Team Approach: Return to Play After Anterior Cruciate Ligament Reconstruction

Dean Wang, MD

Theresa Chiaia, PT, DPT

John T. Cavanaugh, PT, MEd, ATC, SCS

Scott A. Rodeo, MD

Investigation performed at the Sports Medicine and Shoulder Service and the Sports Rehabilitation and Performance Center, Hospital for Special Surgery, New York, NY

Abstract

» Current surgical and rehabilitation techniques have allowed for a relatively high rate of return to sports after anterior cruciate ligament (ACL) reconstruction. Although some patients may be expected to return to sporting activities by as early as 8 months after the surgical procedure, most patients will have not achieved the appropriate rehabilitation benchmarks by this time point and can require as long as 2 years to reach their full preoperative level.

» In addition to the diagnosis and surgical treatment of the ACL injury, the surgeon has to educate the patient about the injury, treatment, and rehabilitation process.

» The physical therapist commonly spends the most time with the patient and therefore must foster a relationship of trust early on with the patient-athlete. Through biomechanical evaluations, factors that contributed to the ACL injury and ongoing deficits during the rehabilitation process are identified and are addressed.

» Assessment of movement quality complements the traditional quantitative measures of performance and informs the medical and rehabilitation team, as well as the patient, of the presence of potentially faulty movement patterns associated with an ACL injury.

» Throughout the course of rehabilitation, the certified athletic trainer works closely with the physical therapist to ensure athlete compliance with the prescribed exercises. Communication between the physical therapist and the certified athletic trainer therefore plays an integral role in the patient's rehabilitation. During the return-to-play phase of rehabilitation, the certified athletic trainer serves as the liaison between the patient, surgeon, physical therapist, and coaching staff.

» This team approach to managing the athlete's injury, rehabilitation, and expectations is key to a successful outcome.

Anterior cruciate ligament (ACL) reconstruction is commonly performed in athletes who sustain an ACL injury with the goal of returning them to preinjury levels of sports participation, particularly in sports involving cutting, pivoting, and jumping maneuvers. Recent advancements in surgical techniques and rehabilitation have contributed to a relatively high rate of return to play after ACL reconstruction[1]. Although some patients may be expected to

Disclosure: There was no source of external funding for this study. The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSREV/A405).

return to sporting activities by as early as 8 to 9 months after the surgical procedure, most patients will not have achieved the appropriate rehabilitation benchmarks by this time point and can require as long as 2 years to return to play[2,3]. Return-to-sport recommendations following ACL reconstruction are varied but are typically based on assessments of knee impairment and function, such as knee range of motion, quadriceps strength, and functional test performance. The clinical scenario presented in this review is an example of the team approach that is required between the surgeon, athletic trainer, and physical therapist for treating athletes after ACL injury to optimize their chances of returning safely to sport at a high level.

Clinical Scenario

A 16-year-old female high school soccer player sustained a non-contact left knee injury during a game while attempting to kick the ball out of bounds on defense. She recalled her knee buckling when she planted her left leg. There was no history of knee injury. She presented to the office 6 days after the injury and reported mild pain and residual swelling in the knee. The physical examination demonstrated normal alignment; however, she was walking with a bent knee gait. The left knee had a 2+ effusion. The range of motion was 5° to 120° of flexion in the left knee and −2° to 135° of flexion in the right knee. The Lachman test was 2B in the left knee (A = firm end point and B = no end point; grade 1 = 3 to 5 mm, grade 2 = 6 to 10 mm, and grade 3 = >10 mm increased translation compared with the uninjured side). The pivot-shift test was 2+ in the left knee and 0 in the right knee (0 = normal, 1+ = glide, 2+ = clunk, and 3+ = gross). There was lateral joint line tenderness. Magnetic resonance imaging (MRI) demonstrated a proximal ACL rupture with the characteristic bone edema pattern on the posterolateral tibial plateau and middle of the lateral femoral condyle. Additionally, there was a peripheral tear in the posterior horn of the lateral meniscus without displacement.

