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Progression of Strength, Flexibility, and Palpation Pain During Rehabilitation of Athletes With Acute Adductor Injuries: A Prospective Cohort Study

OBJECTIVE: To investigate the relationship between repeated clinical measures and the progression of rehabilitation of male athletes with acute adductor injuries.

DESIGN: Prospective observational cohort study.

METHODS: Male athletes with acute adductor injuries received a standardized criteria-based rehabilitation program with 4 repeated clinical measures during rehabilitation: the extent of palpation pain (length and width, in centimeters), the bent-knee fall-out test (BKFO; in centimeters), hip abduction range of motion (in degrees), and eccentric hip adduction strength (in Newton meters per kilogram). We analyzed the association between each clinical measure and the percent progression of rehabilitation until return to sport (RTS), divided into 2 RTS milestones: (1) clinically pain free, and (2) completion of controlled sports training.

RESULTS: The analyses included 61 male athletes for RTS milestone 1 and 50 athletes for RTS milestone 2, and 381 to 675 tests were performed for each clinical measure. The median time to RTS milestones 1 and 2 was 15 days (interquartile range, 12-29 days) and 24 days (interquartile range, 16-34 days), respectively. Each repeated clinical measure individually explained 13% to 36% of the variance in rehabilitation progression to the RTS milestones. The extent of palpation pain explained the highest variance of the progression of rehabilitation (R^2 = 0.26-0.27 for length and R^2 = 0.36 for width, P<.001). Eccentric adduction strength (R^2 = 0.19-0.27, P<.001) improved throughout rehabilitation, whereas the flexibility tests (BKFO, R^2 = 0.13-0.15; P<.001 and hip abduction range of motion, R^2 = 0.19-0.21; P<.001) returned to normal values early in rehabilitation.

CONCLUSION: Repeated measures of adductor strength, flexibility, and palpation pain provided only a rough impression of rehabilitation progress following acute adductor injuries in male athletes. These clinical measures cannot define a precise recovery point during rehabilitation. *J Orthop Sports Phys Ther 2021;51(3):126-134. Epub 28 Oct 2020. doi:10.2519/jospt.2021.9951*

KEY WORDS: *adduction strength, assessment, flexibility, groin pain, management, muscle strain*

Guiding athlete and coach expectations about time to return to sport (RTS) is an essential part of athlete injury management. Clinical measures obtained during an initial assessment after acute muscle injury are poor predictors of time to RTS.[7,10] Using repeated clinical measures may be more useful for estimating the progress of rehabilitation.[2,13] Clinical measures can also provide information on when an athlete has returned to normal values.[5] This information can be used to develop criteria-based rehabilitation programs for specific phase completion or RTS clearance, or to inform specific content decisions, such as exercise selection.

Some daily clinical measures, such as pain during prone active knee flexion and pain during a bilateral squat, resolve very early during rehabilitation from acute hamstring injury. Other measures, such as the length of pain on palpation and strength measured in supine with the hip and knee flexed to 90°, gradually improve and reach normal values later during rehabilitation.[13] Tests that demonstrate a patient's gradual improvement during rehabilitation may be more appropriate for assessing relative recovery. Selecting only the most useful tests can make clinical assessment more efficient. Despite the high prevalence of acute adductor injuries in sport,[1,8] it is unclear which clinical measures should be used to assess rehabilitation progress.

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Our aim was to investigate the association between specific repeated clinical measures and the rehabilitation progress of athletes with acute adductor injuries who were completing a criteria-based rehabilitation protocol.

METHODS

Participants

The present study included a sample of 81 athletes with acute groin injuries from a prospective cohort study with different study aims, as previously described.[9,10] Participants in this convenience sample were consecutively included over 4 years (2013-2017) at an orthopaedic and sports medicine hospital in Doha, Qatar. Detailed descriptions of the magnetic resonance imaging (MRI) findings,[10] rehabilitation protocol (a supplement in a separate open access article),[9] and the prognostic features of baseline clinical examination and imaging findings on RTS time[10] have been previously described.

Male athletes, aged 18 to 40 years, who participated in competitive sports were included. Athletes had to present at the hospital within 7 days of acute onset of groin pain that occurred during sport. Exclusion criteria were gradual onset or exacerbation of ongoing groin pain, clinical signs or symptoms of prostatitis or urinary tract infection, or other known coexisting chronic diseases that could potentially influence treatment, such as significant hip osteoarthritis.

This study only included athletes with a clinically diagnosed acute adductor injury, who followed a standardized criteria-based exercise treatment program, and who were clinically pain free. Ethical approval was obtained by the Shafallah Medical Genetics Center and the Anti-Doping Lab Qatar Institutional Review Boards (project numbers 2012-013 and EXT2014000004), and written informed consent was obtained from all athletes prior to inclusion.

