NICOLA C. CASARTELLI, PhD[1,2] • **NICOLA A. MAFFIULETTI,** PhD[1] • **ROMANA BRUNNER,** PT, MSc[1]
MARCEL BÜCHI, PT, BSc[3] • **RETO SUTTER,** MD[4,5] • **CHRISTIAN W. PFIRRMANN,** MD, MBA[4,5]
FLORIAN D. NAAL, MD[6] • **MICHAEL LEUNIG,** MD[6] • **MARIO BIZZINI,** PT, PhD[1]

Clinical Rating of Movement-Pattern Quality in Patients With Femoroacetabular Impingement Syndrome: A Methodological Study

STUDY DESIGN: Cross-sectional study.

OBJECTIVES: To evaluate intrarater and interrater agreement among physical therapists with different clinical experience in performing a visual rating of movement-pattern quality of patients with femoroacetabular impingement (FAI) syndrome using a semi-quantitative scale.

BACKGROUND: Visual rating of movement patterns in patients with FAI syndrome is of interest, because poor control of dynamic hip motion is frequently noted.

METHODS: A video camera was used to record the performance of 34 patients with FAI syndrome performing single-limb standing, squat, frontal lunge, hop lunge, bridge, and plank. Visual rating of movement, as recorded on video, was performed by a highly experienced, a moderately experienced, and a novice physical therapist on 2 occasions using a semi-quantitative scale. Hip abductor strength was assessed using dynamometry, and hip pain and function were assessed with a patient-reported questionnaire. Intrarater and interrater agreement among physical therapists was evaluated using Gwet's agreement coefficient 1. Construct validity was evaluated as the association between physical therapists' rating and patients' hip abductor strength, pain, and function.

RESULTS: Good intrarater and interrater agreement was observed in the highly experienced and moderately experienced physical therapists when rating single-limb standing, bridge, and plank. Poor to moderate intrarater and interrater agreement was found when they rated squat, frontal lunge, and hop lunge. Poor performers, as rated by the highly experienced physical therapist only, demonstrated lower hip abductor strength ($P<.05$), and similar hip pain and hip function compared to those of good performers.

CONCLUSION: Movement-pattern quality of patients with FAI syndrome should be rated by a highly experienced physical therapist. *J Orthop Sports Phys Ther 2018;48(4):260-269. doi:10.2519/jospt.2018.7840*

KEY WORDS: *agreement, femoroacetabular impingement, hip, movement control, validity, video*

Femoroacetabular impingement (FAI) syndrome is a pathomechanism of the hip joint that is mainly caused by abnormal morphology of the proximal femur and/or acetabulum (cam and pincer morphology, respectively), in combination with vigorous and repetitive hip motion.[11] The FAI pathomechanism may lead to chondrolabral lesions, hip pain, and functional deficits in young and active adults.[11] Moreover, the presence of cam morphology represents an important risk factor for the development of hip osteoarthritis.[1] The prevalence of cam morphology is around 25% in the general population, and increases to 55% in athletes.[10] Patients with FAI syndrome usually present with hip muscle weakness, especially of the hip abductors and flexors.[5,15] In addition, they frequently demonstrate movement-pattern alterations of the hip while performing weight-bearing functional tasks such as walking, squatting, and stair climbing,[8] which seem to be associated with strength deficits of the hip abductors.[5,19] Indeed, hip abductor weakness may lead to excessive femoral adduction, internal rotation, and foot pronation while performing single-limb weight-bearing activities.[19] It has been speculated that poor dynamic control of the hip joint may be a factor contributing to the exacerbation or even development of symptoms in patients with FAI syndrome.[4] Therefore, clinical movement-pattern evaluation of the hip and other

[1]Human Performance Lab, Schulthess Clinic, Zurich, Switzerland. [2]Laboratory of Exercise and Health, ETH Zurich, Zurich, Switzerland. [3]Department of Physical Therapy, Schulthess Clinic, Zurich, Switzerland. [4]Department of Radiology, Orthopaedic University Hospital Balgrist, Zurich, Switzerland. [5]Faculty of Medicine, University of Zurich, Zurich, Switzerland. [6]Department of Orthopaedic Surgery, Schulthess Clinic, Zurich, Switzerland. The study protocol was approved by the Ethics Committee of the Canton of Zurich, Switzerland. This research report included data collected in a larger study, which was registered at ClinicalTrials.gov (NCT02368483). The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article. Address correspondence to Dr Nicola C. Casartelli, Human Performance Lab, Schulthess Clinic, Lengghalde 2, 8008 Zurich, Switzerland. E-mail: nicola.casartelli@kws.ch

body segments may be a critical aspect of the assessment of patients with FAI syndrome, as it may contribute to the design of appropriate nonsurgical training interventions and monitor movement-pattern changes over time.

In clinical practice, movement patterns are usually assessed by observing the performance of functional tasks.[20] To standardize this process, semi-quantitative visual rating scales have been developed.[9,16,18] These scales require clinicians to observe patients while they are performing functional tasks and to rate movement control of the observed joint or body segments using 2 or more scoring options (eg, good and poor). Despite some level of standardization, factors such as the number of body segments to be evaluated and the clinical experience of raters may considerably influence the rating accuracy.[7,24] Whatman et al[24] proposed a semi-quantitative scale to visually evaluate movement-pattern quality of the whole body (overall rating) and several body segments (segmental rating), including the pelvis, which is of particular relevance for patients with FAI syndrome.[8] While a previous study in asymptomatic individuals demonstrated overall good intrarater and interrater agreement for this scale, further analysis has indicated that more experienced therapists show higher intrarater agreement.[24] Based on the elements evaluated by this scale,[24] the latter may be particularly relevant to rate movement-pattern quality of patients with FAI syndrome, who often demonstrate movement-control alterations.[3,8]

The primary aim of this study was to evaluate the intrarater and interrater agreement among physical therapists with different clinical experience in rating movement-pattern quality of patients with FAI syndrome using a semi-quantitative scale. The secondary aim was to evaluate the construct validity by examining the association between therapists' rating scores and patients' hip abductor strength, pain, and function.

