

# The reliability and validity of the Q-angle: a systematic review

Toby O. Smith · Nathan J. Hunt · Simon T. Donell

Received: 22 May 2008 / Accepted: 19 September 2008 / Published online: 8 October 2008  
© Springer-Verlag 2008

**Abstract** The Quadriceps or Q-angle is an index of the vector for the combined pull of the extensor mechanisms and the patellar tendon. It is used as an indicator for patellofemoral joint dysfunction. The purpose of this article is to systematically review and appraise the literature to determine the reliability and validity of this test. An electronic database search was performed accessing AMED, British Nursing Index, CINAHL, the Cochrane database, EMBASE, ovid Medline, Physiotherapy Evidence Database (PEDro), PsycINFO, Pubmed and Zetoc to April 2008. All English language, human subject, clinical trials, assessing the inter- or intra-tester reliability, or the criterion validity, were included. The Critical Appraisal Skills Programme appraisal tool was used to establish the methodological quality of each study. Ten articles including 569 control and 179 patellofemoral disorder knees were reviewed. The findings suggest that there is considerable disagreement on the reliability and validity of the clinical Q-angle measurement. This may be due to a lack of standardisation in the measurement procedure. Further study is advocated to re-evaluate this topic using well-designed, and sufficiently large observational studies of specific patellofemoral dysfunction populations.

**Keywords** Patellofemoral joint · Assessment · Reliability · Validity · Systematic review

## Introduction

The Quadriceps or Q-angle was initially described by Brattström [6]. It is an index of the vector for the combined pull of the extensor mechanisms and the patellar tendon [19, 35, 59]. It is measured by drawing a line from the anterosuperior iliac spine to the centre of the patella, and a second line from the centre of the tibial tubercle to the centre of the patella. The angle where these lines intersect is regarded as the Q-angle [22, 59]. Traditionally, the Q-angle has been measured with subjects in supine, knee extended and with the quadriceps muscle relaxed [32]. This is regarded as the ‘traditional’ or ‘conventional’ method of assessing Q-angle. The Q-angle has also been assessed on standing [10, 27]. Standing and spine methods are illustrated as Figs. 1 and 2, respectively.

The Q-angle measurement is widely used as an indicator of patellofemoral dysfunction, including patellofemoral pain syndrome (PFPS) and patella instability [1, 10, 58]. An increasing Q-angle represents a larger lateral vector [47, 52]. This act to translate the patella laterally and increasing the retropatellar pressure [34, 42, 53]. The resultant increased pressure between the lateral trochlear ridge and the patella causes pain, thus providing the source of PFPS, and ultimately, leads to degeneration of the articular cartilage [4, 25, 27, 35, 42, 59]. In addition, this increase in contact pressure may increase the likelihood of lateral patellar subluxation or dislocation [31]. It has also been suggested that an abnormal Q-angle may also influence neuromuscular response and quadriceps reflex response time, an aetiological factor in PFPS [11].

---

T. O. Smith (✉) · S. T. Donell  
Institute of Orthopaedics, Norfolk and Norwich University  
Hospital, Colney Lane, Norwich NR4 7UY, UK  
e-mail: toby.smith@nnuh.nhs.uk

N. J. Hunt  
Physiotherapy Department, Norfolk and Norwich University  
Hospital, Colney Lane, Norwich NR4 7UY, UK

S. T. Donell  
Faculty of Health, University of East Anglia,  
Norwich NR4 7TJ, UK



**Fig. 1** Q-angle performed in standing



**Fig. 2** Q-angle performed in supine

A number of studies have, however, reported no such relationship between Q-angle and patellofemoral joint symptoms [17, 19–21, 37]. Accordingly, measurement of the Q-angle has reduced in popularity amongst clinicians, as it does not inform on patient management [3, 22].

Reliability is defined as the extent to which a measurement is consistent and free from error. It may also be defined as the reproducibility and consistency of a measure [46]. As Piva et al. [45] suggested, reliability and measurement error are essential properties of any measure, which need to be established before the measure can be considered clinically meaningful. Reliability can be subdivided to inter- and intra-tester. Inter-tester reliability assesses the degree to which different examiners give consistent estimates of the same phenomenon. Intra-tester reliability assesses one assessor's ability to gain reproducible or repeatable responses over time when we do not expect change to occur [46]. The validity of an outcome measure assesses whether an instrument actually measures the phenomena of interest. One measure of validity is the criterion validity. This assesses how an instrument correlates to the "gold standard" or a well-accepted test [16]. When assessing the clinical Q-angle, plain radiographs, magnetic resonance imagery and computed tomography images may be considered such a gold standard [26, 28].

Although Insall et al.'s [32] method of Q-angle measurement remains in widespread use, there has been confusion and disagreement on its reliability. This has resulted in the accuracy of the Q-angle measurement being questioned [22]. Accordingly, the purpose of this study is to systemically review the evidence-base to examine the reliability and validity of the Q-angle. This has considerable clinical importance, given that surgeons and physiotherapists have reported the use of the Q-angle as a mean of assessing treatment success in patellofemoral joint dysfunction patients [2, 40, 58].

## Methodology

### Study eligibility

#### *Inclusion criteria*

- Articles assessing a clinically evaluated Q-angle by two or more examiners at one or more time points (inter- or intra-tester reliability).
- Articles comparing the clinical assessment of the Q-angle to a radiological assessment using MRI, CT or plain radiograph (criterion validity).
- Full text, English-language, clinical articles, non-specific for subject age or gender.

#### *Exclusion criteria*

- Articles with insufficient data pertaining to the method of Q-angle assessment.