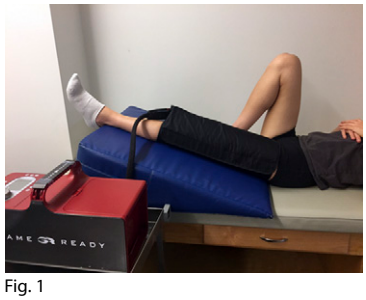

Fig. 1

Photograph showing Game Ready, a commercial cold and compression device used to control postoperative inflammation and pain.

Prior to the surgical procedure, rehabilitation was initiated to maximize range of motion and function. Following 3 weeks of physical therapy, the patient's range of motion and gait had normalized, and she demonstrated the ability to actively contract the quadriceps. The patient then underwent an ACL reconstruction with bone-patellar tendon-bone autograft and all-inside lateral meniscal repair. Postoperatively, a commercial cold and compression device (Fig. 1) was prescribed for home use to control postoperative inflammation and pain. Her weight-bearing was protected for the first week and was then transitioned to weight-bearing as tolerated with her postoperative brace locked at 0° of extension. The patient was instructed by a physical therapist to begin a home exercise program consisting of low-load prolonged stretching to promote full passive extension (Fig. 2); quadriceps setting in a supine or seated position, active-assisted range-of-motion (knee flexion and extension) exercise; and active range-of-motion ankle exercises. Formal physical therapy was initiated 1 week after the surgical procedure and focused on restoring range of motion and gait, patellar mobilization, and minimizing knee effusion. At 3 weeks, the patient demonstrated full passive extension range of motion and good quadriceps control. The postoperative brace was then opened to 60° to assist in restoring a normal gait pattern. The brace and

Fig. 2

Photograph showing low-load prolonged stretching to facilitate extension of the left knee.

crutches were discontinued 5 weeks after the surgical procedure upon demonstration of a non-antalgic gait without deviations and control of pain and swelling. She progressed well throughout the ensuing course of rehabilitation, achieving full symmetrical range of motion by 10 weeks postoperatively. At approximately 3 to 4 months, quality of movement became the focus during body-weight exercises. The patient demonstrated a pain-free, 8-inch (20-cm) forward step-down without deviations, and, thus, progressive plyometric training and running programs were initiated. Controlled soccer-specific agility programs were introduced.

At 6 months, the patient underwent a quality-of-movement assessment. Her first quality-of-movement assessment revealed that she had a very good movement strategy on 2 legs as she initiated and continued to drive movement with the hips. However, she was asymmetrical, shifting to her right (non-injured) side with take-off and landing during the double-leg squat and jump in place. Additionally, during the single-leg squat, she initiated movement with the knees, and the left knee collapsed into valgus because of insufficient use of the posterior chain (gluteals and hamstrings) (Fig. 3). This strategy placed increased strain on her graft. Therefore, it was recommended that she work on single-leg gluteal and eccentric quadriceps strength as well as single-leg movement strategy. The broad jump and forward hop from 1 leg to the opposite leg (hop to opposite side) assessed her ability to control shear forces.