METHODS

Patients

A convenience sample of 34 consecutive patients, aged between 18 and 35 years, with a diagnosis of FAI syndrome was included in the study (**TABLE 1**). Patients were all recruited during medical consultations in a private orthopaedic clinic to participate in a larger intervention study. The diagnosis of FAI syndrome was based on symptoms, clinical signs, and imaging findings.[12] Clinical examinations included performance of the flexion, adduction, internal rotation test[23] and measurements of hip flexion, internal rotation, and abduction range of motion.[17] Cam morphology (cam severity of 2 or greater based on a semi-quantitative scoring system proposed by Reichenbach et al[21]) and chondrolabral lesions (presence of acetabular labral tears and/or articular chondral damage) were assessed using magnetic resonance imaging arthrography. Pincer morphology (acetabular retroversion and/or coxa profunda) was assessed on anteroposterior pelvic radiographs. Patients were

TABLE 1 Patient Characteristics (n = 34)*

Characteristic	Value
Sex, n (%)	
Female	22 (65)
Male	12 (35)
Age, y	25 ± 5 (18-35)
Body mass, kg	68 ± 12 (52-103)
Height, cm	172 ± 9 (154-199)
Body mass index, kg/m^2	23 ± 4 (18-34)
Involved/most involved hip, n (%)	
Right	22 (65)
Left	12 (35)
Dominant side, n (%)	22 (65)
Nondominant side, n (%)	12 (35)
FADIR test, n (%)	
Positive	32 (94)
Negative	2 (6)
Range of motion, deg	
Hip flexion	103 ± 12 (81-129)
Hip internal rotation	24 ± 11 (6-49)
Hip abduction	35 ± 5 (23-46)
Imaging findings, n (%)	
Cam morphology	4 (12)
Pincer morphology	8 (23)
Combined morphology	22 (65)
Chondrolabral lesions, n (%)	30 (88)
No chondrolabral lesions, n (%)	4 (12)
Hip pain and function (0-100)	
Hip Outcome Score ADL	82 ± 14 (41-100)
Hip Outcome Score sport	68 ± 20 (9-94)
Sport activity level (0-8)	
Hip Sports Activity Scale	3 ± 2 (0-8)

Abbreviations: ADL, activities of daily living; FADIR, flexion,adduction, internal rotation.
**Values are mean ± SD (range) unless otherwise indicated.*

excluded if they had a history of previous hip surgery, any surgery to the lower extremities in the prior 6 months, hip dysplasia, hip osteoarthritis (Tönnis grade greater than 1), corticosteroid injections in the previous 3 months, body mass index greater than 35 kg/m^2, or significant cardiopulmonary diseases. Hip pain and function during activities of daily living (ADL) and sport were assessed using the Hip Outcome Score (HOS),[13] and the level of sport activity was assessed using the Hip Sports Activity Scale.[14] The protocol was approved by the Ethics Committee of the Canton of Zurich, Switzerland. All patients signed an informed-consent form before participating in the study.

Study Design

In this cross-sectional study, the quality of movement patterns of patients with FAI syndrome, while standing on the involved/most involved hip, was assessed during the performance of 6 functional tasks (single-limb standing, squat, frontal lunge, hop lunge, bridge, plank). Clinical rating was independently performed on 2 occasions (evaluation 1 and evaluation 2), with 6 weeks between evaluations, by 3 physical therapists using a semi-quantitative visual rating scale. The 3 physical therapists had different levels of clinical experience working with orthopaedic conditions: 29 years (highly experienced physical therapist), 6 years (moderately experienced physical therapist), and less than 1 year (novice physical therapist). Intrarater agreement was evaluated by comparing visual rating scores of each physical therapist between evaluation 1 and evaluation 2. Interrater agreement was evaluated by comparing visual rating scores between the 3 physical therapists at evaluation 1.

Construct validity was evaluated by comparing abductor strength of the involved/most involved hip, as well as patient-reported hip pain and function, between patients who had good versus poor scores as rated by physical therapists at evaluation 1. The levels of association between rating of movement quality and hip abductor strength, pain, and function were selected because hip abductor weakness and pain have been strongly related to pelvis and lower-limb movement-pattern alterations while performing weight-bearing functional tasks.[3,7,19]

Experimental Procedure

All patients performed the following functional tasks in fixed order (because no fatigue effect was expected) and were recorded on a Logitech C920 HD Pro webcam (Logitech, Lausanne, Switzerland): single-limb standing, squat, frontal lunge, hop lunge, bridge, and plank. All patients wore tight shorts and a T-shirt provided by the investigator. Patients were tested barefoot. They first received standardized instructions by the investigator on correct task execution (**TABLE 2**), followed by 1 or 2 familiarization trials. For each standing task (single-limb standing, squat, frontal lunge, hop lunge), the patients were asked to perform a total of 4 repetitions, 2 with the video camera frontal to the patient and 2 with the video camera lateral (squat, frontal lunge, hop lunge) or posterior to the patient (single-limb standing). For lying tasks (bridge, plank), patients were asked to perform a total of 3 repetitions, all performed with the video camera lateral to the patient.

Movement-Pattern Quality Evaluation

Prior to video evaluation, the 3 physical therapists met with the study coordinator to be instructed on the study protocol and rating scale. Good and poor movement-control quality ratings were discussed among physical therapists while watching videos of a patient with FAI syndrome who was not included in the study. The videos with the functional task performances of all patients were then provided to the physical therapists. Each physical therapist had to evaluate all patients, but the evaluation order was randomized using a random-number generator. For each therapist, the same order was main-

