Quality and Variability of Online Available Physical Therapy Protocols From Academic Orthopaedic Surgery Programs for Anterior Cruciate Ligament Reconstruction

Eric C. Makhni, M.D., M.B.A., Erica K. Crump, M.D., Michael E. Steinhaus, M.D., Nikhil N. Verma, M.D., Christopher S. Ahmad, M.D., Brian J. Cole, M.D., M.B.A., and Bernard R. Bach Jr., M.D.

Purpose: To assess the quality and variability found across anterior cruciate ligament (ACL) rehabilitation protocols published online by academic orthopaedic programs. **Methods:** Web-based ACL physical therapy protocols from United States academic orthopaedic programs available online were included for review. Main exclusion criteria included concomitant meniscus repair, protocols aimed at pediatric patients, and failure to provide time points for the commencement or recommended completion of any protocol components. A comprehensive, custom scoring rubric was created that was used to assess each protocol for the presence or absence of various rehabilitation components, as well as when those activities were allowed to be initiated in each protocol. **Results:** Forty-two protocols were included for review from 155 U.S. academic orthopaedic programs. Only 13 protocols (31%) recommended a prehabilitation program. Five protocols (12%) recommended continuous passive motion postoperatively. Eleven protocols (26%) recommended routine partial or non−weight bearing immediately postoperatively. Ten protocols (24%) mentioned utilization of a secondary/functional brace. There was considerable variation in range of desired full-weight-bearing initiation (9 weeks), as well as in the types of strength and proprioception exercises specifically recommended. Only 8 different protocols (19%) recommended return to sport after achieving certain strength and activity criteria. **Conclusions:** Many ACL rehabilitation protocols recommend treatment modalities not supported by current reports. Moreover, high variability in the composition and time ranges of rehabilitation components may lead to confusion among patients and therapists. **Level of Evidence:** Level II.

A successful anterior cruciate ligament (ACL) reconstruction should enable patients to return to their preinjury levels of activity and competition after surgery. This return to activity, however, is contingent upon completion of a rigorous postoperative physical therapy program.[1] Given the importance of post-operative physical therapy in restoring motion, strength, and conditioning, there has been substantial, high-level

From the Department of Orthopaedics (E.C.M., N.N.V., B.J.C.) and Section of Sports Medicine, Sports Medicine Fellowship Program Director (B.R.B.), Rush University Medical Center, Chicago, Illinois; Hospital for Special Surgery (M.E.S.), New York, New York; Department of Orthopaedics, Naval Medical Center San Diego (E.K.C.), San Diego, California; and Columbia University Medical Center (C.S.A.), New York, New York, U.S.A.

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Address correspondence to Eric C. Makhni, M.D., M.B.A., Department of Orthopaedics, Rush University Medical Center, 1611 West Harrison, Suite 300, Chicago, IL 60612, U.S.A. E-mail: ericmakhnimd@gmail.com

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research effort in determining the clinical benefit of various components of ACL rehabilitation.[2-10] Measures that appear to be of clinical benefit include early weight bearing and motion, while those with evidence indicating no benefit include continuous passive motion (CPM), secondary (functional) postoperative bracing, and decreasing the time to return to sport ("accelerated physical therapy").[11,12]

In the United States, there is a movement to transition to a value-driven health care system in which economic resources are invested in health care measures that produce clear clinical benefit.[13-18] In ACL reconstruction, a large proportion of postoperative resource utilization arises from physical therapist-supervised rehabilitation. Consequently, several studies have attempted to determine the impact of such clinical supervision on functional outcomes. These studies report no clear clinical benefit in patients undergoing predominately supervised physical therapy compared with those undergoing home-based programs.[8,12,19-21] Given the rising importance of home-based physical therapy,[20] it is imperative to determine whether these protocols employ current published principles in ACL rehabilitation. Moreover, significant variability between protocols may lead to patient and clinician confusion regarding which protocol to follow. As multiple studies, including those of postoperative orthopaedic rehabilitation, have suggested a correlation between improved clinical benefits and standardization of clinical care pathways,[14,15,17,18,22-24] a baseline assessment of the variability within these protocols is also warranted.

To minimize variability due to individual provider preference, protocols from academic orthopaedic programs were the focus of this study. The purpose of this study was to assess the quality and variability found across ACL rehabilitation protocols published online by academic orthopaedic programs. We hypothesize that only a minority of physical therapy protocols will demonstrate adherence to published best practices in ACL rehabilitation and that there will be substantial variability in the composition and timing of rehabilitation components across different protocols.

