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Anterior Cruciate Ligament Reconstruction Rehabilitation Clinical Practice Patterns

A Survey of the PRiSM Society

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Investigation performed at the Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, USA

Background: Recovery after anterior cruciate ligament (ACL) reconstruction (ACLR) requires extensive postoperative rehabilitation. Although no ideal rehabilitation procedure exists, most experts recommend a fusion of time and strength and functional measures to guide decision making for activity progression during rehabilitation. This process is often directed by surgeon protocols; however, the adoption of contemporary rehabilitation recommendations among surgeons is unknown.

Purpose: To understand the current landscape of surgeon practice as it relates to ACLR rehabilitation recommendations in adolescent athletes.

Study Design: Cross-sectional study.

Methods: An online survey was distributed among members of the Pediatric Research in Sports Medicine (PRiSM) Society in January 2017. The survey was designed to identify clinical practice patterns during 3 key transitional points of rehabilitation after ACLR: progression to jogging, modified sports activity, and unrestricted return to sports.

Results: Responses from 60 orthopaedic surgeons were analyzed. While 80% of surgeons agreed upon initiating jogging within a 1-month range (3-4 months postoperatively), similar levels of agreement were only captured when including a wider 4-month (4-8 months) and 6-month range (6-12 months) for modified sports activity and unrestricted return to sports, respectively. All respondents (100%) reported using knee strength as a determinant to progress to modified sports activity; however, the mode of testing varied, with most using manual muscle testing (60%), followed by isokinetic (28%) or isometric (12%) testing. Most surgeons (68%) reported using some form of functional testing to return to modified sports activity, but the mode of testing and required progression criteria varied considerably among all reported testing procedures. The use of patient-reported outcome measures was limited to 20% of the sample, and no respondents reported using fear or self-efficacy questionnaires. Upon completion of rehabilitation, 73% recommended injury prevention programs, and 50% recommended the use of a functional ACL brace.

Conclusion: Rehabilitation progression practices in adolescent athletes are variable and become more inconsistent as the time from surgery increases. While the majority of the sample considered strength and functional testing important, the mode of testing and criteria thresholds for activity advancement varied considerably.

Keywords: ACL; anterior cruciate ligament; physical therapy; postoperative rehabilitation

The incidence of anterior cruciate ligament (ACL) injuries and ACL reconstruction (ACLR) among youth athletes has been steadily increasing.^{7,9,14,35,38} Unfortunately, outcomes after ACLR may be less than desirable, as recent literature has shown that up to 37% of athletes may never return to their prior level of sports participation.³ Additionally, and perhaps more alarmingly, adolescent athletes appear to be particularly at risk of sustaining secondary ACL injuries upon returning to sports, with documented reinjury rates as high as 30%.^{19,23,42,53}

Postoperative rehabilitation is an essential component of recovery after ACLR, facilitating successful outcomes by optimizing function and reducing the presence of risk factors for repeat or second ACL injuries.^{4,12,21,43,47} Historically, ACLR rehabilitation protocols relied heavily on time-based standards¹⁷; however, most experts currently recommend more comprehensive treatment protocols, as research has supported a blend of time-based and objective functional measures to guide postoperative rehabilitation decision making.^{1,6,26,27} Despite this understanding, a recent report demonstrated significant variability and inconsistent criteria for advancing physical activity and return to sports within published postoperative ACLR protocols.³² Although the responsibility for specific

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rehabilitation procedures and day-to-day management after ACLR is typically borne by the physical therapist, progression through larger functional milestones, such as return to jogging or sports-related activities, is typically directed by the surgeon's postoperative protocol. Literature pertaining to orthopaedic surgeon practice patterns after ACLR commonly focuses on operative decision making, techniques, or outcomes,^{33,34,45} and information regarding surgeon rehabilitation preferences is sparse. Thus, the purpose of this study was to evaluate current rehabilitation recommendations among orthopaedic surgeons regarding adolescent patients after ACLR, with a particular focus on the specific criteria utilized to guide activity progression throughout the entire course of recovery after surgery.

METHODS

Survey Development

A team of clinicians (3 physical therapists [E.M.G., E.T.G., J.A.] and 1 orthopaedic surgeon [T.J.G.]), highly experienced in managing patients after ACLR, collaborated to develop an electronic survey using REDCap electronic data capture tools, hosted at the Children's Hospital of Philadelphia.²⁰ The initial phase of development consisted of the identification of key rehabilitation transitional phases and the formation of preliminary questions guided by previously published reports and clinical expertise.³²⁻³⁴

Because of differences that may exist in rehabilitation and activity progression based on patient characteristics such as age, activity level, surgery type, graft type, and concomitant injuries, it was determined that the questionnaire should be grounded utilizing a standardized case vignette representative of a typical patient encountered by an orthopaedic surgeon. Survey participants were asked to answer the questions in the survey based on their typical treatment of the following patient: "Your patient is a 17-year-old female soccer player who underwent ACL reconstruction using a hamstring autograft. There were no concomitant injuries, and she is having an uncomplicated postoperative recovery. Her goal is to return to soccer competition at the collegiate level upon full recovery."

