IJSPT
INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

Hazzard S, Young M, Lonati D, Asnis P. Return to Golf Rehabilitation Progression after Anterior Cruciate Ligament Reconstruction Using an Evidence-Based Foundation. *IJSPT*. 2026;21(9):906-916. doi:10.26603/001c.167451

Clinical Commentary/Current Concept Review

# Return to Golf Rehabilitation Progression after Anterior Cruciate Ligament Reconstruction Using an Evidence-Based Foundation

Sean Hazzard, P.A., M.B.A.[1], Michael Young, B.S.[1], Danielle Lonati, B.A.[2][a], Peter Asnis, M.D.[1]

[1] Department of Orthopaedic Surgery/Sports Medicine Service, Massachusetts General Hospital, [2] Frank H. Netter School of Medicine at Quinnipiac University

Keywords: anterior cruciate ligament reconstruction, golf, rehabilitation, return to sport, sport-specific progression

https://doi.org/10.26603/001c.167451

International Journal of Sports Physical Therapy

Vol. 21, Issue 9, 2026

## Background

Golf is commonly regarded as a low-impact sport, yet the golf swing generates multiplanar loads across both knees. No validated return-to-golf protocol after anterior cruciate ligament reconstruction (ACLR) has been published, and general return-to-sport timelines do not address golf-specific swing volume, club progression, lead- versus trail-knee demands, or return-to-course exposure.

## Purpose

The purpose of this clinical commentary is to synthesize the available golf-biomechanics and ACLR-rehabilitation evidence and present an evidence-informed, criteria-based progression from putting through unrestricted course play.

## Study Design

Clinical Commentary/Current Concept Review.

## Methods

A targeted narrative search of PubMed/MEDLINE and reference lists was performed through June 2026 for literature addressing golf and knee biomechanics, golf-swing modifications, ACLR rehabilitation and return-to-sport criteria, and graft healing. Recommendations were classified as direct golf-biomechanics evidence, indirect ACLR-rehabilitation evidence, or author-consensus guidance when direct evidence was unavailable.

## Results

No study prospectively evaluated a staged return-to-golf protocol after ACLR. Available evidence indicates that both knees experience meaningful loading throughout the golf swing, with the lead knee subjected to substantial frontal-plane moments and transverse-plane rotational loading during impact and follow-through, while the trail knee also experiences meaningful loading during the backswing and transition. Longer clubs, greater clubhead speed, and larger or faster pressure shifts may increase loading demands across both lower extremities. A six-phase progression is proposed using universal symptom and range-of-motion requirements, objective strength and movement criteria, prescribed swing volumes, lead- and trail-knee considerations, and a separate return-to-course phase.

[a] Corresponding author:
Danielle Lonati
Frank H. Netter School of Medicine
370 Bassett Rd, North Haven, CT 06473
Phone: 508-446-7934. Email: danielle.lonati@gmail.com

## Conclusion

Return to golf after ACLR should be managed as a continuum rather than a single clearance decision. Time from surgery provides a biologic safeguard but should not replace assessment of effusion, pain, motion, gait, strength, movement quality, workload tolerance, and confidence. The proposed protocol is intended to guide clinical decision-making and requires prospective validation.

## Level of Evidence

5

## INTRODUCTION

Anterior cruciate ligament (ACL) injuries frequently occur during sports requiring deceleration, pivoting, or changes of direction. Many active individuals elect ACL reconstruction (ACLR) to restore knee stability and facilitate return to desired activity.[1-4] Contemporary rehabilitation emphasizes a progressive return-to-sport continuum supported by recovery of motion, strength, neuromuscular control, workload tolerance, and psychological readiness rather than an isolated time-based clearance decision.[5-11]

Golf is often categorized as a low-impact activity, but the swing is a rapid, coordinated movement that transfers ground-reaction forces through the lower extremities while the knees move in the sagittal, frontal, and transverse planes. Studies after arthroplasty and other orthopedic procedures describe variable return-to-golf timelines, but these reports rarely provide objective functional milestones or golf-specific volume recommendations.[12-14] One case report described a patellar fracture during a golf swing after ACLR but did not provide rehabilitation criteria or a staged progression.[15] The absence of a validated protocol after ACLR leaves clinicians to extrapolate from general ACL rehabilitation and laboratory studies of uninjured golfers.