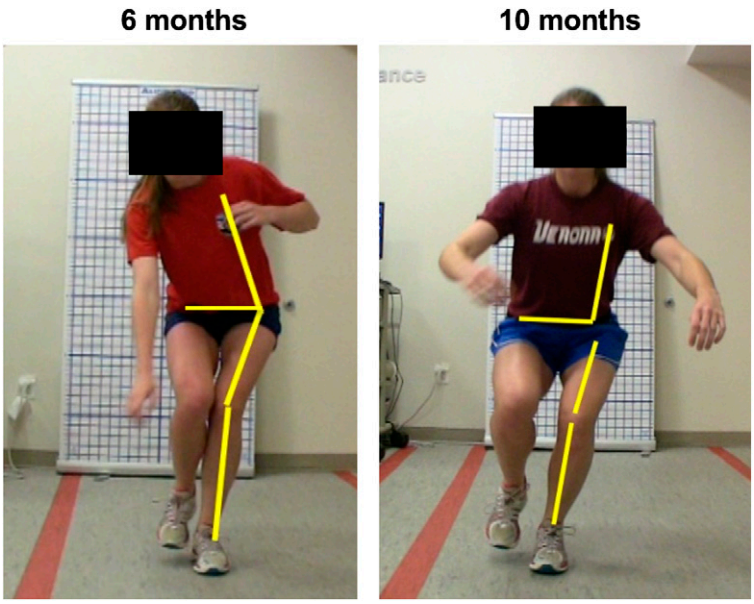

Fig. 3

Photographs showing a single-leg squat on the left knee at 6 and 10 months after ACL reconstruction. *Left:* At 6 months, the patient demonstrated poor alignment and balance. *Right:* At 10 months, the patient demonstrated improved movement strategy, alignment, and balance, with loading of the knee in a safer position.

At 8 months, the patient returned for the second quality-of-movement assessment and she was anxious to return to soccer. In addition to her weekly physical therapy sessions, she had been working on sprinting, agility, and speed with her athletic trainer twice weekly. During landings from horizontal jumps, she was upright and lacked control during single-leg landings and cutting, with valgus noted. Gluteal and quadriceps weakness persisted, which contributed to her lack of ability to decelerate. She continued to move through the knees on 1 leg (Fig. 4). Because of these deficiencies, she was not cleared to return to full play at that time. She continued to work with her certified athletic trainer on single-leg strengthening, agility with resistance, and deceleration training, and on her own for isolated strengthening of the quadriceps, gluteals, and hamstrings. At 10 months, she returned for the third quality-of-

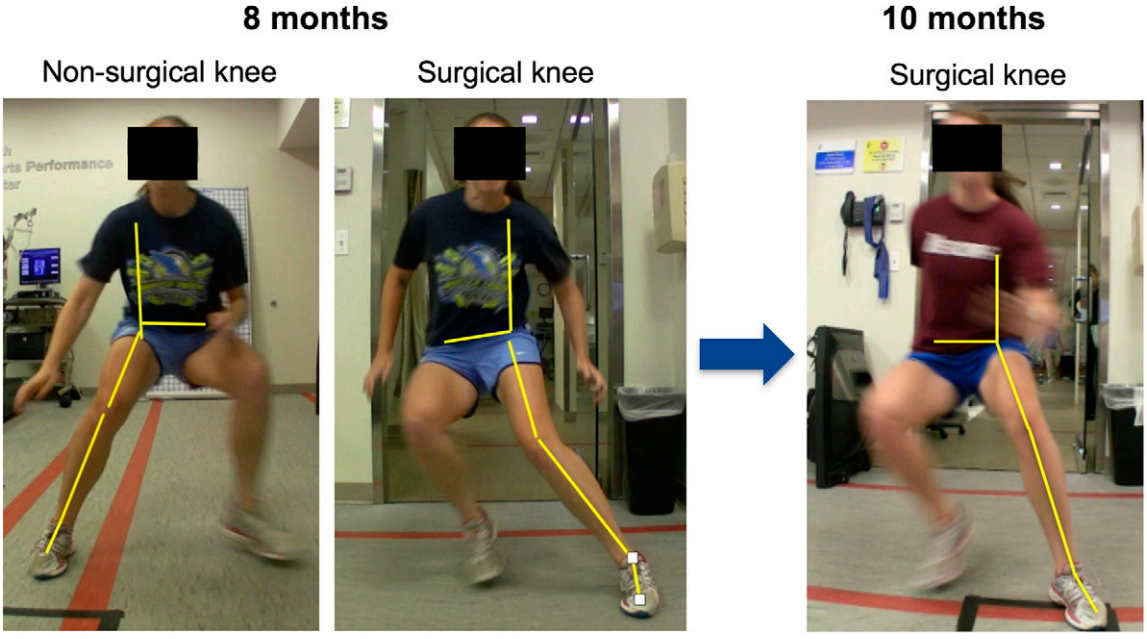

Fig. 4

Photographs showing a cutting movement on the left knee at 8 and 10 months after ACL reconstruction. *Left and middle:* At 8 months, the patient demonstrated poor alignment with the cutting movement on the left, surgically treated knee compared with good alignment (and safe loading) on the right, uninvolved knee. *Right:* At 10 months, the patient demonstrated improved alignment with the cutting movement on the left, surgically treated knee.