Each survey participant was instructed to answer all questions that related to their clinical practice of patients after ACLR. To be time-efficient, the electronic survey incorporated the use of branching logic, which propagated specific follow-up questions only if pertinent responses were selected in previous questions; thus, the total number of questions answered by each participant varied based on

the respondents' individual practice patterns. The survey consisted of 6 sections: (1) clinician demographics and clinical practice information, (2) clinical decisions related to jogging, (3) clinical decisions related to modified sports activity (eg, agility, sport-specific drills/skills), (4) clinical decisions related to unrestricted return to sports, (5) use of injury prevention programs, and (6) use of functional bracing upon return to sports.

The initial development team reviewed and tested the survey among themselves for format, inclusivity of content, clarity, and survey functionality. After all initial revisions were made, the survey was pilot tested among a group of 5 physical therapists and 3 orthopaedic surgeons. All suggestions were considered, and modifications to the survey were made after a consultation among all authors. During pilot testing, the survey took approximately 4 to 7 minutes to complete. The complete survey is available in the Appendix.

Participants were recruited at the 2017 Pediatric Research in Sports Medicine (PRiSM) Annual Meeting. An email containing an electronic link for survey access was sent to all orthopaedic surgeons in attendance. Interested participants clicked the electronic link, connecting them to a more detailed study description, which included eligibility criteria. Access to the survey was granted after selecting "yes" to the question indicating their informed consent to participate. No identifying information was collected on any of the participants, and thus, participation was completely anonymous. Because of the multidisciplinary audience at the meeting, only those identifying themselves as orthopaedic surgeons were included in the analysis. This study received approval from all necessary institutional review boards before onset. The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was used to ensure the quality of reporting the findings of this study.¹⁶

Statistical Analysis

Data were analyzed using SPSS version 24.0 (IBM). Descriptive statistics were utilized to summarize the distribution, frequency, and dispersion of participant responses.

RESULTS

Respondents' Profile

Of the 66 orthopaedic surgeons in attendance, 60 completed the survey (91% response rate). Demographic and professional characteristics of respondents are presented in Table

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Ethical approval for this study was waived by the institutional review board of the Children's Hospital of Philadelphia (protocol No. 16-013163).

TABLE 1
Demographics of Study Respondents^a

	n (%)
Years of experience as an orthopaedic surgeon ^b	
0-4	22 (36.7)
5-10	19 (31.7)
11-15	5 (8.3)
≥16	13 (21.7)
Primary practice setting	
Academic or teaching hospital	45 (75.0)
Private practice	8 (13.3)
For-profit or not-for-profit hospital	7 (11.7)
Region of practice ^c	
South Atlantic (DE, FL, GA, MD, NC, SC, VA, WV)	10 (16.7)
Mid-Atlantic (NJ, NY, PA)	7 (11.7)
East North Central (IL, IN, MI, OH, WI)	2 (3.4)
West North Central (IA, KS, MN, MO, NE, ND, SD)	6 (10.0)
East South Central (AL, KY, MS, TN)	0 (0.0)
West South Central (AR, LA, OK, TX)	9 (15.0)
New England (CT, ME, MA, NH, RI, VT)	6 (10.0)
Pacific (AK, CA, HI, OR, WA)	10 (16.7)
Mountain (AZ, CO, ID, MT, NV, NM, UT, WY)	2 (3.4)
No. of ACLR procedures performed per year ^b	
10-25	11 (18.3)
>25	48 (80.0)
Board certification in orthopaedic surgery ^b	
Yes	46 (76.7)
No	13 (21.7)

^aACLR, anterior cruciate ligament reconstruction.

^bOne participant did not report years of experience, number of ACLR procedures performed, and board certification.

^cEight participants did not report region of practice.

1. A total of 26 states across various geographical regions were represented in the sample. Years in clinical practice was evenly distributed and included those with 0-4 years (37%), 5-10 years (32%), and ≥11 years (30%) of orthopaedic surgery experience. The majority of the sample were board certified in orthopaedic surgery (77%), practiced in an academic or teaching hospital (75%), and performed >25 ACLR procedures each year (80%).

Decision Making Regarding Activity Progression

A large proportion of the sample (88%) indicated that the progression of activity after ACLR was largely a collaborative process, with shared decision making between both the orthopaedic surgeon and the rehabilitation specialist (ie, physical therapist or athletic trainer).

Time Criterion

A small majority (55%) of the orthopaedic surgeons indicated that they would evaluate this patient for 1 to 2 years postoperatively. Other responses indicated a postoperative follow-up duration of 9-12 months (18%), followed by >2 years (20%) and ≤8 months (7%).

Response frequencies pertaining to transitional time points of jogging, modified sports activity, and unrestricted

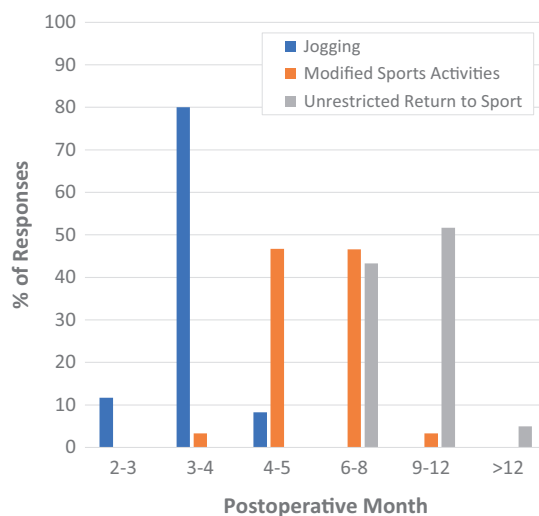


Figure 1. Time-based responses (N = 60) to initiate functional milestones after anterior cruciate ligament reconstruction.

return to sports are presented in Figure 1. Most orthopaedic surgeons indicated that they would initiate jogging between 3 and 4 months postoperatively (80%). Modified sports activity (eg, agility, coordination drills) was most often initiated at 4-5 months (47%) or 6-8 months (47%). Progression to unrestricted return to sports was reported most between postoperative months 6-8 (43%) and 9-12 (52%), with only 5% of the sample delaying this milestone until at least 1 year after ACLR.