Repeated Clinical Measures

During the rehabilitation period, we continuously monitored 4 clinical measures focused on the adductors. The tests were performed by 1 of 13 physical therapists who were trained in the tests. The physical therapists were not blinded to the athlete's diagnosis. The extent of adductor palpation pain (length and width in centimeters) and 2 flexibility tests (sidelying hip abduction range-of-motion test in degrees and the bent-knee fall-out test [BKFO] in centimeters) were measured at every session (5 times per week). Additionally, an eccentric hip adduction strength test in a sidelying position (in Newtons) was measured at every other session (2 to 3 times per week). The extent of palpation pain in length and width was measured to the nearest 0.5 cm, and a simple cross-sectional area (square centimeters) was calculated. The symmetry of flexibility and strength was calculated as the percent of the uninjured side at each measurement time point, and absolute values were reported for each leg in degrees or centimeters for flexibility and torque (Newton meters per kilogram) for strength. The strength and flexibility tests have good intratester and intertester reproducibility.[4,5,9] Reproducibility values for the palpation pain measures are unknown. Test descriptions can be found in the **APPENDIX**.

Treatment Protocol

All athletes followed a standardized criteria-based treatment program based on active exercises, with independent progression of basic resistance exercises and progressive running and change-of-direction drills, as well as a controlled sports training/testing phase. We advised athletes to attend 5 supervised sessions per week (weekdays) at the hospital. The details of the treatment protocol are presented and discussed separately.[9] We used 3 different RTS milestones to evaluate the RTS continuum: (1) meeting the "clinically pain free" criteria (RTS milestone 1; **TABLE 1**), (2) completion of "controlled sports training," and (3) first full team training, regardless of meeting all the protocol criteria. Return-to-sport milestone 2 was the point of clearance to return to full team training. The repeated clinical measures were recorded as described above until RTS milestone 1, and once on the day of completion of RTS milestone 2.

Outcome

We used time to RTS milestones 1 and 2 as study outcomes. To calculate the individual's progression of rehabilitation in percent, we considered the day of injury as 0% and the day of completion of the respective RTS milestone (1 or 2) as 100%.[13]

Statistical Methods

To examine the association between the clinical measures and the progression of rehabilitation, we used the statistical methods as previously described for acute hamstring injuries.[13] We created simple scatter plots comparing each clinical measure and treatment progression, and we chose lines of best fit (trend lines) based on

TABLE 1 Treatment Protocol Completion Criteria

Return-to-Sport Milestone 1: Clinically Pain Free
• Pain-free adductor palpation
• Pain-free maximal isometric adduction in outer-range abduction
• Pain-free maximal passive adductor stretch
• Pain-free hip adduction exercise with elastics at 10-RM
• Pain-free Copenhagen adduction exercise for 10 repetitions
• Pain-free linear sprinting at 100% of self-reported intensity (10 × 30 m)
• Pain-free T test at 100% of self-reported intensity

Abbreviation: RM, repetition maximum.

their associated variance (R^2) and visual inspection. Missing data were excluded from the analyses (eg, due to athlete nonattendance, lack of physical therapist time within the session to perform the measures, or measurement device malfunction). Additionally, we grouped data into deciles (0%-10%, 10.01%-20%, etc), with the median and interquartile range (IQR) calculated for each decile, for each clinical measure, which were used to depict the typical progress of rehabilitation.[13] To improve generalizability of the deciles, we chose to use a maximum of 1 measure for each athlete in each decile. To reduce overrepresentation of athletes with longer times to RTS in the analyses, if an athlete had 2 or more measures performed within a decile, we used the average of the available measures. For example, if an athlete had 3 measures of palpation pain length within the decile of 10% to 20% (where 11% is 8 cm, 14% is 7 cm, and 19% is 6 cm), then we included the average measure (7 cm).

We performed separate secondary analyses for complete adductor tears/avulsion injuries (grade 3) and noncomplete injuries (grades 0-2), confirmed using MRI. Grade 3 adductor injuries have a considerably longer RTS duration (approximately 2 to 3 months) compared to grade 0 to 2 injuries (approximately 2 to 4 weeks), with no statistical differences between grades 0, 1, and 2 as assessed with MRI.[9] The considerable difference in RTS duration could affect the association of the clinical measures with rehabilitation progression. We performed statistical analyses using SPSS software (Version 21; IBM Corporation, Armonk, NY), and we created figures in Excel and Power BI (Microsoft Corporation, Redmond, WA).

RESULTS

Participants

We included 61 athletes (**FIGURE 1**) (mean ± SD age, 26.2 ± 4.3 years [range, 20-37 years]; height, 180.8 ± 9.5 cm [range, 162-210 cm]; weight, 79.1 ± 14.1 kg [range, 47-115 kg]). The majority were football (soccer) players (n = 35) or futsal players (n = 12). Other sports included handball (n = 4), volleyball (n = 4), basketball (n = 4), shot put (n = 1), and table tennis (n = 1). Demographic data from excluded athletes have been previously reported.[9]

The median time from injury to RTS milestone 1 was 15 days (IQR, 12-29 days; range, 6-166 days) and to RTS milestone 2 was 24 days (IQR, 16-34 days; range, 9-212 days). For athletes with grade 0 to 2 injuries (n = 48), the median time to RTS milestone 1 was 13 days (IQR, 11-21 days; range, 6-44 days) and to RTS milestone 2 (n = 38) was 17 days (IQR, 15-27 days; range, 9-64 days). The median time for athletes with grade 3 injuries (n = 13) to reach RTS milestone 1 was 55 days (IQR, 31-75 days; range, 27-166 days) and to reach RTS milestone 2 (n = 12) was 68 days (IQR, 32-84 days; range, 32-212 days), as previously reported.[9] Overall rehabilitation attendance was 88% (IQR, 75%-100%; range, 31%-100%) and 89% (IQR, 76%-100%; range, 48%-100%) for the athletes who completed RTS milestone 1 (n = 61) and RTS milestone 2 (n = 50), respectively.

