Optimizing Recovery After Achilles Tendon Pain

Guidelines Help Deliver Quality Care

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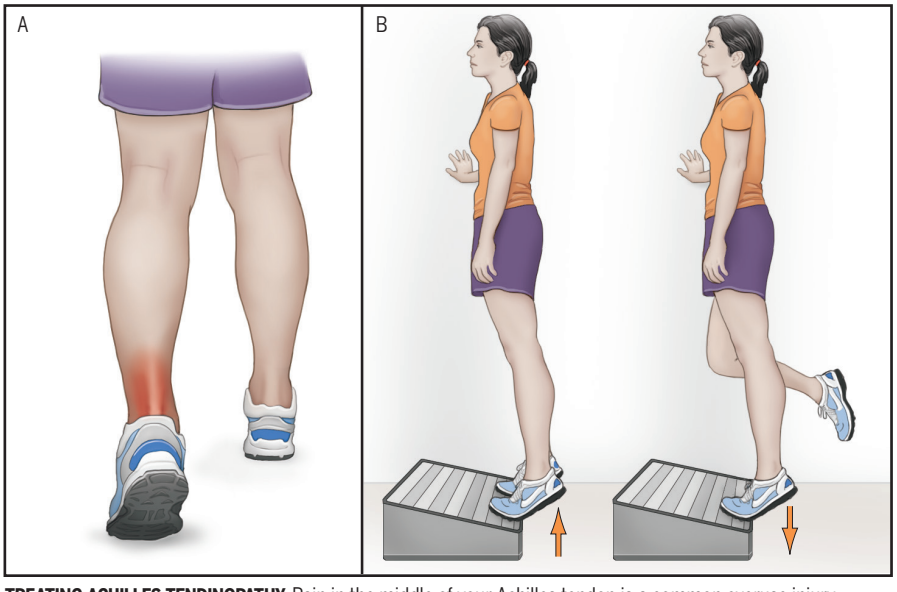
Achilles tendinopathy can temporarily stop many active people, and particularly those who participate in sports. Pain in the Achilles tendon often occurs in the middle of this fibrous tissue that connects the muscles at the back of the lower leg to the heel bone. This type of Achilles soreness or stiffness is common and usually results from an overuse injury. Physical therapists can help ensure that patients with Achilles tendinopathy receive the best quality care to optimize their recovery.

Guidelines published in the May 2018 issue of *JOSPT* recommend best practices from the published literature for evaluating, diagnosing, and treating Achilles tendon pain. These guidelines also suggest how physical therapists can determine when their patients are ready to return to activities after this injury. For patients, these guidelines outline the best rehabilitation treatment options based on scientific research. At the end of the day, optimal care is a combination of the leading science, the clinical expertise of your health care provider, and your input as the patient.



TREATING ACHILLES TENDINOPATHY. Pain in the middle of your Achilles tendon is a common overuse injury related to activity and sports (A). It is often successfully treated with strength training guided by a physical therapist. Strength training uses your body weight with or without additional weight to load the tendon and related muscles, as in the heel-raise exercise shown here, where the body is repeatedly raised using both legs and lowered using only the affected left leg (B). These exercises are done slowly; they can decrease pain, improve mobility, and help you return to your daily activities and sports.

This *JOSPT* Perspectives for Patients is based on an article by Martin et al, titled "Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy Revision 2018" *(J Orthop Sports Phys Ther 2018;48(5):A1-A38. doi:10.2519/jospt.2018.0302)*.

This Perspectives article was written by a team of *JOSPT*'s editorial board and staff. Deydre S. Teyhen, PT, PhD, Editor, and Jeanne Robertson, Illustrator.

NEW INSIGHTS

To update the 2010 guidelines on Achilles tendon pain, expert clinicians and researchers reviewed research published from 2009 to November 2017. They screened 1409 articles and closely examined 126 of the best papers on this topic to find the strongest evidence for diagnosis/classification, differential diagnosis, examination, and treatment to help decrease pain, improve mobility and function, and return you to your activities following Achilles tendinopathy.

PRACTICAL ADVICE

You may recover quickly or over several months from pain in your Achilles tendon. Although you have pain, you should continue your daily activities within your pain tolerance; it is critical that you avoid complete rest.

Your physical therapist will likely prescribe strength training to aid your recovery. Strength training exercises may use your body weight for resistance, and additional weight may be added to help make your calf muscles stronger. These exercises are typically performed slowly for the best results.

If your pain began recently, your physical therapist may use a treatment called iontophoresis, which delivers a medicine (dexamethasone) to the painful area to reduce soreness and improve function. Your physical therapist can help guide your recovery from Achilles tendinopathy, decreasing pain, improving mobility, and restoring muscle power.

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[CASE REPORT]

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Considerations in the Diagnosis and Accelerated Return to Sport of a Professional Basketball Player With a Triceps Surae Injury: A Case Report

STUDY DESIGN: Case report.