Criterion-Based Measures

The most often reported criteria to initiate jogging and modified sports activity were knee range of motion (87% and 72%, respectively), degree of knee effusion (80% and 68%, respectively), thigh muscle strength via manual muscle testing (MMT) (70% and 60%, respectively), ACL laxity tests (55% and 60%, respectively), and lower extremity functional/balance tests (38% and 68%, respectively) (Figure 2). When resuming unrestricted return to sports, a slight majority of the respondents (55%) indicated that they did not require any additional formalized testing.

Thigh Muscle Strength

Thigh muscle strength via MMT was commonly considered a determinant to initiate jogging (70%), while more objective modes of strength testing, such as isokinetic dynamometry (22%) and handheld dynamometry (3%), were not reported as often. Similar findings were noted for initiating modified sports activity, with 60%, 28%, and 12% utilizing MMT, isokinetic dynamometry, and handheld dynamometry, respectively. If a respondent included isokinetic dynamometry as part of his or her assessment, additional data were gathered pertaining to limb symmetry index (LSI) thresholds of the quadriceps and hamstring muscle groups to initiate jogging and modified sports activity.

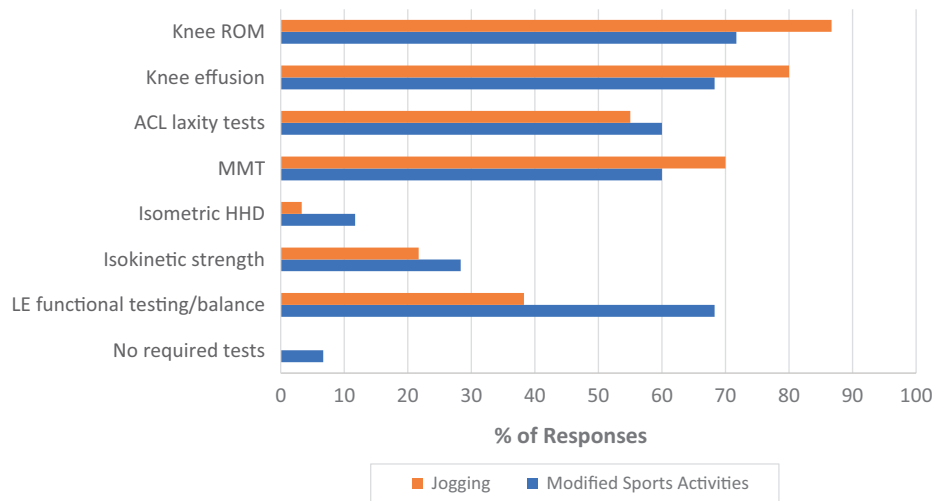


Figure 2. Criterion-based responses for initiating jogging and modified sports activity after anterior cruciate ligament (ACL) reconstruction. HHD, handheld dynamometry; LE, lower extremity; MMT, manual muscle testing; ROM, range of motion.

Interestingly, there was a wide variation of responses and no clear consensus regarding a specific LSI value for functional progression (Figure 3).

Functional Testing

Of all respondents, 65% and 66% utilized more than 1 functional test to initiate jogging and modified sports activity, respectively. The single-leg squat (31%) and straight-leg raise (20%) tests were most frequently utilized for decision making regarding readiness for jogging, while single-leg hop tests were used most often to initiate modified sports activity (60%), followed by the Y Balance Test (37%) and Functional Movement Screen (23%) (Table 2).

Of the 60% that utilized single-leg hop testing for decisions to initiate modified sports activity, the single hop for distance was most common (89%), followed by the triple hop for distance (58%) and triple crossover hop for distance (50%) (Table 3). Additionally, there was no clear consensus as to the required LSI thresholds to begin modified sports activity, as responses ranged from >75% to >95%, with >90% being the most common (44%).

Patient-Reported Outcome Measures (PROMs)

PROMs were utilized by 20% of orthopaedic surgeons to initiate jogging and 12% for progression to modified sports activity. Specific PROMs included the International Knee Documentation Committee (IKDC), Knee Outcome Survey (KOS), Lower Extremity Functional Scale (LEFS), and 36-Item Short Form Health Survey (SF-36); however, no scales related to fear and/or athletic confidence were considered.