The purpose of this clinical commentary is to synthesize the available golf-biomechanics and ACLR-rehabilitation evidence and present an evidence-informed, criteria-based progression from putting through unrestricted course play. The framework addresses range of motion (ROM), gait, quadriceps control, effusion, strength, dynamic balance, rehabilitation exercises, swing volume and effort, lead- versus trail-knee demands, ball- and foot-position modifications, clubhead speed, graft and concomitant-procedure considerations, and walking versus riding.

## EVIDENCE IDENTIFICATION AND DEVELOPMENT OF THE CLINICAL FRAMEWORK

A targeted narrative search of PubMed/MEDLINE was performed through June 2026 using combinations of the terms "anterior cruciate ligament reconstruction," "ACL rehabilitation," "return to sport," "golf," "golf swing," "knee biomechanics," "ground reaction force," "lead knee," "trail knee," "ball position," "stance," "graft maturation," and "ligamentization." Reference lists from relevant systematic reviews and biomechanical studies were also screened. Peer-reviewed human studies addressing golf-related knee loading or modifications, ACLR rehabilitation milestones, return-to-sport testing, and graft healing were prioritized. Non-peer-reviewed online protocols were not used to establish progression criteria.

Because no prospective study has evaluated return to golf after ACLR, this manuscript is framed as a clinical commentary rather than a systematic or scoping review. Recommendations are therefore presented according to three evidence sources: direct golf-biomechanics evidence, indirect evidence from ACLR rehabilitation and return-to-sport literature, and author-consensus guidance where neither body of literature provides a validated threshold. Precise swing-volume prescriptions and the sequence of on-course progression are explicitly identified as proposed starting doses that require individual adjustment and prospective validation.

## GOLF-SWING DEMANDS ON THE KNEE

For a right-handed golfer, the left lower extremity is the lead or target-side limb and the right lower extremity is the trail limb; the relationship is reversed for a left-handed golfer. During the backswing, pressure generally shifts toward the trail limb. During the downswing and follow-through, pressure shifts toward the lead limb while the pelvis and trunk rotate rapidly. Both knees contribute to force production, balance, and deceleration, and neither should be considered unloaded.

## LEAD- AND TRAIL-KNEE LOADING

In vivo and laboratory investigations have demonstrated substantial tibiofemoral force, shear, torque, and frontal-plane moments during the golf swing.[16-22] The lead knee commonly experiences high loading near impact and follow-through as weight transfers toward the target and the body decelerates over the lead limb. Gatt et al. identified large three-dimensional knee moments during a five-iron swing, while D'Lima et al. reported high tibial forces during golf in individuals with instrumented total knee arthroplasty.[16,17] Carson et al. further demonstrated meaningful moments in both knees of professional golfers and reported a greater net abduction moment impulse in the trail knee, emphasizing that laterality cannot be reduced to a simple "lead knee is loaded, trail knee is protected" model.[21]

Accordingly, the same fundamental clinical requirements should apply whether the reconstructed knee is the lead or trail limb. Lead-knee ACLR may justify a slower progression of rotational loading and full-effort swings be-

cause of the demands at impact and follow-through. Trail-knee ACLR requires attention to control during the backswing and transition, including avoidance of uncontrolled valgus, excessive lateral sway, or collapse. There is currently no evidence that a golfer with trail-knee ACLR can safely initiate chipping, pitching, or full swings earlier solely because of surgical-knee laterality.

## CLUB SELECTION, SPEED, FATIGUE, AND SKILL

Longer clubs and higher-effort swings generally require greater force production and larger or faster pressure shifts. Stokes et al. found that the driver produced larger lead-knee translations, rotations, forces, and torques than shorter clubs, and Carson et al. reported associations between clubhead speed and knee moments.[18,21] Prior reviews have summarized knee-injury risk factors and the potential relevance of golf-swing loading to the ACL.[23,24] A recent systematic review also found that force production and center-of-pressure behavior are associated with clubhead speed and skill level, although methods and terminology vary considerably across studies.[25] Clubhead speed should therefore be treated as a continuous workload variable rather than dichotomized at an unvalidated threshold such as 90 miles per hour.