- Animal and cadaver studies.
- Non-English language articles, or unpublished material including university theses and dissertations were excluded, as were single-subject case reports, comments, letters, editorials, protocols, guidelines, abstracts, conference proceedings or review articles. The reference lists of review articles were scrutinised for any clinical articles deemed relevant to the research question.

### Search strategy

The primary search used was an electronic search of the databases AMED, British Nursing Index, CINAHL, the Cochrane database, EMBASE, ovid Medline, Physiotherapy Evidence Database (PEDro), PsycINFO, Pubmed and Zetoc from their inception to April 2008. The key terms and Boolean operators used in each search included: patella AND quadriceps angle; position. These broad search terms and eligibility criteria were adopted in an attempt not to miss any pertinent articles. A secondary search of relevant journals was also undertaken. These journals included: *Knee Surgery Sports Traumatology Arthroscopy* (1993–April 2008), *The Knee* (1994–April 2008), the British and American editions of the *Journal of Bone and Joint Surgery* (1988–April 2008), *American Journal of Sports Science* (1988–April 2008), and *Journal of Orthopaedic Sports and Physical Therapy* (1991–April 2008).

Using the eligibility criteria, two investigators (TS, NH) independently screened all identified titles and abstracts. Full manuscripts of articles, which adhered to these criteria, were ordered. In cases of uncertain relevance, the full manuscripts of these articles were ordered to assess their adherence to the selection criteria in detail. The reference lists of each full manuscript were examined to identify any possible additional publications not identified previously.

The full texts of all articles were then screened against the eligibility criteria by the same two reviewers. If there was disagreement, a consensus was reached through discussion. Each article had to fully satisfy the eligibility criteria to be included. No article was excluded on poor methodological quality. The two investigators were not blinded to the source or authors of the identified articles.

### Data extraction

Data from all included studies were entered into a spreadsheet by a single investigator (NH), and were checked by a second investigator (TS). This spreadsheet tabulated author names and publication date, study design, sample size, population characteristics including diagnosis, subject age and gender, Q-angle assessment procedure, number of tester, frequency of testing, reference test for

criterion validity, statistical analysis, results, and any relevant methodological limitations.

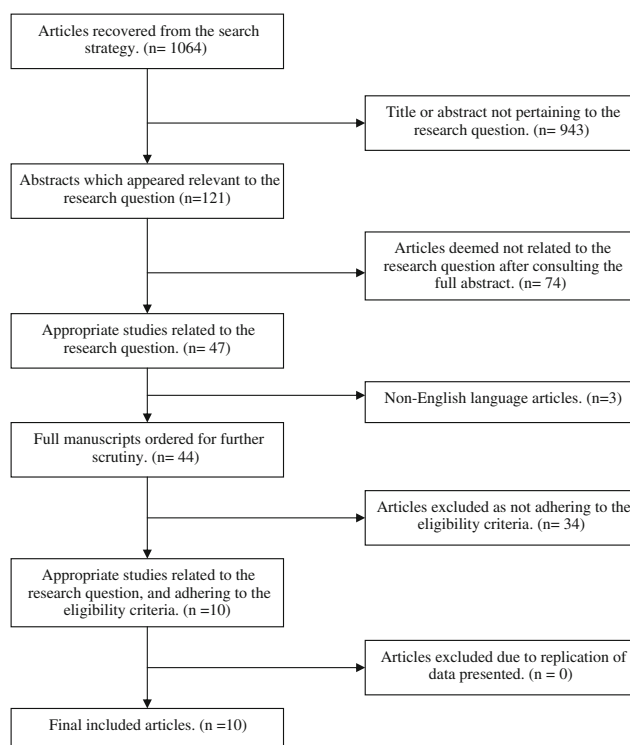
### Critical appraisal

All included articles were assessed using a tool based on the Critical Appraisal Skills Programme [9] appraisal tool (CASP) for diagnostic test studies. This tool comprises three sections: an assessment of study validity; an evaluation of methodological quality and presentation of results; an assessment of external validity. Each article was independently assessed by two reviewers (TS, NH). To maintain reliability, any differences in score were settled through discussion.

## Results

### Search results

Figure 3 outlines the results of our search strategy. The search yielded 1,064 articles whose abstracts were read. Of these, a total of 10 studies were deemed applicable. This included 151 patellofemoral disorder patients (179 knees) and 438 asymptomatic controls (569 knees). This included 256 male and 253 female subjects; Sanfridsson et al. [51]



**Fig. 3** QUORUM chart

did not provide data on the gender of their asymptomatic sample. Mean age ranged from 20 to 31 years with a total mean of 25.4 from the 10 studies reviewed. Data on patient height were provided by five studies. This ranged from 161.0 to 177.8 cm with a total mean of 170.1 cm. Caylor et al. [10] reported their height data in inches. Data on subject weight were documented by five studies. This ranged from 55.9 to 79.0 kg with a total mean of 70.4 kg. Again, Caylor et al. [10] reported their weight data in pounds. These 10 articles are summarised in Tables 1, 2, 3.

#### Intra-tester reliability

Seven studies were identified assessing intra-tester reliability. Based on Landis and Kock's [33] categorisation, Q-angle intra-tester reliability ranged from poor in Greene et al. [22] with an intra-class coefficient (ICC) of 0.37 and 0.22, to an ICC of between 0.81 and 1.00 reflecting almost perfect agreement in Guerra et al. [27], Herrington and Nester [29], Shultz et al. [54], Grelsamer et al. [24] and Caylor et al.'s [10] studies.

Shultz et al. [54] and Guerra et al. [27] compared the conventional supine measure of Q-angle to that of standing. Shultz et al. [54] found no difference in ICC ( $>0.75$ ) between both measurement procedures. Guerra et al. [27] reported no significant differences with intra-tester Q-angle between patients assessed in the conventional position, compared to those assessed in standing.