Table 1. Rehabilitation Protocol Components

Prehabilitation	Range of motion, quadriceps strengthening
Postoperative adjunct therapy	Continuous passive motion, brace use, neuromuscular electric stimulation
Early motion and weight bearing	Flexion/extension goals, weight-bearing parameters
Strengthening	Straight-leg raise, resisted straight-leg raise, quadriceps sets/isometrics, ankle pumps, minisquats, squats, hamstring curls, resisted hamstring curls, leg press, step-up/down, wall sits, single-leg squats, resisted knee extension, lunges
Proprioception	Weight shifting, 1-leg balance, balance board, ball toss, perturbation, balance beam, Theraband control, mini-trampoline balance
Functional testing	Single-hop test, 3-hop test, isokinetic quadriceps strength, isokinetic hamstring strength, quadriceps/hamstring strength ratio, or nonspecific functional test
Activity/sport	Stationary bike, backwards walking, normal gait, elliptical, stair climber, aqua jogging, underwater treadmill, swimming, backwards running, straight-line running/jogging, jumping/plyometrics, cutting/pivoting, agility (carioca, side shuffle), sport-specific drills, return to practice/sport

Methods

This investigation reviewed publicly available physical therapy protocols from U.S. academic orthopaedic surgery programs. Academic programs were selected for initial screening to avoid selection bias of incorporating protocols obtained from search engines online. A list of academic orthopaedic surgery programs in the United States was obtained from the Electronic Residency Application Service. Websites from these programs, along with a general web-based search (www.Google.com), were then used to identify any official ACL reconstruction rehabilitation protocols affiliated with the program using the search term "[Program/affiliate hospital/affiliate medical school name] ACL reconstruction rehabilitation protocol" during searches undertaken in December 2014. Protocols were excluded from review if they were designed for pediatric patients, involved combined meniscus repair, or did not provide any time points for the commencement or recommended completion of any protocol components.

For each program, all official ACL rehabilitation protocols were reviewed and assessed by the study team according to a custom rubric created for this study after full review of all available rehabilitation protocols. This rubric included scoring sections for relevant metrics and was created according to a comprehensive literature review of available studies and protocols regarding components of ACL rehabilitation. The assessment of quality of the protocol focuses on adherence to published guidelines regarding ACL rehabilitation, while the assessment of variability among protocols focuses on the different rehabilitation components found in the individual protocols as well as on the suggested points in the recovery process at which these components are recommended. The following broad categories within each protocol were defined: prehabilitation, postoperative adjunct therapy, range of motion and weight bearing, strengthening exercises, proprioception exercises, return to activity/sport, and functional testing. The complete listing of reviewable metrics is listed in Table 1. The primary outcome of this study was inclusion, or exclusion, of these metrics in each identified rehabilitation protocol. The secondary outcome was the