TABLE 2 Description of Functional Task Performance

Functional Task	Instructions
Single-limb standing	Starting position: standing upright on both limbs with arms hanging freely on the side of the body Movement: flex the knee of the contralateral side to 90° while standing on the tested limb, keeping the 2 thighs parallel to each other. Maintain the position for 5 seconds
Squat	Starting position: standing upright on the tested limb with the contralateral knee flexed to 90° and arms hanging freely on the side of the body Movement: squat until maximum ankle dorsiflexion without lifting the heel from the ground, keeping the trunk upright. Take 3 seconds to reach the end position and maintain it for 3 seconds
Frontal lunge	Starting position: standing upright on both limbs with arms hanging freely on the side of the body Movement: step forward with the tested limb (about 1.5 step length) and lunge until maximum ankle dorsiflexion without lifting the heel from the ground, keeping the trunk upright. Take 3 seconds to reach the end position
Hop lunge	Starting position: standing upright on both limbs with arms hanging freely on the side of the body Movement: jump forward (about 1.5 step length) with the contralateral limb, landing on the tested limb, and lunge until maximal ankle dorsiflexion without lifting the heel from the ground, keeping the trunk upright. Maintain the end position for 3 seconds
Bridge	Starting position: lying supine on a mat with knee flexed, keeping feet in full contact with the ground and arms lying on the side of the body Movement: first extend the hip to 0° to reach a bridging position, then fully extend the contralateral knee while standing on the tested limb, keeping the 2 thighs parallel to each other. Take 2 seconds to reach the end position and maintain it for 5 seconds
Plank	Starting position: lying prone on a mat with forearms and toes supporting the body, and shoulder joints being over elbow joints Movement: lift the contralateral limb off the ground to about 30 cm high. Take 2 seconds to reach the end position and maintain it for 5 seconds

tained at evaluations 1 and 2. Physical therapists were asked to evaluate single sets of videos on 3 different occasions (12 videos, 11 videos, 11 videos) within 1 week, so as to avoid cognitive fatigue. Physical therapists were allowed to watch single trials of patients only once at each evaluation time to avoid differences in evaluation times among physical therapists.

Physical therapists evaluated movement-pattern quality using 2 visual rating subscales proposed by Whatman et al[24]: overall and segmental ratings. For the overall rating, physical therapists were asked to evaluate the movement-pattern quality of the whole body, without discerning body segments. For the segmental rating, they were asked to evaluate movement-pattern quality of single body segments, that is, the trunk (movement out of neutral in the frontal and transverse planes), pelvis 1 (movement out of neutral in the frontal or transverse plane), pelvis 2 (movement away from midline), knee (movement out of line with second toe), foot (movement into excessive pronation), and observable oscillation (repetitive movement of any of the lower extremity segments to and from neutral). For the bridge and plank exercises, the knee and foot segments could not be evaluated. For both the overall and segmental ratings, scores ranged from 0 to 3, where 0 indicated "acceptable movement pattern," 1 "minor movement dysfunction," 2 "moderate movement dysfunction," and 3 "marked movement dysfunction." Because of the very low prevalence of scores 2 and 3 in this study, scores were analyzed using a dichotomous classification, where 0 indicated "good movement-pattern quality" and 1 "poor movement-pattern quality," which included the scores ranging from 1 to 3. This scale, using a dichotomous overall rating, demonstrated intrarater agreement of 87%, 80%, and 82% among highly experienced, moderately experienced, and novice physical therapists, respectively, when rating the movement-pattern quality of asymptomatic individuals. Similarly, intrarater agreement using this scale ranged between 74% and 88% for highly experienced, 66% and 84% for moderately experienced, and 70% and 82% for novice physical therapists, using a dichotomous segmental rating.[24] For each functional task, overall and segmental rating average scores, based on the evaluation of the 4 repetitions (standing tasks) or 3 repetitions (lying tasks), were used for analysis.

Hip Abductor Strength

Isometric hip abductor maximal voluntary contraction (MVC) strength was evaluated with stabilized dynamometry (Nicholas Manual Muscle Tester; Lafayette Instrument Company, Lafayette, IN).[5] Patients lay on their nontested side on a treatment table, with their tested hip at 0° of hip flexion, extension, and rotation, and at approximately 10° of abduction, with the knee fully extended. The contralateral hip and knee were flexed to 45° and 60°, respectively, to provide comfort and stabilization. Prior to hip abductor testing, the mass of the tested limb was measured by resting the limb on the dynamometer pad, positioned 5 cm proximal to the medial malleolus. Patients first completed 2 submaximal familiarization trials, followed by 3 or 4 MVC trials (a difference of no more than 10% between the 2 highest trials was allowed), during which they were asked to perform maximal efforts for 3 to 4 seconds, without regard to the rate of force development. The rest interval between trials was 60 seconds.[5] Standardized verbal encouragement was consistently provided by the investigator. Because the dynamometer measured force in kilograms, force was multiplied by the gravitational acceleration and lever-arm length (distance between the greater trochanter and 5 cm proximal to the lateral malleolus) to obtain torque in Newton meters. The highest MVC torque normalized to body mass was retained for analysis.

Hip Pain and Function

Hip pain and function were evaluated using the HOS.[13] The HOS is a self-reported questionnaire that has been specifically developed for young and active patients with hip conditions. Two independent scores were obtained: 1 for ADL (HOS ADL [19 items, 17 scored]) and 1 for sport activities (HOS sport [9 items, 9 scored]). The scores ranged from 0 to 100, with 100 indicating the best possible score.

Statistics

Descriptive data are presented as number and percentage or mean ± SD. Agreement and hip abductor strength, pain, and function results are presented as mean and the corresponding 95% confidence interval (CI). Percentage agreement and Gwet's agreement coefficient 1 (AC1) were calculated for the evaluation of intrarater and interrater agreement. Gwet's AC1 was recently shown to be more stable and less affected by prevalence and marginal probability than the Cohen kappa coefficient for agreement evaluation.[25] Intrarater and interrater agreement was interpreted according to the calculated Gwet's AC1 and based on the benchmarks provided by Altman[2]: 0.20 or less, poor; 0.21 to 0.40, fair; 0.41 to 0.60, moderate; 0.61 to 0.80, good; 0.81 to 1.00, very good. Good intrarater and interrater agreement was defined as the lower limit of the 95% CI of the Gwet's AC1 being greater than 0.60, indicating a 95% probability of at least good agreement within raters and between pairs of raters. Shapiro-Wilk tests were used to control for data normality, and unpaired t tests were used to evaluate differences in hip abductor strength, pain, and function between patients performing with good versus poor movement-pattern quality, based on overall rating and segmental ratings of pelvis 1 and pelvis 2. Percentage agreement and Gwet's AC1 were calculated using AgreeStat Version 2015.6 (Advanced Analytics, LLC, Gaithersburg, MD), and unpaired t tests were conducted using PASW Statistics Version 18.0 (IBM Corporation, Armonk, NY). The significance level was set at $P<.05$.

