




Clinical examination for athletes with inguinal-related groin pain: interexaminer reliability and prevalence of positive tests

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ABSTRACT

Objectives To evaluate the interexaminer reliability of abdominal palpation and resistance tests in athletes with longstanding groin pain, and to identify the prevalence of positive clinical tests in athletes classified with inguinal-related groin pain.

Methods Male athletes (18–40 years) with longstanding groin pain were prospectively recruited between March 2019 and October 2020 at a sports medicine hospital. Two examiners performed history taking and standardised clinical examination (including abdominal palpation, scrotal invagination and abdominal resistance tests) blinded to each other's findings. Interexaminer reliability was calculated using Cohen's Kappa statistic (κ). Examiners classified groin pain using the Doha agreement meeting terminology. A differentiation was made between 'defined inguinal-related groin pain' (according to recommended definition criteria) and 'likely inguinal-related groin pain' (expert-based application of the Doha agreement classification when not all recommended criteria were present).

Results Overall, 44 athletes were included (61 symptomatic sides). Interexaminer reliability of inguinal palpation pain provocation tests varied from fair to moderate ($\kappa=0.35$ – 0.49). Reliability of posterior wall structure palpation (firm/soft) was slight ($\kappa=0.01$), and posterior wall bulging (yes/no) fair ($\kappa=0.29$). Reliability for abdominal resistance tests varied from fair to substantial ($\kappa=0.35$ – 0.72). In athletes classified with defined inguinal-related groin pain, recognisable injury pain on palpation during scrotal invagination when athletes performed a Valsalva manoeuvre was the most prevalent positive palpation test (79%). Abdominal resistance tests were positive in 21%–49% of these cases.

Conclusion The interexaminer reliability for clinical examination tests used to classify inguinal-related groin pain in athletes varies from slight to substantial. There is no single perfect clinical examination test.

Trial registration number NCT03842826.

INTRODUCTION

Groin pain in the inguinal region without an inguinal hernia is a common diagnostic and therapeutic challenge in sports medicine.¹ Unclear aetiology and heterogenous terminology, such as sports(man)'s hernia,

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The classification of inguinal-related groin pain is based on injury history and clinical examination findings (palpation/resistance test pain). Scientific support for any specific clinical examination test is limited.

WHAT THIS STUDY ADDS

⇒ This is the first study evaluating the interexaminer reliability of commonly performed abdominal palpation and resistance tests for classifying inguinal-related groin pain in athletes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ There is no single perfect test for classifying athletes with inguinal-related groin pain.
 ⇒ After history taking, we recommend performing abdominal palpation including scrotal invagination, and abdominal resistance as pain provocation tests to obtain a complete overview of all potentially relevant clinical examination findings.
 ⇒ Further research is needed to evaluate if specific clinical examination findings influence management (conservative and/or surgical) or prognosis.

Gilmore's groin and incipient hernia, cause confusion.^{2,3} Two consensus meetings, the Doha agreement meeting (involving groin pain experts from multiple disciplines)⁴ and the British Hernia Society's meeting (involving primarily general surgeons),⁵ addressed the terminology and proposed the terms inguinal-related groin pain⁴ and inguinal disruption,⁵ respectively. A recent e-survey found that the term inguinal-related groin pain is most often used by clinicians, and this term is used in our study.⁶

Classifying inguinal-related groin pain is done using history and clinical examination findings. The main symptom is activity-related pain in the inguinal canal region and also recognisable pain on palpation of the inguinal canal.⁴ It is more likely when symptoms are aggravated by resisted abdominal testing, during Valsalva, coughing or sneezing.



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Despite the importance of clinical examination in classifying inguinal-related groin pain, the reliability of these physical tests is unknown. It is also unknown how often athletes with inguinal-related groin pain report recognisable injury pain during each specific clinical examination test. For example, the Doha agreement classification states that inguinal-related groin pain is more likely when symptoms are aggravated with resisted abdominal testing, but this has never been quantified.

The primary aim of our study was to evaluate the interexaminer reliability of abdominal palpation and resistance tests for classifying inguinal-related groin pain in athletes with longstanding groin pain. The secondary aim was to identify the prevalence of positive clinical tests in athletes with inguinal-related groin pain.

METHODS

This study was part of a larger interexaminer reliability study on clinical examination findings in athletes with longstanding groin pain and was registered on ClinicalTrials.gov (NCT03842826) prior to participant inclusion. Some participants in this study were also part of a previous study⁷ examining the interexaminer reliability of the Doha agreement meeting classification system (ClinicalTrials.gov: NCT03590145).

Protocol deviation

We deviated from the original protocol for the secondary aim. We additionally differentiated inguinal-related groin pain as: (1) 'defined inguinal-related groin pain' (according to the recommended definition criteria⁴) and (2) 'likely inguinal-related groin pain' (expert-based application of the Doha agreement classification when not all recommended criteria were present). This was done to ensure a more complete and transparent reporting of the findings.