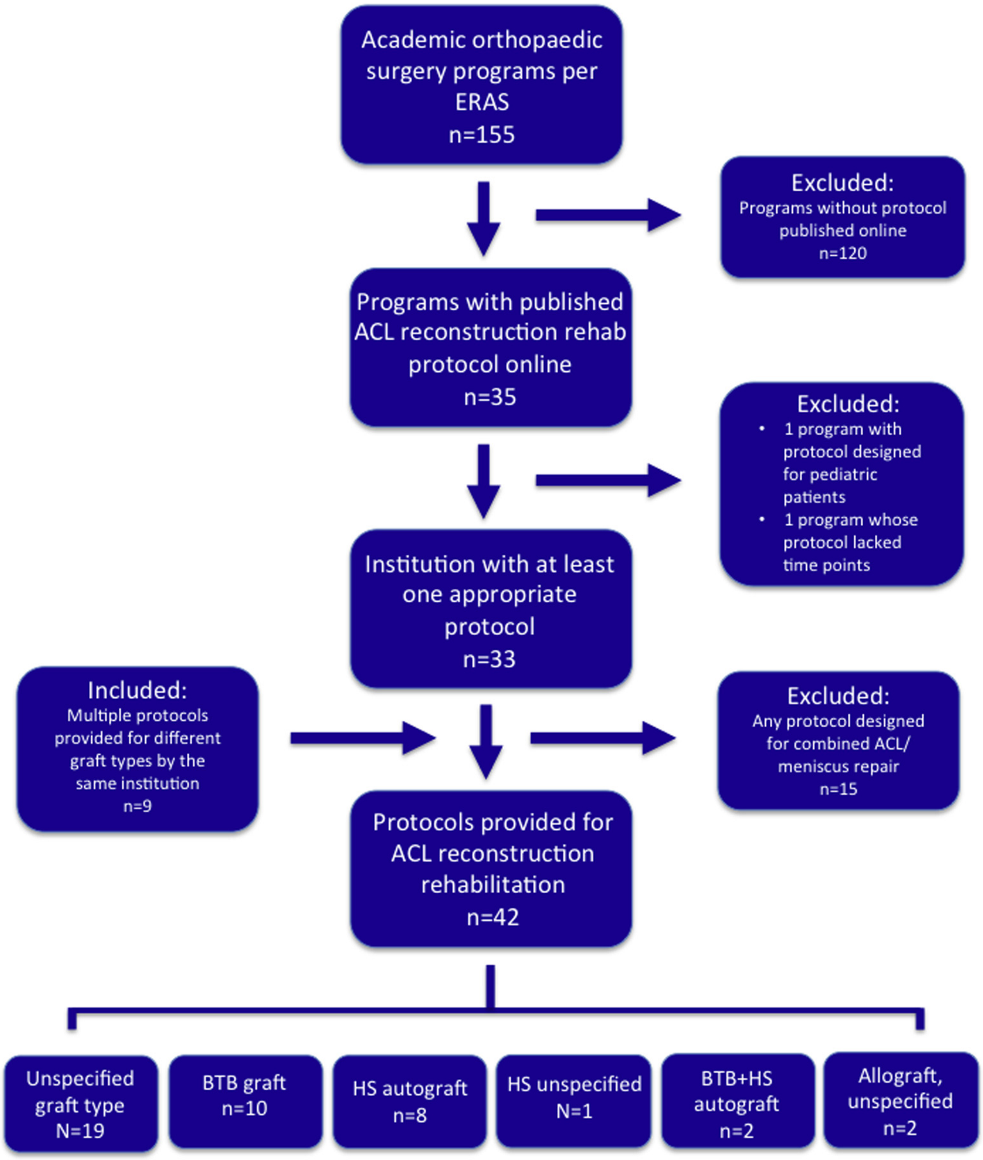

Fig 1. Flow diagram for the study. (ACL, anterior cruciate ligament; BTB, bone-tendon-bone; ERAS, electronic residency application service; HS, hamstring.)

appropriate timetable for commencement of these individual components. For example, with regards to single-leg squats, inclusion or exclusion of this activity was noted for each protocol, as well as when (in the recovery period) this activity was allowed to be attempted.

Results

In total, 155 programs were included for review. Thirty-three of these 155 academic orthopaedic programs (21%) provided publicly available (online) rehabilitation programs that met the eligibility criteria, with a total of 42 protocols that were included in this study (Fig 1).

Prehabilitation

Of the 42 included protocols, 13 (31%) explicitly recommended a preoperative rehabilitation activity set (Fig 2A). Six protocols (14%) specifically delineated types of range-of-motion activities to complete, and 8 protocols (19%) explicitly recommended quadriceps strengthening exercises.

Postoperative Adjunct Therapy

Three types of postoperative adjunct therapies were assessed (Fig 2B): bracing (both immediate postoperative as well as functional/secondary), CPM, and neuromuscular electric stimulation (NMES; as an assist to quad strengthening). An overwhelming majority—40 of 42 protocols (95%)—recommended immediate postoperative bracing. In the 2 protocols