RESULTS

Movement-Pattern Quality

The percentages of patients performing with good movement-pattern quality as rated by physical therapists are provided in **TABLE 3** for overall and pelvis 1 and 2 segmental ratings (see **APPENDIX A** for remaining segmental ratings, available at www.jospt.org). Based on overall rating, the moderately experienced physical therapist generally judged more patients as good performers (82%) compared with the highly experienced and novice physical therapists (58% and 43%, respectively). Functional tasks were similarly ranked among physical therapists, with hop lunge, squat, and frontal lunge performed with good movement-pattern quality by fewer patients than single-limb standing, plank, and bridge.

Intrarater Agreement

Percent agreement and Gwet's AC1 are reported for all functional tasks, physical therapists, and overall and pelvis 1 and 2 segmental ratings in **TABLE 4** (see **APPENDIX B** for remaining segmental ratings, available at www.jospt.org). Good agreement was observed for the highly and moderately experienced physical therapists in overall rating of single-limb standing, bridge, and plank. For single-limb standing, poor to moderate segmental rating agreement was found in trunk and oscillation (highly experienced physical therapist) and pelvis 1 (moderately experienced physical therapist). For the bridge, poor to moderate segmental rating agreement was observed in pelvis 2 by both the highly and moderately experienced physical therapists. For plank, moderate segmental rating agreement was found in trunk and oscillation (highly experienced physical therapist) and pelvis 2 (both highly and moderately experienced physical therapists). In addition, good agreement was observed in the novice physical therapist for overall rating of squat and hop lunge.

TABLE 3 Percentage of Patients (n = 34) With FAI Syndrome Demonstrating Good Movement-Pattern Quality*

Functional Task	Highly Experienced	Moderately Experienced	Novice
Single-limb standing			
Overall rating	82	97	79
Segmental rating			
Pelvis 1	85	88	85
Pelvis 2	85	100	100
Squat			
Overall rating	15	65	12
Segmental rating			
Pelvis 1	15	47	26
Pelvis 2	18	88	59
Frontal lunge			
Overall rating	65	85	41
Segmental rating			
Pelvis 1	56	56	50
Pelvis 2	59	97	88
Hop lunge			
Overall rating	15	59	9
Segmental rating			
Pelvis 1	18	32	18
Pelvis 2	18	88	38
Bridge			
Overall rating	88	97	41
Segmental rating			
Pelvis 1	91	100	38
Pelvis 2	50	71	21
Plank			
Overall rating	82	91	74
Segmental rating			
Pelvis 1	88	85	74
Pelvis 2	47	68	50

Abbreviation: FAI, femoroacetabular impingement.
**Values are percent.*

Interrater Agreement

Percent agreement and Gwet's AC1 are reported for all functional tasks, pairs of physical therapists, and for overall and pelvis 1 and 2 segmental ratings in **TABLE 5** (see **APPENDIX C** for remaining segmental ratings, available at www.jospt.org). Good agreement was observed between the highly and moderately experienced physical therapists in the overall rating of single-limb standing, bridge, and plank. Poor segmental rating agreement was found between the highly and moderately experienced physical therapists in trunk and oscillation for single-limb standing, and in pelvis 2 for the bridge and plank. In addition, good agreement was observed between the highly experienced and novice physical therapists in overall rating of squat.

Construct Validity

Differences in hip abductor strength, HOS ADL score, and HOS sport score between patients performing with good and poor movement-pattern quality, as evaluated by the highly experienced therapist, are presented in **TABLE 6**. Based on the highly

experienced therapist, poor performers demonstrated significantly lower hip abductor strength than good performers using overall rating for all functional tasks, using segmental rating in pelvis 1 and pelvis 2 for squat, hop lunge, and bridge, and in pelvis 1 for frontal lunge ($P<.05$). Based on the moderately experienced therapist, poor performers had significantly lower hip abductor strength than good performers using segmental rating in pelvis 2 for bridge and in pelvis 1 for plank ($P<.05$; data not provided). Poor performers reported lower HOS ADL scores than good performers, as evaluated by the highly experienced physical therapist using overall rating for squat ($P<.001$) and by the moderately experienced physical therapist using segmental rating in pelvis 1 for single-limb standing ($P<.05$; data not provided). In contrast, no difference for any of the variables was found between good and poor performers when using the ratings from the novice therapist (data not provided).

DISCUSSION

Good intrarater agreement was found in the highly and moderately experienced physical therapists when rating single-limb standing, bridge, and plank, and for the novice physical therapist when rating squat and hop

TABLE 4 Intrarater Agreement of Movement-Pattern Quality Rating (n = 34)

