A Comparison of Psychological Readiness and Patient-Reported Function Between Sexes After Anterior Cruciate Ligament Reconstruction

Christopher Kuenze, PhD, ATC*; David Robert Bell, PhD, ATC†; Terry L. Grindstaff, PhD, PT, ATC, CSCS‡; Caroline Michele Lisee, MEd, ATC*; Thomas Birchmeier, MS, ATC*; Ashley Triplett, MS*; Brian Pietrosimone, PhD, ATC§

*Michigan State University, East Lansing; †University of Wisconsin, Madison; ‡Creighton University, Omaha, NE; §University of North Carolina at Chapel Hill

Context: Postoperative functional and return-to-sport outcomes after anterior cruciate ligament reconstruction (ACLR) differ by sex. However, whether sex disparities are observed in patient-reported outcome measures (PROMS) before return to sport after ACLR is unclear.

Objectives: To compare common PROMS between young men and women who had not yet returned to sport after ACLR.

Design: Cross-sectional study.

Setting: University laboratory.

Main Outcome Measure(s): Forty-five young men (age = 18.7 ± 2.7 years, time since surgery = 6.8 ± 1.4 months) and 45 matched for age (±1 year) and time since surgery (±1 month; age = 18.8 ± 2.8 years, time since surgery = 6.9 ± 1.4 months) with ACLR participated. Participants completed the Tegner Activity Scale, ACL Return to Sport After Injury scale, Tampa Scale of Kinesiophobia, International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Score, and Knee Injury and Osteoarthritis Outcome Score (KOOS). The PROMS were compared between men and women using Mann-Whitney U tests. Odds ratios were calculated to evaluate the odds of a male reporting a PROM value above the previously established normative value as compared with a female.

Results: Sex differences were present for the IKDC score (P = .01) and KOOS Pain score (P = .04) but not for the Tegner activity level (P = .22), ACL Return to Sport after Injury scale score (P = .78), Tampa Scale of Kinesiophobia score (P = .64), or other KOOS subscales (P values = .40 to .52). The odds of reporting values above normative levels differed only for the IKDC score (odds ratio = 2.72, 95% confidence level = 1.16, 6.38).

Conclusions: After ACLR, young men and women reported similar levels of knee-related function, fear of movement, and readiness for return to sport and were equally likely to meet clinically meaningful normative values before return to sport. Overreliance on patient reports or objective functional outcomes in evaluating patient progress and readiness for return to sport after ACLR may limit clinicians in their ability to comprehensively evaluate and develop individualized interventional approaches that optimize patient outcomes.

Key Words: ACL Return to Sport after Injury scale, fear of movement, fear of reinjury, symptoms, quality of life

Key Points

- Young men and women matched for age and time since reported similar scores and similar odds of meeting established clinical cutoff scores on the ACL Return to Sport after Injury scale and the Tampa Scale of Kinesiophobia.
- Young men demonstrated better scores on the International Knee Documentation Committee instrument (Cohen d = 0.48) and Knee Injury and Osteoarthritis Outcome Score Pain subscale (Cohen d = 0.25) than their young women counterparts.
- Young men were at 2.72 times greater odds of reporting International Knee Documentation Committee scores equal to or greater than sex-specific normative values than the matched cohort of young women.
- Integration of objective evaluations of lower extremity strength, functional movement, and patient-reported outcomes is essential to effectively evaluate clinical success among this clinical population.