Injury Prevention Programs and Functional Bracing

Although most orthopaedic surgeons recommended injury prevention programs after ACLR (73%), there was no

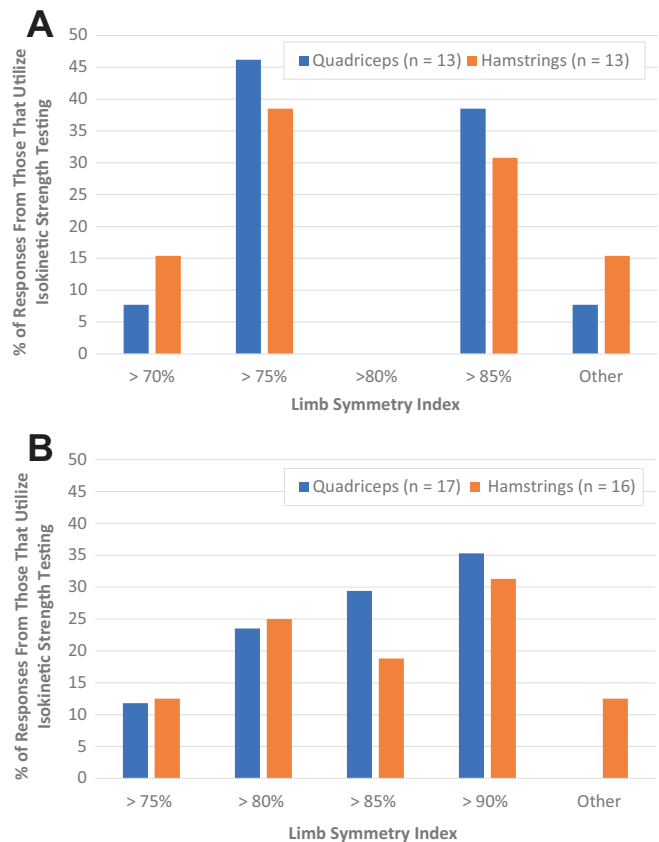


Figure 3. Thigh muscle strength requirements to initiate (A) jogging and (B) modified sports activity for respondents who utilize isokinetic testing.

clear consensus on the specific program preference. The FIFA 11+ (39%), Santa Monica PEP (27%), Sports-metrics (11%), and clinic-specific/individually adapted programs (23%) were all reported by respondents (Figure 4).

TABLE 2
Selection of Functional Tests to Initiate Jogging and Modified Sports Activity

	n (%)
Jogging (n = 23)^a	
Single-leg squat	19 (31)
Straight-leg raise	12 (20)
Lateral step down	5 (8)
Y Balance Test	5 (8)
Functional Movement Screen	5 (8)
Modified sports activity (n = 41)^b	
Single-leg hop tests	36 (60)
Y Balance Test	22 (37)
Functional Movement Screen	14 (23)
Drop vertical jump	12 (20)
Balance assessment tool	7 (12)

^a65% used more than 1 test.

^b66% used more than 1 test.

TABLE 3
Type of Hop Test Utilized and Criteria to Initiate Modified Sports Activity^a

	n (%)
Type of hop test	
Single hop for distance	32 (88.9)
Triple hop for distance	21 (58.3)
Triple crossover hop for distance	18 (50.0)
Timed 6-m hop	11 (30.6)
LSI threshold	
>75%	1 (2.8)
>80%	8 (22.2)
>85%	8 (22.2)
>90%	16 (44.4)
>95%	2 (5.6)
Other value not listed	1 (2.8)

^aBased on respondents who utilized hop testing as part of their test battery to initiate modified sports activity (n = 36). LSI, limb symmetry index.

Additionally, there was a clear dichotomy in brace prescription, with exactly half of the surgeons requiring the athlete to utilize a functional knee brace upon resuming unrestricted return to sports (Figure 5).

DISCUSSION

The results of this study offer a comprehensive analysis of surgeon preferences related to rehabilitation protocols after ACLR within youth athletes. A large proportion of surgeons (88%) indicated that decisions related to activity progression after ACLR were made within a joint decision-making framework, involving both the surgeon and the rehabilitation specialist. While our results clearly show that surgeons rely heavily on office-based physical examination procedures (eg, knee laxity, range of motion), shared decision making is highlighted by the additional requirement of

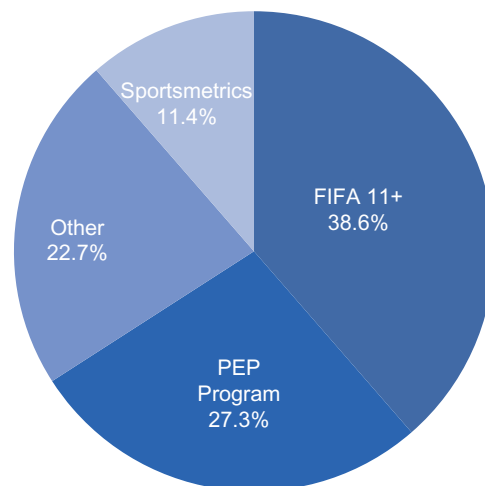


Figure 4. Frequency of recommended injury prevention programs.