	Percent Agreement			Gwet's AC1*		
Functional Task	Highly Experienced	Moderately Experienced	Novice	Highly Experienced	Moderately Experienced	Novice
Single-limb standing						
Overall rating	97	97	85	0.96 (0.88, 1.00)†	0.97 (0.91, 1.00)†	0.78 (0.57, 0.99)
Segmental rating						
Pelvis 1	94	79	79	0.92 (0.81, 1.00)†	0.72 (0.49, 0.95)	0.69 (0.44, 0.94)
Pelvis 2	88	100	100	0.85 (0.69, 1.00)†	1.00 (1.00, 1.00)†	1.00 (1.00, 1.00)†
Squat						
Overall rating	71	77	85	0.52 (0.21, 0.83)	0.54 (0.25, 0.84)	0.83 (0.67, 0.99)†
Segmental rating						
Pelvis 1	82	56	79	0.74 (0.51, 0.96)	0.23 (−0.15, 0.61)	0.69 (0.44, 0.94)
Pelvis 2	79	85	68	0.67 (0.41, 0.93)	0.83 (0.67, 0.99)†	0.37 (0.04, 0.70)
Frontal lunge						
Overall rating	82	79	82	0.71 (0.47, 0.95)	0.72 (0.49, 0.95)	0.65 (0.38, 0.91)
Segmental rating						
Pelvis 1	74	62	71	0.52 (0.21, 0.83)	0.24 (−0.10, 0.58)	0.41 (0.09, 0.73)
Pelvis 2	79	91	82	0.64 (0.37, 0.91)	0.90 (0.79, 1.00)†	0.78 (0.58, 0.97)
Hop lunge						
Overall rating	77	68	91	0.65 (0.39, 0.91)	0.36 (0.03, 0.69)	0.90 (0.79, 1.00)†
Segmental rating						
Pelvis 1	85	65	82	0.78 (0.57, 0.99)	0.42 (0.08, 0.76)	0.76 (0.56, 0.97)
Pelvis 2	88	91	65	0.83 (0.64, 1.00)†	0.90 (0.77, 1.00)†	0.35 (0.01, 0.70)
Bridge						
Overall rating	91	97	68	0.90 (0.77, 1.00)†	0.97 (0.90, 1.00)†	0.44 (0.10, 0.77)
Segmental rating						
Pelvis 1	91	91	79	0.90 (0.79, 1.00)†	0.90 (0.79, 1.00)†	0.62 (0.34, 0.89)
Pelvis 2	68	82	85	0.35 (0.03, 0.68)	0.68 (0.42, 0.93)	0.80 (0.61, 0.99)†
Plank						
Overall rating	88	97	77	0.84 (0.68, 1.00)†	0.96 (0.89, 1.00)†	0.55 (0.26, 0.85)
Segmental rating						
Pelvis 1	97	91	71	0.96 (0.89, 1.00)†	0.87 (0.72, 1.00)†	0.46 (0.14, 0.78)
Pelvis 2	88	88	79	0.77 (0.54, 0.99)	0.78 (0.57, 1.00)	0.60 (0.32, 0.88)

Abbreviation: AC1, agreement coefficient 1.
**Values in parentheses are 95% confidence interval.*
†The lower limit of the 95% confidence interval of Gwet's AC1 is greater than 0.60.

lunge. In addition, good interrater agreement was observed between the highly and moderately experienced physical therapists when rating patients while performing single-limb standing, bridge, and plank, and between the highly experienced and novice physical therapists when rating squat. Movement-pattern quality evaluated by the highly experienced physical therapist was strongly associated with hip abductor strength, but not with patient-reported hip pain and function.

To the best of our knowledge, this is the first study to evaluate the movement-pattern quality of patients with FAI syndrome during the performance of a large spectrum of functional tasks. These tasks correspond to activities frequently encountered by patients in their daily life and sport activities, and are routinely used in clinical practice.[22] Because the evaluation of movement-pattern quality using semi-quantitative scales seems to be influenced by the clinical experience of raters,[7,24] we compared clinical ratings between physical therapists with different levels of experience in orthopaedics (29 years versus 6 years versus less than 1 year).

TABLE 5 Interrater Agreement of Movement-Pattern Quality Rating (n = 34)

	Percent Agreement			Gwet's AC1*		
Functional Task	Highly Versus Moderately Experienced	Highly Experienced Versus Novice	Moderately Experienced Versus Novice	Highly Versus Moderately Experienced	Highly Experienced Versus Novice	Moderately Experienced Versus Novice
Single-limb standing						
Overall rating	85	79	77	0.82 (0.65, 0.99)†	0.70 (0.46, 0.94)	0.70 (0.47, 0.93)
Segmental rating						
Pelvis 1	85	94	85	0.81 (0.63, 0.99)†	0.92 (0.81, 1.00)†	0.81 (0.63, 0.99)†
Pelvis 2	85	85	100	0.83 (0.67, 0.99)†	0.83 (0.67, 0.99)†	1.00 (1.00, 1.00)†
Squat						
Overall rating	44	85	47	−0.07 (−0.45, 0.31)	0.81 (0.63, 0.99)†	0.00 (−0.38, 0.38)
Segmental rating						
Pelvis 1	44	77	62	0.03 (−0.38, 0.43)	0.65 (0.39, 0.91)	0.29 (−0.07, 0.64)
Pelvis 2	29	47	71	−0.41 (−0.73, −0.08)	0.00 (−0.38, 0.38)	0.52 (0.21, 0.83)
Frontal lunge						
Overall rating	74	71	56	0.58 (0.29, 0.87)	0.41 (0.10, 0.73)	0.18 (−0.20, 0.55)
Segmental rating						
Pelvis 1	71	82	65	0.42 (0.10, 0.74)	0.65 (0.38, 0.91)	0.30 (−0.04, 0.63)
Pelvis 2	62	65	85	0.42 (0.08, 0.76)	0.42 (0.08, 0.76)	0.83 (0.67, 0.99)†
Hop lunge						
Overall rating	56	77	44	0.18 (−0.20, 0.55)	0.70 (0.47, 0.93)	−0.01 (−0.41, 0.39)
Segmental rating						
Pelvis 1	56	71	68	0.30 (−0.08, 0.67)	0.59 (0.30, 0.87)	0.48 (0.16, 0.80)
Pelvis 2	29	68	50	−0.41 (−0.73, −0.08)	0.46 (0.13, 0.79)	0.07 (−0.32, 0.45)
Bridge						
Overall rating	91	53	44	0.90 (0.77, 1.00)†	0.13 (−0.25, 0.51)	0.03 (−0.38, 0.43)
Segmental rating						
Pelvis 1	91	41	38	0.90 (0.79, 1.00)†	−0.08 (−0.48, 0.32)	−0.08 (−0.50, 0.34)
Pelvis 2	68	71	50	0.38 (0.05, 0.71)	0.46 (0.14, 0.78)	0.01 (−0.35, 0.36)
Plank						
Overall rating	91	85	82	0.89 (0.75, 1.00)†	0.78 (0.57, 0.99)	0.75 (0.54, 0.97)
Segmental rating						
Pelvis 1	91	85	82	0.89 (0.75, 1.00)†	0.79 (0.59, 0.99)	0.74 (0.51, 0.96)
Pelvis 2	74	68	71	0.48 (0.17, 0.79)	0.35 (0.03, 0.68)	0.43 (0.11, 0.75)

Abbreviation: AC1, agreement coefficient 1.
**Values in parentheses are 95% confidence interval.*
†The lower limit of the 95% confidence interval of Gwet's AC1 is greater than 0.60.