Clinical Measures and Rehabilitation Progression

The results were similar for the analyses of RTS milestones 1 and 2. For an easier overview, we report the results for RTS milestone 2; results for RTS milestone 1 are in the supplemental file. The association between each clinical measure and rehabilitation progression is shown in **TABLE 2**. Scatter plots for each clinical measure are presented in **FIGURE 2**. Corresponding box plots of progression in deciles of time to RTS milestone 2 are presented in **FIGURE 3**, with descriptive statistics in **TABLE 3**. Tabular overviews and scatter and box plot figures for athletes with grade 0 to 2 and grade 3 injuries, as

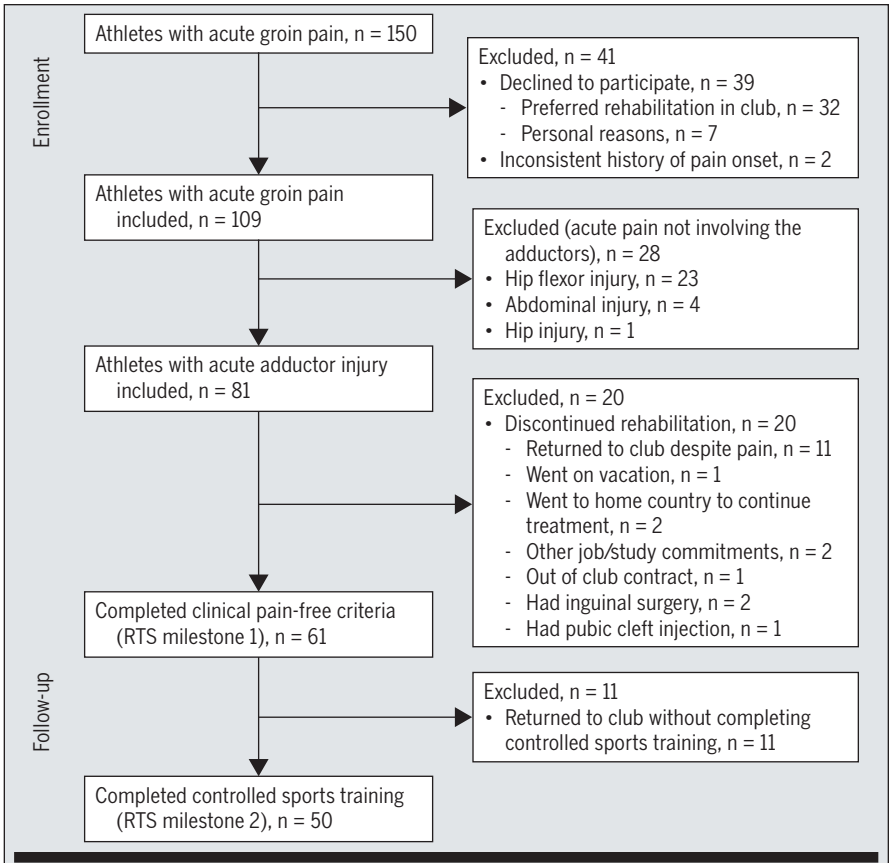

FIGURE 1. Flow chart of athlete inclusion. Abbreviation: RTS, return to sport.

assessed on MRI, are presented separately, with analyses for both RTS milestones 1 and 2, and can be found in the supplemental file.

DISCUSSION

Four repeated clinical measures individually explained 13% to 36% of the variance in rehabilitation progression following acute adductor injuries in male athletes, regardless of whether analyses were performed for RTS milestone 1 or 2. The extent of palpation pain (length and width) explained the highest variance of the progression of rehabilitation, with a linear association toward being pain free at RTS milestone 1 that remained thereafter. Eccentric strength measures increased considerably relatively early in rehabilitation, and subsequently continued to increase in smaller increments throughout rehabilitation. Both flexibility measures (the BKFO and hip abduction range of motion) improved early and were similar to the uninjured side after approximately 20% to 40% of the total rehabilitation duration. Improvements in any of the clinical measures only provided a rough impression of recovery and were not able to define a precise recovery point during rehabilitation.

Studies using clinical measures as part of assessment usually only report results from the initial examination and at RTS.[3,15,16] There is currently only 1 other study comparing daily clinical measures with rehabilitation progression in acute muscle injuries, with a focus on acute hamstring injuries.[13] The clinical measures of palpation pain length, an outer-range strength test, and an active range-of-motion test were most useful. Similar to our study, the individual measures explained 18% to 29% of the variance in rehabilitation progress.[13] There are currently no universally accepted guidelines for interpretation of R^2 values; however, our results can be described as only "moderate" associations at best. We found that palpation pain length and width had the highest explanation of variance, with a linear trend indicating that clinicians may use 2 or more measurement points to assist in obtaining an impression of the expected progression of rehabilitation toward being clinically pain free (RTS milestone 1). Palpation pain does not need to be assessed daily to track this progression.