movement assessment. At that time, she displayed a hip strategy during single-leg squats (Fig. 3), good control and alignment during an 8-inch (20-cm) forward step-down, and a 30-second hold on a single-leg bridge. This translated to symmetry during double-leg tasks and control on the affected leg with good alignment during dynamic single-leg tasks (Fig. 4). The isokinetic test revealed a 95% limb symmetry, and the functional hop tests revealed a 97% limb symmetry. On the basis of her performance on the latest quality-of-movement assessment, she was allowed to progressively return to playing soccer without a brace.

Team Approach

Orthopaedic Surgeon

The orthopaedic surgeon is typically one of the first members of the team to evaluate the patient after the initial injury. Thus, the surgeon has the important responsibility of educating the patient about the injury, describing the treatment options, providing an overview of the rehabilitation process, and setting realistic expectations about return to play. Making the diagnosis is really just a small part of the initial patient interaction; rather, the surgeon has to educate the patient about the injury, treatment, and rehabilitation process. The surgeon is also responsible for organizing and overseeing the team that will participate in all phases of the patient's treatment. Patients come in with varying levels of knowledge, fears, and questions about the injury, and the surgeon's job is to address these issues. The nuances of graft selection, the impact of other concomitant pathology on the treatment and outcome (meniscal or chondral injury, for example), and the long-term risk of posttraumatic arthritis need to be addressed.

Setting appropriate and realistic expectations is critical. The impact of patient expectations on postoperative patient satisfaction has received increased attention across orthopaedics, especially for common procedures such as ACL reconstruction. Recent studies have highlighted the importance of psychological factors and fear of reinjury on outcomes and rate of return to play after an ACL injury. Higher preoperative Short Form (SF)-12 mental component summary scores have been shown to be predictive of achieving clinically important improvements after ACL reconstruction[4,5]. This emphasizes the importance of setting realistic expectations preoperatively with patients and considering any psychological, social, or emotional factors in the decision-making process.

The timing of the surgical procedure is critical, as ACL reconstruction performed in the early period after injury increases the risk of postoperative arthrofibrosis[5-8]. Postoperative loss of motion, particularly loss of terminal extension, is correlated with decreased patient satisfaction, functional limitations in sport activities, and the development of osteoarthritis in the long term[9]. Patients undergoing a surgical procedure with knee extension loss are 5 times more likely to have extension loss issues after a surgical procedure[8]. Patients who have an effusion and stiffness beyond 4 weeks after the injury who undergo ACL reconstruction are also at high risk of developing arthrofibrosis, suggesting that a surgical procedure performed on an actively inflamed knee plays an important role in the development of postoperative stiffness. Because preoperative range of motion is predictive of postoperative range of motion and can be improved with preoperative rehabilitation, the ideal approach is to allow for swelling to resolve and for the patient to regain full range of motion prior to the surgical procedure[10].

Many factors should be considered with regard to the progression of rehabilitation after ACL reconstruction. These factors include graft type, placement of the graft relative to the anatomic location of the native ACL, graft fixation, the presence of associated injuries (e.g., meniscal tear, multiple ligament injury), and individual patient-specific factors (e.g., knee laxity, tibial slope, age, activity level). For instance, in the setting of a concomitant meniscal repair, knee flexion should be limited to 90° in the early postoperative period to avoid excessive loads on the repair site prior to its full healing. Nevertheless, several goals remain constant for rehabilitation after ACL reconstruction, which include restoring motion and quadriceps strength and progression of functional activities that do not exceed the limits of graft healing. Early emphasis on reestablishing full extension is important for quadriceps function. Because of the associated problems with stiffness after ACL reconstruction, more aggressive protocols that allow for early range of motion and immediate weight-bearing have become more widely adopted[9,11,12]. These protocols need to be balanced against evidence suggesting that a brief period of immobilization and protected weight-bearing may be beneficial for graft healing at the tendon-bone interface[13]. Although inadequate healing may be only one of several factors that contribute to graft failure, rehabilitation in the immediate postoperative period clearly has an important role in graft healing and graft incorporation, and further research is needed to understand the optimal amount of motion and mechanical loading that is needed to reduce the risk of ACL graft failure. One of the guiding principles of return to play is that the timeline should not outpace the physiology of the surgical reconstruction.