Fatigue may alter knee flexion, tibial rotation, and frontal-plane moments during repeated swings.[26] The progression should therefore prioritize total swing volume and next-day knee response before maximizing distance or speed. More skilled golfers may generate greater force and clubhead speed but may also demonstrate more repeatable balance strategies.[25,27] A study comparing skilled golfers with and without a history of knee injury found lower-extremity kinematic differences but no significant between-group difference in knee joint moment, supporting individualized assessment rather than a single mechanical assumption.[28] Handicap alone is not an adequate clearance criterion; baseline clubhead speed, usual practice volume, competitive level, and the ability to reproduce a controlled submaximal swing should guide dosage.

Sex-related differences in golf-swing kinematics have been reported, including lower knee-flexion angles in women in one study.[29] However, the available literature does not establish sex-specific return-to-golf thresholds after ACLR. Men and women should therefore progress according to individual strength, movement quality, speed, workload, symptoms, and surgical factors rather than separate timelines.

## STANCE AND BALL-POSITION MODIFICATIONS

Selected address modifications may reduce components of lead-knee loading. An externally rotated or "toe-out" lead-foot position and an open foot stance have reduced selected lead-knee moments, rotations, forces, or torques in laboratory studies.[18,19] These studies do not support automatically opening the shoulder line or moving the entire lead side away from the target. A practical modification is a comfortable increase in lead-foot external rotation, introduced gradually and reviewed for effects on balance, symptoms, and ball flight.

Ball-position terminology must distinguish two independent directions. Moving the ball one ball diameter closer to the golfer reduced the lead-knee internal-rotation moment, whereas moving the ball one ball diameter away from the target, toward the trail-foot direction along the target line, reduced the lead-knee adduction moment.[30] These positions are not synonymous, their combined use has not been validated, and moving the ball along the target line may alter club path and ball flight. Such changes should be considered optional symptom- or load-modification strategies rather than mandatory protocol elements and should ideally be coordinated with a qualified golf professional.

## FOUNDATIONAL ACLR CRITERIA FOR ALL GOLF PHASES

The treating surgeon's restrictions and the rehabilitation plan for concomitant procedures supersede this framework. Meniscal repair, meniscal root repair, cartilage restoration, multiligament reconstruction, osteotomy, or other procedures may delay weight bearing, deep flexion, rotation, impact loading, or walking tolerance. The golfer should not progress merely because a suggested postoperative week has been reached.

Across phases, progression requires stable or improving symptoms, no episodes of instability, and no increase in effusion after the current activity dose. Early phases require full knee extension, absence of a straight-leg-raise lag, and normalized or near-normal gait without an assistive device. Knee flexion should be within approximately 10° of the contralateral limb before chipping and pitching and should be symmetric before rotational full-swing phases. These milestones are consistent with criterion-based ACLR rehabilitation frameworks.[5-9]

Objective strength should be measured with isokinetic dynamometry, a fixed handheld dynamometer, or another reproducible method rather than manual muscle testing alone. The proposed minimum quadriceps limb symmetry index (LSI) is 70% before partial wedge swings, 80% before full wedges and short irons, and 90% before long irons, woods, and driver. Hamstring and hip strength, single-leg squat and step-down quality, dynamic balance, and progressive plyometric tolerance should accompany quadriceps testing. Hop testing is not required for putting or chipping. When appropriate for the golfer's age, baseline activity level, and goals, an LSI of at least 90% across an appropriate hop battery with acceptable landing mechanics is recommended before unrestricted full-effort swings; otherwise, an age- and goal-appropriate assessment of repeated single-leg load acceptance may be used.[6-11]

LSI can overestimate recovery when both limbs are deconditioned; therefore, clinicians should also consider absolute strength, preinjury data when available, movement quality, and the demands of the individual golfer. Psychological readiness and confidence should be assessed throughout the progression, particularly when the recon-

structed knee is the lead limb or the golfer demonstrates persistent protective movement.

## SYMPTOM-RESPONSE AND WORKLOAD RULES

During golf activity, pain should remain minimal and should not cause altered stance, shortened follow-through, loss of balance, or avoidance of loading the surgical limb. As a practical author-consensus rule, pain greater than 2 of 10, a sense of instability, or progressive deterioration in swing quality should end the session. The knee should return to its pre-session pain and effusion status by the following morning and no later than 24 hours. A reactive increase in effusion, motion loss, limp, or pain lasting beyond 24 hours indicates excessive load and should prompt regression to the prior tolerated dose.