Rates of anterior cruciate ligament (ACL) injury and ACL reconstruction (ACLR) have increased more than 60% in the past 20 years. During this time, physically active women under 20 years of age experienced the highest rates of noncontact ACL injuries and the greatest increase in the total number of ACLRs. More concerning is the fact that 24% to 30% of young female athletes who do return to sport will experience a second ACL injury to the ipsilateral or contralateral knee within 2 years of ACLR, which is more than double the rate for young male athletes. In addition, female patients tend to have worse functional outcomes, are less likely to return to sport, and have greater odds of reporting values above normative levels for functional outcomes compared with male patients.
and are more likely than male patients to develop posttraumatic osteoarthritis. This is further supported by 2 prospective studies,\(^6,7\) that indicated female patients described worse pain at 1 year post-ACLR as well as less ability than male patients to participate in sport and recreation at 1, 2, and 5 years post-ACLR. These clear sex-related disparities in clinical outcomes highlight the need to identify modifiable clinical factors that may be targeted, specifically among female patients, during rehabilitation to improve the short- and long-term outlook for these patients attempting a return to sport after ACLR. A growing body of evidence has established clinically meaningful disparities between male and female patients in quadriceps strength,\(^8\) movement quality,\(^9\) and functional performance\(^10\) after ACLR. In all cases, these findings have shown better recuperation among male patients of similar ages and activity levels.

The clinical assessment of psychological outcomes has become increasingly common during the rehabilitation process after ACLR.\(^11,12\) This has most commonly been done using patient-reported outcome measures (PROMs) that evaluate anxiety, confidence, fear of reinjury, and self-efficacy.\(^11,12\) In support of these assessments, improved psychological readiness for return to sport and reduced fear of movement, assessed 4 to 6 months after ACLR via the ACL Return to Sport after Injury (ACLR-SI) scale and Tampa Scale of Kinesiophobia (TSK-11), respectively, have been linked to successful return to preinjury levels of sport at 1 year and a reduced risk of subsequent ACL injury at 2 years after ACLR among young and active individuals.\(^11,12\) However, according to the authors of a recent review,\(^13\) the psychological response to ACLR may not be consistent between the sexes. Female patients tended to describe greater psychological distress and lesser self-efficacy that male patients at similar time points after ACLR.\(^13\) Whereas the ACL-RSI scale and TSK-11 are commonly used to assess psychological readiness for return to sport among individuals with ACLR, little is known about the influence of patient sex on these outcome measures. This factor is especially important given the previously described sex-based disparities in functional outcomes,\(^10\) rates of return to sport,\(^5\) and rates of reinjury,\(^2\) all of which have been linked to psychological outcomes among this clinical population. A clear understanding of sex differences in ACL-RSI and TSK-11 scores and examinations of the relationships between these outcomes and patient-reported function will assist in identifying the importance of psychological outcomes in perceived function among male and female patients with recent ACLR.

Due to reported disparities in return to sport rates, reinjury rates, and long-term joint health between men and women with ACLR, it is essential to identify whether these sex-related differences are present while patients are still engaged in clinical care. If this is the case, then sex-specific evaluation and treatment strategies aimed at improving patient-reported outcomes and mitigating the risk of poor clinical outcomes among female patients after ACLR can be implemented. Therefore, the purpose of our study was to determine differences in patient-reported knee function, fear of movement, and psychological readiness for return to sport between male and female patients matched for age and time since surgery who had not yet returned to sport after ACLR. We hypothesized that female patients would report worse knee function, greater fear of movement, and less psychological readiness for return to sport than male patients. The exploratory purpose of our research was to evaluate the odds of a male patient meeting clinically acceptable thresholds for knee-related function, fear of movement, and psychological readiness for sport when compared with his female counterpart and to determine the strength of the relationships among these variables.

### METHODS

This investigation was a multisite cross-sectional study in which all reported measures were collected during a single testing session. This research was approved by Creighton University, Michigan State University, the University of North Carolina at Chapel Hill, and the University of Wisconsin-Madison Institutional Review Boards for Human Subjects or Health Science Research. All participants gave written informed consent before testing.

