For interpreting Cronbach’s Alpha coefficient, 0.80 is considered the threshold value for sufficient internal consistency of the different items included in the questionnaire (Dijkers et al. 2002). Since shorter questionnaires are known to be less reliable (Selfe et al. 2001b), we claim that even the value of 0.71 supports the internal consistency of the Dutch MFIQ. The convergent validity analysis revealed statistically significant associations between the total

### Table 3
Convergent validity of the MFIQ-DV in PFPS (n = 20) and non-PFPS (n = 19) patients: correlation analyses between the MFIQ-DV total scores and visual analogue scales

<table>
<thead>
<tr>
<th>Test</th>
<th>PFPS Patient</th>
<th>non-PFPS Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFIQ-DV rho&lt;sup&gt;b&lt;/sup&gt; (p-value)</td>
<td>MFIQ-DV rho&lt;sup&gt;b&lt;/sup&gt; (p-value)</td>
<td></td>
</tr>
<tr>
<td>VASa rest</td>
<td>−0.21 (0.208)</td>
<td>0.42 (0.025)</td>
</tr>
<tr>
<td>VASa movement</td>
<td>0.42 (0.020)</td>
<td>0.50 (0.007)</td>
</tr>
<tr>
<td>VASa night</td>
<td>−0.08 (0.671)</td>
<td>0.36 (0.060)</td>
</tr>
</tbody>
</table>

<sup>a</sup>visual analogue scale for pain at rest, during movement, and at night.
<sup>b</sup>Spearman Rank correlation coefficient.

### Table 4
Outcome on the clinical tests in the PFPS (n = 20; 31 symptomatic knees) and non-PFPS patients (n = 19; 28 knees)

<table>
<thead>
<tr>
<th>Test</th>
<th>PFPS</th>
<th>Non-PFPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vastus medialis coordination test positive</td>
<td>5 (16.1%)</td>
<td>2 (7.1%)</td>
</tr>
<tr>
<td>Patellar apprehension test positive</td>
<td>10 (32.3%)</td>
<td>4 (14.3%)</td>
</tr>
<tr>
<td>Waldron’s test phase I positive</td>
<td>14 (45.2%)</td>
<td>9 (32.1%)</td>
</tr>
<tr>
<td>Waldron’s test phase II positive</td>
<td>7 (22.6%)</td>
<td>6 (21.4%)</td>
</tr>
<tr>
<td>Clarke’s test positive</td>
<td>15 (48.4%)</td>
<td>7 (25.0%)</td>
</tr>
<tr>
<td>Eccentric step test positive</td>
<td>13 (41.9%)</td>
<td>5 (17.9%)</td>
</tr>
</tbody>
</table>

### Table 5
Validity of five clinical tests for the diagnosis of PFPS in knee patients.

<table>
<thead>
<tr>
<th>Test</th>
<th>+ LR&lt;sup&gt;a&lt;/sup&gt;</th>
<th>95% CI&lt;sup&gt;b&lt;/sup&gt;</th>
<th>−LR&lt;sup&gt;c&lt;/sup&gt;</th>
<th>95% CI&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vastus medialis coordination test</td>
<td>2.26</td>
<td>1.88 to 2.92</td>
<td>0.90</td>
<td>0.57 to 0.88</td>
</tr>
<tr>
<td>Patellar apprehension test</td>
<td>2.26</td>
<td>2.09 to 2.45</td>
<td>0.79</td>
<td>0.83 to 0.98</td>
</tr>
<tr>
<td>Waldron’s test phase I</td>
<td>1.41</td>
<td>0.62 to 3.20</td>
<td>0.81</td>
<td>0.36 to 1.84</td>
</tr>
<tr>
<td>Waldron’s test phase II</td>
<td>1.05</td>
<td>0.98 to 1.13</td>
<td>0.99</td>
<td>0.92 to 1.06</td>
</tr>
<tr>
<td>Clarke’s test</td>
<td>1.94</td>
<td>1.05 to 3.59</td>
<td>0.69</td>
<td>0.37 to 1.28</td>
</tr>
<tr>
<td>Eccentric step test</td>
<td>2.34</td>
<td>1.88 to 2.92</td>
<td>0.71</td>
<td>0.57 to 0.88</td>
</tr>
</tbody>
</table>