Setting

The study was performed at Aspetar Orthopaedic and Sports Medicine Hospital in Doha, Qatar.

Participants

Participants were prospectively assessed for eligibility between March 2019 and October 2020 if they were: (1) a male athlete (performing sports ≥ 1 time/week), (2) 18–40 years old and (3) experiencing sports-related groin pain of ≥ 4 weeks duration. Exclusion criteria were: (1) prior assessment/treatment by one of the two examiners (< 6 months) for the same complaint, (2) any prior surgery in the hip and groin area, (3) clinical signs of prostatitis or urinary tract infections, (4) more than 7 days between the two examiners assessment.

Procedures

A general surgeon (ZV, 24 years of clinical experience) and a physiotherapist (AS, 11 years of clinical experience) with specific clinical interest/experience in groin injuries performed a standardised clinical examination (online supplemental appendix A). Both examiners were

trained in the standardised clinical examination by the same orthopaedic surgeon (PH, with > 35 years of clinical experience) specialised in groin injuries. Additionally, 10 practice sessions were performed to make sure both examiners performed the clinical examination tests in a comparable way. Both examiners were blinded to any imaging findings. Study participants were instructed not to share any information from the first examination with the second examiner. The order of examiners was decided by the clinic from which the participant was recruited: if the participant was recruited in the general surgeon's clinic, the general surgeon performed the first clinical assessment. If the participant was recruited from a sports medicine clinic within the hospital, the physiotherapist performed the first clinical assessment. Both examiners performed a semistructured history taking prior to the clinical examination. Both examiners were blinded to each other's history taking, clinical examination findings and classifications.

Participant characteristics

Participant characteristics were registered and included age, weight, height, sport participation including level (elite, subelite, amateur) and frequency/duration, and a detailed injury history. Additionally, participant-reported function was registered using two validated questionnaires: (1) the Copenhagen Hip and Groin Outcome Score (HAGOS)⁸ and (2) the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire modified to focus on groin problems only.⁹ The HAGOS is a valid Patient-Reported Outcome Questionnaire with six separate subscales: for the assessment of symptoms, activity limitations, participation restrictions and QOL in physically active, young to middle-aged patients with longstanding hip and/or groin pain.⁸ Each subscale is scored from 0 to 100, where 100 indicates no hip and/or groin symptoms and 0 indicates extreme symptoms. The OSTRC overuse injury questionnaire is a validated 4-item questionnaire for monitoring acute injuries, overuse injuries and/or illness in elite athletes. A severity score (0–100) is then derived with 0 indicating no problems and 100 maximum problems.⁹ Both questionnaires were available in English or Arabic, based on athlete preference.

Standardised clinical examination

The standardised clinical examination of the inguinal area consisted of palpation tests of the lower abdominal/inguinal region (with and without scrotal invagination of the inguinal canal), and resisted abdominal testing (figure 1). These tests were part of a more extensive standardised clinical examination of the groin (online supplemental appendix A). Participants were instructed to report any pain during palpation or resisted abdominal tests (yes/no). They were then asked if this pain corresponded to their recognisable injury pain (yes/no). If the participant reported recognisable injury pain, a score on an 11-point Numeric Pain Rating Scale (NPRS)