A total of 45 pairs of men and women matched for age (±1 year) and time since surgery (±1 month) with a history of primary, unilateral ACLR were enrolled in this study (Table 1). Demographic (age and sex) and surgical (graft source and date of surgery) characteristics were provided by participants at intake. Participants were included in the study if they were between 13 and 25 years old; had a history of primary, unilateral ACLR using patellar tendon or hamstring autograft tissue; were between 5 and 9 months post-ACLR; and had not yet fully returned to sport. Participants were excluded if they had a history of lower extremity injury in the previous 6 weeks, a neurologic condition that might affect lower extremity strength assessment, or either a multiligament injury that required reconstruction or an articular cartilage injury that required surgical intervention.

| Characteristic | Males | Females | P Value |
|----------------|-------|---------|---------|
| Participants, No. | 45    | 45      | NA      |
| Age, y          | 18.7 ± 2.7 | 18.8 ± 2.8 | .94     |
| Body mass index, kg/m\(^2\) | 25.1 ± 4.4 | 23.5 ± 3.4 | .08     |
| Preinjury Tegner activity level* | 9.0 [7.0, 10.0] | 9.0 [6.0, 10.0] | .34     |
| Graft source, HSA/BTB | 24/21 | 24/21    | .99     |
| Months since surgery | 6.8 ± 1.4 | 6.9 ± 1.4 | .59     |

Abbreviations: BTB, bone-patellar tendon-bone graft; HSA, hamstrings autograft; NA, not applicable.

* Reported as mean ± SD except where indicated.

| Characteristic | Males | Females | P Value |
|----------------|-------|---------|---------|
| Participants, No. | 45 | 45 | NA |
| Age, y | 18.7 ± 2.7 | 18.8 ± 2.8 | .94 |
| Body mass index, kg/m\(^2\) | 25.1 ± 4.4 | 23.5 ± 3.4 | .08 |
| Preinjury Tegner activity level* | 9.0 [7.0, 10.0] | 9.0 [6.0, 10.0] | .34 |
| Graft source, HSA/BTB | 24/21 | 24/21 | .99 |
| Months since surgery | 6.8 ± 1.4 | 6.9 ± 1.4 | .59 |

Abbreviations: BTB, bone-patellar tendon-bone graft; HSA, hamstrings autograft; NA, not applicable.

* Reported as mean ± SD except where indicated.

| Characteristic | Males | Females | P Value |
|----------------|-------|---------|---------|
| Participants, No. | 45 | 45 | NA |
| Age, y | 18.7 ± 2.7 | 18.8 ± 2.8 | .94 |
| Body mass index, kg/m\(^2\) | 25.1 ± 4.4 | 23.5 ± 3.4 | .08 |
| Preinjury Tegner activity level* | 9.0 [7.0, 10.0] | 9.0 [6.0, 10.0] | .34 |
| Graft source, HSA/BTB | 24/21 | 24/21 | .99 |
| Months since surgery | 6.8 ± 1.4 | 6.9 ± 1.4 | .59 |

Abbreviations: BTB, bone-patellar tendon-bone graft; HSA, hamstrings autograft; NA, not applicable.

* Reported as mean ± SD except where indicated.
been reported to predict failed return to the preinjury level of sport and subsequent ACL injury within 1 year of ACLR, respectively. Unfortunately, sex-specific cutoff values have not been established and, therefore, all comparisons in this analysis were based on the general recommendations for individuals with ACLR. We used the TSK-11 to assess fear of movement associated with the individual’s ACL, a score of greater than 17 at the time of clearance for return to sport has been linked to 3.73 times greater odds of subsequent ACL injury within 1 year of assessment. The IKDC subjective score provided a single, general estimate of patient-reported knee function that takes into account symptoms and function after ACLR. Sex-specific normative values have been established for young individuals with and without a history of knee injury. Consistent with Logerstedt et al., we considered the sex-specific value corresponding to the 15th percentile as indicating normal knee function. Last, the KOOS subscale scores were used to evaluate sex-related differences in patient-reported pain, symptoms, activities of daily living, sport and recreation, and quality of life. Sex-specific normative values have been established for the KOOS subscales among individuals without a history of knee-joint injury, and the corresponding mean value for each subscale was considered indicative of a normal subscale score. The TAS was primarily used to describe the peak physical activity intensity in which participants were engaged before ACL injury.