Only one primary workload variable should be increased at a time: number of swings, swing effort, club length, practice frequency, walking volume, or environmental complexity. During the first two sessions of a new phase, at least one recovery day is recommended between golf exposures. If a session is tolerated, total swing count may generally increase by approximately 10 swings or 10%-20%, but effort and volume should not be increased simultaneously. These values are proposed starting points rather than validated injury-prevention thresholds.

## TIME AND GRAFT CONSIDERATIONS

Biologic graft remodeling continues for many months after ACLR, and imaging or histologic appearance differs according to graft type and graft region.[31-40] Available maturation studies of bone-patellar tendon-bone, hamstring, and quadriceps tendon autografts do not establish a direct relationship between imaging maturation and the capacity to tolerate a golf swing. No golf-specific evidence supports separate club-progression thresholds based solely on graft choice.

Graft choice may nevertheless influence rehabilitation through donor-site pain, strength deficits, fixation biology, or surgeon preference.[8,41] Patellar-tendon harvest may produce anterior-knee symptoms during squatting or walking hills; hamstring harvest may affect knee-flexor capacity; and quadriceps-tendon harvest may contribute to persistent quadriceps deficits. These impairments should be addressed directly rather than managed by a universal graft-specific delay. Suggested postoperative windows in Table 1 are earliest guideposts for an uncomplicated isolated ACLR and should be lengthened when criteria are unmet or concomitant procedures are present.

## SIX-PHASE RETURN-TO-GOLF PROGRESSION

The proposed progression follows the return-to-participation, return-to-sport, and return-to-performance continuum described in contemporary ACL literature.[7] Passing a phase indicates readiness to attempt the next controlled exposure; it does not imply unrestricted golf. Detailed entry criteria, starting dosage, and exit criteria are summarized in Table 1.

## PHASE 1: PUTTING

Putting introduces golf-specific standing and low-amplitude weight shifting with minimal swing rotation. It may begin when the golfer can stand comfortably with full knee extension, perform a straight-leg raise without lag, walk with normalized or near-normal gait, and maintain stable pain and effusion. A mirror or video can identify persistent unloading, lateral trunk lean, or asymmetrical setup. The goal is not perfect static 50/50 pressure but a comfortable, repeatable stance without avoidance of the surgical limb.

A suggested first exposure is 20-30 putts or 10-15 minutes. Duration may increase by 5-10 minutes per session to approximately 30-45 minutes if the knee remains at baseline the next day. Putting should be paused if prolonged standing increases swelling, gait deteriorates, or the golfer develops compensatory habits.

## PHASE 2: CHIPPING AND SHORT PITCHING

Chipping begins after normalized gait, full extension, flexion within approximately 10° of the opposite limb, and no reactive effusion. The golfer should demonstrate three 30-second single-leg balance trials without contralateral foot contact or marked trunk and pelvic compensation, followed by controlled balance under light perturbation. These durations are author-consensus operational criteria because no validated golf-specific balance threshold exists.

The first session should include approximately 20 chips with a short backswing at 25%-40% perceived effort. If tolerated, 10-15 short pitches may be added at no more than approximately 50% effort, with a total session volume of 30-40 swings. Distance should be an observed outcome rather than the primary progression target because the club required for a 50- or 100-yard shot varies by age, sex, skill, and equipment. Two symptom-stable sessions should be completed before advancing.

## PHASE 3: PARTIAL WEDGES

Partial wedge swings introduce greater trunk and pelvic rotation and more purposeful pressure transfer. Entry criteria include symmetric knee ROM, no reactive effusion, quadriceps LSI of at least 70%, 10 controlled single-leg squats to approximately 60° of knee flexion, and 10 controlled step-downs without pain, dynamic valgus, or loss of pelvic control. The golfer should also tolerate anti-rotation and controlled trunk-rotation exercises without knee symptoms.