Recommend Functional Brace Use Upon Resuming Unrestricted Sports Participation

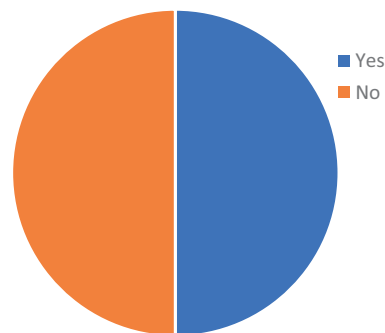


Figure 5. Frequency of functional brace utilization upon resumption of unrestricted sport participation.

physical performance tests (eg, strength, hop tests, quality of movement assessment) typically performed and interpreted by rehabilitation specialists. These results are particularly noticeable at the time of returning to on-field activities and may be reflective of an increased awareness of research indicating that the use of objective physical performance measures helps guide activity progression and the identification of risk factors related to secondary ACL injuries.^{1,6,26,27} Although there was broad agreement on the use of such performance measures, 32% of respondents indicated that they did not require such testing, and responses regarding the specific mode of testing and “passing” criteria varied substantially. For example, while a small majority of surgeons (60%) reported utilizing single-leg functional hop tests to resume modified sports activity, the hop test selection varied such that only 30% utilized the full complement of hop tests, originally described by Noyes et al.³⁶ While some research has shown utility in isolated hop tests,⁴¹ the use of the entire battery of tests has been strongly advocated for by many experts.^{1,13,29,30} In addition

to the variability in test selection, required minimum LSI criteria varied from >75% to >95%, leaving surgeons unable to achieve a majority (defined as $\geq 50\%$) agreement on this reference point. While many contemporary guidelines recommend an LSI of >90% as best practice,^{13,22,30,52,54} the response variability seen within our results may be reflective of the fact that there remains no clear consensus regarding ideal cutoff scores for hop tests within the literature.⁵²

Interestingly, while nearly all respondents indicated assessing thigh muscle strength as an important factor for activity progression, only a small proportion of surgeons utilized objective measures of handheld or isokinetic dynamometry. Instead, the majority of our respondents reported using MMT as the primary means of strength assessment. While MMT is an easily accessible means of gross strength assessment, it may lack the sensitivity to detect strength deficits that may be present during the late phases of recovery after ACLR.¹⁰ Neuromuscular impairments resulting in quadriceps strength deficits are common after ACLR,^{25,39,44} which may contribute to persistent functional impairments^{11,24} and increase the risks of developing post-traumatic osteoarthritis³⁷ or secondary knee injuries upon returning to cutting or pivoting sports.^{13,19,27} Thus, failing to incorporate more objective measures of strength after ACLR may lead to poorly informed postoperative decision making and may prematurely expose the athlete to high-risk activities.

Among those practitioners who did employ objective means of strength assessment, the cutoff values varied considerably. For example, to progress to modified sports activity, there was no clear agreement on the preferred LSI, with response frequencies widely distributed between 75% and 90% (Figure 3). This lack of agreement may be reflective of an absence of clear evidence to guide practice, with a large variability of LSI thresholds seen within the published literature.^{1,32,48-50,54} Regardless, many recently published reports advocate for LSI values of >90% to resume modified sports activity, and our results indicate that these standards are not reflected within current practice.^{1,5,48,49,51,52} Future investigations should attempt to determine what factors influence surgeon preferences for hop testing, strength assessment, and assignment of LSI cutoff values; this information may help reduce unnecessary variation in clinical practice and possibly improve patient outcomes.

With regard to time-based progression milestones, surgeon-directed rehabilitation practice patterns became more variable as the time from surgery increased. While 80% of surgeons agreed on progression to jogging within a 1-month range (postoperative 3-4 months), similar levels of agreement were only captured when including a much wider 4-month range (4-8 months) for modified sports activity and 6-month range (6-12 months) for unrestricted return to sports (see Figure 1). This variation in progression recommendations is particularly interesting at the time of unrestricted return to sports. Our results demonstrate a noteworthy divide between practitioners recommending unrestricted return to sports between 6-8 (43%) and 9-12 (52%) months postoperatively. Although there are

not many data available for comparison, our results may indicate a slight shift toward more conservative practice standards. A 2011 study of the Canadian Orthopaedic Association showed that the majority of surgeons allowed for unrestricted return to sports between 6 and 9 months post-operatively,³⁴ while our results show a slight majority favoring 9 to 12 months. While this may be reflective of adherence to more contemporary rehabilitation recommendations calling for more prolonged time frames before returning to sports,^{8,13,22} it may also be because of geographical or sampling bias. The sharp divide between surgeons allowing for unrestricted return to sports before 9 months is concerning, particularly in light of recent research demonstrating that the rate of repeat ACL injuries was significantly reduced by 51% for each month that return to sports was delayed until 9 months after surgery.¹⁹ This variability in return-to-sports recommendations may prematurely expose athletes to high-risk activities after ACLR and create an environment that facilitates confusion among parents or patients when seeking surgical consultation from multiple practitioners.

Recent literature has advocated for the use of knee-specific PROMs, such as the KOS or IKDC, to quantify functional deficits that may affect a patient's successful return to sports participation after ACLR.^{1,11} Surprisingly, only 12% of respondents indicated incorporating these measures into their protocol recommendations at the time of returning to modified sports activity. Additionally, current rehabilitation recommendations advocate for the use of scales that seek to understand an athlete's psychological readiness for sports and fear of reinjuries.^{2,11,13,28} Impairments identified by the use of scales such as the Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) or the Tampa Scale for Kinesiophobia have been associated with interlimb functional asymmetries⁵⁵ and an increased risk of second ACL injuries.⁴⁰ Regrettably, there were no respondents who indicated the use of such measures in their current rehabilitation protocols.