Eccentric hip adduction strength increased consistently throughout rehabilitation progression. This occurred at a higher rate early in rehabilitation, when pain during testing likely had a stronger influence on the results. In the last decile of rehabilitation before RTS milestone 1, the injured leg reached similar median and IQR values as those of healthy professional football players (3.2 Nm/kg; IQR, 2.7-3.6 Nm/kg versus 3.0 Nm/kg; IQR, 2.4-3.6 Nm/kg, respectively).[5] Eccentric strength continued to increase during controlled sports training, reaching a median of 3.3 Nm/kg (IQR, 2.9-3.6 Nm/kg) in the last decile before RTS milestone 2.

In contrast to the hamstring injury study, neither of the flexibility measures we used appeared useful to define rehabilitation progress. The symmetry measures explained only 14% to 19% of rehabilitation variance, with the median symmetry achieved at approximately 20% to 30% of the total rehabilitation time (median symmetry for grade 3 injuries was slightly later, at approximately 30% to 40% of the total rehabilitation time). Both measures had a large variation in absolute values, and had already, at these early stages, returned to similar values and ranges as those of healthy male football players in the same country.[5] In line with the current evidence, which suggests that reduced hip range of motion is not associated with groin injury in sport,[6,14] hip range-of-motion measures were not very useful to determine rehabilitation progress. Hip range of motion returned to normal values early after an acute adductor injury, even without including passive stretching exercises in rehabilitation.

TABLE 2 Variance Explained of the Association Between the Individual Clinical Measures and the Rehabilitation Progression Until Return-to-Sport Milestone 2 (50 Athletes)

Clinical Measure	Trend Line	R^2	*P* Value	Measures, n
Palpation length, cm	Polynomial (second)	0.27	<.001	675
Palpation width, cm	Polynomial (second)	0.36	<.001	675
Palpation CSA, cm^2	Polynomial (second)	0.15	<.001	675
Eccentric adduction strength				
Symmetry, %	Logarithmic	0.24	<.001	399
Injured leg, Nm/kg	Power	0.27	<.001	399
Uninjured leg, Nm/kg	Power	0.12	<.001	432
BKFO				
Symmetry, %	Power	0.14	<.001	671
Injured leg, cm	Logarithmic	0.13	<.001	671
Uninjured leg, cm	Polynomial (third)	<0.01	.356	671
Hip abduction ROM				
Symmetry, %	Logarithmic	0.19	<.001	653
Injured leg, deg	Power	0.20	<.001	653
Uninjured leg, deg	Polynomial (third)	0.01	.031	653

Abbreviations: BKFO, bent-knee fall-out test; CSA, cross-sectional area; ROM, range of motion.

Association Differences According to MRI Grading

The secondary analyses indicated that the clinical progression of grade 3 injuries was

slightly different from that of grade 0 to 2 injuries. Specifically, palpation extent measures were less useful in grade 3 injuries, and flexibility measures (both the BKFO and abduction range of motion) explained a higher variance for grade 3 injuries (supplemental file). This appears to be due to an earlier reduction in palpation pain extent in grade 3 injuries (localized to the adductor longus insertion), with relatively little variation in palpation pain extent after halfway through rehabilitation.

For the flexibility measures, athletes with grade 3 injuries appear to be more affected initially than those with grade 0 to 2 injuries, and demonstrate a relatively large improvement in flexibility in the first 40% of the rehabilitation progression. Athletes with grade 0 to 2 injuries had a smaller reduction in flexibility, which was similar to the uninjured side at approximately 10% to 20% of the rehabilitation duration. Eccentric strength explained a higher proportion of the variance in grade 0 to 2 injuries. The injured leg in grade 0 to 2 injuries reached similar strength values to those of noninjured football players[5] approximately halfway through rehabilitation. The injured leg in grade 3 injuries did not achieve these values at the completion of RTS milestone 1. Most of these athletes had below-normal values in the last decile of rehabilitation before RTS milestone 2. Despite these smaller differences between MRI grades, the total explained variance in rehabilitation progression still only ranged between 5% and 45%, thereby not adding much further clinical value.

Strengths and Limitations

A strength of this study is that all athletes followed a standardized rehabilitation program.[9] It is unknown whether using a different rehabilitation program would have affected the findings. In our rehabilitation protocol, RTS milestone 1 was determined with specific clinical pain-free criteria. Implementing different criteria would likely affect our findings considerably. If the palpation pain criterion was removed, players might return with pain, and the associations for the extent of palpation pain would change. Similarly, if specific flexibility or strength symmetry values were included as additional criteria for either RTS milestone 1 or 2, this would influence the associations of these measures.