The intra-tester reliability of the Q-angle in the conventional method with the quadriceps contracted was assessed by Guerra et al. [27]. They reported no significant difference in Q-angle intra-tester reliability for assessing Q-angle with the quadriceps contracted compared to non-contracted.

The intra-tester reliability of assessing Q-angle in different knee flexion angulations was also assessed in Greene et al. [22] and Caylor et al.'s [10] studies. As Table 2 demonstrates, there was a trend for a greater intra-tester reliability ICC when the knee was assessed in full extension compared to 20° and 24° flexion, respectively, but this difference was not substantial.

#### Inter-tester reliability

Tables 3 and 4 demonstrate that the inter-tester reliability of the Q-angle also varies. This ranged from poor agreement [22, 58] to substantial agreement [10, 24, 45, 54].

The ICC of inter-tester reliability of the Q-angle when measured conventionally in supine was documented in five articles. This ranged from 0.20 [22] to 0.75 [54]. In comparison, the Q-angle was assessed in standing in two studies [10, 54]. The ICC score ranged from 0.72 [54] to 0.83 [10]. One article was identified which compared the

conventional supine method, to a Q-angle performed in standing [10]. This study suggested that there was no substantial difference in inter-tester Q-angle between patients assessed in the conventional supine position compared to those assessed in standing.

The inter-tester reliability of assessing Q-angle in different knee flexion angulations was also assessed in Greene et al.'s [22] and Caylor et al.'s [10] studies. As Table 2 demonstrated, there appeared no substantial difference in inter-tester reliability or assessing Q-angle in full extension compared to 20° and 24° flexion, respectively.

#### Criterion validity

There was disagreement in criterion validity findings between the studies reviewed. As Table 3 outlines, Greene et al. [22] reported poor agreement between the clinical and reference radiograph. This is contrary to Sanfridsson et al. [51] and Ando et al.'s [1] studies, which report no statistically significant difference between clinical and radiographic measurements of the Q-angle, suggesting the Q-angle has acceptable criterion validity.

The validity of assessing Q-angle with the quadriceps contracted and relaxed was not evaluated. However, Greene et al. [22] assessed the criterion validity of assessing Q-angle in full knee extension compared to 20° knee flexion, reporting poorer agreement between clinical and radiological assessments of Q-angle in flexion, compared to full extension.

#### Critical appraisal results

The methodology quality of the ten articles reviewed was poor. As Table 4 highlights, the studies adequately stated their research question and used an appropriate methodology in all but Ando et al.'s [1] study, which, did not clearly define their study's research question. A considerable weakness to the evidence was the poor acknowledgment of patient or subject characteristics in all but Guerra et al. [27] or Piva et al.'s [45] study. This was particularly in view of history and descriptions of patellofemoral pathology, age, weight and height, or source of recruitment. The method of assessing Q-angle was not fully presented for limb orientation, subjects placement, quadriceps contraction or apparatus and landmarks used in all but Grelsamer et al. [24], Tomsich et al. [58] or Greene et al.'s [22] studies.

The analysis of the results was clearly presented in the majority of studies, appropriately using inferential statistics in all but Ando et al.'s [1] studies. The precision of these findings was not documented in the literature with confidence intervals. Only Guerra et al. [27] or Piva et al.'s [45] studies could be generalisable into context as only these

**Table 1** Summary of the studies included in this systematic review

<i>Study</i>	Ando et al. [1]
Design	Observational
Sample size	69 subjects (69 knees)
Population	43 subjects with history of patella dislocation but no previous surgical correction: 35 males, 8 females; Mean age = 20 years (range 13–38) 26 subjects with no history of knee pathology: 14 males, 12 females; Mean age = 23 years (range 14–31)
Q-angle test	Clinical Q-angle—Supine, quads relaxed, knee extended. ASIS, centre of patella and TT (Insall's method) Radiological Q-angle—CT Scan of conventional measurement of Q-angle and other methods No detail provided on assessors
Reliability assessment	No detail provided on number of measurements repeated
Validity assessment	CT Scan Q-angle compared to clinical Q-angle
<i>Study</i>	Caylor et al. [10]
Design	Observational
Sample size	26 control (52 knees) 50 patients with PFPS (50 knees)
Population	Asymptomatic subjects—9 males, 17 females; Mean age = 24.5 years; Mean height = 68 inches; Mean weight = 146 lbs PFPS—18 males, 32 females; Mean age = 23 years; Mean height = 67 inches; Mean weight = 150 lbs
Q-angle test	2 methods of Q-angle measurement. Both in standing with weight distributed equally on both feet Position 1 = knee extended (in comfortable manner); Position 2 = knees flexed (mean = 24.3°). Goniometer axis over centre of patella, one end over centre of TT and one arm following a line created by a piece of string held on the ASIS 2 assessors (unknown training) performed both measurements twice Blinded from previous measure and other assessor
Reliability assessment	Mean of 2 values was calculated for Position 1 and 2 for both assessors
Validity assessment	Not assessed
<i>Study</i>	Greene et al. [22]
Design	Observational
Sample size	25 subjects (50 knees)
Population	20 subjects with no recorded pathology 5 symptomatic subjects—presence of knee symptoms recorded as 1 failed ACL reconstruction, 1 ACL deficit knee with PF crepitus, 3 with occasional bilateral patellofemoral crepitus In total: 20 males, 5 females. Mean age = 27.3 years (range 22–38)
Q-angle test	Clinical Q-angle—4 different Q-angle methods using ASIS—centre of patella—TT with 18 cm goniometer: (1) supine, relaxed quadriceps, knee extended, foot neutral (2) supine relaxed quadriceps, knee flexed to 20° 25 assessors, combination of orthopaedic surgeon, residents and medical students. Each assessor measured each participant Radiological Q-angle—plain Radiograph with radiographic marker (fluoroscopic guidance) using ASIS—centre of patella—TT. Each participant had a 52 inch radiograph obtained for both knees
Reliability assessment	3 assessors then measured 13 participants twice again
Validity assessment	Plain radiograph Q-angle compared to clinical Q-angle
<i>Study</i>	Grelsamer et al. [24]
Design	Observational
Sample size	69 subjects (69 knees)