BACKGROUND: Acute injuries of the triceps surae and Achilles tendon are common in sports. Rupture of the plantaris tendon can be challenging to diagnose. There is limited evidence detailing the diagnosis, rehabilitation, and accelerated return to sport of elite professional basketball players who have sustained calf injuries.

CASE DESCRIPTION: A 25-year-old male professional basketball player sustained an injury to his calf during a professional basketball game. This case report details the presumptive diagnosis, graduated progression of intervention, and return to play of a professional athlete with a likely isolated plantaris tendon tear.

OUTCOMES: The patient returned to postseason competition 10 days post injury. Objective measures were tracked throughout rehabilitation and compared to baseline assessments. Before returning to play, the athlete showed improvements beyond the minimal clinically important difference for calf girth (2 cm) and numeric pain-rating scale score (4 points, 0-10 scale). Functional testing was conducted that included the Y Balance Test lower quarter and the Functional Movement Screen, with results that exceeded or returned the athlete to preseason levels.

DISCUSSION: This report details the case of a professional basketball player who returned to competitive play in an accelerated time frame following injury to his calf. Diagnosing a plantaris tendon rupture can be challenging, and anatomical variations of this muscle should be considered. It was demonstrated in this case that physical therapy rehabilitation was helpful in making a treatment-based clinical diagnosis when imaging was unclear.

LEVEL OF EVIDENCE: Therapy, level 5.
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KEY WORDS: *Achilles tendinopathy, calf strain, plantaris rupture, return to sport*

The plantaris muscle is often misunderstood due to discrepancies in its morphological presentation, insertion, and function.[1,3,5,7,15,16,22-26,37,45,55,63,66,67,70] Tears are often misdiagnosed as tendocalcaneus or Achilles tendon pathology,[25] medial gastrocnemius strain, "tennis leg,"[5,24,56,70,75] or sometimes deep vein thrombosis.[41,56] Controversy exists as to whether an isolated tear is even possible.[6,21,41,56] The exact pain mechanisms, functional implications, and their association with midportion Achilles tendinopathy and/or, more commonly, a tear of the medial gastrocnemius[15,24,44,62,70] are still being studied.[16,22,70] The mechanism of injury is frequently attributed to eccentric loads with running and jumping.[5,13,16,25,66] Magnetic resonance imaging (MRI), diagnostic ultrasound, and surgical exploration have shown that isolated rupture of the plantaris tendon is possible.[13,15,25,64,66]

The plantaris is a small vestigial muscle that originates on the inferior aspect of the lateral supracondylar line of the femur and the oblique popliteal ligament (**FIGURE 1**). Its tendon has been traditionally described as extending distally and medially to insert and fuse with the tendocalcaneus.[1,23,45,55,67] Recently, anatomists have described a variety of presentations, suggesting that the tendon may be independent of the Achilles (**FIGURE 2**).[14,16,46,61,66,70] dos Santos et al[16] note that the tendon fuses with the Achilles but that its bone insertion has been overlooked. This difference may be functionally relevant to the continuum of different pain presentations that have been documented with injury and a player's expeditious return to play.[9,12,43,49,50,53] Biedert[5] reported a case in which an elite soccer player sustained a plantaris tendon rupture, experienced persistent pain and inability to return to play because of tension between the plantaris and the Achilles tendons, and was only able to return after a distal tenotomy was performed. Others report incidences where return was possible with nonsurgical treatment.[30,34] Players who present with the variant morphology may have an advantage regarding recovery, because when the tendon is ruptured, there is no remaining soft tissue connection that can generate pain.

The plantaris is innervated by the tibial nerve and acts synergistically with the

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gastrocnemius to flex the knee and plantar flex the ankle.[1,23,45,55,67] Absent in 5% to 20% of the population, it is considered an organ of proprioception due to high muscle spindle density.[45,66] Mechanically, the tendon is reported to be stronger, stiffer, and less extensile than the neighboring Achilles tendon per cross-sectional area, and it has been shown that under similar tensile stresses, the Achilles elongates a greater distance than does the plantaris, which may fail.[40,46] Isolated rupture of the plantaris is associated with rapid eccentric loading during weight-bearing sports activities where the knee is hyperextended and the ankle is forced into dorsiflexion,[5,63] and is often linked with the subjective report of a "snapping/popping" sensation, as if the calf was struck with direct trauma.[20,63,66,70] The exact source of pain as related to the midportion of the Achilles tendon is still in question.[72] Other symptoms include swelling of the posteromedial calf proportional to the severity of soft tissue damage and pain with ankle dorsiflexion, resisted plantar flexion, and/or knee flexion.[4,9,16,30,35,44,47] Cases describing the injury, diagnosis, intervention, and rehabilitation of plantaris tendon rupture have been reported,[5,13,24,25] but there is little regarding the return to elite professional basketball.