A limitation of this study was that it only included 1 physical therapist for each level of clinical experience, limiting the generalizability of the results. In addition, clinical ratings of physical therapists were neither compared with a gold standard (eg, body kinematics) nor with ratings of a consensus panel to test their concurrent validity. Another limitation, which contrasts with clinical practice, is that movement was observed from video recordings, providing only 1 or 2 views for each functional task.

The results of this study suggest that the clinical experience of physical therapists influences the accuracy of movement-pattern quality rating, and that it should be considered when semi-quantitative scales are used, especially for research purposes.[7] Clinical rating of patients with FAI syndrome while performing simple functional tasks (bridges, planks, and single-limb standing) can be implemented with confidence using a semi-quantitative scale for evaluating movement-pattern quality changes over time and between raters, when

TABLE 6 Construct Validity of Movement-Pattern Quality as Rated by the Highly Experienced Physical Therapist*

	Hip Abductor Strength, Nm/kg			Hip Outcome Score ADL (0-100)			Hip Outcome Score Sport (0-100)		
Functional Task (Good Performers)	**Good Performers**	**Poor Performers**	**Mean Difference†**	**Good Performers**	**Poor Performers**	**Mean Difference†**	**Good Performers**	**Poor Performers**	**Mean Difference†**
Single-limb standing									
Overall rating (n = 28)	1.86 ± 0.40	1.37 ± 0.43	0.49 (0.12, 0.86)‡	82 ± 14	81 ± 12	1 (−11, 14)	67 ± 21	70 ± 20	−3 (−22, 16)
Segmental rating									
Pelvis 1 (n = 29)	1.82 ± 0.42	1.49 ± 0.50	0.33 (−0.10, 0.76)	83 ± 14	80 ± 8	3 (−10, 16)	67 ± 22	73 ± 10	−5 (−26, 15)
Pelvis 2 (n = 29)	1.82 ± 0.42	1.49 ± 0.50	0.33 (−0.10, 0.76)	83 ± 14	80 ± 8	3 (−10, 16)	67 ± 22	73 ± 10	−5 (−26, 15)
Squat									
Overall rating (n = 5)	2.19 ± 0.40	1.70 ± 0.42	0.49 (0.08, 0.89)‡	93 ± 2	80 ± 14	13 (7, 18)§	82 ± 3	65 ± 21	17 (−3, 36)
Segmental rating									
Pelvis 1 (n = 5)	2.26 ± 0.32	1.69 ± 0.41	0.57 (0.17, 0.96)‖	82 ± 21	82 ± 12	0 (−14, 13)	63 ± 26	69 ± 20	−6 (−26, 14)
Pelvis 2 (n = 6)	2.19 ± 0.34	1.69 ± 0.42	0.50 (0.13, 0.87)‡	84 ± 20	82 ± 12	2 (−10, 15)	67 ± 25	68 ± 20	−1 (−20, 17)
Frontal lunge									
Overall rating (n = 22)	1.91 ± 0.42	1.53 ± 0.39	0.38 (0.09, 0.68)‡	84 ± 12	79 ± 16	5 (−5, 15)	71 ± 19	63 ± 23	8 (−7, 23)
Segmental rating									
Pelvis 1 (n = 19)	1.91 ± 0.36	1.61 ± 0.49	0.30 (0.01, 0.60)‡	84 ± 13	80 ± 15	4 (−6, 13)	69 ± 19	66 ± 22	3 (−11, 18)
Pelvis 2 (n = 20)	1.87 ± 0.39	1.63 ± 0.49	0.24 (−0.07, 0.55)	84 ± 12	80 ± 15	4 (−6, 13)	70 ± 19	66 ± 23	4 (−10, 19)
Hop lunge									
Overall rating (n = 5)	2.14 ± 0.47	1.71 ± 0.41	0.43 (0.02, 0.85)‡	87 ± 9	81 ± 14	6 (−7, 20)	73 ± 9	67 ± 22	6 (−14, 26)
Segmental rating									
Pelvis 1 (n = 6)	2.12 ± 0.44	1.70 ± 0.42	0.41 (0.03, 0.80)‡	82 ± 19	82 ± 12	0 (−12, 13)	63 ± 23	69 ± 20	−6 (−24, 13)
Pelvis 2 (n = 6)	2.12 ± 0.44	1.70 ± 0.42	0.41 (0.03, 0.80)‡	82 ± 19	82 ± 12	0 (−12, 13)	63 ± 23	69 ± 20	−6 (−24, 13)
Bridge									
Overall rating (n = 30)	1.85 ± 0.41	1.21 ± 0.22	0.64 (0.21, 1.07)‖	83 ± 14	74 ± 7	9 (−6, 23)	69 ± 21	61 ± 17	8 (−14, 30)
Segmental rating									
Pelvis 1 (n = 31)	1.83 ± 0.42	1.21 ± 0.26	0.62 (0.12, 1.13)‡	83 ± 14	72 ± 6	11 (−5, 28)	69 ± 21	55 ± 16	14 (−11, 39)
Pelvis 2 (n = 17)	1.95 ± 0.41	1.60 ± 0.42	0.35 (0.06, 0.64)‡	85 ± 14	79 ± 13	6 (−4, 15)	74 ± 17	62 ± 22	12 (−2, 26)
Plank									
Overall rating (n = 28)	1.85 ± 0.40	1.42 ± 0.51	0.43 (0.05, 0.81)‡	83 ± 14	79 ± 9	4 (−9, 16)	68 ± 21	67 ± 19	1 (−17, 20)
Segmental rating									
Pelvis 1 (n = 30)	1.81 ± 0.41	1.49 ± 0.62	0.32 (−0.15, 0.80)	83 ± 14	80 ± 11	3 (−12, 18)	68 ± 20	66 ± 25	2 (−20, 25)
Pelvis 2 (n = 16)	1.83 ± 0.38	1.73 ± 0.50	0.10 (−0.22, 0.41)	81 ± 14	83 ± 13	−2 (−11, 8)	69 ± 20	67 ± 21	2 (−13, 16)

Abbreviation: ADL, activities of daily living.
**Values are mean ± SD unless otherwise indicated.*
†Values in parentheses are 95% confidence interval.
‡Significant difference (P<.05).
§Significant difference (P<.001).
‖Significant difference (P<.01).