Upon the completion of rehabilitation, there was good agreement (73%) among respondents advocating for the use of ongoing injury prevention programs. Although specific injury prevention program recommendations varied, these results are in agreement with the current evidence, which shows the general effectiveness of injury prevention programs but does not show the superiority of a single specific program.⁴⁶

Finally, there was an even distribution between those who do and do not recommend the use of functional bracing upon return to sports. This result is similar to that of McRae et al,³⁴ who found that 45% of surgeons did not recommend the use of functional bracing in 2011. Although the literature supporting the effectiveness of functional bracing in the prevention of repeat ACL injuries is limited,³¹ it appears as though many surgeons continue to favor its use. This may reflect a comfort level in personal clinical experience or may also reflect consideration for patients' individualized preferences for bracing after ACLR.

Proper rehabilitation after ACLR is necessary to enable successful recovery and allow young athletes to achieve

their goals of returning to sports while mitigating impairments associated with a reinjury.^{12,15,21,43,47} Orthopaedic surgeons are not only called on as experts in surgical reconstruction but they also serve the role as primary director of patient management. While the details of physical performance testing are not part of standard surgeon training, mounting evidence supporting the use of such tests to improve patient management after ACLR suggests that surgeons should invest time in continued education of test application and interpretation or ensure that their team members (eg, physical therapists, athletic trainers) are utilizing postoperative protocols reflective of contemporary recommendations.

Interestingly, the variability in rehabilitation practices seen within the current study is similar to that seen within physical therapists¹⁸ and likely reflects a lack of interdisciplinary consensus regarding optimal patient management after ACLR.⁵² Regardless of the reason, future research efforts should be directed toward identifying optimal rehabilitation progression standards after ACLR and seeking efficient methods to ensure that these standards are adopted within clinical practice.

This study is not without limitations. The survey has not been previously validated, and it is possible that some participants may have interpreted questions differently than intended. Survey respondents consisted of a fairly homogeneous group of highly experienced pediatric specialist surgeons who work mostly within academic teaching institutions, and thus, our data may not be generalizable to the larger subset of surgeons in practice. However, this similarity in environment and training may actually underestimate the true degree of variability in practice that would be seen if a more diverse sample of surgeons were included. Finally, as with any survey study, respondent answers may have been influenced by recall or reporting bias.

CONCLUSION

This study offers a comprehensive characterization of surgeon rehabilitation practices after ACLR. The data indicate that there is a fairly large degree of variability in recommended clinical practices, which increases as the time from surgery increases. Future research should be directed toward understanding what factors contribute to this variability in clinical approaches, as such inconsistency may facilitate feelings of confusion among patients, parents, and other medical professionals and affect outcomes after ACLR.

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APPENDIX

ACLR Survey for Physical Therapists or Orthopaedic Surgeons

Dear Colleagues,

Anterior cruciate ligament (ACL) reconstruction is a common surgical procedure, and patients often require an intensive and progressive course of rehabilitation. Although there has been extensive research on ACL reconstruction, clinical practice patterns detailing rehabilitation are currently unclear. In an attempt to gain insight into this factor, the Sports Medicine and Performance Center at the Children’s Hospital of Philadelphia invites you to participate in this survey.

To participate, you need to be a physical therapist or orthopaedic surgeon who currently works with patients after ACL reconstruction. The survey takes approximately 5 to 7 minutes to complete. Your participation is completely voluntary, and your responses are anonymous. The survey includes a few demographic questions, followed by a series of questions regarding your rehabilitation practices in the management of athletes after ACL reconstruction.

Your responses will be kept completely confidential and analyzed anonymously. Please feel free to contact Dr Elliot Greenberg (greenberge@email.chop.edu) or Dr Theodore Ganley (ganley@email.chop.edu) with any questions, concerns, or technical problems. If you have questions about your rights as a research participant, you can contact the orthopaedic research office at the Children’s Hospital of Philadelphia: (267) 426-7607.

If you are interested in participating in this study, please select this option in the consent question below.

Thank you in advance for your participation.

Dr Elliot M. Greenberg, PT, PhD
 Dr Theodore J. Ganley, MD

Consent I consent to participate in the study
 I do not consent to participate in the study

Are you an orthopaedic surgeon or a physical therapist? Orthopaedic surgeon
 Physical therapist
 Neither

PRACTICE PATTERNS

How many anterior cruciate ligament (ACL) reconstructions do you perform each year? None
 <10
 10-25
 >25

What is your primary practice setting? Private practice
 For-profit or nonprofit hospital
 Academic teaching hospital
 Other

Other: _____

How many years have you been practicing as an orthopaedic surgeon? 0-4 years
 5-10 years
 11-15 years
 >16 years

Are you board certified in orthopaedic surgery? Yes
 No

What state do you practice in? Alabama
 Alaska
 Arizona
 Arkansas

(continued)

Appendix (continued)

-
- California
 - Colorado
 - Connecticut
 - Delaware
 - Florida
 - Georgia
 - Hawaii
 - Idaho
 - Illinois
 - Indiana
 - Iowa
 - Kansas
 - Kentucky
 - Louisiana
 - Maine
 - Maryland
 - Massachusetts
 - Michigan
 - Minnesota
 - Mississippi
 - Missouri
 - Montana
 - Nebraska
 - Nevada
 - New Hampshire
 - New Jersey
 - New Mexico
 - New York
 - North Carolina
 - North Dakota
 - Ohio
 - Oklahoma
 - Oregon
 - Pennsylvania
 - Rhode Island
 - South Carolina
 - South Dakota
 - Tennessee
 - Texas
 - Utah
 - Vermont
 - Virginia
 - Washington
 - West Virginia
 - Wisconsin
 - Wyoming
-

Do you normally prescribe formal rehabilitation before ACL reconstruction?