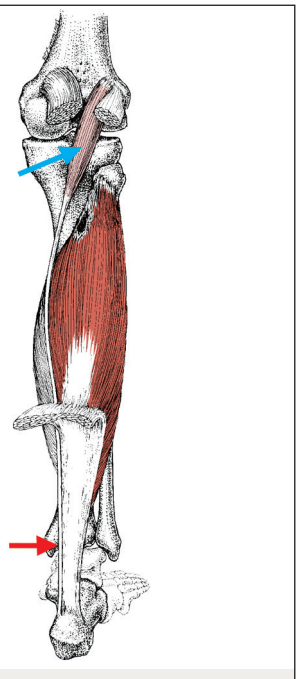

FIGURE 1. Typical anatomy of the plantaris, with the tendon conjoined with the Achilles. The blue arrow represents the plantaris muscle belly, and the red arrow represents the plantaris tendon. Reprinted with permission from *Mediclip Manual Medicine Volume 2*. Copyright ©Wolters Kluwer.

CASE DESCRIPTION

The patient was a 25-year-old man who injured his left calf while playing professional basketball. While defending an opposing player, he jumped and turned 180° toward his left, raising his right arm to block the basketball. Ground contact was made with his right leg, but, as he landed, his momentum (influenced by contact made with an opposing player) rotated his body to the left and posteriorly. The ball of his left foot contacted the ground and, as he attempted to slow his motion, his ankle was forced eccentrically into dorsiflexion with the knee flexed, and he fell over another player and onto his back. He was able to walk off the court but was unable to return. Medical evaluation by the team physician demonstrated obvious edema, with tenderness over the deep medial aspect of the proximal half of the posterior calf. Neurocirculatory status, confirmed through the assessment of sensation, motor function, digital capillary refill, and dorsal pedal and posterior tibial artery pulses, was intact. Doppler ultrasound revealed patent vessels, with no evidence of deep vein thrombosis. Aggressive cryotherapy was supplemented by intermittent use of pneumatic compression[17,59,60] on day 1 in the training facility and, beginning on day 3, during the evening when he was home.[31,32,35] Elevation and compression interventions were implemented, as there was no concern regarding compartment syndrome. Ibuprofen was prescribed as needed, with the intention of decreasing inflammation.[39,42]

Imaging

One day post injury, T2-weighted axial MRI, utilizing a fast-recovery, fast spin-echo sequence, revealed a significant amount of hemorrhagic fluid dissecting the fascial planes between the left gastrocnemius and soleus.[4,5,15,66] Interstitial edema and hemorrhage of the proximal soleus were noted, and, typical of a plantaris rupture, fluid was visualized deep to the lateral head of the gastrocnemius (**FIGURE 3**),[4,15,22,27] although no tear could be identified. The inability to visualize a ruptured tendon or muscle has been well documented, and many believe that the diagnosis of plantaris strain is

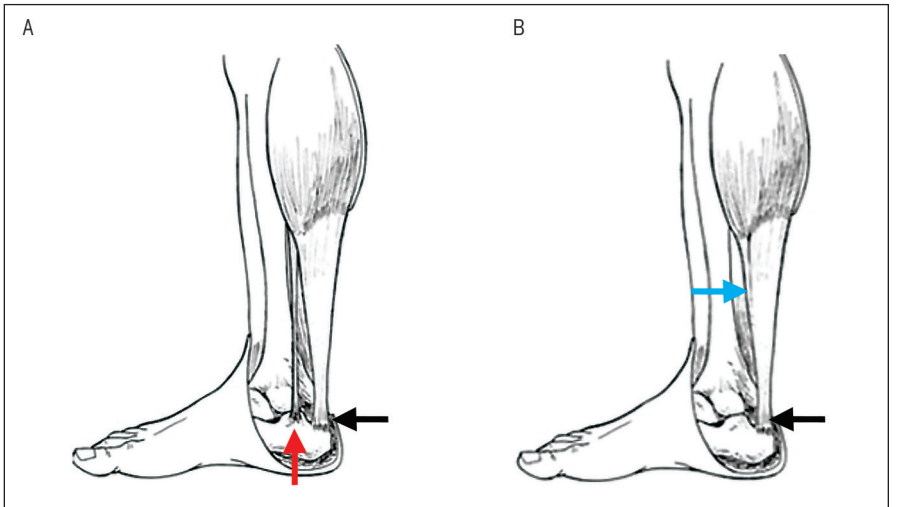

FIGURE 2. Plantaris insertion variations. (A) Anatomical variation of the plantaris tendon (red arrow), which is independent of the Achilles tendon (black arrow), and (B) typical insertion of the plantaris tendon (blue arrow), with insertion into the Achilles tendon (black arrow). Reprinted with permission from dos Santos et al.[16]

appropriate even when no tear is initially seen.[22,27,37] The initial impression included rupture of the plantaris at the myotendinous junction (due to profuse swelling), with a grade 2 strain of the medial gastrocsoleus complex, although suspicion of the latter diminished during the clinical examination and throughout intervention.