Begin with 10 wedge swings at approximately 50% usual effort and 10 at approximately 75% effort. If the next-day response is acceptable, add a third set of 10 or progress selected swings toward 80%-90% effort. Initial sessions should generally remain at 30-40 swings, with a ceiling of approximately 50-60 swings before Phase 4. A launch monitor may be used to regulate relative clubhead speed, but

**Table 1. Proposed six-phase return-to-golf progression after ACL reconstruction.**

| Phase and earliest guidepost* | Golf activity | Minimum entry criteria | Suggested starting dose and progression | Exit criteria |
|---|---|---|---|---|
| Phase 1: Putting (~4-6 wks) | Putting on level surface | Full extension; no straight-leg-raise lag; normalized or near-normal gait; stable pain and effusion; comfortable standing | 20-30 putts or 10-15 min. Increase 5-10 min/session toward 30-45 min. Mirror/video may identify unloading or trunk lean. | Two sessions without next-day pain, effusion, motion loss, or gait change; repeatable stance without protective unloading |
| Phase 2: Chip/pitch (~6-10 wks) | Short chips, then short pitches | Full extension; flexion within ~10° of opposite limb; no reactive effusion; 3 x 30-s single-leg balance and controlled light perturbation | 20 chips at 25%-40% effort, then 10-15 pitches at no more than 50% effort; 30-40 total swings; recovery day between first sessions | Two symptom-stable sessions; no loss of balance or compensatory weight avoidance |
| Phase 3: Partial wedges (~12-20 wks) | Waist-height and three-quarter wedge swings | Symmetric ROM; no reactive effusion; quadriceps LSI at least 70%; 10 single-leg squats to ~60°; 10 controlled step-downs | 10 swings at ~50% and 10 at ~75% effort; progress toward 30-40 total, then 50-60; increase volume or effort, not both | Tolerates 50-60 partial/full wedge swings over repeated sessions without next-day reaction |
| Phase 4: Full wedges/short irons (~16-28 wks) | Full wedges; 9-, 8-, and 7-irons | Quadriceps, hamstring, and hip strength at least 80% LSI; controlled squat/step-down; dynamic balance ~90% LSI; functional hip/ankle mobility | 10 shots per short iron (30 total) at ~75% effort; progress to 45-60 swings and usual controlled speed after stable sessions | Full wedge and short-iron bag tolerated on at least 2 sessions without reactive symptoms or altered mechanics |
| Phase 5: Long clubs/driver (~20-32 wks) | Long irons, hybrids, fairway woods, driver last | No/trace effusion; symmetric ROM; quadriceps/hamstring strength at least 90% LSI; multidirectional plyometrics; age-/goal-appropriate hop battery at least 90% LSI or equivalent single-leg load-acceptance testing with sound mechanics | 5-10 swings per club; no more than 30 initial full swings at 50%-75% effort; progress by ~10 swings/session toward 60-75 and then usual speed | Two to three range sessions with 40-60 full swings and no next-day reaction; confidence and mechanics acceptable |
| Phase 6: Return to course (~24-36 wk) | Riding, walking, bunker play, uneven lies, full rounds | Meets Phase 5; walks 30-45 min on variable terrain; controls slopes/uneven stance; no reactive symptoms | 3-6 holes riding; 9 holes riding; 9 holes walking with a push cart; 18 holes riding; 18 holes walking with a push cart. Carry a bag last. Begin with 5-10 bunker shots. | Tolerates 18 holes at desired mode and subsequent practice/round frequency without symptoms; progresses toward preinjury performance |

*Postoperative windows are earliest guideposts for an uncomplicated isolated ACLR, not clearance criteria. Surgeon restrictions and concomitant procedures supersede this table.
ACLR, anterior cruciate ligament reconstruction; LSI, limb symmetry index; ROM, range of motion.

the target should be a percentage of the golfer's usual speed rather than an absolute threshold.

## PHASE 4: FULL WEDGES AND SHORT IRONS

Phase 4 begins after the golfer completes the wedge progression without increased pain or effusion and demonstrates quadriceps, hamstring, and hip strength of at least 80% LSI, controlled single-leg step-down and squat mechanics, and dynamic balance of approximately 90% LSI when a Y-Balance or comparable test is used. Functional hip rotation and ankle dorsiflexion should permit the golfer to assume the normal address position and rotate without compensatory knee valgus, heel rise, or loss of balance. No golf-specific numeric hip- or ankle-ROM threshold has been validated; marked side-to-side restriction should be addressed before increasing swing demand.