**Table 1** continued

Population	Subjects—no screening for pathology 45 males: Mean Age = 30.2 years; Mean height = 172.5 cm; Mean weight = 75.1 kg 24 females: Mean age = 28.8 years; Mean height = 161.0 cm; Mean weight = 55.9 kg
Q-angle test	Supine, relaxed quads, 10° knee flexion (no specification), hip and leg in neutral with patella pointing upwards Measured using a long arm goniometer using 2 assessors where 1 assessor positioned the axis over the centre of patella with each arm in line with the ASIS and TT, whilst the other assessor recorded the angle No details of training for the 2 assessors
Reliability assessment	2 assessors measured Q-angle twice each
Validity assessment	Not assessed
<i>Study</i>	Guerra et al. [27]
Design	Observational
Sample size	60 subjects (60 knees)
Population	Asymptomatic knees 30 males: Mean age = 31 ± 6 years; Mean height = 177.8 ± 5.4 cm; Mean weight = 81.5 ± 10.8 kg 30 females: Mean age = 30 ± 7 years; Mean height = 167.3 ± 6.6 cm; Mean weight = 60.3 ± 14 kg
Q-angle test	4 different Q-angle methods assessed using standard goniometer with lengthened arm (1) Standing with feet placed perpendicular to coronal plane, quadriceps contracted (2) Same as (1) but with quads relaxed (3) Supine with feet placed perpendicular to the horizontal surface aligned with a fixed reference point, quads contracted (4) Same as (3) but with quads relaxed. ASIS, centre of patella and TT were marked with pen One assessor but no other information about assessor
Reliability assessment	1 assessor. All subjects measured once. 20 min after, 16 of the subjects were re-measured. Assessor blinded
Validity assessment	Not assessed
<i>Study</i>	Herrington and Nester [29]
Design	Observational
Sample size	109 subjects (218 knees)
Population	Asymptomatic—51 males, 58 female. Mean age: 21.7 ± 4 years (range 18–31)
Q-angle test	ASIS, centre of patella, and TT marked by single experienced physiotherapist. Mid-heel and second toes placed over tape on floor, perpendicular to frontal plane. Digital photo taken and enlarged to A4 size. Lines drawn on image connecting the markers, then Q-angle measured with goniometer 1 assessor who was an experienced physiotherapist
Reliability assessment	All subjects measured once on both knees. 10 subjects randomly selected for repeat measurement
Validity assessment	Not assessed
<i>Study</i>	Piva et al. [45]
Design	Observational
Sample size	30 PFPS subjects (30 knees)
Population	PFPS—PFPS reported for longer than 4 week period. No history of surgery, other knee trauma or concomitant conditions of the knee 13 males, 17 female Mean age = 29.1 ± 8.4 years (range 15–50); Mean height = 171 ± 11.1 cm; Mean weight = 79 ± 18.6 kg

**Table 1** continued

Q-angle test	Supine, knee extended, quads relaxed. Measurement points were ASIS—centre of patella—TT. Patient asked to hold index finger on ASIS. Centre of patella and TT marked with ink. Standard goniometer used for all measurements. All subjects measured once by 4 examiners working in pairs
Reliability assessment	4 assessors: 2 pairs of physiotherapists with different levels of clinical experience
Validity assessment	1 measurement performed each assessor, which was then compared
Study	Not assessed
Design	Sanfridsson et al. [51]
Sample size	Observational
Population	80 control (80 knees) 28 patients with history of patellar dislocation (56 knees) Both knees were measured from all subjects
Q-angle test	Asymptomatic control—no demographical details Patellar dislocation—20 females, 8 males; Mean age = 20 years (range 14–29) Clinical Q-angle—Supine, knee extended. Measured from ASIS—centre of patella—TT Radiological Q-angle—assessed in standing with 2 types of measurement: 1 from ASIS—centre of patella—TT, and 1 from centre of proximal femur—centre of patella—TT. Anatomical landmarks located with lead marker and assessed by 1 orthopaedic surgeon
Reliability assessment	Assessors were orthopaedic surgeons
Validity assessment	2 measurements performed in 18 symptomatic knees
Study	Plain radiograph Q-angle compared to clinical Q-angle
Design	Shultz et al. [54]
Sample size	Observational
Population	16 control (16 knees) Asymptomatic Control—7 males, 9 females; Mean age = 25.6 ± 3.2 years; Mean height = 171.1 ± 10.8 cm; Mean weight = 70.7 ± 17.3 kg
Q-angle test	Supine Q angle, feet shoulder width apart, toes pointing vertically Goniometer axis over centre of patella in line with ASIS and TT 6 assessors consisting of physiotherapists and athletic trainers Experience: a combination of recent and 18 month post training of measurement technique
Reliability assessment	Mean of 3 attempts recorded from each tester compared
Validity assessment	Not assessed
Study	Tomsich et al. [58]
Design	Observational
Sample size	27 subjects (27 knees)
Population	Asymptomatic—7 males, 20 females. Mean age 21 ± 5.5 years
Q-angle test	Supine, knee extended, relaxed quads. String from ASIS to centre of patella. Goniometer positioned with axis over centre of patella, 1 arm to TT and the other along the string. Foot position standardised with a KT-100 foot stabilizer 3 assessors. All physiotherapists (2.5–5.5 years experience of orthopaedic practice)
Reliability assessment	3 Q-angle measurements taken by each assessor
Validity assessment	Not assessed

ASIS anterior superior iliac spine, *kg* kilograms, *lbs* pounds (in weight), *PF* patellofemoral joint, *PFPS* patellofemoral pain syndrome, *TT* tibial tubercle

articles clearly described their cohort's characteristics. The clinical relevance of the evidence-base could only be ascertained in Piva et al. [45], Caylor et al. [10] and

Sanfridsson et al.'s [51] studies as these identified how their results could be incorporated into practice with symptomatic cohorts.