Abdominal palpation tests:	
<p>Rectus abdominis muscle/insertion¹⁵ The rectus abdominis muscle is palpated slightly lateral to the umbilicus and followed distally to the pubic insertion. <i>Score: pain (yes/no)</i></p>	 <p>1a</p>
<p>Pubic tubercle (image 1a) Examiner palpates the lateral/craniolateral border of the pubic tubercle at the insertions of the inguinal ligament and conjoint tendon. <i>Score: pain (yes/no)</i></p>	 <p>1b</p>
<p>Inguinal ligament (image 1b) Examiner palpates the medial 0.5-3cm of the inguinal ligament. <i>Score: pain (yes/no)</i></p>	 <p>1c*</p>
<p>External ring (medial border) Examiner palpates the medial border of the external ring at the lateral border of the rectus abdominis (superolateral of the pubic tubercle). The examiner palpates an area of 0.5-3cm. <i>Score: pain (yes/no)</i></p>	<p>Palpation tests during scrotal invagination of the inguinal canal (image 1c):</p> <p>External ring Examiner inverts the scrotum with the index finger and palpates the external inguinal ring approximately 1 cm cranio-lateral to the pubic tubercle. <i>Score: size (L/M/S), and pain (yes/no)</i></p> <p>Conjoint tendon Examiner palpates the conjoint tendon during invagination of the inguinal canal, directly medial after passing the external inguinal ring. <i>Score: pain (yes/no)</i></p> <p>Posterior wall palpation Examiner palpates the posterior wall of the inguinal canal during invagination. <i>Score: structure (soft/firm)</i></p> <p>Bulging/Valsalva Examiner palpates the posterior wall and asks the participant to perform a Valsalva maneuver by inhaling deeply first and then to exhale forcefully against the backside of his hand. Pain is recorded and bulging scored positive if the examiner feels “ballooning” of the posterior wall during Valsalva. <i>Score: bulging (yes/no), and pain (yes/no)</i></p>
Abdominal resistance tests	
<p>Straight sit-up 0° hip flexion (Figure 1d) The participant performs a sit-up movement, lifting head and scapulae from the couch, while the examiner resists the movement by holding one arm on the participant’s knees and the other arm on the participant’s chest (isometric test). <i>Score: pain (yes/no)</i></p>	 <p>1d</p>
<p>Cross test 0° hip flexion (Figure 1e) The participant performs an oblique sit up where the opposite hip is simultaneously flexed with an extended knee. The examiner resists the movement by fixating the shoulder and the opposite hip just above the knee cap. This isometric test is also performed on the opposite side. <i>Score: pain (yes/no)</i></p>	 <p>1e</p>
<p>Straight sit-up 45° hip flexion¹⁵ (Figure 1f) The participant performs a sit-up movement, lifting head and scapulae from the couch, while the examiner resists the movement by holding one arm on the patient’s knees and the other arm on the patient’s chest (isometric test). <i>Score: pain (yes/no)</i></p>	 <p>1f</p>
<p>Oblique sit-up 45° hip flexion¹⁵ (Figure 1g) The participant performs an oblique sit up. The examiner resists the movement by fixating the shoulder and the opposite leg just above the knee cap. This isometric test is also performed on the opposite side. <i>Score: pain (yes/no)</i></p>	 <p>1g</p>

Figure 1 Summary of abdominal palpation and resistance tests performed as part of the standardised clinical examination protocol (online supplemental appendix A). Pain provocation tests were scored positive if the participant reported recognisable injury pain (in his inguinal area). L, large (> fingertip); M, medium (~fingertip); S, small (< fingertip). * Picture reproduced with permission from Serner *et al.*¹³

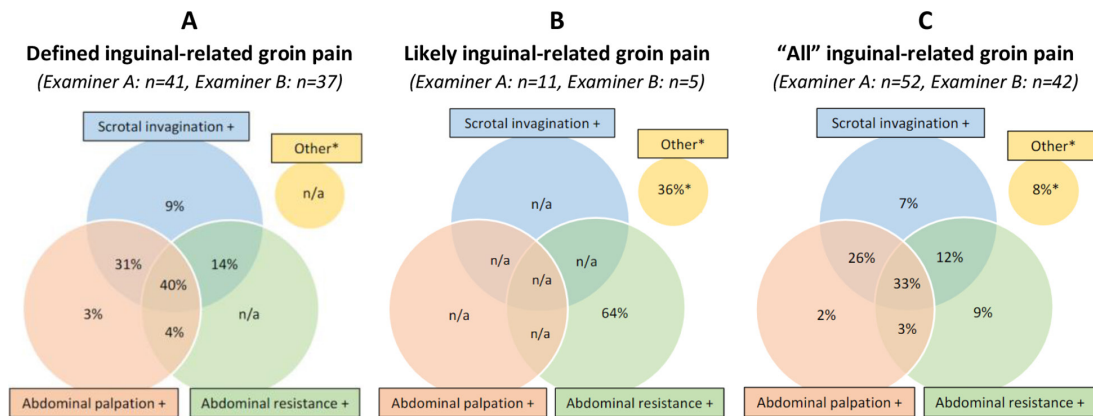


Figure 2 Associations between positive (+) clinical examination findings (recognisable injury pain) and; (A) Defined inguinal-related groin pain, (B) likely inguinal-related groin pain, (C) 'all' inguinal-related groin pain (inguinal-related groin pain+likely inguinal-related groin pain). *Classification was made based on history and/or other clinical examination findings, but with negative inguinal palpation or abdominal resistance tests. n/a, not applicable.

was elicited, where 0 indicated 'no (injury) pain' and 10 indicated 'worst possible pain'. All NPRS scores from 1 to 10 were registered as a positive test. When participants reported recognisable injury pain during resisted abdominal testing, an NPRS Score (0–10) and the participant reported pain location(s) were registered by the examiner as: adductor, iliopsoas, inguinal, pubic and/or other. An abdominal resistance test was scored positive if the participant reported recognisable injury pain in his inguinal area.