Sample demographics were compared between the sexes using 1-way analyses of variance except for graft sources, which were compared using a Fisher exact test. Between-sexes comparisons of Tegner activity level, ACL-RSI score, TSK-11 score, and KOOS subscale scores were conducted using Mann-Whitney U tests. The magnitudes of between-groups differences were assessed via Cohen’s d effect sizes with 95% confidence intervals (CIs). Odds ratios and 95% CIs were calculated to evaluate the odds of a male participant reporting a given patient-reported outcome value above the previously established clinical cutoff or normative value compared with a female participant. Sex-specific normative values established normal function with respect to the IKDC subjective score and the KOOS subscales (Supplemental Table 1). All statistical analyses were performed using SPSS (version 24.0, IBM Corp, Armonk, NY), and the a priori α level for between-sexes comparisons was .05.

A priori sample-size estimates were based on moderate effects for sex on the KOOS Sport and Recreation score among 4438 individuals 12 months after ACLR. Based on these estimates, a minimum of 72 total participants (36 per group) were required to detect differences between groups in this study. Sample-size estimation was completed using G*Power (version 3.1; Heinrich-Heine-Universität, Düsseldorf, Germany).

### RESULTS

Male and female participants did not significantly differ by age, body mass index, preinjury activity level, graft source, or time since surgery (Table 1). Between-groups comparison of PROMs indicated sex differences for the IKDC subjective score (P = .01) and KOOS Pain subscale (P = .04), whereas no differences were evident in ACL-RSI score (P = .86), TSK-11 score (P = .76), or any of the other KOOS subscale scores (P values = .40 to .52; Table 2). Male participants were at 2.72 (95% CI = 1.16, 6.38) times greater odds of reporting IKDC scores equal to or greater than age- and sex-specific normative values than were female participants. Male participants were not at greater odds than female participants of reporting values above clinical cutoffs for the ACL-RSI or TSK-11 scores or age- and sex-specific normative values for the KOOS subscale scores (Table 3).

### DISCUSSION

The primary purpose of our study was to evaluate sex differences in PROMs of knee function, fear of movement, and psychological readiness for sport as well as among

---

**Table 2. Sex Comparisons of Common Patient-Reported Outcomes Among Participants After Anterior Cruciate Ligament Reconstruction**

| Outcome | Males | Females | P Value | Cohen’s d Effect Size (95% Confidence Interval) |
|---------|-------|---------|---------|-----------------------------------------------|
| Current Tegner activity level | 6.0 [4.0, 10.0] | 6.0 [3.0, 10.0] | .22 | NA |
| Anterior Cruciate Ligament Return to Sport after Injury score | | | | |
| Tampa Scale of Kinesiophobia score | 82.5 [35.0, 100.0] | 75.0 [5.8, 98.3] | .86 | 0.06 (−0.35, 0.47) |
| International Knee Documentation Committee subjective score | 19.0 [11.0, 33.0] | 20.0 [11.0, 29.0] | .76 | 0.09 (−0.32, 0.51) |
| Knee Injury and Osteoarthritis Outcome Score | 88.5 [50.0, 100.0] | 79.3 [47.1, 98.9] | .01* | 0.48 (0.06, 0.90) |
| | **Outcome** | **Males** | **Females** | **P Value** | **Cohen’s d Effect Size (95% Confidence Interval)** |
| Pain | 97.2 [61.1, 100.0] | 94.4 [72.2, 100.0] | .04* | 0.25 (−0.17, 0.66) |
| Symptoms | 71.4 [42.9, 100.0] | 67.9 [59.3, 100.0] | .52 | 0.10 (−0.32, 0.51) |
| Activities of Daily Living | 100.0 [73.5, 100.0] | 100.0 [80.9, 100.0] | .46 | 0.05 (−0.37, 0.46) |
| Sport and Recreation | 95.0 [50.0, 100.0] | 90.0 [50.0, 100.0] | .40 | 0.05 (−0.37, 0.46) |
| Quality of Life | 62.5 [32.3, 100.0] | 62.5 [12.5, 100.0] | .50 | 0.16 (−0.26, 0.57) |

Abbreviation: NA, not applicable.