**Table 2** Intra- and inter-tester results of the Q-angle studies included in this systematic review

Author	Q-angle measurement	Mean Q-angle in degrees (SD) male/female	Inter-tester reliability (ICC with SEM)	Intra-tester reliability (ICC with SEM)	Difference between tests in Q-angle ( <i>P</i> value)
Caylor et al. [10]	In standing in 0° flexion	12.43 ± 6.05	0.83 (2.49)	Range 0.84 (2.23) to 0.90 (2.01)	N/D
	In standing in mean 24° flexion	10.80 ± 5.93	0.65 (3.50)	Range 0.83 (0.68) to 0.83 (2.45)	
Greene et al. [22]	Conventional (left)	N/D	0.20	0.37	N/D
	Conventional (right)		0.26	0.22	
	In 20° flexion (left)		0.29	0.27	
	In 20° flexion (right)		0.17	0.14	
Grelsamer et al. [24]	Conventional	13.3/15.7 (overall SD = 4.5)	0.63	0.91	N/D
Guerra et al. [27]	In standing	8.6 ± 3.8/13.5 ± 4.8	N/D	0.87 (1.47)	0.65
	In standing with Quad contraction	7.4 ± 3.7/12.0 ± 4.1		0.84 (1.54)	0.23
	Conventional	8.4 ± 4.5/14.2 ± 3.5		0.75 (2.15)	0.39
	Conventional with Quad contraction	6.6 ± 4.3/10.7 ± 3.2		0.73 (1.86)	0.93
Herrington and Nester [29]	Conventional (left)	11.6 ± 5.2/14.4 ± 5.2	N/D	0.98	0.001
	Conventional (right)	11.3 ± 4.9/13.3 ± 5.5			
Piva et al. [45]	Conventional	12.2 ± 4.3	0.70 (2.4 with 95% CI 0.46-0.85)	N/D	N/D
Sanfridsson et al. [51]	Conventional	N/D	N/D	N/D	N/D
Shultz et al. [54]	Conventional	Range 10.9 ± 4.2 to 15.9 ± 4.6	Range 0.62 (3.5) to 0.75 (2.7)	Range 0.88 (1.7) to 0.98 (0.7)	N/D
	In standing	Range 10.8 ± 6.2 to 18.0 ± 7.0	Range 0.72 (3.7) to 0.79 (3.5)	Range 0.89(5.9) to 0.98 (0.8)	
Tomsich et al. [58]	Conventional	N/D	0.23 (3.7)	0.63 (2.7)	N/D

ICC Interclass coefficient, SD standard deviation, N/D not documented, SEM standard error of measurement

**Table 3** Criterion validity as assessed by comparing clinical to radiological Q-angle measurements from the studies included in this systematic review

Author	Q-angle measurement	Mean clinical Q-angle in degrees (SD) Male/Female	Mean radiological Q-angle in degrees (SD) Male/Female	Mean difference of clinical versus radiological Q-angle in degrees (SD)	Difference between clinical versus radiological test ( <i>P</i> value)	ICC of clinical versus radiological Q-angle
Ando et al. [1]	Conventional	Asym 13 ± 6 PD 14 ± 7	Asym 13 ± 3 PD 11 ± 5	N/D	0.05	N/D
Greene et al. [22]	Conventional (left)	N/D	N/D	1.59 ± 5.0	N/D	0.32
	Conventional (right)			1.89 ± 4.8		0.32
	In 20° flexion (left)			1.89 ± 5.6		0.19
	In 20° flexion (right)			1.36 ± 5.8		0.13
Sanfridsson et al. [51]	Conventional	N/D	N/D	N/D	0.004	N/D

Asym asymptomatic, N/D not documented, SD standard deviation, ICC interclass coefficient, PD patellar dislocation

**Table 4** A summary of the CASP results

CASP factors	Ando et al. [1]	Caylor et al. [10]	Guerra et al. [27]	Greene et al. [22]	Grelsamer et al. [24]	Herrington and Nester [29]	Piva et al. [45]	Sanfridsson et al. [51]	Shultz et al. [54]	Tomsich et al. [58]
Clearly focused question stated	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Appropriate design	N	Y	Y	Y	Y	N	Y	Y	Y	Y
Appropriate reference test available	Y	N/D	N/D	Y	N/D	N/D	N/D	Y	N/D	N/D
Did all receive reference and diagnostic test	N	N/A	N/A	Y	N/A	N/A	N/A	N	N/A	N/A
Could reference test findings influenced diagnostic test result	Y	N/A	N/A	Y	N/A	N/A	N/A	N	N/A	N/A
Population characteristics clearly defined	N	N	Y	N	N	N	Y	N	N	N
Q-angle clearly defined	N	N	N	Y	Y	N	N	N	N	Y
Appropriate results analysis	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Precise statistical results presented	N	N	N	N	N	N	Y	N	N	N
Appropriate interpretation	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ability to generalise results	N	N	Y	N	N	N	Y	N	N	N
Were the results applicable to clinical practice	N	Y	N	N	N	N	Y	N	N	N

Y yes, N no, N/D not documented, N/A not applicable

## Discussion

The findings of this review suggest that there is disagreement on the reliability and validity of the clinical Q-angle measurement. Inter-tester reliability ranged from an ICC of 0.20–0.70. Intra-tester reliability ICC ranged from 0.22 to 0.75. This variability may be due to the lack of standardisation of measurement procedure or control of potential confounding variables.