Initial Examination and Preseason Measures

The patient presented to the initial physical therapy examination without putting weight on the affected leg, and used a universal turning knee scooter to ambulate. He reported generalized deep medial calf pain and soreness through the proximal half of the lower leg, without specific point tenderness (**TABLE 1**).

The patient's numeric pain-rating scale (NPRS) score[18,19,58] was 6/10, and circumferential measurements[71,73] taken 10 cm distal to the superior aspect of the tibial tuberosity were 44.5 cm (right) and 46 cm (left), and those taken at 15 cm were 43 cm (right) and 45.5 cm (left) (**TABLE 2**). The ankle was notably limited (0°) in dorsiflexion passive range of motion (ROM), with a firm end feel that appeared to be influenced by muscular guarding. Talocrural accessory joint mobility testing was limited but equal bilaterally, and manually resisted plantar flexion strength was graded 3+ to 4– (maximum grade of 5), with generalized "soreness." He presented with grade 4– strength with knee flexion without pain. It was inappropriate to conduct functional testing at this time, but preseason Functional Movement Screen (FMS) and Y Balance Test (YBT) data were available (**TABLE 3**) to allow for later comparisons in determining appropriateness for return to play (**TABLE 4**). The FMS[10,11] and the YBT have demonstrated good reliability,[2,10,11,54,65,68,69] although little has been reported about their ability to predict injury in elite basketball players.[2] Preseason YBT scores demonstrated a

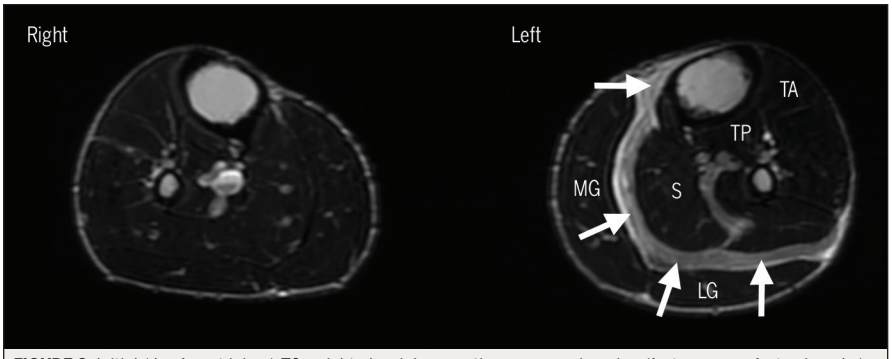

FIGURE 3. Initial (day 1 post injury) T2-weighted, axial magnetic resonance imaging (fast recovery, fast spin-echo) image. The white arrows represent edema. Abbreviations: LG, lateral gastrocnemius; MG, medial gastrocnemius; S, soleus; TA, tibialis anterior; TP, tibialis posterior.

TABLE 1 Clinical Examination Findings

Clinical Examination	Clinical Findings
Observation	Obvious edema of the left proximal calf
Palpation	Deep tenderness over medial aspect of proximal calf and gastrocnemius
AROM	Dorsiflexion, –4°
PROM	Dorsiflexion, 0°
Manual muscle testing	Plantar flexion, 3+; knee flexion, 4–
Special tests	Neurocirculatory status intact, Thompson test negative, anterior drawer negative, talar tilt negative, squeeze test negative, Homans' sign negative

Abbreviations: AROM, active range of motion; PROM, passive range of motion.

TABLE 2 Clinical Outcomes

	Initial	Phase 1 (Days 1-3)	Phase 2 (Days 4-7)	Reassessment (Day 8)	Phase 3 (Days 8-9)	Return to Play (Day 10)	Difference
NPRS (0-10)	6	3	0-3	0-3	0-2	0-2	4
Left calf girth, cm (10 cm distal to the superior aspect of tibial tuberosity)	46	45.5	45	44	44	44	2
Left calf girth, cm (15 cm distal to the superior aspect of tibial tuberosity)	45.5	45.5	45.25	45	45	45	0.5
AROM: ankle dorsiflexion, deg	–4	–2	2	6	8	10	14
MMT: ankle plantar flexion	3+	4–	4	4	4	4/4+	...
MMT: knee flexion	4–	4	4	4+	4+	4+/5	...

Abbreviations: AROM, active range of motion; MMT, manual muscle testing; NPRS, numeric pain-rating scale.

left-sided deficit in anterior (–7.5 cm) and posteromedial (–5.5 cm) reach, and a composite difference of –3.93, suggesting some balance deficit or stiffness in the left ankle. The preseason FMS total score (17) was above the cut score of 14 reportedly linked to injury in other populations.[2]

The initial clinical impression supported suspicion of a plantaris rupture at the myotendinous junction, with suspected strain of the medial gastrocsoleus complex, although the patient did not display specific point tenderness and only generalized soreness with resisted plantar flexion. Limitations in strength and joint motion were likely due to effects of acute inflammation.