Return to play should be a coordinated decision between the patient, surgeon, physical therapist, and athletic trainer. Fitness is often well perceived by the physical therapists and athletic trainers but tends to be overlooked by orthopaedic surgeons because it is not typically gauged by the surgeon in the office. Therefore, the objective data provided by quantitative and qualitative assessments can inform orthopaedic surgeons regarding any existing neuromuscular deficits in the patient, which helps with counseling the patient and reinforces the message that the patient may be receiving from all other parties on his or her readiness for return to play.

Additionally, mental fitness remains a key component of return to play that may require special attention from a sports psychologist or similar specialist. Orthopaedic surgeons should be able to make these types of referrals if they believe that it can be beneficial for the patient.

Physical Therapist

The physical therapist meets the patient early on in the rehabilitation process. As the person who spends the most time with the patient, the physical therapist must foster a relationship of trust early on with the patient-athlete as they embark on this journey of return to play together. The physical therapist gains an understanding of the patient, the patient's goals, the patient's personality, and how to get the most from the patient. Expectations are continually reinforced. The physical therapist addresses the deficits created by the surgical procedure and the injury. Through biomechanical evaluations, factors that contributed to this injury are identified and are addressed. Education is the mainstay of the rehabilitation process as it not only increases compliance with the rehabilitation process, but also empowers the athlete to take ownership of his or her recovery of function. The physical therapist takes on the role of captain of the rehabilitation program by facilitating communication between all parties.

The focus during this immediate postoperative phase is control of pain and swelling to promote active quadriceps contraction and range of motion. Poor compliance with postoperative activity modification and weight-bearing will result in increased pain and swelling with subsequent loss of range of motion and inhibition of quadriceps function[14,15]. During the first 6 weeks of rehabilitation, the physical therapist should aim to protect the graft and donor site and needs to consider the functional deficits created by the initial trauma of injury and the second trauma of the surgical procedure. As rehabilitation progresses, a solid foundation of core, gluteal, and hip strengthening creates a platform for effective quadriceps function. This allows the patient to progress to body-weight exercises and single-leg function. As rehabilitation progresses to 12 weeks, the focus of rehabilitation shifts to the whole patient, in addition to ongoing rehabilitation of the involved extremity. Faulty movement patterns are strongly implicated in ACL injury and have been described as a combined loading pattern of decreased hip and knee flexion, femoral internal rotation, knee valgus, and high quadriceps activity not balanced by the hamstrings[16]. Because ACL injuries are typically non-contact injuries, it is imperative to identify and address the risk factors that may have led to the injury. Are there deficits that lead to this faulty movement pattern? A biomechanical evaluation helps to identify factors that contribute to the risk of the knee collapsing into valgus during a single-leg squat. Deficits in ankle mobility and gluteal strength, which contribute to faulty movement patterns, are also identified and are addressed. The use of videos of the patient performing specific movements is paramount to changing these movement patterns as it allows the patient to directly appreciate the factors that may have contributed to the injury. These videos also inform the orthopaedic surgeon and allow physical therapists to track progress.

Accordingly, ACL injury prevention programs have been developed to decrease the risk of ACL injury by correcting these faulty movement patterns[17,18]. For instance, the Hospital for Special Surgery quality-of-movement assessment consists of a series of purposefully selected tasks that progress in a hierarchal fashion from relatively static to dynamic tasks, from 2 legs to 1 leg, and from vertical to horizontal landings. The assessment of movement quality complements the information gathered from traditional quantitative measures of performance. Data gathered from the quality-of-movement assessment inform the medical and rehabilitation team, as well as the patient, of the presence of potentially faulty movement patterns that have been associated with ACL injury and the factors that may contribute to these faulty movements. These factors can be related to strength, in which the athlete does not have enough strength to support the movement; range of motion and/or flexibility deficits that limit the athlete's ability to perform the movement; and/or movement know-how, such as in athletes who do not know how to engage the hips. A knee-dominant strategy will increase ACL graft strain and patellofemoral stress[19]. Targeted recommendations address any identified deficits to correct these movement patterns and ultimately allow the athlete to safely return to play.