* All analyses were completed using Mann-Whitney U tests. Data were reported as median [minimum, maximum].

* Indicates a between-sexes difference (P < .05).
individuals who had not yet returned to sport after ACLR. Young men demonstrated better IKDC scores (Cohen $d =$ 0.48), 2.72 times greater odds of scores equal to or greater than sex-specific normative values, and better KOOS Pain subscale scores (Cohen $d =$ 0.25) than young women (Table 2). Contrary to our hypothesis, male and female participants did not differ in ACL-RSI, TSK-11, or KOOS subscale scores except on the Pain subscale at this important clinical time point (Table 2). Similarly, male and female participants displayed similar odds of achieving established clinical cutoff scores or normative values on the PROMs (Table 3). With these results, we showed that despite consistently poorer objective outcomes during the first year after ACLR, women were not more likely to perceive worse functional or psychological effects of ACLR than men during the terminal phases of their rehabilitation.

Men and women reported similar ACL-RSI and TSK-11 scores (Table 2) and were equally likely to reach clinically meaningful cutoff scores for these measures (Table 3) within the first 9 months after ACLR. This absence of sex differences in fear of movement and psychological readiness is interesting, given that authors of a recent review of the literature indicated that men and women coped with ACL injury and experienced the process of rehabilitation differently from psychological and psychosocial perspectives. Although the literature in this area is still developing, men have tended to display greater self-efficacy after surgery, whereas women described greater anxiety related to recovery and return to activity after ACLR. We hypothesized that these variations would ultimately result in clinically meaningful differences in fear of movement and readiness for return to sport during the terminal phases of rehabilitation; however, our results did not support these hypotheses. Patients who fail to meet clinically important cutoff scores on the ACL-RSI or TSK-11 scales during rehabilitation may reflect a variety of psychological barriers that may or may not be informed by their sex, gender identification, or other factors (eg, strength, jumping performance, movement biomechanics) that we did not examine in this study. Therefore, if a patient exhibits fear of movement or a lack psychological readiness on the basis of these scales, it may be beneficial to evaluate a broad complement of psychological outcomes (ie, locus of control, self-efficacy, anxiety, athletic identity, and fear of reinjury) postoperatively in order to develop an individualized patient profile that can guide selection of the best treatment approach for the person’s needs.

Sex-based differences were present for the KOOS Pain subscale but were not identified for any of the other KOOS subscale scores (Table 2). This finding is consistent with the work of Ageberg et al, who also identified sex differences in the KOOS Pain score among individuals who were 1 year post-ACLR; however, the sex difference they reported was no longer apparent at the 2-year follow-up. In our work, although was a significant ($P =$ .04), small-magnitude (Cohen $d =$ 0.25) difference occurred between the sexes, the odds of a male or female participant describing pain scores equal to or better than sex-specific normative values did not differ ($OR = 2.20$, 95% CI = 0.91, 5.33). In addition, women reported moderately worse IKDC scores (mean difference = 5.5 points, Cohen $d =$ 0.48) than men did, which is both interesting and contrary to previous literature in this area. Similarly, whereas previous researchers have observed sex differences in sport and recreation and quality-of-life subscales, it is important to note that these differences, reported 1 and 2 years post-ACLR, were small in magnitude (Cohen $d$ values $= 0.05$ to 0.16, mean difference $= 1.4$ to 4.4 points) and the change between time points did not exceed the minimal clinically important difference ($\geq 8$ points). Furthermore, sex did not signifi-
cantly influence the odds of participants achieving important sex- and age-specific normative scores on the IKDC or any KOOS subscales (Table 3). These results suggest that although female sex may have a small effect on general knee function, the magnitude of difference may not be large enough to be detected consistently during the terminal phases of rehabilitation before return to activity after ACLR. We suggest that overreliance on perceived knee function, without the use of evidence-based functional assessments, may result in rehabilitative decisions, based on incomplete information, that do not adequately address the needs of individual patients with ACLR while taking into account demographic considerations.