The methodological quality of the evidence-base appears limited. This is the most notable in the description of the cohorts recruited, and method of conducting the Q-angle. The conventional Q-angle assessment was poorly demonstrated in the articles reviewed, with the exception of Grelsamer et al. [24], Tomsich et al. [58] or Greene et al.'s [22] studies. The literature poorly presented and standardised the methodology in respect to important confounding variables such as hip, knee, ankle or foot orientation, patients position, co-morbidities such as hypermobility, or whether the quadriceps were contracted during testing [27, 30, 42, 47, 53]. Such limited standardisation reduces the clinician's ability to replicate the findings into clinical practice. This also prevented the present review from comparing the Q-angle results between studies. For instance, Herrington and Nester [29] calculated their Q-angle photographically. Such differences may attribute to the range in both inter- and intra-tester ICC values between studies. Future study is suggested to rectify this lack of consensus and to standardise Q-angle method amongst clinicians and researcher internationally. Following this, further study can be undertaken on well-defined population groups to determine the reliability and validity of this uniform measure.

With the exception of Shultz et al. [54], Tomsich et al. [58], Herrington and Nester [29] and Piva et al. [45], the articles in this review poorly document the training and experience of the assessors used in their studies. Assessor experience and skill may be a factor in the reliability of the Q-angle. On analysis, there did not appear to be a substantial difference in reliability findings between those articles, which detailed that the assessors were specially taught the Q-angle test for the investigation, compared to those who were not. However, such a statement cannot be made with confidence since the majority of articles neglected to detail how their assessors were taught the Q-angle measurement under investigation in these articles. Further study is recommended to investigate this notion by controlling investigator experiences and teaching, and to inform how much experience and teaching is required to provide the optimally reliable recording of the Q-angle in clinical practice.

There is some debate as to whether the Q-angle should be assessed in terminal extension or in 20°, 30° or 90° knee flexion [21, 39, 44, 55]. When the knee is flexed greater than 20°, the patellar is more centralised than in the zero degrees flexion where it is slightly lateralised [7, 43, 59]. By assessing in some degree of flexion, this may reflect the gait stance phase better, where the patella will be located within the trochlea groove. Some degree of flexion is also more indicative of when PFPS patients experience their aggravating position of stair descent or sitting for prolonged period [8, 12]. Therefore, by assessing in some flexion, this may be regarded as more clinically meaningful than in terminal extension [55]. The results of this study suggested that there was no substantial difference in reliability in 20° and 24° of knee flexion [10, 22]. Further

study is suggested to assess whether reliability and validity varies in different knee flexion ranges using well-defined and controlled studies to answer these research questions.

The clinical relevance and usefulness of the Q-angle has been debated within the literature. It is unclear whether the Q-angle is an indicator of pain intensity in PFPS cohorts. Previous work has questioned whether there is a correlation between retropatellar pain and AKP symptoms and Q-angle [36, 38, 57]. Conversely, others have reported such an association between Q-angle and PFPS [15, 41]. Until the reliability of a standardised Q-angle has been undertaken on asymptomatic control and different patellofemoral disorder patient groups, it remains unclear whether the Q-angle is of prognostic value for these disorders. This may then inform surgeons and physiotherapists as to whether factors such as vastus medialis or glutei muscle control, or tibial and foot biomechanics should be examined initially as aetiological factors before considering the Q-angle [5, 13, 48].

It remains unclear whether the Q-angle should be used for patellar instability populations [59]. Only Ando et al. [1] and Sanfridsson et al. [51] assessed Q-angle with patellar instability cohorts. Greene et al. [22] acknowledge that the traditional assessment of the Q-angle has been problematic in this cohort as the subluxable patella lies lateral to the femoral trochlear and therefore, decreased the Q-angle measure. This would, therefore fail to acknowledge a severe malalignment and over-compensation of the trochlea and with the facet [23]. Reider et al. [49] assessed the Q-angle with 50 patellofemoral disorder patients. In this study, chondromalacia patella patients presented with a Q-angle of 19°, subluxated patellar patients has a normal Q-angle of 17.1°, whilst patients who had a previous patellar dislocation had a Q-angle of 10°. This is in agreement with the findings from France and Nester's [18] study, which concluded that if the centre of the patella was 1 mm laterally displaced, the Q-angle would be reduced by 1.1°, and therefore, if a 5 mm lateral displacement existed, the Q-angle would be reduce by 5.2°; a potential clinically meaningful level. In agreement, Biedert and Warnke [3] suggested that high and low Q-angles should be considered abnormal and an aetiological factor of patellofemoral disorders, where high values indicate PFPS, and low values suggest patellar instability.

This systematic review has two potential weaknesses. First, non-English language articles were excluded, due to the costs of translation. This may have limited the scope of this review and its conclusions. Second, unpublished sources of data or "grey literature" were excluded by only including studies, which had been peer-reviewed, in an attempt to maintain quality. This however, allowed the potential for publication bias to impact on our findings [50, 56]. Finally, due to the poor documentation of Q-angle, in

addition to poor description of cohort characteristics between the groups, it was inappropriate to analyse the results of this systematic review using a formal meta-analysis. Furthermore, Egger et al. [14] recommended that meta-analysis should not be undertaken for studies with observational study designs; the methodology used in all the studies appraised.