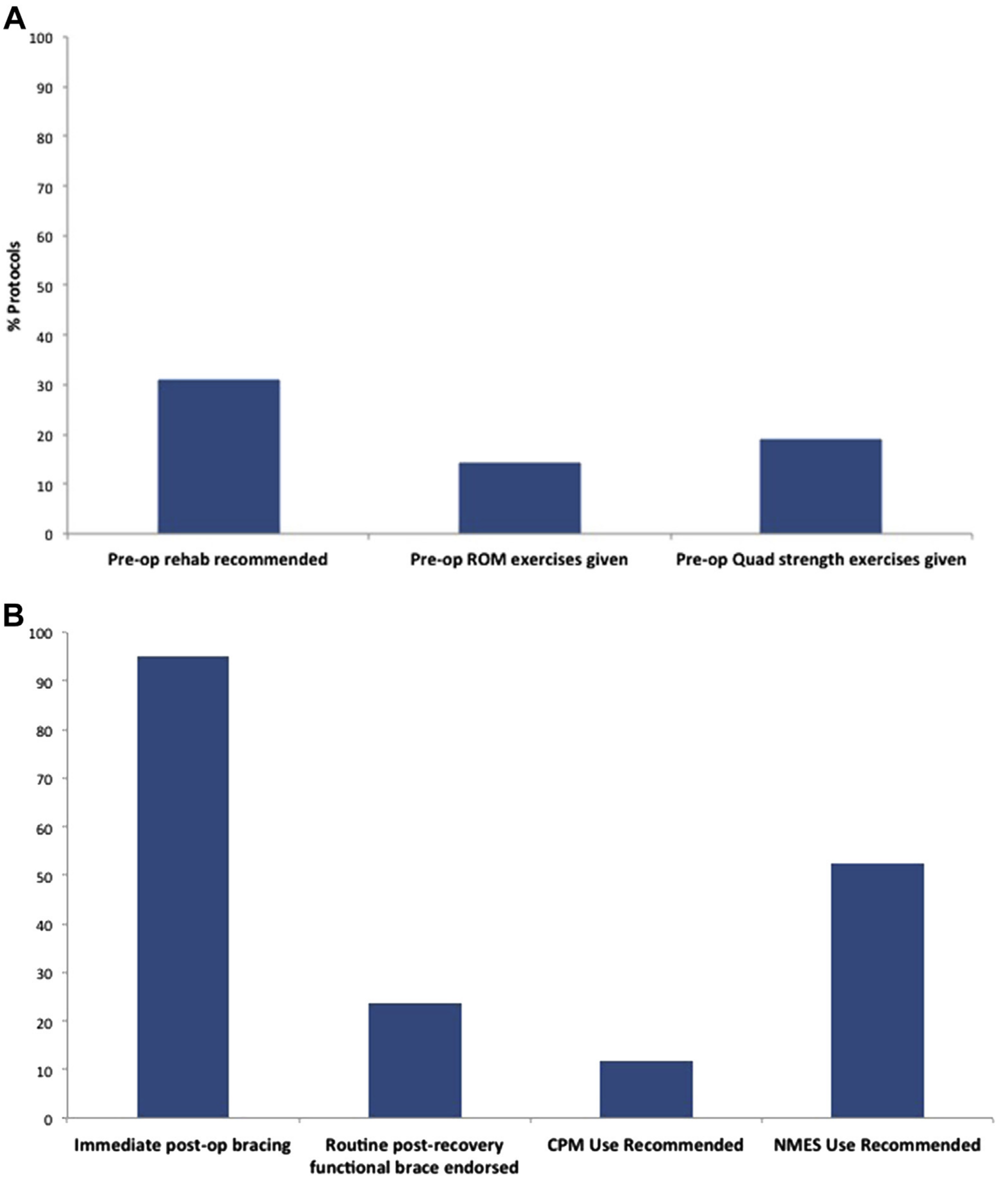

Fig 2. (A) Preoperative and (B) early postoperative variability in physical therapy protocols. (A) Prehabilitation was mentioned in approximately 30% of protocols. (B) Ten percent of protocols continued to advocate for routine CPM use postoperatively, and approximately 20% of protocols recommended routing postoperative functional bracing following recovery. (CPM, continuous passive motion; NMES, neuromuscular electric stimulation; quad, quadriceps; ROM, range of motion.)

that did not recommend this type of bracing, there was no written recommendation (either for or against) regarding immediate postoperative bracing. Ten different protocols (24%) reported guidelines for transitioning to a "secondary" or postrecovery functional brace. These guidelines included either recommendations for transitioning to a secondary brace or instructions to consult with a clinician prior to

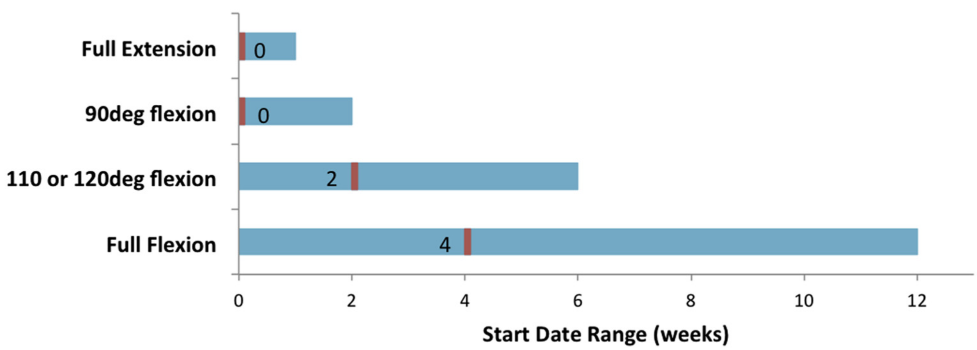

Fig 3. Time-based goals for achieving range-of-motion milestones. The target time point for achieving full flexion ranged from 0 weeks postoperatively to 12 weeks postoperatively. The numbered line within each range indicates median of data set. (Deg, degrees.)