Certified Athletic Trainer

In the clinical scenario, a certified athletic trainer was a member of the patient's medical team and was able to work with her at her high school. Throughout the course of rehabilitation, the certified athletic trainer works closely with the physical therapist to ensure athlete compliance with the prescribed exercises, making sure that they are done correctly with the correct intensity, volume, and movement. The certified athletic trainer also acts as another individual to monitor the various elements of activity modification recommended by the surgeon and physical therapist. Communication between the physical therapist and the certified athletic trainer therefore plays an integral role in the patient's rehabilitation.

The role of the certified athletic trainer takes on considerably more responsibility if or when a patient is limited in the number of physical therapy visits allowed by his or her insurance carrier. During the return-to-play phase of rehabilitation, the certified athletic trainer serves as the liaison between the patient, surgeon, physical therapist, and coaching staff. The certified athletic trainer, who is typically directly present on the field, can directly supervise the amount of athletic exposures. The volume of activity needs to be carefully

monitored during daily and weekly practice sessions so as to deter fatigue and thus decrease the chance of reinjury.

Conclusions

The importance of both precise surgical management and careful and comprehensive rehabilitation points out the critical importance of a team approach, with combined input from the surgeon, physical therapist, and athletic trainer. This team approach to managing the athlete's injury, rehabilitation, and expectations is key to a successful outcome. ACL reconstruction is performed so that the athlete can return to a high level of play while minimizing the risk of a second injury. However, surgical success does not guarantee successful return to play; successful rehabilitation along with a successful surgical procedure is needed to optimize the chance of achieving a successful outcome. Progression through rehabilitation is based on meeting functional criteria and allowing ongoing tissue healing. As the majority of ACL injuries are noncontact and a result of faulty movement patterns, rehabilitation must focus on identifying and addressing risk factors that contribute to injury. The athlete is expected to demonstrate the ability to decelerate on each leg. Quantitative measurement of movement quality is helpful in informing the team when an athlete can safely return to play.

Dean Wang, MD[1],
Theresa Chiaia, PT, DPT[1],
John T. Cavanaugh, PT, MEd, ATC, SCS[1],
Scott A. Rodeo, MD[1]

[1]Sports Medicine and Shoulder Service (D.W. and S.A.R.) and Sports Rehabilitation and Performance Center (T.C. and J.T.C.), Hospital for Special Surgery, New York, NY

E-mail address for S.A. Rodeo: rodeos@hss.edu

ORCID iD for D. Wang: 0000-0002-3005-1154
ORCID iD for T. Chiaia: 0000-0003-0334-9438
ORCID iD for J.T. Cavanaugh: 0000-0002-7045-8661
ORCID iD for S.A. Rodeo: 0000-0002-0745-9880

References

1. Mohtadi NG, Chan DS. Return to sport-specific performance after primary anterior cruciate ligament reconstruction: a systematic review. Am J Sports Med. 2017 Oct 1: 363546517732541. [Epub ahead of print].

2. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: two-thirds of patients have not returned by 12 months after surgery. Am J Sports Med. 2011 Mar; 39(3):538-43. Epub 2010 Nov 23.

3. Ardern CL, Taylor NF, Feller JA, Whitehead TS, Webster KE. Sports participation 2 years after anterior cruciate ligament reconstruction in athletes who had not returned to sport at 1 year: a prospective follow-up of physical function and psychological factors in 122 athletes. Am J Sports Med. 2015 Apr;43(4):848-56. Epub 2015 Jan 12.

4. Nwachukwu BU, Chang B, Voleti PB, Berkanish P, Cohn MR, Altchek DW, Allen AA, Williams RJ. 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 Oct;45(12):2784-90. Epub 2017 Jul 20.