Clinical entity classification

Inguinal-related groin pain is defined in the Doha agreement meeting classification system as: pain in the inguinal canal region that worsened with exercise (history) and tenderness of the inguinal canal (clinical examination). Inguinal-related groin pain was also suggested to be more likely if the pain is aggravated during abdominal resistance testing or on Valsalva, cough or sneeze. An additional classification (likely inguinal-related groin pain) was used to include patients, not completely fulfilling the criteria of the Doha classification, although it was the overall impression by the experienced clinician that inguinal-related pain was a main factor in the patient's problem. The two separate classifications were:

1. Defined inguinal-related groin pain (according to the defined criteria).

Inguinal-related groin pain was classified based on the criteria defined in the Doha agreement meeting classification system⁴: As a minimum, the athlete had to report pain in the inguinal canal region that worsened with exercise, and recognisable tenderness (injury pain) of the inguinal canal during palpation (with or without scrotal invagination). This was determined by the specific findings reported by each examiner.

2. Likely inguinal-related groin pain.

As a minimum, the athlete had to report pain in the inguinal canal region that worsened with exercise. If recognisable tenderness was absent during palpation, and only history suggested inguinal-related groin pain

and/or other clinical examination tests (such as abdominal resistance testing) provoked recognisable injury pain in the inguinal canal region, the classification 'likely inguinal-related groin pain' could be made at the discretion of the examiner. This clinical decision also took the other findings from the complete examination into account.

Statistical plan

Participant characteristics were reported using descriptive statistics according to measurement scale and distribution. Reliability of clinical examination tests with a dichotomous outcome were analysed using Cohen's Kappa statistic (κ).¹⁰ Clinical examination tests for athletes with bilateral groin pain were analysed per side. The size of the inguinal external ring was analysed as an ordinal variable using linear weighted κ . Agreement was considered almost perfect if $\kappa=0.81$ – 1.00 , substantial $\kappa=0.61$ – 0.80 , moderate $\kappa=0.41$ – 0.60 , fair $\kappa=0.21$ – 0.40 , slight $\kappa=0$ – 0.20 and poor if $\kappa<0$.¹⁰ Additionally, the prevalence, prevalence index, overall agreement, positive agreement, negative agreement and bias index were calculated.^{11 12} The mean prevalence of positive clinical tests (ie, the average between both examiners) was calculated for defined and for likely inguinal-related groin pain.

Sample size calculation

A prevalence between 30% and 60% was expected for the main three clinical entities of groin pain (adductor-related, inguinal-related and iliopsoas-related) in our research population.¹ Assuming that approximately 4 out of every five tests (80%) targeting each entity were positive,^{13 14} we expected a prevalence of positive tests of approximately 24%–48% in the whole sample. With an expected Kappa of at least 0.8 with a 95% CI lower limit of 0.4, using a 2-tailed test and assuming no bias between examiners, at least 60 symptomatic sides were needed for this study.¹² No dropouts were expected due to the cross-sectional character of the study. We continued participant inclusions until we had at least 60 symptomatic sides.

Patient and/or public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Forty-four athletes with groin pain were included. Overall, 17 athletes reported bilateral symptoms, thus 61 symptomatic and 27 asymptomatic sides were examined by both examiners. **Table 1** presents the participants characteristics. One participant refused scrotal invagination during the second clinical examination. Some of the examination findings during scrotal invagination (conjoint tendon, bulging and posterior wall; **figure 1C**) were not assessable by one or both of the examiners (specified in **tables 2–3**), mainly because of a smaller external ring size.

Table 2 presents the reliability and agreement values of all abdominal pain provocation tests. The interexaminer reliability of inguinal palpation and abdominal resistance as pain provocation tests varied from fair to substantial ($\kappa=0.35$ – 0.72). The reliability of rectus abdominis palpation was slight to substantial depending on the location ($\kappa=0.17$ for the insertion, $\kappa=0.66$ for the muscle/tendon). Following the criteria for defined inguinal-related groin pain (pain in the inguinal canal region AND tenderness during palpation), examiner A classified inguinal-related groin pain in 41/61 (67%) symptomatic sides, and examiner B in 37/61 (61%) symptomatic sides. Examiner A classified ‘likely inguinal-related groin pain’ in 11/61 (18%) symptomatic sides and examiner B in 5/61 (8%) symptomatic sides. The interexaminer reliability of other clinical palpation findings during invagination of the inguinal canal not focusing on pain (external ring size, bulging and the posterior wall structure) was found slight to moderate ($\kappa=0.01$ – 0.56) (**table 3**).

Figure 2 presents the associations between positive clinical examination findings (mean prevalence between the two examiners) and ‘defined’, ‘likely’ and ‘all’ (‘defined’+‘likely’) inguinal-related groin pain. **Figure 3** presents the mean prevalence of palpation pain locations in athletes classified with ‘defined inguinal-related groin pain’. Online supplemental appendix B presents overviews of: (1) participant reported pain locations during abdominal resistance tests, (2) participant reported pain during palpation tests that was not related to the groin pain experienced during sports (as reported by the athlete) and (3) the mean prevalence of positive clinical examination tests in athletes classified with ‘all’ (defined+likely) inguinal-related groin pain.