Rehabilitation and Intervention

Phase 1 The aim of phase 1 (days 1-3) (**TABLE 5**) was to decrease edema and pain, improve ROM and strength, and protect suspected injured tissue to allow healing.[13,30,34,38,66] The intervention was based on standard rehabilitation strategies for acute soft tissue injuries and was effective in abating pain by the end of each session. Day 1 involved ice massage and sustained medial specific soft tissue mobilization to the Achilles at its insertion, with the tendon in neutral. Force was applied perpendicular to gastrocnemius fiber direction using both thumbs to the point of tissue resistance and the onset of mild discomfort, with the goal of improving tissue extensibility.[8] Effleurage and lymph drainage techniques were utilized to reduce edema.[5,8,48,66,74] Passive dorsiflexion and plantar flexion ROM was introduced with the knee positioned in extension, then flexion. Isometric plantar flexion and dorsiflexion were introduced at 25% of the player's maximum effort to encourage muscle pump mechanisms[74] to help reduce swelling and maintain neuromuscular/neurophysiologic function.[5,8,33,48,66,74] Subsequently, knee flexion strengthening exercises, using an elastic band (Thera-Band; Performance Health, Akron, OH) for resistance, were performed in addition to hip internal and external ROM activities with the knee flexed to maintain functional strength and motion throughout the lower extremity. It was apparent that he could generate substantive force (reported as 75% of maximum strength) with knee flexion, which suggested that the extent of gastrocsoleus strain might have been less than initially suspected. He participated in unweighted ambulation using an underwater treadmill (HydroWorx; Middletown, PA) pool[48] and treaded water for 15 minutes to maintain aerobic capacity. Weight bearing was progressed with standing lateral weight shifts and shallow pool walking on day 3, as the player

TABLE 3 Preseason Functional Testing (Prior to Injury)

	Left	Right	Involved-Side Difference/Final*
Y Balance Test			
Anterior stance	66.5	74	–7.5
Posteromedial stance	116.5	122	–5.5
Posterolateral stance	118	119	–1
Composite	84.31	88.24	–3.93
Functional Movement Screen			
Squat	2		2
Hurdle step	2	2	2
Lunge	3	3	3
Shoulder mobility	2	2	2
Active SLR	3	3	3
Push-up	2		2
Rotary stability	3	3	3
Total			17

Abbreviation: SLR, straight leg raise.
**Final scores are for the Functional Movement Screen.*

TABLE 4 Return to Play: Functional Testing

	Left	Right	Involved-Side Difference/Final*
Y Balance Test			
Anterior stance	70	75	–5
Posteromedial stance	121	122	–1
Posterolateral stance	116	117	–1
Composite	88.06	90.07	–2.01
Functional Movement Screen			
Squat	2		2
Hurdle step	2	2	2
Lunge	2	3	2
Shoulder mobility	2	2	2
Active SLR	3	3	3
Push-up	2		2
Rotary stability	3	3	3
Total			16

Abbreviation: SLR, straight leg raise.
**Final scores are for the Functional Movement Screen.*

demonstrated the ability to increase weight on his affected limb without pain or a compensatory gait pattern. Each session concluded with 15 minutes in the cold tub,[3,35,36,72] followed by pneumatic compression to reduce swelling.[31,32,35,59,60] While the evidence related to the efficacy of this modality is sparse, its use has been supported for the recovery of elite athletes and long-distance runners,[17] and in the management of individuals with vascular dysfunction.[59,60] As such, pneumatic compression was administered on day 1, 3 times per day, for 1 to 2 hours, with 20 minutes of rest between bouts. On the third day, the player was issued a compression sock and instructed to utilize the pneumatic compression device multiple times in the afternoon/evening, and to wear the device to bed with the leg elevated. He noted increased optimism regarding ambulation and a decreased NPRS score of 3/10 at the onset of treatment on day 3. By the end of his physical therapy session, he reported an NPRS score of 0. Patient education focused on maintaining compliance with edema control strategies and improving movement and exercise tolerance, without progressing too quickly. There were noted decreases in edema and pain and improved ROM, strength, and weight bearing (**TABLE 2**). Encouraged by the response to treatment and by lack of focal point tenderness, sharp pain, or elicitation of pain with knee flexion or ankle plantar flexion, the physical therapist became increasingly convinced that the plantaris tendon was completely ruptured and that the related musculature was sound.