- Yes, for all patients
 - For some patients (with certain physical examination findings)
 - No, I don't prescribe this
-

Where did you hear about this survey?

- Email invitation
 - Social media (Facebook, Twitter, etc)
-

For the remainder of this survey, please answer the questions based on your typical treatment of the patient described below.

“Your patient is a 17-year-old female soccer player who underwent ACL reconstruction using a hamstring autograft. There were no concomitant injuries, and she is having an uncomplicated postoperative recovery. Her goal is to return to soccer competition at the collegiate level upon full recovery.”

(continued)

Appendix (continued)

For the patient described earlier, how long after ACL reconstruction would you continue to follow up with her?

- 1-3 months
- 4-5 months
- 6-8 months
- 9-12 months
- 1-2 years
- >2 years

Who is responsible for determining this athlete's readiness to begin to run, initiate plyometric and agility training, and unrestricted return to sports?

- Orthopaedic surgeon
- Rehabilitation specialist (PT, ATC)
- Both the orthopaedic surgeon and rehabilitation specialist
- Other

Other: _____

PROGRESSION TO JOGGING AFTER ACL RECONSTRUCTION

I would typically allow the athlete in this example to begin jogging at _____ months after surgery. (FILL IN THE BLANK FROM THE CHOICES AVAILABLE)

- 2-3 months
- 3-4 months
- 4-5 months
- ≥6 months

Are there specific physical tests, examination findings, or criteria that you utilize to assist in the decision to progress to jogging? (CHECK ALL THAT APPLY)

- Knee range of motion
- Strength assessment (manual muscle testing)
- Strength assessment (handheld dynamometry)
- Strength assessment (isokinetic testing)
- Knee effusion
- Lower extremity functional testing or balance assessment
- Patient-reported outcome measures
- ACL laxity test (eg, Lachman, anterior drawer, etc)
- None
- Other

Other: _____

If "Strength assessment (isokinetic testing)" is selected:
 What QUADRICEPS strength criterion is required for progression to jogging?

- Side-to-side deficit of less than 30%
- Side-to-side deficit of less than 25%
- Side-to-side deficit of less than 20%
- Side-to-side deficit of less than 15%
- Side-to-side deficit of less than 10%
- Other

Other: _____

If "Strength assessment (isokinetic testing)" is selected:
 What HAMSTRING strength criterion is required for progression to jogging?

- Side-to-side deficit of less than 30%
- Side-to-side deficit of less than 25%
- Side-to-side deficit of less than 20%
- Side-to-side deficit of less than 15%
- Side-to-side deficit of less than 10%
- Other

Other: _____

If "Lower extremity functional testing or balance assessment" is selected:
 Which of the following functional performance or balance tests do you use to assist with the decision to progress to jogging? (CHECK ALL THAT APPLY)

- Straight-leg raise
- Functional Movement Screen (FMS)
- Y Balance Test or Star Excursion Balance Test
- Lateral step down test
- Balance assessment tool (eg, Balance Error Scoring System [BESS])
- Single-leg squat
- Other

Other: _____

Appendix (continued)

<p><i>If “Functional Movement Screen (FMS)” is selected:</i> What criteria of the Functional Movement Screen do you utilize for advancement to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)</p> <p>Other: _____</p>	<input type="checkbox"/> Composite FMS score <input type="checkbox"/> Performance on isolated movements <input type="checkbox"/> Side-to-side symmetry for unilateral movements <input type="checkbox"/> Other
<p><i>If “Y Balance Test or Star Excursion Balance Test” is selected:</i> What criteria of the Y Balance Test do you utilize for advancement to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)</p> <p>Other: _____</p>	<input type="checkbox"/> Anterior reach difference of <4 cm <input type="checkbox"/> Composite reach with <10% side-to-side asymmetry <input type="checkbox"/> Other
<p><i>If “Patient-reported outcome measures” is selected:</i> What patient-reported outcome measure do you utilize for the determination to progress to jogging? (CHECK ALL THAT APPLY)</p>	<input type="checkbox"/> Lower Extremity Functional Scale (LEFS) <input type="checkbox"/> International Knee Documentation Committee (IKDC) <input type="checkbox"/> Knee Outcome Survey (KOS) <input type="checkbox"/> Short Form-36 (SF-36) <input type="checkbox"/> PROMIS quality of life measures <input type="checkbox"/> Pedi-FABS <input type="checkbox"/> Fear or self-efficacy survey (eg, Tampa Scale for Kinesiophobia)