DISCUSSION

This is the first study evaluating the interexaminer reliability of commonly performed abdominal palpation and resistance tests for classifying inguinal-related groin pain in athletes. The interexaminer reliability of palpation pain provocation tests varied from fair to moderate ($\kappa=0.35$ – 0.49). The reliability of posterior wall structure

Table 1 Participant characteristics (n=44)

Age, y	28.5±5.7
Weight, kg	76.1±11.3
Height, cm	176.1±8.5
Main sports	
Soccer	31 (70%)
Fitness/running	3 (7%)
Futsal	3 (7%)
Running	3 (7%)
Basketball	1 (2%)
Swimming	1 (2%)
Body building	1 (2%)
Volleyball	1 (2%)
Level	
Elite	16 (36%)
Subelite	8 (18%)
Amateur	20 (45%)
Onset of injury	
Sudden	12 (27%)
Gradual	32 (73%)
Duration of symptoms, months	4.5 (2–9)
Pain on cough/sneeze, yes	16 (36%)
Time between examinations	
0 days	29 (66%)
1–2 days	6 (14%)
3–5 days	7 (16%)
6–7 days	2 (5%)
HAGOS	
Symptoms (0–100)	61 (50–79)
Pain (0–100)	73 (59–80)
ADL (0–100)	70 (60–85)
Sport/rec (0–100)	53 (35–72)
PA (0–100)	50 (25–63)
QOL (0–100)	45 (35–60)
OSTRC	
Participation (0–25)	17 (17–25)
Volume (0–25)	19 (13–25)
Performance (0–25)	13 (11–25)
QOL (0–25)	17 (17–25)
Severity score (0–100)	66 (50–92)

Data reported as mean ± SD, median (IQR), number (%). For the HAGOS, a score of 100 indicates no symptoms and a score of 0 indicates extreme symptoms. For the severity score of the OSTRC, this scoring is inverse. ADL, activities of daily living; HAGOS, Hip and Groin Outcome Score; OSTRC, Oslo Sports Trauma Research Centre; PA, participation in physical activities; QOL, quality of life; Sports/rec, function in sport and recreation.

palpation was slight ($\kappa=0.01$), posterior wall bulging fair ($\kappa=0.29$) and external ring size moderate ($\kappa=0.56$). The interexaminer reliability for abdominal resistance tests

Table 2 Interexaminer reliability of abdominal pain provocation tests including palpation and resistance (n=61)

	Kappa (95% CI)	Kappa interpretation	Overall agreement	Positive agreement	Negative agreement	Bias index	Prevalence (PI)	Mean prevalence of positive tests in IRGP*
Abdominal palpation pain								
Pubic tubercle	0.41 (0.18 to 0.64)	Moderate	71%	68%	73%	0.10	46% (-0.08)	66%
Inguinal ligament	0.39 (0.16 to 0.62)	Fair	69%	62%	74%	0.25	40% (-0.20)	58%
External ring (medial border)	0.49 (0.26 to 0.72)	Moderate	75%	68%	80%	0.11	39% (-0.23)	59%
External ring*	0.35 (0.10 to 0.61)	Fair	70%	59%	76%	0.03	37% (-0.27)	55%
Conjoint tendon*	0.42 (0.18 to 0.65)	Moderate	70%	62%	75%	0.26	39% (-0.21)	54%
Posterior wall (during Valsalva)*	0.40 (0.17 to 0.64)	Fair	70%	73%	67%	0.13	55% (0.10)	79%
Any inguinal palpation pain without invagination†	0.61 (0.41 to 0.81)	Substantial	80%	81%	80%	0.07	51% (0.02)	77%
Any inguinal palpation pain during invagination‡	0.54 (0.31 to 0.76)	Moderate	78%	83%	70%	0.12	64% (0.28)	94%
Any inguinal palpation pain without or during invagination*	0.65 (0.44 to 0.87)	Substantial	85%	89%	76%	0.08	69% (0.38)	100%
Rectus abdominis insertion	0.17 (-0.16 to 0.50)	Slight	71%	36%	81%	0.07	23% (-0.54)	-
Rectus abdominis muscle/tendon	0.66 (0.37 to 0.95)	Substantial	92%	71%	95%	0.02	14% (0.72)	-
Abdominal resistance pain								
Straight sit-up 0°	0.63 (0.39 to 0.87)	Substantial	87%	71%	92%	0.03	23% (-0.54)	30%
Cross test 0° –shoulder affected side	0.67 (0.44 to 0.91)	Substantial	89%	74%	93%	0.08	22% (-0.56)	27%
Cross test 0° –shoulder contralateral side§	0.61 (0.40 to 0.82)	Substantial	82%	76%	86%	-0.02	37% (-0.26)	49%
Straight sit-up 45°	0.72 (0.52 to 0.92)	Substantial	89%	80%	92%	0.02	29% (-0.43)	38%
Oblique sit-up 45° –shoulder affected side	0.35 (-0.03 to 0.73)	Fair	84%	44%	90%	-0.03	15% (-0.70)	21%
Oblique sit-up 45° –shoulder contralateral side§	0.56 (0.32 to 0.80)	Moderate	82%	69%	87%	-0.08	29% (-0.43)	39%
Pain during any abdominal resistance test	0.54 (0.32 to 0.75)	Moderate	77%	74%	79%	0.03	44% (-0.11)	58%

*1 participant with unilateral groin pain refused a second inguinal invagination and was therefore excluded from this specific analyses. The conjoint tendon (three sides) and posterior wall (one side) were not assessable during scrotal invagination by at least one of the examiners.