## Conclusions

The findings of this review suggest that there is disagreement on the reliability and validity of the clinical Q-angle measurement. This may be due to the variability in measurement procedure. Further study is recommended to establish a standardised clinical Q-angle protocol, and then to assess the reliability and validity of this recruiting a clearly defined asymptomatic control and patellofemoral disorder cohort matched for confounding variables. Following this, surgeons and physiotherapists will then be able to determine whether the Q-angle is a suitable clinical measure to be used to assess PFPS and patellar instability patients. This will then also allow a more appropriate debate over the usefulness of this measurement for the evaluation of these complex musculoskeletal disorders.

**Acknowledgments** We thank Miss Kate Hulse for her assistance with the photographs used in this study.

## References

1. Ando T, Hirose H, Inoue M, Shino K, Doi T (1993) A new method using computed tomographic scan to measure the rectus femoris-patellar tendon Q-angle comparison with conventional method. *Clin Orthop Relat Res* 289:213–219
2. Arno SA (1990) The A-angle: a quantitative measurement of patella alignment and realignment. *J Orthop Sports Phys Therp* 12:237–242
3. Biedert RM, Warnke K (2001) Correlation between the Q angle and the patella position: a clinical and axial computed tomography evaluation. *Arch Orthop Trauma Surg* 121:346–349
4. Boden BP, Pearsall AW, Garrett WE Jr, Feagin JA Jr (1997) Patellofemoral instability: evaluation and management. *J Am Acad Orthop Surg* 5:47–57
5. Brindle TJ, Mattacola C, McCrory J (2003) Electromyographic changes in the gluteus medius during stair ascent and descent in subjects with anterior knee pain. *Knee Surg Sports Traumatol Arthrosc* 11:244–251
6. Brattström H (1964) Shape of the intercondylar groove normally and in recurrent dislocation of the patella. *Acta Orthop Scand* 68(Suppl):S1–S44
7. Brunet ME, Brinker MR, Cook SD, Christakis P, Fong B, Patron L, O'Connor DP (2003) Patellar tracking during simulated quadriceps contraction. *Clin Orthop Relat Res* 414:266–275
8. Brushhøj C, Hölmich P, Nielsen MB, Albrecht-Beste E (2008) Acute patellofemoral pain: aggravating activities, clinical examination, MRI and ultrasound findings. *Br J Sport Med* 42:64–67