Phase 2 The goals of phase 2 (days 4-7) (**TABLE 5**) were to continue to decrease pain and edema and to improve ROM, functional/neuromuscular strength, soft tissue pliability, weight bearing, and proprioception, while maintaining endurance, with the intention of returning the player to on-court activities. On day 4, the player ambulated (weight bearing as tolerated), with an initial NPRS score of 3/10. Cryotherapy modalities continued,[29] and specific soft tissue mobilization was progressed to include the Achilles tendon. Talocrural joint mobilizations (grades I and II) were used for their neurophysiologic effects, and grades III and IV were used to improve ankle mobility and counter the effects of decreased activity.[8,30] Passive ROM to the hip and ankle was transitioned to include progressive manually resisted ROM and ankle strengthening with a TheraBand (Performance Health). With a functional return to basketball in mind, proprioceptive and weight-bearing activities were progressed to standing heel raises with the knee in flexion and extension, focusing on good eccentric control. The treadmill (AlterG; Fremont, CA) treadmill was introduced at 50% body weight for 20 minutes at 8.05 kph on the fourth day, aimed at progressing walking and running based on what the therapists and trainers believed were moderate but safe baseline parameters. Having no difficulty, he quickly advanced to full weight bearing by day 5, without negative repercussions. Additionally, hip/pelvic strengthening was

TABLE 5 Phases of Rehabilitation and Intervention

	Phase 1 (Days 1-3)	Phase 2 (Days 4-7)	Phase 3 (Days 8-9)	Return to Play (Day 10)
Ambulation and gait training	NWB with universal turning knee scooter. Standing weight shifts, progressed to walking in HydroWorx pool	WBAT to FWB. AlterG: walk/jog 3-5 mph at 40% body weight	FWB	FWB
Manual therapy	SSTM to gastrocnemius, effleurage, lymph drainage techniques	STM with addition of Achilles tendon. Talocrural joint mobilization	As before	As before. STM to entire LE
Therapeutic exercise	Progressive ROM activities. Resisted knee flexion with resistive band. Lateral standing weight shifts	Progressive ROM. Resisted ankle strengthening with resistive band. Hip/pelvic strengthening. Standing heel raises with knee flexed and extended	As before. Double-leg heel walk-outs. Smooth operators. Heel walk	As before and as indicated
Cardiopulmonary	Treading water in pool	VersaClimber: 1-min intervals, 10 times	VersaClimber	On-court running
Court and return-to-sport activities	None	125 midrange shots (various distances). Progressed to 200 jump shots with lateral movement	35-min workout with full-court running, double- and single-leg jumping	Full participation with on-court warm-up, shootaround, and game participation
Edema control	Ice massage (5 min). Cold tub (15 min). Pneumatic compression (3 times per day, 1-2 h, and 20 min of rest). Compression sock	As before	As before	As before

Abbreviations: FWB, full weight bearing; LE, lower extremity; NWB, non–weight bearing; ROM, range of motion; SSTM, specific soft tissue mobilization; STM, soft tissue mobilization; WBAT, weight bearing as tolerated.

performed, and a vertical climber (VersaClimber; Heart Rate Inc, Santa Ana, CA) was prescribed to increase endurance. On-court activities were initiated with 125 stationary midrange shots from various distances, and progressed to 200 jump shots with lateral movement by day 6. He noted improvements in pain and function daily. While he reported feeling tight and stiff in the morning, symptoms were alleviated with therapy, and circumferential lower-leg measurements and visual definition of the calf musculature continued to improve (**TABLE 2**). The sports medicine team was encouraged that by day 7, the player was recovering well from the acute sequelae associated with what appeared to be an isolated plantaris rupture, and that there did not appear to be irritation of the medial gastrocsoleus, Achilles tendon, or associated soft tissue.

Reassessment and Follow-up MRI

The patient was re-evaluated 8 days post injury, with the goal of determining readiness for more aggressive on-court progressions and a return to practice. Subjectively, he continued to feel stiff in the morning, but denied new or increased symptoms following interventions from the previous day. He walked with a mild limp at the start of the day but could bear full weight without compensation by mid morning. The patient's NPRS score ranged from 0 to 3, and circumferential measurements demonstrated a decrease of 2 and 0.5 cm since the initial evaluation (**TABLE 2**). Ankle dorsiflexion active ROM (6°) and knee and ankle plantar flexion strength (4/5) improved as therapy continued, with the addition of heel walking exercises and on-court practice that included 35 minutes of drills and progressions. Follow-up MRI demonstrated a 50% decrease in swelling on day 8, with resolution of interstitial edema absolving damage to the soleus and increasing confidence in the diagnosis of an isolated plantaris rupture (**FIGURE 4**).

Phase 3: Return to Play The goals of phase 3 were to continue to improve functional strength and endurance and to re-establish neurophysiologic and neuromuscular control in preparation for a return to play. On day 8, the player reported feeling less stiff and sore than he had the previous morning and reported no pain, paresthesia, or increased swelling. After consultation between the physical therapist and team physician, it was agreed that there were risks involved with potential approval of the player's return to play, and it was documented that a return might result in several possible outcomes, including (1) reinjury, rebleeding, and regression; (2) the development of compartment syndrome and discontinuation of play; (3) increased pain, soreness, and stiffness that might inhibit the ability to play in a safe and effective manner; and (4) successful return to play. Each outcome was communicated and discussed with key stakeholders involved with the case, namely, the player. The player was cleared to participate in an aggressive basketball workout that included full-court running and double- and single-leg jumping and cutting. He noted that the most painful maneuver to perform was jumping off the left leg for power, but that he felt that he was functioning at 70% (or better) of his preinjury performance.[9,12,49-53] At this point, the player believed that he could play at the needed level, and the sports medical team and coaching staff agreed that while there was still risk, he would contribute to the competitiveness of the team.