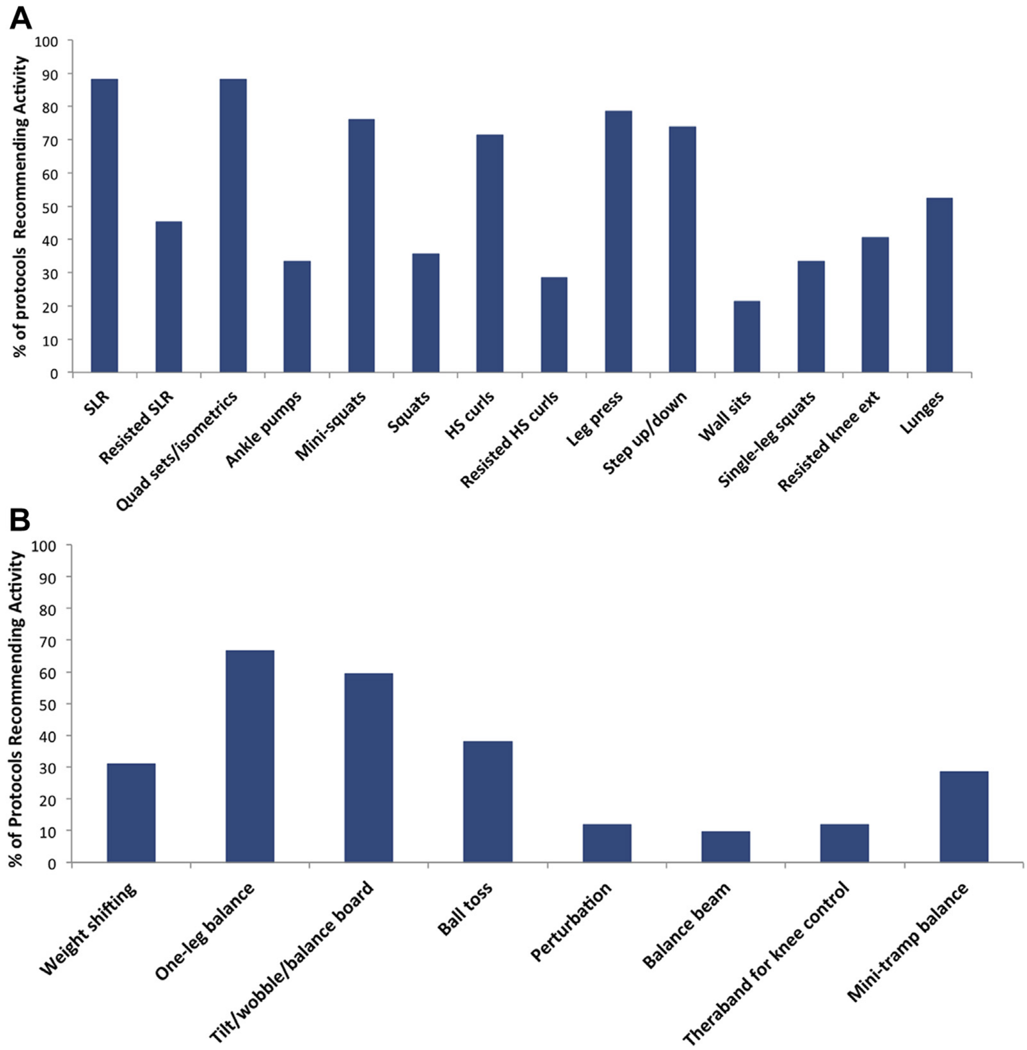

Fig 4. (A) Strengthening and (B) proprioception exercises. A significant variation was found with regards to composition of both types of exercises in rehabilitation protocols. (HS, hamstring; quad, quadriceps; SLR, straight-leg raise.)

transitioning to a secondary functional brace. Five protocols (12%) recommended CPM use. Approximately half of all protocols (22 of 42; 52%) recommended NMES as a useful adjunct to quadriceps strengthening efforts. Most of these protocols (20 of 22) recommended commencement of NMES in the first postoperative week, while the remaining 2 protocols recommended initiation starting 1 week postoperatively.

Early Motion and Weight Bearing

All protocols (42 of 42) recommended immediate motion postoperatively. Every protocol similarly gave completion goals dates by which to achieve full extension (Fig 3). For range-of-motion milestones with regards to flexion, 26 protocols (62%) set goals for 90° of flexion, compared with 31 and 37 protocols (74% and 88%, respectively) that set goals for 110° or 120° of flexion and full flexion (>135°), respectively.

Regarding postoperative weight bearing, there were 11 protocols (26%) that recommended either routine partial weight bearing or routine non−weight bearing for at least the first week after surgery. There was a 9-week range in the stated goal for achieving full weight bearing (1 to 10 weeks postoperatively, with a median of 3 weeks).

Strengthening

Fourteen different basic strengthening exercises were included in the rubric for assessing ACL physical therapy protocols (Table 1). On average, each protocol presented an average of 7.2 different strengthening exercises (Fig 4A). Only 4 protocols (9.5%) provided clear instruction on the proper mechanics in performing these exercises. Seven of 14 exercises appeared in greater than 50% of protocols. Wide variation was identified with regards to earliest commencement dates of the most common strengthening exercises (those appearing in >50% of protocols; Fig 5A). Among the