<sup>a</sup>Positive likelihood ratio,
<sup>b</sup>95% CI,
<sup>c</sup>Negative likelihood ratio.
scores obtained with the MFIQ-DV and the visual analogue scales for pain during movement in both the PFPS patients and the non-PFPS subjects. These results support the convergent validity of the total scores obtained with the MFIQ-DV in both PFPS and non-PFPS knee patients. Neither the total scores obtained with the MFIQ-DV, nor any of the individual item scores indicated a statistically significant difference between the PFPS and the non-PFPS knee pain patients. Thus, the disease specificity of the MFIQ-DV for PFPS patients is questionable. It is concluded that these data support the internal consistency and the convergent validity of the scores obtained with the MFIQ-DV in both PFPS and non-PFPS patients. Before the use of the MFIQ-DV in clinical practice and research settings can be advised, however, the test-retest reliability, content validity, responsiveness, and other forms of validity should be examined.

These results should be interpreted with some caution. First, some of the tests of interest in the present investigation are manual tests during which the tester applies a force to the patella. It is difficult to quantify and to standardize the amount of force used, this issue requires further investigation. Second, this sample was not randomly selected. Still, most reports on PFPS studied a sample of convenience (e.g. Bennell et al., 2002, Watson et al., 2001; Brechter and Powers, 2002; Thomée et al., 2002). A high number of rehabilitation centres and private practices for physiotherapy were contacted for the subjects’ recruitment. Since PFPS patients were the topic of interest in the present study, physiotherapists might have primarily referred patients with suspected PFPS for study participation. This might have introduced selection bias into the trial, as evidenced by the high number of PFPS patients in this sample of knee pain patients (20 of 39% or 51%), which is distinctive from previously reported epidemiological data suggesting that between 25% and 40% of knee patients have PFPS (Brody and Thein, 1998; Powers, 1998; Wilk et al., 1998). Still, since likelihood ratios are independent of the prevalence of the condition of interest in the sample (Fritz and Wainer, 2001), this is unlikely to have biased these results. Third, the testers were senior physical therapy students. At the time the study took place, they were holders of a bachelor degree in physical therapy and completed their final year of the master program in physical therapy. These students received a significant amount of training prior to the study. Still, their skills may not be reflective of most experienced physical therapists and medical doctors who currently use these tests. On the other hand, from a study examining the intertester reliability of clinical tests of the sacroiliac joint it was concluded that the years of experience did not affect the reliability (Potter and Rothstein, 1985). Fourth, physical examination tests are generally not performed in isolation, but together with the interview, inspection and several other tests. Consequently, the data presented here are somewhat artificial. Finally, the order of the tests performed should have been randomized. There may have been cumulative increases in pain. To test for this cumulative effect it would have been of interest to obtain a VAS from each subject after each test was performed. Even with the order of the tests randomized, this would enable to identify bias related to cumulative increases in pain.

6. Conclusion

These data question the validity of Waldron’s test phase I, Waldron’s test phase II, and Clarke’s test in the diagnosis of PFPS. In patients presenting with knee pain, a positive outcome on either the vastus medialis coordination test, the patellar apprehension test, or the eccentric step test increases the probability of PFPS to a small, but sometimes important degree. Furthermore, the present report provided evidence supporting the internal consistency, and the convergent validity of the scores obtained with the MFIQ-DV in both PFPS and non-PFPS knee pain patients. The disease specificity of the MFIQ-DV for PFPS patients is questionable.

Acknowledgements

The authors would like to thank all the study participants, and all the physicians and physiotherapists who assisted with subject recruitment. Special thanks to Katrien Vanherberghen, who holds a master degree in physical therapy and has English as her native language, for editing the final version of the manuscript. The authors are grateful to René Nijjs (PhD, statistician) for his advice on the statistical analysis.

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