Return to Competitive Play[9,12,49-53] On the morning of day 10, the athlete presented with no increase in symptoms or edema from the previous workout. Prior to the game, he received specific soft tissue mobilization and could fully partake in warm-ups and shoot around activities, stating that he was ready to return to play. The physical therapist consulted with the team physician, noting no increase in the

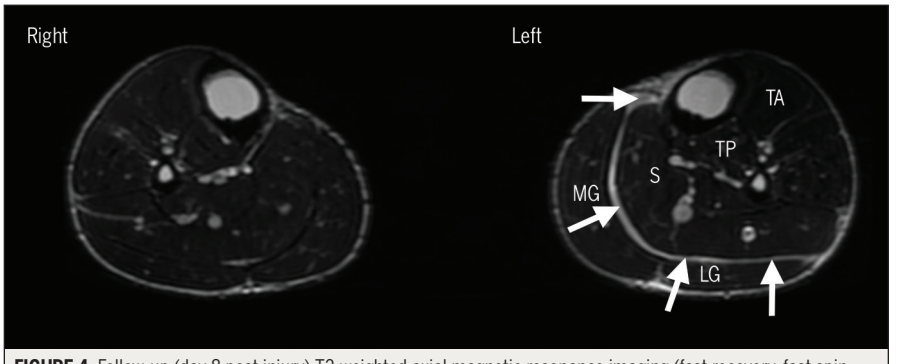

FIGURE 4. Follow-up (day 8 post injury) T2-weighted axial magnetic resonance imaging (fast recovery, fast spin-echo) image. The white arrows represent diminished edema. Abbreviations: LG, lateral gastrocnemius; MG, medial gastrocnemius; S, soleus; TA, tibialis anterior; TP, tibialis posterior.

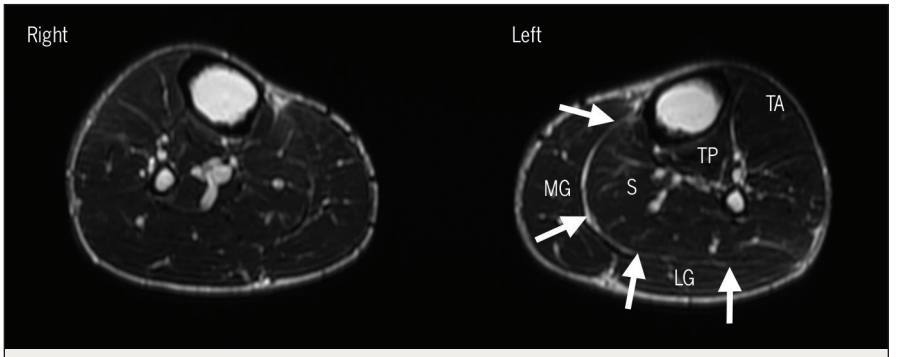

FIGURE 5. Exit physical (17 days post injury): T2-weighted axial magnetic resonance imaging (fast recovery, fast spin-echo) image. The white arrows represent minimal edema. Abbreviations: LG, lateral gastrocnemius; MG, medial gastrocnemius; S, soleus; TA, tibialis anterior; TP, tibialis posterior.

athlete's pain or swelling and that he felt well enough to compete. Functional testing was conducted, including the YBT lower-quarter test and the FMS, and the results (**TABLE 4**) demonstrated that performance had improved compared to preseason values (**TABLE 3**).

He competed in postseason games without a drop in preinjury performance or production, and his numeric pain rating continued to decrease (to 2/10) throughout the week. He reported only mild morning stiffness following games and noted resolution with activity and as the day progressed. Soft tissue mobilization was administered to the entire leg to assist postgame recovery and help maintain muscle extensibility, and selected therapeutic exercises were continued to improve functional ankle strength. Circumferential measurements validated decreased edema, as the player wore a compression sock and continued utilization of the cold tub, ice, and pneumatic device (**TABLE 5**). He used a hot pack before and during games to maintain muscle pliability and could fully participate in practice, pregame activities, and game play. He experienced some intermittent muscle cramping (game 1) but performed at a level commensurate with preinjury ability.

OUTCOMES

Objective measures were tracked throughout rehabilitation and compared to baseline assessments (**TABLE 2**). Calf girth and NPRS were improved beyond the minimal clinically important difference, with a 0.5- to 2.0-cm difference in calf girth between sides[27,57,73] and an NPRS score difference of 4[18,19,58] before return to play. Given the short time frame, muscle performance and ROM gains were likely neurophysiologic in nature and due to decreased facilitative guarding and edema.