A practical first short-iron session is 10 shots each with a 9-, 8-, and 7-iron for a total of 30 swings. After two symptom-stable sessions, volume may progress toward 45-60 swings, with effort restored from approximately 75% toward the golfer's usual controlled speed. Optional lead-foot toe-out or one of the independently studied ball-position modifications may be trialed when the reconstructed knee is the lead limb or when symptoms occur, but ball-flight effects should be assessed with a golf professional.[18,19,30]

## PHASE 5: LONG IRONS, HYBRIDS, WOODS, AND DRIVER

Longer clubs/driver are introduced only after no or trace effusion, symmetric ROM, quadriceps and hamstring strength of at least 90% LSI, acceptable hip strength, and completion of multidirectional plyometrics. When appropriate for the golfer's age, baseline activity level, and goals, the golfer should also achieve at least 90% LSI on an appropriate hop-test battery with controlled takeoff and landing mechanics. An age- and goal-appropriate assessment of repeated single-leg load acceptance may be substituted when hop testing is not appropriate. The golfer should tolerate a lateral bound and hold, rotational step and catch, and repeated single-leg loading without pain, valgus collapse, or appre-

hension. These criteria are more stringent than the minimum requirements for earlier golf phases because driver swings combine high speed, greater force production, and repeated rotation.

Progress clubs in sequence rather than hitting the entire bag during the first session. A suggested exposure is 5-10 swings each with a long iron or hybrid, fairway wood, and driver, for no more than approximately 30 full swings. Begin near 50%-75% usual effort and progress toward 90%-100% only after symptom-stable sessions. Add approximately 10 swings per session until 60-75 full swings are tolerated. The driver should be the final club restored. Golfers with lead-knee ACLR, high baseline clubhead speed, high practice volume, or residual apprehension may require smaller increases and additional submaximal sessions.

## PHASE 6: RETURN TO THE COURSE

Range tolerance does not establish readiness for an entire round. Before course play, the golfer should complete two to three range sessions containing 40-60 full swings without next-day pain, effusion, motion loss, or gait change; walk for 30-45 minutes on variable terrain; and demonstrate safe negotiation of slopes, curbs, and uneven surfaces. A progressive on-course sequence is recommended: three to six holes while riding, nine holes while riding, nine holes walking with a push cart, 18 holes while riding, and finally 18 holes walking with a push cart. Carrying a bag should be introduced last because it adds load and fatigue and may alter gait.

Bunker play should begin after full swings are tolerated, initially with 5-10 shots from a stable lie. Uneven lies, deep rough, and steep slopes should be added only after the golfer can control stance and weight transfer without apprehension or reactive symptoms. During early rounds, the golfer may use preferred lies, avoid extreme slopes, or pick up rather than attempt an awkward recovery shot. Consecutive-day play should be delayed until at least two complete rounds at the current level are tolerated. Return to competition or preinjury performance is a later endpoint and may require restoration of usual clubhead speed, accuracy, practice volume, and confidence.

## PHASE-SPECIFIC PHYSICAL PREPARATION

Golf-specific exposure should complement, not replace, standard ACLR rehabilitation. Early preparation emphasizes motion, quadriceps activation, gait, and general lower-extremity strength. Later phases should develop unilateral force production and absorption, hip and trunk control, rotational tolerance, and fatigue resistance. Phase-specific physical preparation is outlined in Table 2, which provides examples rather than a mandatory exercise list; exercise selection should reflect examination findings and the golfer's preinjury physical capacity.

## LEAD- AND TRAIL-KNEE, SWING, AND PATIENT-SPECIFIC CONSIDERATIONS

The clinician should observe the golfer from face-on and down-the-line views when possible. Findings warranting further assessment include an excessive target-side lateral slide, reverse pivot or falling away from the target, abrupt or uncontrolled lead-knee extension through impact, trail-knee collapse, marked dynamic valgus, persistent unloading of the surgical limb, shortened follow-through, and inability to hold the finish. These observations are clinical flags rather than proven mechanisms of ACL graft overload. Their relevance should be judged by symptoms, force-control capacity, and change from the golfer's preinjury swing.