†If any of the above three tests (pubic tubercle, inguinal ligament, external ring (medial border)) were scored positive.

‡If any of the above three tests (external ring, conjoint tendon during invagination, posterior wall) were scored positive.

§Pain reported on the contralateral side (eg, patient reported recognisable injury pain in the left inguinal canal region during an oblique sit-up with resistance on the right shoulder).

IRGP, inguinal-related groin pain according to the defined clinical entity; PI, prevalence index.

Table 3 Interrater reliability of clinical findings during invagination of the inguinal canal (n=88)

Inguinal palpation	Kappa (95% CI)	Kappa interpretation	OA	PA	NA	Bias index	Prevalence (PI)	Mean prevalence in defined IRGP*	Mean prevalence in non-IRGP†
External ring size (S/M/L) (n=86)‡	0.56 (0.43 to 0.70)	Moderate	70%	**	**	**	**	S: 15% M: 18% L: 67%	S: 14% M: 30% L: 56%
Bulging (y/n) (n=67)§	0.29 (0.05 to 0.52)	Fair	64%	64%	65%	0.06	49% (-0.01)	Yes: 54% No: 31% n/a: 15%	Yes: 26% No: 57% n/a: 18%
Posterior wall structure (firm/soft) (n=59)¶	0.01 (-0.38 to 0.40)	Slight	70%	18%	81%	-0.10	19% (-0.63)	Soft: 68% Firm: 10% n/a: 22%	Soft: 54% Firm: 24% n/a: 23%

*Based on the average prevalence in defined inguinal-related groin pain between examiner A (n=41) and B (n=37).

†Based on the average prevalence in non-inguinal-related groin pain (ie no likely or defined inguinal-related groin pain classified by the examiner OR fully asymptomatic side) between examiner A (n=36) and B (n=44). One participant refused inguinal examination of the second examiner and no classification was made for this participant by examiner B. Cases classified with likely inguinal-related groin pain were not separately described due to the small sample size.

‡1 Participant refused inguinal examination of the second examiner.

§1 Participant refused inguinal examination of the second examiner, 19 inguinal canals were not assessable for bulging by at least one of the examiners.

¶1 Participant refused inguinal examination of the second examiner, 27 inguinal canals were not assessable for posterior wall structure by at least one of the examiners.

**, Not applicable ; IRGP, inguinal-related groin pain; L, large (>fingertip); M, medium (~fingertip); NA, negative agreement; n/a, not assessable by the examiner; OA, overall agreement; PA, positive agreement; PI, prevalence index; S, small (< fingertip).

varied from fair to substantial ($\kappa=0.35\text{--}0.72$). Abdominal resistance tests were positive in 21%–49% of athletes classified with defined inguinal-related groin pain.

No previous studies have been published on the interexaminer reliability of clinical examination tests to classify inguinal-related groin pain, or the presence of an inguinal hernia. Only one study¹⁵ investigated the reliability of rectus abdominis palpation and resistance tests. This study included nine athletes with and nine athletes without groin pain who were assessed by

four blinded examiners. The interexaminer reliability values for abdominal resistance tests found in that study ($\kappa=0.41\text{--}0.57$) are in line with our findings ($\kappa=0.35\text{--}0.72$). Contrarily, rectus abdominis palpation as pain provocation test was found less reliable in our study: $\kappa=0.17\text{--}0.66$ compared with $\kappa=0.83$ reported by Holmich.¹⁵ The wide confidence intervals around the kappa values for rectus abdominis palpations tests in our study indicate a higher uncertainty around our estimated reliability. Additionally, the prevalence index in our study was relatively high