The cross-sectional research design of our work allowed for an expanded sample size but introduced heterogeneity into the patient population, specifically in the time since surgery at the point of study enrollment. Our participants were 5 to 9 months post-ACLR, which, although an important clinical period, can be a highly variable time for functional recovery, ranging from reintegration into activities of daily living to the transition to sport-specific activities. Narrowing of the inclusion criteria according to functional progress instead of time since surgery and a prospective research design to allow assessment of outcomes across the therapeutic window would enable future researchers to overcome these limitations. Furthermore, rehabilitation access, intensity, and compliance were not controlled in this study. Postsurgical rehabilitation was performed at several facilities, local to each data-collection site, and under the direction of numerous providers (eg, physical therapist, athletic trainer), thereby introducing additional sources of variation to our data. Standardized rehabilitation programs would remove these sources of clinical variations.

CONCLUSIONS

Men and women reported similar knee-related function, fear of movement and readiness for return to sport despite consistent evidence that women experienced worse objectively measured clinical outcomes after ACLR. Overreliance on patient reports or objective functional outcomes in evaluating patient progress and readiness for return to sport after ACLR may limit a clinician’s ability to comprehensively evaluate and develop individualized interventional approaches that optimize patient outcomes. Integration of objective evaluations of lower extremity strength, functional movement, and patient-reported outcomes are essential for effectively evaluating clinical success among this population.

REFERENCES

1. Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. _Am J Sports Med._ 2014;42(10):2363–2370. doi:10.1177/0363546514542796

2. Paterno MV, Rauh MJ, Schmitt LC, Ford KR, Hewett TE. Incidence of second ACL injuries 2 years after primary ACL reconstruction and return to sport. _Am J Sports Med._ 2014;42(7):1567–1573. doi:10.1177/0363546514530088

3. Grindem H, Snyder-Mackler L, Moksnes H, Engebretsen L, Risberg MA. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. _Br J Sports Med._ 2016;50(13):804–808. doi:10.1136/bjsports-2016-096031

4. Ageberg E, Forsblad M, Herbertsson P, Roos EM. Sex differences in patient-reported outcomes after anterior cruciate ligament reconstruction: data from the Swedish knee ligament register. _Am J Sports Med._ 2010;38(7):1334–1342. doi:10.1177/0363546510361218

5. Brophy RH, Schmitz L, Wright RW, et al. Return to play and future ACL injury risk after ACL reconstruction in soccer athletes from the Multicenter Orthopaedic Outcomes Network (MOON) group. _Am J Sports Med._ 2012;40(11):2517–2522. doi:10.1177/0363546512459476

6. von Porat A, Roos EM, Roos H. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. _Ann Rheum Dis._ 2004;63(3):269–273. doi:10.1136/ard.2003.008136

7. Swinton LR, Renstrom P. Factors affecting outcome after anterior cruciate ligament injury: a prospective study with a six-year follow-up. _Scand J Med Sci Sports._ 2008;18(3):318–324. doi:10.1111/j.1600-0838.2007.00696.x

8. Kuenze C, Pietrosimone B, Lisee C, et al. Demographic and surgical factors affect quadriceps strength after ACL reconstruction. _Knee Surg Sports Traumatol Arthrosc._ 2019;27(3):921–930. doi:10.1007/s00167-018-5215-9

9. Kuenze CM, Trigsted S, Lisee C, Post E, Bell DR. Sex differences on the Landing Error Scoring System among individuals with anterior cruciate ligament reconstruction. _J Athl Train._ 2018;53(9):837–843. doi:10.4085/1060-6050-459-17

10. Webster KE, Feller JA. Younger patients and men achieve higher outcome scores than older patients and women after anterior cruciate ligament reconstruction. _Am J Sports Med._ 2019;47(4):857–862. doi:10.1177/0363546518825258

11. McPherson AL, Feller JA, Hewett TE, Webster KE. Psychological readiness to return to sport is associated with second anterior cruciate ligament injuries. _Am J Sports Med._ 2019;47(4):857–862. doi:10.1177/0363546518833043