No golf-specific evidence supports a fixed pressure-distribution target at address or impact after ACLR. Full-swing progression should instead restore an individualized, repeatable pressure shift without protective unloading of the surgical limb, excessive lateral translation, or loss of balance. The physical therapist should manage impairments and graded exposure, whereas a qualified golf professional should evaluate performance consequences and technical changes. Collaboration is especially important when altering ball position, foot angle, stance width, or weight-transfer strategy. Table 3 summarizes laterality and other modifying factors and distinguishes supported findings from consensus recommendations.

## DISCUSSION

This protocol addresses a clinically important evidence gap while avoiding the implication that precise return-to-golf timelines have been validated after ACLR. The available golf literature provides a biomechanical foundation but consists largely of small laboratory

studies involving healthy, often skilled, and predominantly male golfers.[16-30] General ACLR literature supplies objective rehabilitation milestones, but many return-to-sport studies focus on pivoting and cutting sports with substantially different reinjury profiles. The protocol therefore uses time as a minimum biologic guidepost and criteria as the primary determinant of progression.

The framework extends beyond a club-only progression. Effusion, ROM, gait, and quadriceps control are applied consistently across phases. Yardage is not used as the principal dose because the same distance may require a sand wedge for one golfer and a mid-iron for another. Swing effort, club class, number of swings, next-day response, and eventually clubhead speed provide more transferable workload measures. A separate course phase addresses walking, riding, bag transport, bunker play, uneven lies, and the accumulated fatigue of a round.

Available data justify closer monitoring of lead-knee rotation and deceleration but also demonstrate important trail-knee loading. Accordingly, laterality modifies the emphasis and rate of progression rather than the universal entry criteria. Similarly, graft type may change the impairment profile but does not currently justify a unique golf protocol in the absence of direct evidence.

**Table 2. Phase-specific physical preparation and example clinical tests.**

| Golf phase | Physical preparation priorities | Example exercises | Suggested clinical performance measures |
|---|---|---|---|
| Phases 1-2 | Control effusion; restore extension and flexion; quadriceps activation; normalize gait; develop basic hip, calf, and balance capacity | Quadriceps sets; straight-leg raise; sit-to-stand; bridge; calf raise; step-up; supported split squat; double- to single-leg balance | No lag; normalized gait; flexion within ~10° before Phase 2; 3 x 30-s single-leg balance without major compensation |
| Phase 3 | Unilateral strength; pelvic and trunk control; controlled rotation; single-leg load tolerance | Single-leg squat; step-down; split squat; single-leg Romanian deadlift; Pallof press; cable lift/chop; balance with trunk rotation | Quadriceps LSI at least 70%; 10 controlled single-leg squats to ~60°; 10 step-downs; no reactive effusion |
| Phase 4 | Increase lower-extremity and hip strength; dynamic balance; rotational endurance; functional hip and ankle mobility | Rear-foot-elevated split squat; lateral lunge; loaded step-up; resisted trunk rotation; medicine-ball preparation drills; Y-Balance tasks | Quadriceps/hamstring/hip strength at least 80% LSI; dynamic balance ~90% LSI; address and rotation without knee compensation |
| Phase 5 | Rate of force development; multidirectional load acceptance; deceleration; repeated rotational capacity | Lateral bound and hold; rotational step and catch; squat jump; low-level single-leg hop; medicine-ball scoop toss; fatigue-resistance circuits | Strength at least 90% LSI; age-/goal-appropriate hop battery at least 90% LSI or equivalent single-leg load-acceptance test; sound mechanics; tolerates repeated plyometrics without symptoms |
| Phase 6 | Walking endurance; terrain tolerance; accumulated swing and lower-extremity fatigue; sport-specific confidence | Incline/decline walking; variable-surface carries; prolonged standing; simulated uneven lies; repeated swing blocks separated by walking | Walks 30-45 min on variable terrain; tolerates 40-60 full swings; no next-day effusion, pain, ROM loss, or gait change |

Exercise selection should be individualized. Numeric hip- and ankle-mobility thresholds have not been validated for return to golf after ACLR; clinicians should address meaningful asymmetry or compensatory movement. ACLR, anterior cruciate ligament reconstruction; LSI, limb symmetry index; ROM, range of motion.