performed by physical therapists with a moderate to high level of clinical experience. In contrast, clinical rating of more complex functional tasks like squats, hop lunges, and frontal lunges resulted in poor to moderate intrarater and interrater agreement. The overall low agreement observed when evaluating complex functional tasks can be explained by the general difficulty for physical therapists to simultaneously rate many scoring categories (trunk, pelvis 1, pelvis 2, knee, foot, oscillation, and overall).[6] In contrast, fewer scoring categories had to be rated for bridges and planks, and a larger number of patients could properly perform bridges, planks, and single-limb standing compared with squats, hop lunges, and frontal lunges, therefore facilitating their rating and probably increasing agreement. We speculate that the surprisingly good agreement results observed for the novice physical therapist when rating squat and hop lunge may be explained by the therapist's particular ability in rating dynamic and complex functional tasks, despite little clinical experience. We are, however, cautious in generalizing these results because (1) they were not supported by equally good agreement results for the respective segmental ratings, (2) the worst agreement results were found for the novice physical therapist when evaluating simpler functional tasks, and (3) low association with hip muscle strength was demonstrated by the novice physical therapist in rating both squats and hop lunges.

Hip abductor strength was different between patients with poor versus good movement-quality ratings, with those with poor quality of movement being weaker, but only when ratings were provided by the highly experienced physical therapist. These results are consistent with previous work suggesting that hip abductor function is a critical determinant of lower extremity movement patterns.[7,19] Specifically, hip abductor weakness may lead to excessive femoral adduction, internal rotation, foot pronation, and to resultant compensatory movements, such as lateral trunk lean and contralateral pelvic drop, when performing single-limb weight-bearing activities.[19] The association between poor movement-pattern quality and hip abductor weakness may explain, at least partly, why in our study a larger number of patients could properly perform less demanding (eg, bridges and planks) than more demanding functional tasks (eg, squats and hop lunges).[22] Hip abductor strength differences between good and poor performers were not observed from the ratings of the moderately experienced physical therapist. This may be explained by the fact that the therapist probably overestimated the number of good performers, that is, on average 82%, in contrast with 58% reported by the highly experienced physical therapist, despite high agreement. In addition, very few differences in hip pain and function were observed between good and poor performers as rated by all therapists, suggesting overall poor associations between functional impairments reported by patients and those observed and quantified by therapists. It has to be noted that the criterion we used for defining good agreement (ie, lower limit of the 95% CI of Gwet's AC1 greater than 0.60) was very strict. Therefore, due to the fair to moderate intrarater agreement observed for the highly experienced physical therapist when evaluating squats, hop lunges, and frontal lunges (**TABLE 4**), but very strong associations between the therapist's movement rating and patients' hip abductor strength (**TABLE 6**), clinical movement-pattern quality rating of dynamic and complex tasks may be acceptable if performed by very experienced physical therapists.

CONCLUSION

Movement-pattern quality of patients with FAI syndrome using a semi-quantitative scale should preferably be rated in cross-sectional and longitudinal research projects by a highly experienced physical therapist, especially when evaluating complex functional tasks such as single-limb squat and hop lunge movements. ◉

KEY POINTS

FINDINGS: Clinical rating of movement-pattern quality in patients with femoroacetabular impingement (FAI) syndrome showed good and fair to moderate intrarater agreement when evaluating simple and more complex functional tasks, respectively, and strong associations with hip abductor strength when performed by a highly experienced physical therapist, using a semi-quantitative scale.

IMPLICATIONS: Movement-pattern quality assessment in patients with FAI syndrome using the evaluated semi-quantitative rating scale should be performed in cross-sectional and longitudinal research projects by highly experienced physical therapists.

CAUTION: Clinical rating of movement-pattern quality by physical therapists was neither compared with objectively assessed body kinematics nor with a rating of a consensus panel. The use of a single rater for each level of experience also limits the generalizability of these findings.

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APPENDIX A

PERCENTAGE OF PATIENTS (N = 34) WITH FAI SYNDROME DEMONSTRATING GOOD MOVEMENT-PATTERN QUALITY*

Functional Task	Highly Experienced	Moderately Experienced	Novice
Single-limb standing			
Segmental rating			
Trunk	53	91	74
Knee	94	100	97
Foot	97	100	56
Oscillation	21	88	65
Squat			
Segmental rating			
Trunk	32	53	47
Knee	24	88	6
Foot	41	79	32
Oscillation	18	71	18
Frontal lunge			
Segmental rating			
Trunk	76	79	71
Knee	62	91	32
Foot	79	88	68
Oscillation	38	94	56
Hop lunge			
Segmental rating			
Trunk	15	41	32
Knee	15	76	0
Foot	44	79	26
Oscillation	9	71	9
Bridge			
Segmental rating			
Trunk	97	100	91
Oscillation	94	100	68
Plank			
Segmental rating			
Trunk	85	88	88
Oscillation	76	100	76

Abbreviation: FAI, femoroacetabular impingement.
**Values are percent.*

APPENDIX B

INTRARATER AGREEMENT OF MOVEMENT-PATTERN QUALITY RATING (N = 34)