5. Shelbourne KD, Foulk DA. Timing of surgery in acute anterior cruciate ligament tears on the return of quadriceps muscle strength after reconstruction using an autogenous patellar tendon graft. Am J Sports Med. 1995 Nov-Dec; 23(6):686-9.

6. Almekinders LC, Moore T, Freedman D, Taft TN. Post-operative problems following anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 1995;3(2):78-82.

7. McHugh MP, Tyler TF, Gleim GW, Nicholas SJ. Preoperative indicators of motion loss and weakness following anterior cruciate ligament reconstruction. J Orthop Sports Phys Ther. 1998 Jun;27(6):407-11.

8. Mayr HO, Weig TG, Plitz W. Arthrofibrosis following ACL reconstruction—reasons and outcome. Arch Orthop Trauma Surg. 2004 Oct; 124(8):518-22. Epub 2004 Aug 3.

9. Beynnon BD, Johnson RJ, Naud S, Fleming BC, Abate JA, Brattbakk B, Nichols CE. Accelerated versus nonaccelerated rehabilitation after anterior cruciate ligament reconstruction: a prospective, randomized, double-blind investigation evaluating knee joint laxity using Roentgen stereophotogrammetric analysis. Am J Sports Med. 2011 Dec;39(12):2536-48. Epub 2011 Sep 27.

10. Wilk KE, Arrigo CA. Rehabilitation principles of the anterior cruciate ligament reconstructed knee: twelve steps for successful progression and return to play. Clin Sports Med. 2017 Jan; 36(1):189-232.

11. Beynnon BD, Uh BS, Johnson RJ, Abate JA, Nichols CE, Fleming BC, Poole AR, Roos H. Rehabilitation after anterior cruciate ligament reconstruction: a prospective, randomized, double-blind comparison of programs administered over 2 different time intervals. Am J Sports Med. 2005 Mar; 33(3):347-59.

12. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. Am J Sports Med. 1990 May-Jun;18(3):292-9.

13. Camp CL, Lebaschi A, Cong GT, Album Z, Carballo C, Deng XH, Rodeo SA. Timing of postoperative mechanical loading affects healing following anterior cruciate ligament reconstruction: analysis in a murine model. J Bone Joint Surg Am. 2017 Aug 16;99(16): 1382-91.

14. Deandrade JR, Grant C, Dixon AS. Joint distension and reflex muscle inhibition in the knee. J Bone Joint Surg Am. 1965 Mar;47: 313-22.

15. Shakespeare DT, Stokes M, Sherman KP, Young A. Reflex inhibition of the quadriceps after meniscectomy: lack of association with pain. Clin Physiol. 1985 Apr;5(2): 137-44.

16. Griffin LY, Albohm MJ, Arendt EA, Bahr R, Beynnon BD, Demaio M, Dick RW, Engebretsen L, Garrett WE Jr, Hannafin JA, Hewett TE, Huston LJ, Ireland ML, Johnson RJ, Lephart S, Mandelbaum BR, Mann BJ, Marks PH, Marshall SW, Myklebust G, Noyes FR, Powers C, Shields C Jr, Shultz SJ, Silvers H, Slauterbeck J, Taylor DC, Teitz CC, Wojtys EM, Yu B. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. Am J Sports Med. 2006 Sep;34(9):1512-32.

17. Graziano J, Chiaia T, de Mille P, Nawabi DH, Green DW, Cordasco FA. Return to sport for skeletally immature athletes after ACL reconstruction: preventing a second injury using a quality of movement assessment and quantitative measures to address modifiable risk factors. Orthop J Sports Med. 2017 Apr 20;5(4):2325967117700599.

18. Di Stasi S, Myer GD, Hewett TE. Neuromuscular training to target deficits associated with second anterior cruciate ligament injury. J Orthop Sports Phys Ther. 2013 Nov;43(11):777-92, A1-11. Epub 2013 Oct 11.

19. Escamilla RF, Macleod TD, Wilk KE, Paulos L, Andrews JR. Anterior cruciate ligament strain and tensile forces for weight-bearing and non-weight-bearing exercises: a guide to exercise selection. J Orthop Sports Phys Ther. 2012 Mar;42(3):208-20. Epub 2012 Feb 29.