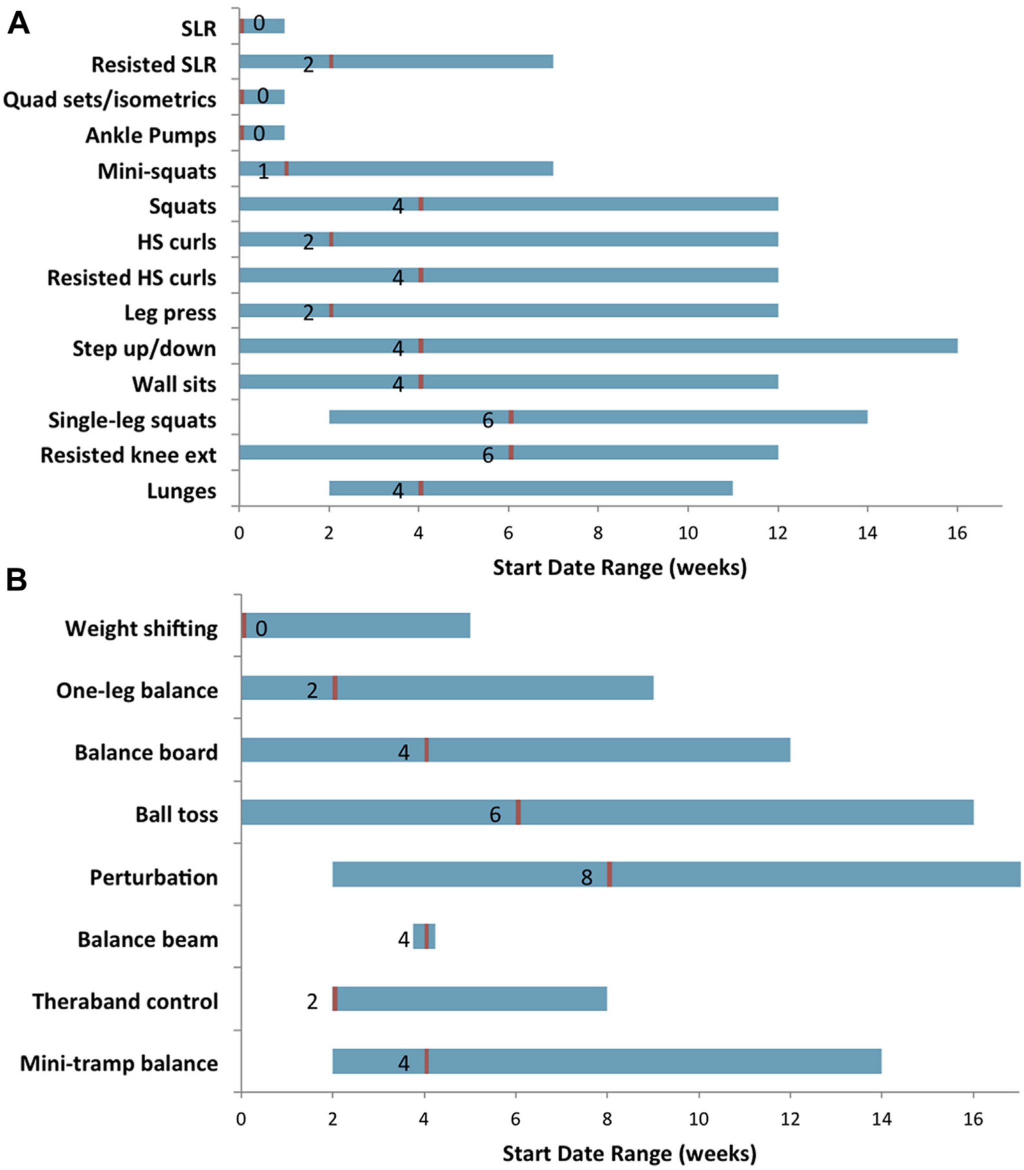

Fig 5. (A) Strengthening and (B) proprioception exercises. Significant variation was found with regards to allowable start times for exercises. Numbered line within each range indicates median of data set. (HS, hamstring; quad, quadriceps; SLR, straight-leg raise.)

strengthening exercises with highest variability were step-up/step-down exercises (16 weeks range for earliest start date), as well as hamstring curls and leg press (each with an earliest allowable start date of around 12 weeks).

Proprioception

Eight different proprioceptive exercises were included in the rubric for assessing ACL physical therapy protocols (Table 1). On average, each protocol presented an average of 2.4 different proprioceptive exercises (Fig 4B). Two of 8 proprioceptive exercises appeared in greater than 50% of protocols. As with the strengthening exercises, wide variation was identified with regards to earliest commencement dates of the most common strengthening exercises (those appearing in >50% of protocols; Fig 5).

Return to Activity/Sport

With respect to return to sport guidelines and prerequisites, 5 protocols (12%) failed to mention return to sport as a goal of ACL rehabilitation. Only 8 different protocols (19%) recommended return to sport after achieving certain strength and activity criteria.

Each protocol was additionally assessed for inclusion of a variety (n = 15) of different rehabilitation activities (Fig 6A). Of these 15 activities, 11 activities (73%) appeared in greater than 50% of protocols. Again, considerable variability with respect to earliest start dates was noted across these rehabilitation activities (Fig 6B).

Functional Testing

Six different functional activity components were included in the study's rehabilitation rubric (Fig 7A).