12. Paterno MV, Flynn K, Thomas S, Schmitt LC. Self-reported fear predicts functional performance and second ACL injury after ACL reconstruction and return to sport: a pilot study. _Sports Health._ 2018;10(3):228–233. doi:10.1177/1941738117745806

13. Sims M, Mulcahey MK. Sex-specific differences in psychological response to injury and return to sport following ACL reconstruction. _JBJS Rev._ 2018;6(7):e9. doi:10.2106/JBJS.RVW.17.00170

14. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. _Am J Sports Med._ 2009;37(5):890–897. doi:10.1177/0363546508330143

15. Webster KE, Feller JA, Lambros C. Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. _Phys Ther Sport._ 2008;9(1):9–15. doi:10.1016/j.ptspt.2007.09.003

16. Woby SR, Roach NK, Urmostin M, Watson PJ. Psychometric properties of the TSK-11: a shortened version of the Tampa Scale for Kinesiophobia. _Pain._ 2005;117(1–2):137–144. doi:10.1016/j.pain.2005.05.029

17. Irgang JJ, Ho H, Harner CD, Fu FH. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. _Knee Surg Sports Traumatol Arthrosc._ 1998;6(2):107–114. doi:10.1007/s001670050082

18. Irgang JJ, Anderson AF, Boland AL, et al. Development and validation of the International Knee Documentation Committee Subjective Knee Form. _Am J Sports Med._ 2001;29(5):600–613. doi:10.1177/03635465010290051301

19. Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. _J Orthop Sports Phys Ther._ 1998;28(2):88–96. doi:10.2519/iospt.1998.28.2.88
20. Webster KE, Feller JA. Development and validation of a short version of the Anterior Cruciate Ligament Return to Sport After Injury (ACL-RSI) scale. *Orthop J Sports Med*. 2018;6(4):2325967118763763. doi:10.1177/2325967118763763

21. Anderson AF, Irrgang JJ, Kocher MS, Mann BJ, Harrast JJ; International Knee Documentation Committee. The International Knee Documentation Committee Subjective Knee Evaluation Form: normative data. *Am J Sports Med*. 2006;34(1):128–135. doi:10.1177/0363546505280214

22. Logerstedt D, Di Stasi S, Grindem H, et al. Self-reported knee function can identify athletes who fail return-to-activity criteria up to 1 year after anterior cruciate ligament reconstruction: a Delaware-Oslo ACL cohort study. *J Orthop Sports Phys Ther*. 2014;44(12):914–923. doi:10.2519/jospt.2014.4852

23. Paradowski PT, Bergman S, Sunden-Lundius A, Lohmander LS, Roos EM. Knee complaints vary with age and gender in the adult population. Population-based reference data for the Knee Injury and Osteoarthritis Outcome Score (KOOS). *BMC Musculoskelet Disord*. 2006;7:38. doi:10.1186/1471-2474-7-38

24. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods*. 2007;39(2):175–191. doi:10.3758/bf03193146

25. Nwachukwu BU, Chang B, Voleti PB, et al. Preoperative short form health survey score is predictive of return to play and minimal clinically important difference at a minimum 2-year follow-up after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2017;45(12):2784–2790. doi:10.1177/0363546517714472

26. Losciale JM, Bullock G, Cromwell C, Ledbetter L, Pietrosimone L, Sell TC. Hop testing lacks strong association with key outcome variables after primary anterior cruciate ligament reconstruction: a systematic review. *Am J Sports Med*. 2020;48(2):511–522. doi:10.1177/0363546519838794

27. Kyritsis P, Bahr R, Landreau P, Miladi R, Witvrouw E. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *Br J Sports Med*. 2016;50(15):946–951. doi:10.1136/bjsports-2015-095908

Address correspondence to Christopher Kuenze, PhD, ATC, Michigan State University, 308 West Circle Drive, Room 105C, East Lansing, MI 48906. Address e-mail to kuenzech@msu.edu.