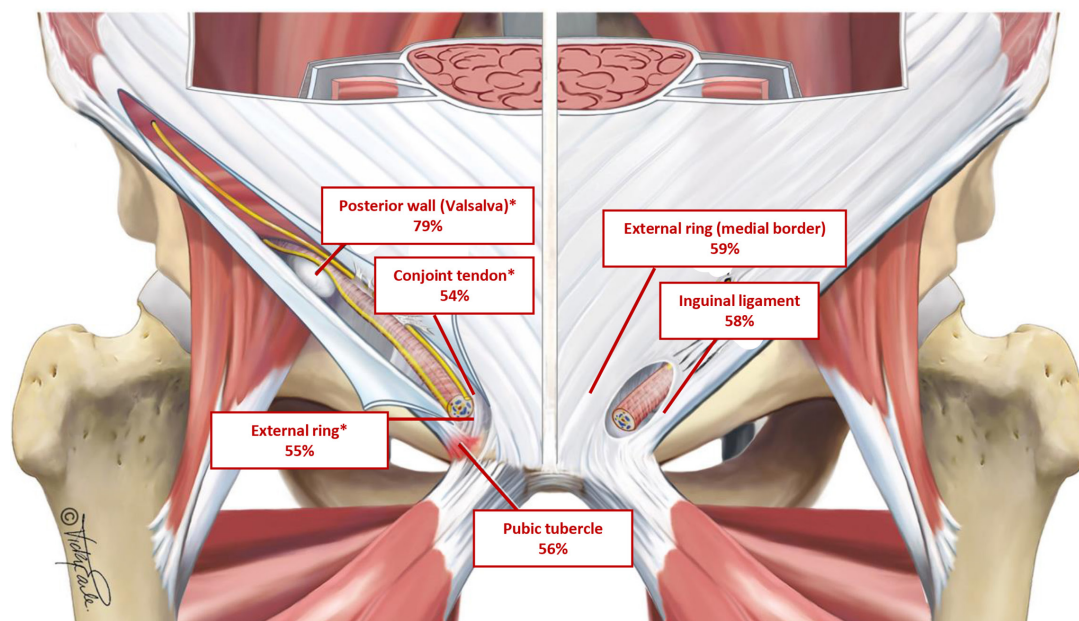


Figure 3 Mean prevalence of palpation pain locations in athletes classified with defined inguinal-related groin pain (examiner A: n=41, examiner B: n=37). *Palpation test performed on scrotal invagination. Picture modified with permission from Vuckovic et al.³

(-0.54 and 0.72), which increases chance agreement and reduces the kappa accordingly.¹² Pain provocation tests reproducing recognisable injury pain in the rectus abdominis area are categorised as 'other causes for groin pain' and not as inguinal-related groin pain according to the Doha agreement meeting classification system.⁴

An additional potential explanation for the slight reliability of the rectus abdominis insertion ($\kappa=0.17$) is the close proximity of the pubic symphysis. Pubic-related groin pain is classified when athletes report recognisable injury pain during palpation of the pubic symphysis and the directly adjacent bone.⁴ It can be challenging for clinicians (and patients) to determine if recognisable injury pain originates from pubic symphysis, the distal rectus abdominis, or both. It should also be noted that the distal rectus abdominis insertion comprises an external tendon (attaching cranially on the pubic bone) and an internal tendon (interlaced with the contralateral tendon, anterior of the pubic symphysis), and that the palpation in our study was focused on the external tendon insertion only.¹⁶ The proximity of these structures may cause confusion in the classification/diagnosis.

There is no consensus on what level of reliability is needed before recommending a test in clinical practice. Interexaminer reliability values of widely used musculoskeletal clinical examination tests vary a lot. For example: kappa values for classifying subacromial pain syndrome ($\kappa=0.10-1.00$),¹⁷ medial tibial stress syndrome or concurrent lower leg injury ($\kappa=0.73-0.89$),¹⁸ or sacroiliac joint, disc and facet joint pain ($\kappa<0.20$) vary from poor to perfect reliability. Using a combination of clinical examination tests is recommended by the Dutch guideline for the diagnosis and treatment of subacromial pain syndrome to improve the diagnostic accuracy based on level 2 evidence.¹⁹ In our study, the interexaminer reliability of the individual inguinal palpation pain provocation tests was fair to moderate ($\kappa=0.35-0.49$), while for the clustered palpation tests (ie, 'any' inguinal palpation pain) moderate to substantial ($\kappa=0.54-0.65$). The interexaminer reliability of the majority of abdominal resistance tests was higher than those of the palpation tests.

In athletes classified with defined inguinal-related groin pain, palpation pain was almost always present during scrotal invagination (94%). Four out of every five of these athletes also reported pain during at least one of the transabdominal palpation tests. Scrotal invagination is not part of standard training for some musculoskeletal health professionals (such as physiotherapists). The combination of transabdominal palpation tests and abdominal resistance tests will be sufficient to classify ~90% of the cases with inguinal-related groin pain. Not performing scrotal invagination may lead to missing the classification in 1 in 10 cases (figure 2).