We standardized the progression of rehabilitation duration to percent, rather than using duration in days, because there was large variation in the absolute number of days included. Each measurement point was not the same for all athletes, and all athletes did not have measurements at the same percentage progression. Therefore, the graphs

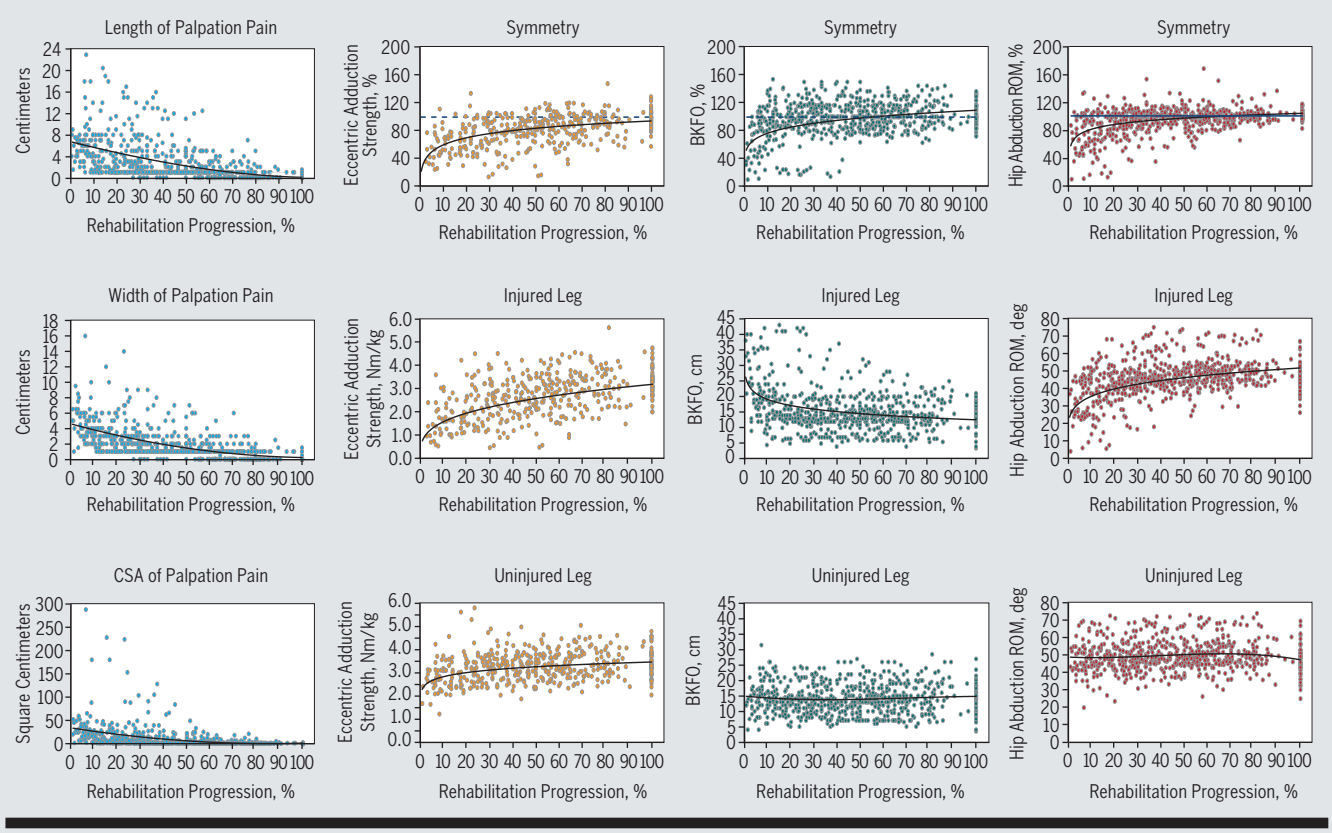

FIGURE 2. Scatter plots of each clinical measure in relation to progression of rehabilitation (percent) up to return-to-sport milestone 2. Abbreviations: BKFO, bent-knee fall-out test; CSA, cross-sectional area; ROM, range of motion.

represent a collation of cross-sectional time points rather than a true progression of each measure.

Thirteen different physical therapists performed the clinical tests, which might have affected the reproducibility of the clinical measures. To reduce variation, all physical therapists performed standardization sessions with 1 physical therapist (A.S.), who also performed about half of the total measurements in this study.

Our study was limited to 4 clinical measures, due to practical considerations primarily related to the duration of rehabilitation appointment sessions, which focused on appropriate exercise progression over additional testing. We included tests related to palpation pain, muscle stretch (flexibility), and muscle resistance (strength), which are considered to be key elements of both diagnosis and RTS decisions following acute muscle injuries.[7,12] Initially, we planned to use more tests, especially strength tests, but after pilot testing the protocol, we decided to include only 1 strength measure. We chose a unilateral test over a bilateral test, such as an adductor squeeze test, to ensure we were able to compare the injured leg to the uninjured leg. We chose an eccentric test over an isometric test, as we wanted continuity throughout rehabilitation until RTS. We considered an eccentric test to be more relevant at RTS for acute adductor injuries, as has been shown in general for adductor-related groin pain.[11] The limitation is that some athletes were unable to perform the eccentric test early in rehabilitation, especially athletes with grade 3 injuries. Isometric tests are less strenuous and may be preferred when eccentric tests are not possible, although the association with the progression of rehabilitation remains unknown.