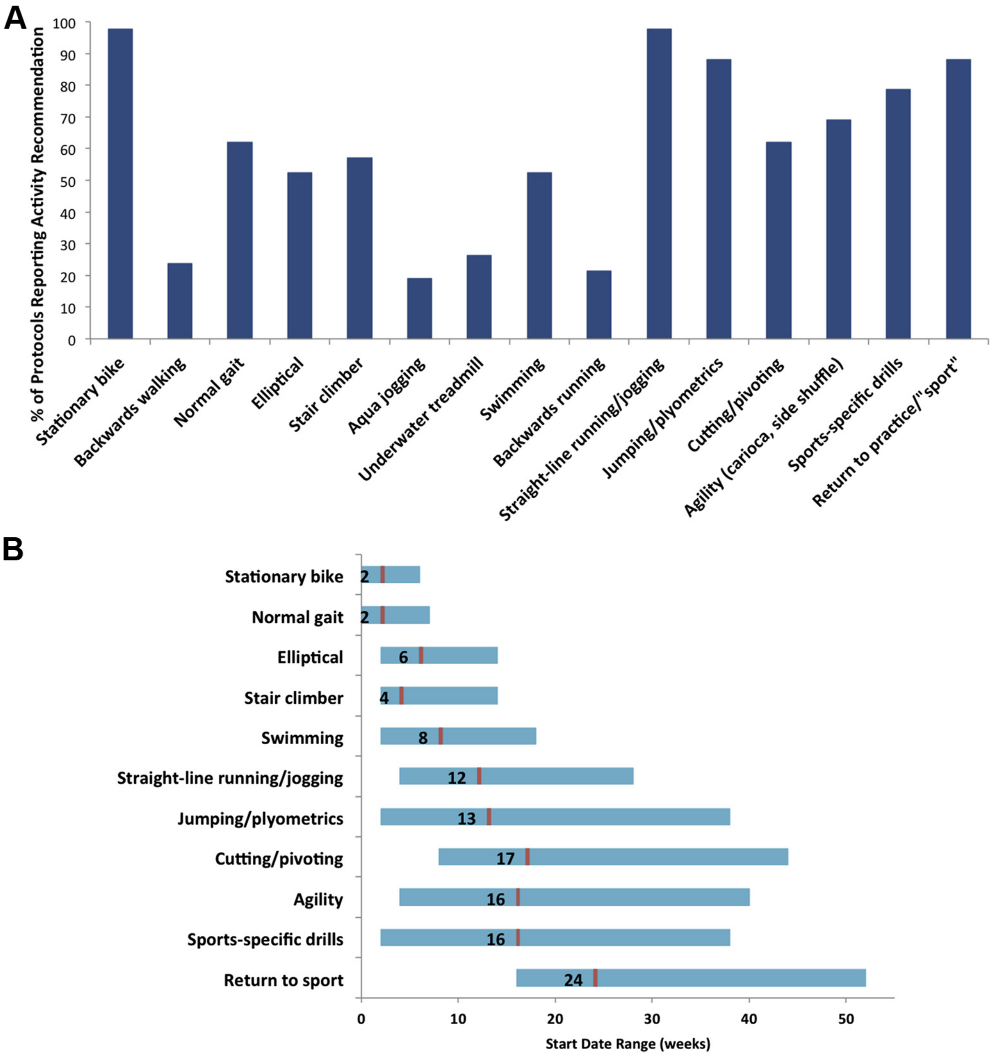

Fig 6. (A) Return to activity/ sports and (B) start dates. Numbered line within each range indicates median of data set.

None of these functional tests appeared in greater than 50% of physical therapy protocols. As with other variables, substantial variation existed in allowable start times for these functional activity components (Fig 7B).

Discussion

The results of this study indicate that only a minority of academic programs publish ACL physical therapy protocols online and that within these protocols, there is a significant amount of variation with regards to exercises incorporated and timing of rehabilitation milestones. Several of these protocols were found to provide guidelines for rehabilitation practices that have been shown to provide no meaningful clinical benefit (such as secondary bracing and CPM), and most protocols lacked clear instruction in performing various functional and athletic activities. Moreover, substantial variation existed with regards to both the type of rehabilitation components included in the study protocols as well as to the earliest start dates of these protocols. This variation of included components is indicative of the general lack of consensus regarding best-practice components of ACL rehabilitation and represents a possible area for increased process standardization.

The study authors were surprised to find that such a low proportion of academic orthopaedic programs made their ACL physical therapy protocols available online. Moreover, these protocols were typically not directed toward a patient readership. It is likely that many orthopaedic surgeons provided individualized protocols to patients either directly or through affiliated physical therapists. However, there has been a trend toward increased emphasis on home-based physical therapy, given the numerous clinical studies that have consistently reported no difference in clinical outcome between patients undergoing supervised versus home-based ACL rehabilitation.[8,12,19-21] Moreover, because of the current economic pressures on the United States health care system, this dependence on home-based care is expected to grow. Patients are expected to be