9. CASP (2007) Critical Skills Appraisal Programme. Learning & Development Public Health Resource Unit. Available from: [http://www.phru.nhs.uk/casp/critical\\_appraisal\\_tools.htm](http://www.phru.nhs.uk/casp/critical_appraisal_tools.htm)
10. Caylor D, Fites R, Worrell TW (1993) The relationship between quadriceps angle and anterior knee pain syndrome. *J Orthop Sport Phys Ther* 17:11–16
11. Chester R, Smith TO, Sweeting D, Dixon J, Wood S, Song F (2008) The relative timing of VMO and VL in anterior knee pain: a systematic review and meta-analysis. *BMC Musculoskelet Disord* 9:64
12. Crossley KM, Bennell KL, Cowan SM, Green S (2004) Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? *Arch Phys Med Rehabil* 85:815–822
13. Donell S (2006) Patellofemoral dysfunction—extensor mechanisms malalignment. *Curr Orthop* 20:103–111
14. Egger M, Davey Smith G, Schneider M (2001) Systematic reviews of observational studies. In: Egger M, Davey Smith G, Altman DG (eds) *Systematic reviews in health care*. BMJ Books, London, pp 211–228
15. Emami MJ, Ghahramani MH, Abdinejad F, Namazi H (2007) Q-angle: an invaluable parameter for evaluation of anterior knee pain. *Arch Iran Med* 10:24–26
16. Evans R, Elwyn G, Edwards A (2004) Review of instruments for peer assessment of physicians *BMJ* 328:1240
17. Fairbank JC, Pynsent PB, van Poortvliet JA, Phillips H (1984) Mechanical factors in the incidence of knee pain in adolescents and young adults. *J Bone Joint Surg* 66-B:685–693
18. France L, Nester C (2001) Effect of errors in the identification of anatomical landmarks on the accuracy of Q angle values. *Clin Biomech* 16:710–713
19. Fredericson M, Yoon K (2006) Physical examination and patellofemoral pain syndrome. *Am J Phys Med Rehabil* 85:234–243
20. Fulkerson JP (1994) Patellofemoral pain disorders: evaluation and management. *J Am Acad Ortho Surg* 2:124–132
21. Fulkerson JP, Kalenak A, Rosenberg TD, Cox JS (1992) Patellofemoral pain. *Instr Course Lect* 41:57–71
22. Greene CC, Edwards TB, Wade MR, Carson EW (2001) Reliability of the Quadriceps angle measurement. *Am J Knee Surg* 14:97–103
23. Grelsamer RP (2000) Current Concept Review. Patellar Malalignment. *J Bone Joint Surg* 82-A:1639–1650
24. Grelsamer RP, Dubey A, Weinstein CH (2005) Men and women have similar Q angles: a clinical and trigonometric evaluation. *J Bone Joint Surg* 87:1498–1501
25. Grelsamer RP, Klein JR (1998) The biomechanics of the patellofemoral joint. *J Orthop Sport Phys Ther* 28:286–298
26. Grelsamer RP, Newton PM, Staron RB (1998) The medial-lateral position of the patella on routine magnetic resonance imaging: when is normal not normal? *Arthroscopy* 14:23–28
27. Guerra JP, Arnold MJ, Gajdosik RL (1994) Q-angle: effects of isometric quadriceps contraction and body position. *J Orthop Sport Phys Ther* 19:200–204
28. Herrington L (2006) The effect of corrective taping of the patella on patella position as defined by MRI. *Res Sport Med* 14:215–223
29. Herrington L, Nester C (2004) Q-angle undervalued? The relationship between Q-angle and medio-lateral position of the patella. *Clin Biomech* 19:1070–1073
30. Horton MG, Hall TL (1998) Quadriceps femoris muscle angle: normal values and relationships with gender and selected skeletal measures. *Phys Ther* 69:897–901
31. Hughston JC, Walsh WM, Puddu G (1984) Patellar subluxation and dislocation. Saunders Co, Philadelphia, pp 21–40
32. Insall J, Falvo KA, Wise DW (1976) Chondromalacia Patellae. A prospective study. *J Bone Joint Surg* 58-A:1–8
33. Landis JR, Kock GG (1977) The measurement of observer agreement for categorical data. *Biometrics* 33:159–174
34. Lee TQ, Morris G, Csintalan RP (2003) The influence of tibial and femoral rotation on patellofemoral contact area and pressure. *J Orthop Sport Phys Ther* 33:686–693
35. Livingston LA (1998) The Quadriceps angle: a review of the literature. *J Orthop Sport Phys Ther* 28:105–109
36. Livingston LA, Mandigo JL (1999) Bilateral Q angle asymmetry and anterior knee pain syndrome. *Clin Biomech* 14:7–13
37. Kannus P, Niittymaki S (1994) Which factors predict outcome in the nonoperative treatment of patellofemoral pain syndrome? A prospective follow-up study. *Med Sci Sports Exerc* 26:289–296
38. Karlsson J, Thomeé R, Swärd L (1996) Eleven year follow-up of patello-femoral pain syndrome. *Clin J Sport Med* 6:22–26
39. Kolowich PA, Paulos LE, Rosenberg TD, Farnsworth S (1990) Lateral release of the patella: indications and contraindications. *Am J Sports Med* 18:359–365
40. McConnell J (1986) The management of chondromalacia patellae: a long term solution. *Aust J Physiother* 32:215–223
41. Messier SP, Davis SE, Curl WW, Lowery RB, Pack RJ (1991) Etiologic factors associated with patellofemoral pain in runners. *Med Sci Sports Exerc* 23:1008–1015
42. Mizuno Y, Kumagai M, Mattessich SM, Eilas JJ, Ramrattan N, Cosgarea AJ, Chao EYS (2001) Q-angle influences tibiofemoral and patellofemoral kinematics. *J Orthop Res* 19:834–840
43. Nagamine R, Otani T, White SE, McCarthy D, Whiteside LA (1995) Patellar tracking measurement in the normal knee. *J Orthop Res* 13:115–122
44. Nissen CW, Cullen MC, Hewett TE, Noyes FR (1998) Physical and arthroscopic examination techniques of the patellofemoral joint. *J Orthop Sport Phys Ther* 28:277–285
45. Piva SR, Fitzgerald K, Irrgang JJ, Jones S, Hando BR, Browder DA, Childs JD (2006) Reliability of measures of impairments associated with patellofemoral pain syndrome. *BMC Musculoskelet Disord* 31:33
46. Polgar S, Thomas SA (2000) *Introduction to research in the health sciences*, 4th edn. Churchill Livingstone, London, pp 136–140
47. Powers CM (2003) The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical perspective. *J Orthop Sport Phys Ther* 33:639–646
48. Powers CM, Maffucci R, Hampton S (1995) Rearfoot posture in subjects with patellofemoral pain. *J Orthop Sports Phys Ther* 22:155–160
49. Reider B, Marshall JL, Warren RF (1981) Clinical characteristics of patellar disorders in young athletes. *Am J Sports Med* 9:270–274
50. Rothstein HR, Sutton AJ, Borenstein M (2005) Publication bias in meta-analysis. In: Rothstein HR, Sutton AJ, Borenstein M (eds) *Publication bias in meta-analysis. Prevention assessment and adjustment*. Wiley, Chichester, pp 1–7
51. Sanfridsson J, Arnbjörnsson A, Fridén T, Ryd L, Svahn G, Jonsson K (2001) Femorotibial rotation and the Q-angle related to the dislocating patella. *Acta Radiol* 42:218–224
52. Schulthies SS, Francis RS, Fisher AG, Van de Graaff KM (1995) Does the Q angle reflect the force on the patella in the frontal plane? *Phys Ther* 75:24–30
53. Sendur OF, Gurer G, Yildirim T, Ozturk E, Aydeniz A (2006) Relationship of Q angle and joint hypermobility and Q angle values in different positions. *Clin Rheumatol* 25:304–308
54. Shultz SJ, Nguyen AD, Windley TC, Kulas AS, Botic TL, Beynon BD (2006) Intratester and intertester reliability of clinical measures of lower extremity anatomic characteristics: implications for multicenter studies. *Clin J Sport Med* 16:155–161

55. Söbjerg TO, Lauritzen J, Hvid I, Boe S et al (1987) Arthroscopic determination of patellofemoral malalignment. *Clin Orthop* 215:243–247
56. Song F, Eastwood AJ, Gilbody S, Duley L, Sutton AJ (2000) Publication and related biases. *Health Technol Assess* 4:1–115
57. Thomeé R, Renström P, Karlsson J, Grimby G (1995) Patellofemoral pain syndrome in young women. I. A clinical analysis of alignment, pain parameters, common symptoms and functional activity level. *Scand J Med Sci Sports* 5:237–244
58. Tomsich DA, Nitz AJ, Thelkeld AJ, Shapiro R (1996) Patellofemoral alignment: reliability. *J Orthop Sport Phys Ther* 23:200–208
59. Tsujimoto K, Kurosaka M, Yoshiya S, Mizuno K (2000) Radiographic and computed tomographic analysis of the position of the tibial tubercle in recurrent dislocation and subluxation of the patella. *Am J Knee Surg* 13:83–88