CONCLUSION

Repeated measures of adductor strength, flexibility, and palpation pain provided only a rough impression of rehabilitation progress following acute adductor injuries in male athletes. These clinical measures cannot define a precise recovery point during rehabilitation. ◉

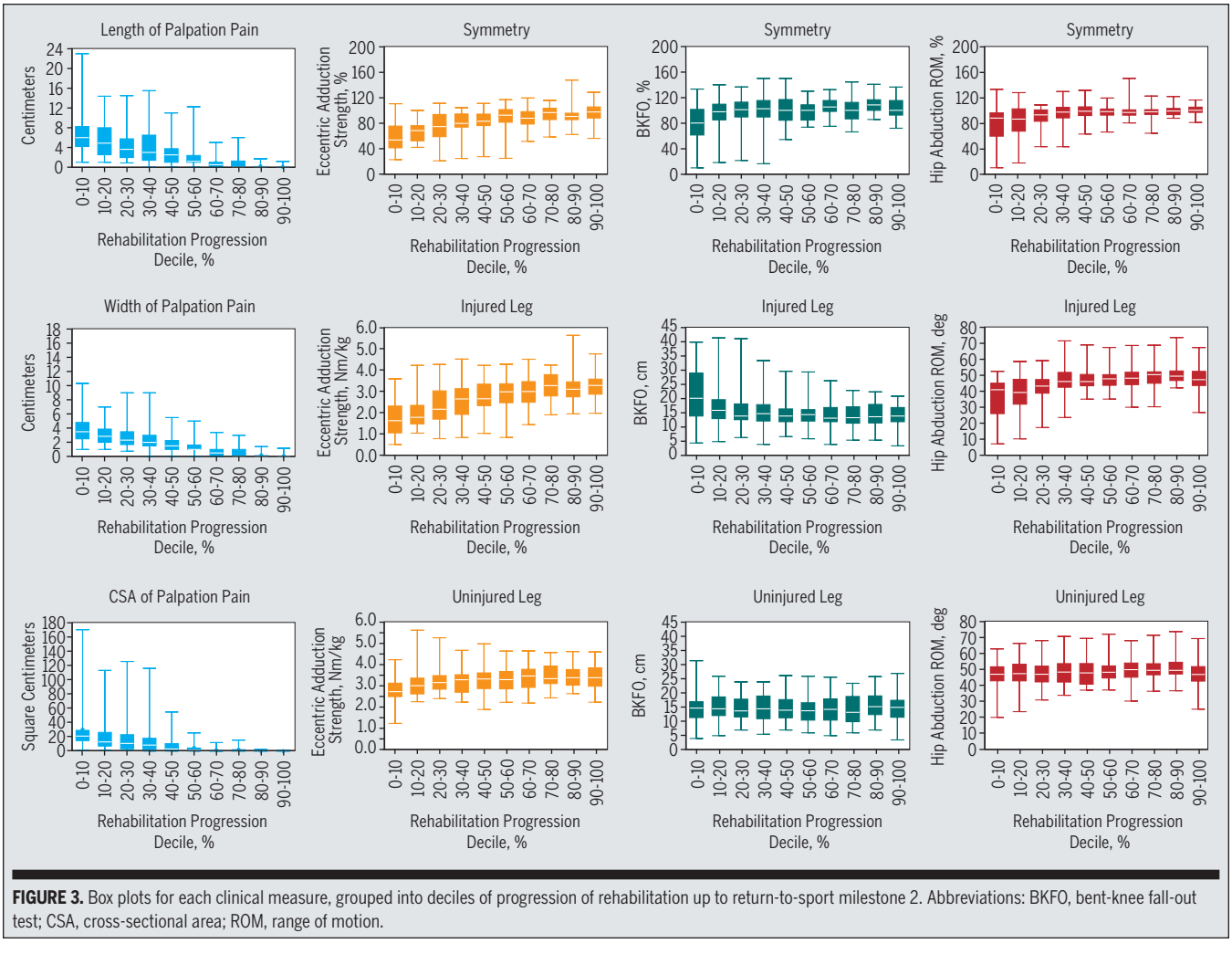

FIGURE 3. Box plots for each clinical measure, grouped into deciles of progression of rehabilitation up to return-to-sport milestone 2. Abbreviations: BKFO, bent-knee fall-out test; CSA, cross-sectional area; ROM, range of motion.