Abdominal resistance tests were positive in approximately half of the athletes classified with inguinal-related groin pain. The most prevalent positive abdominal resistance test (49%) was the cross-test with shoulder resistance

on the contralateral side and resisted hip flexion on the ipsilateral side. A recent study²⁰ investigated the diagnostic accuracy of four different clinical examination tests for the diagnosis of 'core muscle injury', which is a different term used for groin pain in the inguinal canal region.⁶ This study found a sensitivity of 100% and specificity of 3% for both a 'resisted cross-body sit up' test (which has similarities with the cross test in our study) and an adductor contracture test. These sensitivity values may be overestimated due to incorporation bias, since the index tests were part of the reference standard.

Overclassification, or overdiagnosis, may be a pitfall after performing clinical examination in the inguinal canal area. We found that several palpation tests caused pain that was not recognisable injury pain, according to the athletes (6%–24%). To prevent overdiagnosis and potentially unnecessary treatment, it is important to always ask the athlete if pain during palpation tests replicates the injury pain and to elicit the pain location during abdominal resistance tests. On the contrary, some athletes report recognisable injury pain in the inguinal canal region during sports and/or during abdominal resistance testing, but are pain free on inguinal palpation. According to the Doha agreement definitions, these cases would not be classified as inguinal-related groin pain. In our study, examiners could classify these cases as 'likely inguinal-related groin pain', to provide a full overview of potentially involved clinical examination findings in inguinal-related groin pain. Future research should investigate if the specific presence of palpation pain is required to guide prognosis and/or treatment.

There is no gold standard for the classification of inguinal-related groin pain, nor an accepted reference standard. We believe it would be inappropriate to analyse and report our data for diagnostic accuracy purposes (sensitivity, specificity etc). For clinical implications, however, we reported the mean prevalence of positive test findings in athletes classified with inguinal-related groin pain. When a test is highly prevalent (such as recognisable injury pain during scrotal invagination), it should be included as part of the diagnostic work-up for the target condition (inguinal-related groin pain). In these instances, a negative test can potentially assist in ruling out the target condition.

Imaging is regularly used as part of the diagnostic process in athletes with groin pain in the inguinal region. Ultrasound is often the imaging modality of choice in these instances.²¹ There is, however, no sound evidence that specific ultrasound findings can differentiate between athletes with and without inguinal-related groin pain.²² For example, posterior wall bulging on ultrasound is suggested to be related to the pathoetiology of 'posterior wall weakness',²³ but is also found commonly (~65%) in asymptomatic athletes.²² The interobserver reliability of assessing the posterior wall for bulging on ultrasound is unknown. Clinically, we found that bulging was present in 26% of sides without inguinal-related groin, and a soft posterior wall in 54% of these sides. The interexaminer

reliability adds uncertainty to this with $\kappa=0.29$ and $\kappa=0.01$, respectively. The unknown interexaminer or intraexaminer reliability of ultrasound findings and the presence of bulging and soft posterior walls without pain make interpretation complex. We recommend interpreting ultrasound findings with caution, and only using them as an adjunct to injury history and clinical examination findings, and not as a standalone diagnostic modality.

Our study showed that there is no single perfect test for classifying athletes with inguinal-related groin pain. Knowing the benefits and limitations of specific clinical examination tests can assist clinicians in their diagnostic work and ultimately in providing an optimal treatment plan. After history taking, we recommend performing abdominal palpation including scrotal invagination, and abdominal resistance as pain provocation tests to obtain a complete overview of all potentially relevant clinical examination findings. Further research is needed to evaluate if specific clinical examination findings influence management (conservative and/or surgical) or prognosis.

Limitations

This is the first study evaluating the interexaminer reliability of standardised clinical examination tests that clinicians use to classify athletes with inguinal-related groin pain. Our study has some limitations. First, the examiners were experienced clinicians that both worked in a specialised groin clinic and our results may therefore not be generalisable to less experienced clinicians. We tried to compensate for this by standardising and describing each test in detail (online supplemental appendix A), prior to commencement of our study. Second, there is no gold (reference) standard available for inguinal-related groin pain. For the overview of the prevalence of positive tests, examiners used the Doha agreement terminology, but were also allowed to classify likely inguinal-related groin pain when not all criteria were present. This approach potentially decreases the reproducibility due to a higher level of subjectivity. On the other hand, it might reflect clinical practice and increase external generalisability as not all diagnostic findings are always present during physical examination. Thirdly, the percentage of inguinal-related groin pain was higher than reported in the literature and probably reflects selection bias in a tertiary clinic with predominantly male athletes. Lastly, our study only included male athletes, which limits generalisability to female or transgender athletes. Inguinal-related groin pain is less prevalent in female athletes, potentially due to the different anatomy of the inguinal canal (the spermatic cord runs through the inguinal canal in men, while in women this is the round ligament of the uterus).

CONCLUSION

The interexaminer reliability for clinical examination tests used to classify inguinal-related groin pain in athletes varies from slight to substantial. There is no single perfect

clinical examination test. We recommend using full abdominal palpation, including scrotal invagination and abdominal resistance testing as pain provocation tests for classifying athletes with inguinal-related groin pain.

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