	Percent Agreement			Gwet's AC1*		
Functional Task	Highly Experienced	Moderately Experienced	Novice	Highly Experienced	Moderately Experienced	Novice
Single-limb standing						
Segmental rating						
Trunk	77	91	71	0.54 (0.25, 0.84)	0.90 (0.77, 1.00)†	0.54 (0.24, 0.84)
Knee	94	100	94	0.94 (0.85, 1.00)†	1.00 (1.00, 1.00)†	0.94 (0.85, 1.00)†
Foot	97	100	82	0.97 (0.91, 1.00)†	1.00 (1.00, 1.00)†	0.67 (0.40, 0.93)
Oscillation	65	85	79	0.35 (0.01, 0.70)	0.82 (0.65, 0.99)†	0.63 (0.35, 0.90)
Squat						
Segmental rating						
Trunk	74	82	77	0.48 (0.17, 0.79)	0.65 (0.38, 0.91)	0.54 (0.25, 0.84)
Knee	79	77	91	0.64 (0.37, 0.91)	0.69 (0.45, 0.93)	0.90 (0.79, 1.00)†
Foot	77	88	79	0.54 (0.24, 0.83)	0.83 (0.64, 1.00)†	0.64 (0.37, 0.91)
Oscillation	88	74	77	0.83 (0.66, 1.00)†	0.56 (0.26, 0.86)	0.63 (0.36, 0.90)
Frontal lunge						
Segmental rating						
Trunk	77	79	68	0.63 (0.36, 0.90)	0.70 (0.46, 0.94)	0.44 (0.10, 0.77)
Knee	82	85	94	0.69 (0.43, 0.94)	0.82 (0.65, 0.99)†	0.90 (0.68, 1.00)†
Foot	88	88	71	0.83 (0.66, 1.00)†	0.85 (0.69, 1.00)†	0.46 (0.14, 0.78)
Oscillation	71	85	77	0.46 (0.14, 0.78)	0.83 (0.67, 0.99)†	0.54 (0.25, 0.84)
Hop lunge						
Segmental rating						
Trunk	71	74	82	0.52 (0.21, 0.83)	0.48 (0.17, 0.78)	0.72 (0.49, 0.96)
Knee	79	74	100	0.69 (0.44, 0.94)	0.58 (0.29, 0.87)	1.00 (1.00, 1.00)†
Foot	85	79	74	0.71 (0.47, 0.96)	0.69 (0.44, 0.94)	0.62 (0.34, 0.89)
Oscillation	91	88	94	0.90 (0.77, 1.00)†	0.78 (0.57, 1.00)	0.93 (0.84, 1.00)†
Bridge						
Segmental rating						
Trunk	97	100	71	0.97 (0.91, 1.00)†	1.00 (1.00, 1.00)†	0.59 (0.30, 0.87)
Oscillation	94	100	74	0.94 (0.85, 1.00)†	1.00 (1.00, 1.00)†	0.51 (0.20, 0.81)
Plank						
Segmental rating						
Trunk	82	97	88	0.78 (0.58, 0.97)	0.96 (0.89, 1.00)†	0.85 (0.69, 1.00)†
Oscillation	77	100	74	0.67 (0.42, 0.92)	1.00 (1.00, 1.00)†	0.51 (0.20, 0.81)

Abbreviation: AC1, agreement coefficient 1.
**Values in parentheses are 95% confidence interval.*
†The lower limit of the 95% confidence interval of Gwet's AC1 is greater than 0.60.

APPENDIX C

INTERRATER AGREEMENT OF MOVEMENT-PATTERN QUALITY RATING (N = 34)

	Percent Agreement			Gwet's AC1*		
Functional Task	Highly Versus Moderately Experienced	Highly Experienced Versus Novice	Moderately Experienced Versus Novice	Highly Versus Moderately Experienced	Highly Experienced Versus Novice	Moderately Experienced Versus Novice
Single-limb standing						
Segmental rating						
Trunk	56	68	71	0.26 (−0.11, 0.64)	0.40 (0.06, 0.73)	0.59 (0.30, 0.87)
Knee	94	91	97	0.94 (0.85, 1.00)†	0.90 (0.79, 1.00)†	0.97 (0.91, 1.00)†
Foot	97	59	56	0.97 (0.91, 1.00)†	0.36 (0.00, 0.71)	0.33 (−0.04, 0.69)
Oscillation	32	50	71	−0.34 (−0.68, 0.00)	0.02 (−0.34, 0.38)	0.54 (0.24, 0.84)
Squat						
Segmental rating						
Trunk	68	62	82	0.37 (0.04, 0.70)	0.27 (−0.08, 0.62)	0.65 (0.38, 0.91)
Knee	29	82	12	−0.39 (−0.73, −0.05)	0.76 (0.56, 0.97)	−0.76 (−1.00, −0.52)
Foot	62	68	53	0.27 (−0.08, 0.62)	0.40 (0.06, 0.73)	0.07 (−0.28, 0.43)
Oscillation	47	88	41	−0.04 (−0.40, 0.31)	0.83 (0.66, 1.00)†	−0.16 (−0.52, 0.20)
Frontal lunge						
Segmental rating						
Trunk	85	77	79	0.78 (0.57, 0.99)	0.62 (0.34, 0.89)	0.67 (0.41, 0.93)
Knee	65	59	41	0.45 (0.12, 0.78)	0.18 (−0.17, 0.52)	−0.12 (−0.50, 0.27)
Foot	91	82	79	0.88 (0.73, 1.00)†	0.71 (0.47, 0.95)	0.69 (0.44, 0.94)
Oscillation	44	65	62	−0.12 (−0.41, 0.39)	0.30 (−0.04, 0.63)	0.39 (0.04, 0.74)
Hop lunge						
Segmental rating						
Trunk	74	71	68	0.56 (0.26, 0.86)	0.54 (0.24, 0.84)	0.40 (0.06, 0.73)
Knee	32	85	24	−0.34 (−0.68, 0.00)	0.83 (0.67, 0.99)†	−0.45 (−0.83, −0.07)
Foot	65	71	47	0.33 (−0.01, 0.67)	0.46 (0.14, 0.78)	−0.06 (−0.41, 0.30)
Oscillation	38	88	38	−0.19 (−0.56, 0.19)	0.86 (0.71, 1.00)†	−0.19 (−0.56, 0.19)
Bridge						
Segmental rating						
Trunk	97	88	91	0.97 (0.91, 1.00)†	0.87 (0.73, 1.00)†	0.90 (0.79, 1.00)†
Oscillation	94	68	68	0.94 (0.85, 1.00)†	0.53 (0.23, 0.83)	0.56 (0.27, 0.85)
Plank						
Segmental rating						
Trunk	85	85	77	0.81 (0.63, 0.99)†	0.81 (0.63, 0.99)†	0.70 (0.47, 0.93)
Oscillation	77	71	77	0.70 (0.47, 0.93)	0.54 (0.24, 0.84)	0.70 (0.47, 0.93)

Abbreviation: AC1, agreement coefficient 1.
**Values in parentheses are 95% confidence interval.*
†*The lower limit of the 95% confidence interval of Gwet's AC1 is greater than 0.60.*