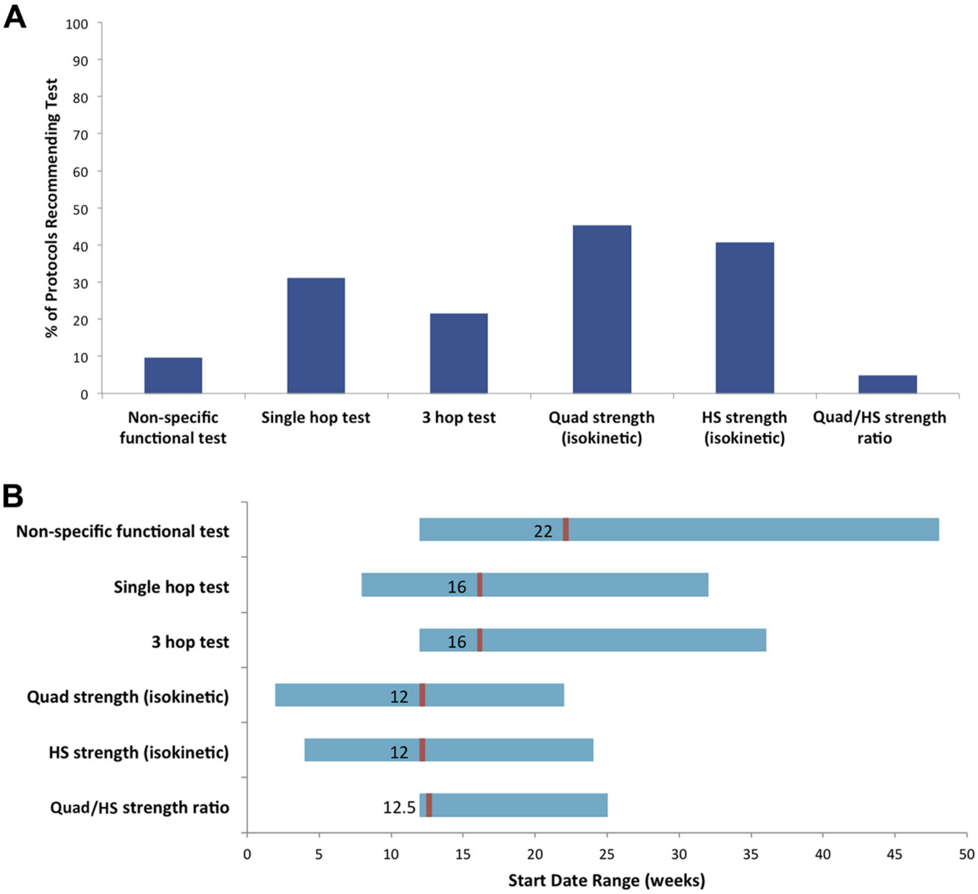

Fig 7. (A) Functional activity components and (B) start dates of anterior cruciate ligament rehabilitation protocols. Numbered line within each range indicates median of data set. (HS, hamstrings; quad, quadriceps.)

increasingly proactive in matters regarding their health care, including education about disease conditions and treatment.[17] Therefore, patients are still likely to consult these online protocols for reference when navigating their own rehabilitation processes.

Interestingly, 1 protocol was identified that specifically referenced this trend in health care resource allocation. This protocol emphasized minimal physical therapy sessions with an emphasis on patient education and self-directed rehabilitation. This protocol allocated only 8 clinician-supervised visits over the first postoperative year. However, this protocol was the exception, and similar emphasis was excluded from all other protocols. Because the rehabilitation process is so crucial to facilitating successful outcomes after ACL reconstruction,[1,20] patients must be able to readily access their physical therapy protocols throughout the recovery period. Considering the results from this study, improved online access to protocols should be considered.

Along with adherence to published guidelines for medicine, quality can be improved through standardization of clinical care pathways. This has been demonstrated in studies involving inpatient procedures, particularly total joint replacement.[17,18,22,25] The results from our study indicate that there is considerable variation in both the types of components that rehabilitation protocols recommend and in the timing at which that these activities may be initiated. It is reasonable to expect that individual patients may differ in how quickly or aggressively they progress through the recovery period after ACL reconstruction. In fact, many experts have advocated for aggressive protocols[1] for patients with high activity levels at baseline who may benefit from an earlier return to sport or activity (e.g., elite athletes). However, our analysis concluded that not only were large time ranges suggested for each rehabilitation activity but also that there were no explicit guidelines in these protocols that guided the patient as to when progression to these activities was considered reasonable. Before patients were expected to manage their own rehabilitation, this omission and lack of clarity may have been acceptable as long as the patient's therapist was able to guide the patient through the recovery process. However, with patients expected to manage their own rehabilitation, this variability and lack of clarity may create confusion and overexertion as patients attempt to progress through the recovery process without clear guidelines. Therefore, a decrease in the variability across these protocols may help patients navigate the recovery process more safely and with a concomitant higher chance of successful return to activity.

While most of the evidence regarding improvement in clinical outcomes from care standardization has focused on inpatient procedures, there is recent evidence that supports standardization in outpatient physical therapy as well. Hando and colleagues[23] followed a series of patients with hip osteoarthritis who underwent a standardized physical therapy regimen that consisted of interventions proven to be clinically effective. The authors noted significant improvements across a number of functional metrics and scores. Unfortunately, this study did not compare their evidence-driven protocol with that of a traditional protocol, but the authors were able to provide evidence that standardization of physical therapy is nonetheless highly effective in the outpatient setting.

Limitations

It is important to note that this study does have several limitations. Even though over 150 programs were considered for inclusion, only 42 protocols met all inclusion and exclusion criteria. This number represents a minority of the available ACL rehabilitation protocols accessible online. Moreover, combined meniscus repair protocols were excluded. It is also likely that individual practitioners from these academic programs may have personal websites that independently publish their preferred physical therapy protocols. However, our methodology was chosen to select a series of protocols while minimizing selection bias. A second limitation is the incorporation of protocols designed for different patients (depending on graft type) into a single study cohort. In our study, there were protocols designed specifically for bone-tendon-bone autograft that were assessed alongside protocols designed for soft tissue autograft patients. However, in our attempt to classify these protocols according to target patient (by graft type received), we found that many protocols failed to identify a target patient population. While some exercises (such as resisted leg extension) may be particularly sensitive to graft type, a majority of rehabilitation components are likely insensitive to this variable. Moreover, as the goal of this study was to document the variability across different protocols, the impact of protocol segregation according to graft type is likely less contributory.

Conclusions

Many ACL rehabilitation protocols recommend treatment modalities not supported by current reports. Moreover, high variability in the composition and time ranges of rehabilitation components may lead to confusion among patients and therapists.

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