## FUTURE VALIDATION

A prospective pilot study is the next logical step. Feasibility outcomes should include recruitment, adherence, time spent in each phase, reasons for regression, and adverse symptom responses. Clinical outcomes should include effusion, ROM, strength, hop performance, patient-reported knee function, psychological readiness, and reinjury or reoperation. Golf outcomes should include time to putting, range practice, nine- and 18-hole play; walking versus riding; restoration of preinjury swing volume and clubhead speed; handicap or performance level; and patient satisfaction. Recording surgical-knee laterality, graft type, concomitant procedures, sex, age, handicap, and baseline speed would allow future refinement of the progression.

## LIMITATIONS

No included study directly tested the safety or effectiveness of this protocol in patients after ACLR. Knee moments estimated during a golf swing are not equivalent to direct ACL graft strain, and studies performed in healthy golfers or individuals after arthroplasty cannot be transferred without uncertainty. Laboratory samples were small and heterogeneous, definitions of swing phases and forces varied, and sex-specific evidence was limited. The phase windows, swing volumes, symptom rules, balance durations, and on-course sequence are author-consensus recommendations informed by load-management principles rather than validated cutoffs. Clinicians must individualize the protocol and follow surgeon-specific restrictions.

## CONCLUSION

Return to golf after ACLR should progress from controlled participation to full sport and ultimately return to performance. The golfer should demonstrate stable symptoms, restored motion and gait, objective strength, appropriate movement quality, and tolerance of progressively greater swing and course workloads. Both lead- and trail-knee demands require consideration, and swing modifications should be clearly defined and coordinated with a golf professional. The proposed six-phase protocol provides a comprehensive clinical framework, but prospective validation is required before it can be considered a validated standard of care.

Submitted: April 02, 2026 CDT. Revised: June 30, 2026 CDT. Accepted: July 02, 2026 CDT. Published: September 01, 2026 CDT.
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**Table 3. Patient- and swing-specific modifiers of the return-to-golf progression.**

| Factor | Current evidence or concern | Practical application | Evidence status |
|---|---|---|---|
| Lead-knee ACLR | High rotational, compressive, and frontal-plane demands commonly occur near impact/follow-through. | Use the same universal criteria; progress full-effort swings conservatively; consider comfortable lead-foot toe-out/open foot stance; monitor lateral slide and abrupt lead-knee extension. | Direct golf biomechanics plus clinical extrapolation |
| Trail-knee ACLR | Trail knee contributes to loading and transition; meaningful abduction moment impulse has been reported. | Do not automatically accelerate the timeline. Monitor backswing loading, trail-knee valgus/collapse, excessive sway, and transition control. | Direct golf biomechanics plus clinical extrapolation |
| Ball closer to golfer | One-ball-diameter change reduced lead-knee internal-rotation moment in one laboratory study. | Optional trial when lead-knee rotation is a concern; evaluate strike and ball flight. | Direct golf biomechanics; not studied after ACLR |
| Ball away from target | One-ball-diameter movement toward the trail-foot direction reduced lead-knee adduction moment but may alter club path. | Treat as a separate modification from moving closer to the golfer; coordinate with golf professional; combined use is untested. | Direct golf biomechanics; not studied after ACLR |
| Clubhead speed/skill | Higher speed and more forceful pressure strategies may increase demand; handicap does not fully capture exposure. | Progress by percentage of usual speed and total swings. Consider launch-monitor feedback, baseline practice volume, and competitive demands. | Direct/indirect golf evidence plus consensus dosing |
| Weight transfer | No validated ACLR-specific pressure-distribution target exists for address or impact; protective unloading or excessive lateral translation may alter the swing. | Restore the golfer's individualized, repeatable pressure shift while monitoring surgical-limb loading, lateral translation, and balance. | Clinical consensus |
| Sex | Some kinematic differences are reported, but no sex-specific ACLR golf thresholds exist. | Use the same objective criteria and individualize by strength, speed, movement, symptoms, and workload. | Insufficient direct evidence |
| Graft type | Healing characteristics and donor-site impairments differ, but no graft-specific golf progression has been validated. | Address quadriceps, hamstring, and anterior-knee deficits; follow surgeon restrictions rather than a universal graft-based delay. | Indirect ACLR evidence |
| Concomitant procedure | Meniscal, cartilage, osteotomy, or multiligament procedures may restrict weight bearing, flexion, rotation, or impact. | Procedure-specific restrictions supersede all suggested windows and may delay walking, bunker play, and uneven lies. | Procedure-specific guidance |

ACLR, anterior cruciate ligament reconstruction.

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