TABLE 3 Values for Each Clinical Measure, Grouped Into Deciles of Progression in Rehabilitation Until Return-to-Sport Milestone 2[a]

	Progression in Rehabilitation Decile, %									
Clinical Measure	**0-10**	**10-20**	**20-30**	**30-40**	**40-50**	**50-60**	**60-70**	**70-80**	**80-90**	**90-100**
Palpation length, cm	6.0 (4.2-8.3)	4.9 (2.5-8)	3.6 (2-5.8)	3.0 (1.4-6.5)	2.5 (1.0-3.8)	1.2 (1-2.4)	0.5 (0-1)	0 (0-1.3)	0 (0-0.1)	0 (0-0)
Palpation width, cm	3.5 (2.5-4.8)	2.9 (2-3.9)	2.3 (1.7-3.5)	2.0 (1.5-3)	1.5 (1.0-2.3)	1.0 (1.0-1.6)	0.5 (0-1)	0 (0-1)	0 (0-0.1)	0 (0-0)
Palpation CSA, cm^2	21.1 (15-29)	12.9 (7-26)	10.8 (3-23)	8.5 (2-18)	3.0 (1-11)	1.4 (1-4)	0.3 (0-1)	0 (0-2)	0 (0-0.1)	0 (0-0)
Eccentric adduction strength										
Symmetry, %	54 (41-76)	68 (52-76)	75 (59-94)	79 (74-95)	83 (76-94)	93 (82-101)	89 (79-98)	97 (86-104)	91 (86-96)	98 (88-106)
Injured leg, Nm/kg	1.62 (1.1-2.3)	1.78 (1.5-2.4)	2.16 (1.7-3)	2.65 (1.9-3.1)	2.65 (2.3-3.3)	2.98 (2.5-3.4)	2.99 (2.5-3.5)	3.27 (2.8-3.8)	3.10 (2.7-3.5)	3.28 (2.9-3.6)
Uninjured leg, Nm/kg	2.72 (2.5-3.1)	3.00 (2.6-3.4)	3.15 (2.8-3.5)	3.28 (2.7-3.5)	3.31 (2.9-3.6)	3.28 (2.9-3.7)	3.45 (2.9-3.8)	3.33 (3.1-3.9)	3.38 (3.0-3.8)	3.37 (3.0-3.8)
BKFO										
Symmetry, %	80 (61-102)	98 (85-110)	101 (90-113)	103 (90-115)	100 (85-117)	100 (85-109)	105 (98-115)	100 (87-112)	109 (100-116)	100 (93-115)
Injured leg, cm	20.5 (14-29)	16.0 (13-20)	14.0 (13-18)	15.0 (12-18)	15.0 (12-17)	14.5 (12-16)	13.5 (12-17)	13.5 (11-17)	14.0 (12-18)	14.0 (12-17)
Uninjured leg, cm	15.0 (11-17)	14.5 (12-19)	14.0 (12-18)	14.5 (11-19)	14.0 (11-18)	14.0 (11-17)	14.5 (11-18)	13.5 (10-19)	15.5 (12-19)	15.0 (12-18)
Hip abduction ROM										
Symmetry, %	88 (60-97)	87 (68-103)	93 (83-101)	98 (89-105)	99 (92-106)	99 (93-103)	97 (93-101)	98 (94-102)	100 (94-104)	101 (97-106)
Injured leg, deg	41 (26-45)	39 (32-47)	47 (39-47)	46 (42-52)	46 (43-50)	47 (43-50)	48 (44-52)	50 (45-52)	49 (46-52)	47 (43-52)
Uninjured leg, deg	47 (43-52)	47 (43-53)	47 (42-52)	48 (42-54)	48 (41-54)	48 (44-52)	50 (45-54)	49 (47-53)	49 (47-54)	47 (43-52)

Abbreviations: BKFO, bent-knee fall-out test; CSA, cross-sectional area; ROM, range of motion.
[a]*Values are median (interquartile range).*

KEY POINTS

FINDINGS: Four repeated clinical measures each explained only 13% to 36% of the variance in rehabilitation progression following acute adductor injuries in male athletes.

IMPLICATIONS: Repeated clinical measures (mainly extent of palpation pain) may be used as part of a general assessment of rehabilitation progress; however, clinicians should not rely on repeated clinical measures when providing prognostic estimations. Daily testing cannot be recommended for this purpose.

CAUTION: The study results relate only to rehabilitation progress. The clinical measures may be useful for other purposes.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Dr Serner was responsible for study conception and design and data acquisition, analysis, and interpretation, and drafted the article. Drs Hölmich, Thorborg, Tol, and Weir were involved in study conception and design and data interpretation. Roald Otten and Sean Lanzinger were involved in study design and data acquisition and interpretation. Dr Whiteley was involved in data analysis and interpretation. All authors provided critical revision and approval of the final article.

DATA SHARING: Individual participant data that underlie the results reported in this article, after de-identification, are available on request to the corresponding author for use in meta-analyses or other reasonable studies, given a methodologically sound proposal.

PATIENT AND PUBLIC INVOLVEMENT: There was no patient or public involvement in the development of this study.