PROGRESSION TO MODIFIED SPORTS ACTIVITY AFTER ACL RECONSTRUCTION

<p>I would typically allow the athlete in this example to begin modified sport-specific activities (agility, sport-specific drills/skills, etc) at _____ months after surgery. (FILL IN THE BLANK FROM THE CHOICES AVAILABLE)</p>	<input type="radio"/> 2-3 months <input type="radio"/> 3-4 months <input type="radio"/> 4-5 months <input type="radio"/> 6-8 months <input type="radio"/> 9-12 months <input type="radio"/> ≥12 months
<p>Are there specific physical tests, examination findings, or criteria that you utilize to assist in the decision to progress to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)</p> <p>Other: _____</p>	<input type="checkbox"/> Knee range of motion <input type="checkbox"/> Strength assessment (manual muscle testing) <input type="checkbox"/> Strength assessment (handheld dynamometry) <input type="checkbox"/> Strength assessment (isokinetic testing) <input type="checkbox"/> Knee effusion <input type="checkbox"/> Lower extremity functional testing or balance assessment <input type="checkbox"/> Patient-reported outcome measures <input type="checkbox"/> ACL laxity test (eg, Lachman, anterior drawer, etc) <input type="checkbox"/> None <input type="checkbox"/> Other
<p><i>If “Strength assessment (isokinetic testing)” is selected:</i> What QUADRICEPS strength criterion is required for progression to agility, plyometrics, and modified sport-specific activities?</p> <p>Other: _____</p>	<input type="radio"/> Side-to-side deficit of less than 30% <input type="radio"/> Side-to-side deficit of less than 25% <input type="radio"/> Side-to-side deficit of less than 20% <input type="radio"/> Side-to-side deficit of less than 15% <input type="radio"/> Side-to-side deficit of less than 10% <input type="radio"/> Other
<p><i>If “Strength assessment (isokinetic testing)” is selected:</i> What HAMSTRING strength criterion is required for progression to agility, plyometrics, and modified sport-specific activities?</p> <p>Other: _____</p>	<input type="radio"/> Side-to-side deficit of less than 30% <input type="radio"/> Side-to-side deficit of less than 25% <input type="radio"/> Side-to-side deficit of less than 20% <input type="radio"/> Side-to-side deficit of less than 15% <input type="radio"/> Side-to-side deficit of less than 10% <input type="radio"/> Other

(continued)

Appendix (continued)

If “Lower extremity functional testing or balance assessment” is selected:
 Which of the following functional performance or balance tests do you use to assist with the decision to progress to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)

- Functional Movement Screen (FMS)
- Y Balance Test
- Single-leg hop test
- Drop vertical jump
- Balance assessment tool (eg, Balance Error Scoring System [BESS])
- Patient-reported outcome measures
- Other

Other: _____

If “Functional Movement Screen (FMS)” is selected:
 What criteria of the Functional Movement Screen do you utilize for advancement to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)

- Composite FMS score
- Performance on isolated movements
- Side-to-side symmetry for unilateral movements
- Other

Other: _____

If “Y Balance Test or Star Excursion Balance Test” is selected:
 What criteria of the Y Balance Test do you utilize for advancement to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)

- Anterior reach difference of <4 cm
- Composite reach with <10% side-to-side asymmetry
- Other

Other: _____

If “Single-leg hop test” is selected:
 What single-leg hop tests do you utilize for advancement to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)

- Single hop
- Triple hop
- Triple crossover hop
- Timed 6-m hop
- Other

Other: _____

What single-leg hop criteria do you utilize for advancement to agility, plyometrics, and modified sport-specific activities?

- Side-to-side deficit of less than 25%
- Side-to-side deficit of less than 20%
- Side-to-side deficit of less than 15%
- Side-to-side deficit of less than 10%
- Side-to-side deficit of less than 5%
- Other

Other: _____

If “Patient-reported outcome measures” is selected:
 What patient-reported outcome measure do you utilize for the determination to progress to agility, plyometrics, and modified sport-specific activities? (CHECK ALL THAT APPLY)

- Lower Extremity Functional Scale (LEFS)
- International Knee Documentation Committee (IKDC)
- Knee Outcome Survey (KOS)
- Short Form-36 (SF-36)

- PROMIS quality of life measures
- Pedi-FABS
- Fear or self-efficacy survey (eg, Tampa Scale for Kinesiophobia)

PROGRESSION TO UNRESTRICTED RETURN TO SPORTS AFTER ACL RECONSTRUCTION

I would typically allow the athlete in this example to begin sports at _____ months after surgery. (FILL IN THE BLANK FROM THE CHOICES AVAILABLE)

- 2-3 months
- 3-4 months
- 4-5 months
- 6-8 months
- 9-12 months
- ≥12 months

Are there any additional tests, measures, or criteria, beyond those needed to initiate sports-related activities, that you require before allowing an athlete to participate in unrestricted sports activity?

- Yes
- No

(continued)

Appendix (continued)

If "Yes" is selected:

What additional tests or measures do you require? _____

RECOMMENDATION OF ONGOING INJURY PREVENTION PROGRAM

Do you recommend a specific ACL injury prevention program at discharge?

- Yes
 No
-

If "Yes" is selected:

What ACL prevention program do you recommend?

- Sportsmetrics
 Santa Monica PEP
 FIFA 11+
 Other

Other: _____

USE OF FUNCTIONAL BRACING AT THE TIME OF RETURN TO SPORTS

For the patient described in this example, would you typically recommend the use of a knee brace upon resumption of sports activities?

- Yes
 No
-

If "Yes" is selected:

What type of brace do you recommend?

- Functional ACL brace
 Neoprene knee sleeve
 Other

Other: _____