ACKNOWLEDGMENTS: *We would like to express our sincere appreciation to all the physical therapists who were involved in the clinical testing and/or rehabilitation of the athletes in this study (Dermot Simpson, Kostas Epameinontidis, Damien Delahunty, Einar Einarsson, Arnlaug Wangensteen, Arnhild Bakken, Abdallah Itani, Nicol van Dyk, and Tone Bere). We would also like to acknowledge all Aspetar sports medicine physicians, radiologists, nurses, and administrative assistants, as well as the doctors and physical therapists from the National Sports Medicine Program (Qatar), all of whom contributed to making this project possible.*

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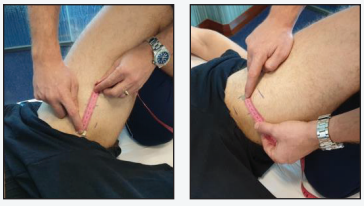
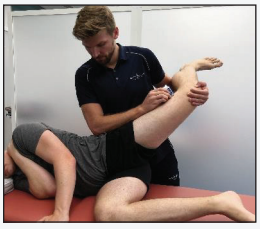
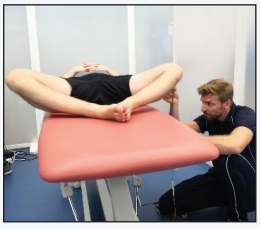
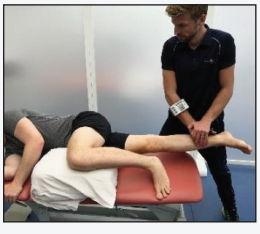
APPENDIX

CLINICAL TEST DESCRIPTIONS[a]

Clinical Test	Description	Illustration
Adductor longus palpation pain length and width	The patient lies supine, with the tested leg placed in a relaxed position and the knee on the examiner's thigh. The hip of the tested leg is flexed, slightly abducted, and externally rotated. A mark is made at the most proximal and distal sites of palpation pain, as well as the most medial and lateral sites of palpation pain. The distances between these measures are recorded to the nearest 0.5 cm and represent the length and width of palpation pain, respectively[9] Test reproducibility: not available	
Sidelying hip abduction range-of-motion test	The patient is in sidelying on the nontested side, with the hip and knee of the bottom/nontested leg in about 90° of hip and knee flexion. The height of the bed is adjusted so that the hip of the tested leg is at the same height as the tester's hip. The tester stabilizes the participant's pelvis with his or her own hip, and holds medially on the knee of the tested leg, which is placed in a relaxed knee flexion angle, with the examiner's forearm supporting the patient's lower leg. The patient's leg is then abducted toward the ceiling to end range, maintaining the hip in neutral flexion/extension. The range of motion is measured with a digital inclinometer on the lateral thigh mark of the tested leg. The test is performed twice, and the average score is recorded[9] Test reproducibility: intratester $ICC_{3,1}$ = 0.88 (95% CI: 0.65, 0.96); SEM, 3° (7%); MDC, 9° (19%).[9] Intertester $ICC_{1,2}$ = 0.77 (95% CI: 0.59, 0.87); SEM, 4° (7%); MDC, 12° (25%)[5]	
Bent-knee fall-out test	The patient lies supine, with approximately 90° of knee flexion, 45° of hip flexion, and the feet together. This is achieved by flexing one leg first, so that the medial malleolus is placed next to the medial knee joint line of the contralateral leg, which is then positioned similarly. The patient is instructed to allow the knees to fall outward while keeping the feet together. The examiner uses gentle overpressure to check that the player has relaxed at the limit of movement. The distance between the most distal point on the head of the fibula and the surface of the bed is measured using a rigid tape measure, and distance is recorded to the nearest 0.5 cm[9] Test reproducibility: intratester $ICC_{2,1}$ = 0.90; SEM, 10%.[4] Intertester $ICC_{1,1}$ = 0.93 (95% CI: 0.90, 0.96); SEM, 1.1 cm (9%)[5]	
Sidelying eccentric hip adduction strength test	The weight (kilograms) and lever arm (centimeters) of the patient are measured. The lever arm is measured from the anterior superior iliac spine to 8 cm proximal from the most prominent point of the lateral malleolus, which is marked together with an equivalent point medially on the tibia. For the test, the patient is in sidelying on the side of the tested leg, with a straight hip and knee. The hip and knee of the nontested leg are placed in approximately 90° of flexion, with the knee resting on a stack of folded towels to maintain pelvic position. The patient holds on to the side of the bed with one hand for stabilization. The tester lifts the leg off the bed into full adduction and applies resistance to the adducted leg with a handheld dynamometer on the medial tibia mark, ensuring that the leg is not pushed into the bed. A practice test should be performed, followed by 3 maximal contractions, with a rest of 30 seconds between each repetition. The participant exerts a 3-second maximal voluntary isometric contraction against a handheld dynamometer, and a break is then performed by the examiner by pushing the leg slowly (approximately 2 seconds). The standardized instruction for the tests is, "Go ahead, push, push, push, push, push," lasting 5 seconds. Patients are instructed to push as hard as possible within their comfort zone. The highest score is recorded[9] Test reproducibility: intratester $ICC_{3,1}$ = 0.82 (95% CI: 0.56, 0.93); SEM, 25 N (10%); MDC, 70 N (29%).[9] Intertester $ICC_{3,1}$ = 0.66 (95% CI: 0.14, 0.86); SEM, 32 N (13%); MDC, 88 N (37%)[5]	

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient; MDC, minimum detectable change; SEM, standard error of measurement.
[a]*Images in panels B through D are reproduced with permission from Serner et al.*[9]