While preseason YBT results showed a left-side deficit in the anterior (−7.5 cm), posteromedial (−5.5 cm), and composite (−3.93) scores, return-to-play testing demonstrated comparatively improved symmetry, total excursion, and composite score values (**TABLES 3** and **4**). The composite FMS score (16) was 1 point lower than his preseason score (17) due to diminished performance on the left lunge test, but the player felt strongly that he was able to compete, and his decision was supported by the medical staff, coaches, and relevant front-office administrative personnel.

DISCUSSION

This case, involving a suspected isolated tear of the plantaris muscle of a professional basketball player, is notable for several reasons. First, while rupture of the plantaris is typically associated with forced eccentric ankle dorsiflexion and knee extension, his knee remained flexed, suggesting that the extent of strain at the talocrural joint was significant because of active insufficiency of the gastrocnemius and plantaris at the knee. Additionally, (1) anatomical variation, limitations with imaging, and clinical presentation make plantaris dysfunctions difficult to diagnose; (2) the rehabilitation and return to play for elite athletes sustaining complete plantaris rupture are not well described; and (3) there is an opportunity to compare preseason functional measures.

Anatomical Variation

Controversy exists regarding the significance or prevalence of an isolated tear of the plantaris, and the difficulty associated with diagnosis may be complicated by the presence of anatomical variation.[5,14,16,24,66,70] Traditional anatomy textbooks locate the plantaris insertion medial and distal from its origin and fused with the tendocalcaneus or Achilles tendon,[1,23,45,55,67] but it has been recently noted that it may attach independently on the calcaneus (**FIGURE 2**).[5,14,16,24,66,70] This variance may be functionally relevant to the continuum of pain presentations documented with injury and the expeditious ability to return to play.[9,12,43,49-51,53] Ultimately, we cannot modify the athlete's anatomy, and imaging typically provides information that, when coupled with the history and physical examination, may inform the diagnosis and intervention.

Imaging

Studies utilizing MRI, sonography, or surgical exploration show that plantaris injuries may occur in isolation or concomitantly with tears of the gastrocnemius, soleus, or popliteus,[4,7,15,22,27,37,63] but prolific edema can make the precise identification of the involved structures difficult. Magnetic resonance imaging studies suggest that the diagnosis of plantaris strain is appropriate when fluid is observed with a strong clinical suspicion, even when no tear is initially seen.[22,27,37] In the current report, an empirically informed diagnosis was based on observation of patient response following the graduated progression of intervention. In contrast, Biedert[5] reported on an elite athlete who presented with little hemorrhage or swelling in the posteromedial aspect of the calf. While the high signal intensity seen on T2-weighted images did suggest the presence of a persisting hematoma and an edematous process, the normal signal intensity found in the gastrocsoleus complex was evidence of focal tearing of the plantaris.[5] In our case, the significant edema present confounded the ability to determine which structures were specifically involved. There was a large amount of hemorrhagic fluid dissecting along the fascial planes and myotendinous junction of the gastrocsoleus complex, and interstitial edema and hemorrhage of the proximal soleus were also noted, with fluid deep to the lateral head of the gastrocnemius muscle (**FIGURE 3**). This pattern was typical of a plantaris rupture at the myotendinous junction and a suspected grade 2 gastrocsoleus strain, and the aggressive edema-reduction efforts aided the diagnosis of an isolated plantaris tear during follow-up. Clinically, the torn plantaris is considered less severe than Achilles or gastrocsoleus tears and is nonsurgically treated.[14,39] Follow-up MRI supported the clinical findings (**FIGURES 4** and **5**),

and, as swelling diminished, the Achilles and gastrocsoleus complex appeared healthy, with normal signal intensity.

Rehabilitation and Return to Play

Evidence is lacking on return-to-play criteria for athletes who have sustained a plantaris rupture and their readiness to compete.[9,12,53] While there was a differential diagnosis of a gastrocsoleus strain, the exam findings were not consistent with these diagnoses. We therefore felt comfortable accelerating the athlete's rehabilitation progressions and return to play. The prescription of rest through controlled weight bearing, cryotherapy, pneumatic compression, and elevation was essential in diminishing edema to allow healing to occur and prevent complications known to be associated with plantaris or triceps surae strains.[35,63] But, there was also a sense of urgency in determining whether the player could return to play.

Nonsurgical treatment is typically administered for 3 to 16 weeks, particularly when there is involvement of the gastrocsoleus complex.[7,24,25] While immobilization is indicated during the acute phase of muscle healing due to histological factors such as capillary growth, granulation tissue formation, muscle fiber regeneration, and biomechanical tensile strength development, these factors have more precedence when healing, repair, and tissue regeneration are the goals.[30,38,39] In this case, immobilization, protected weight bearing, and edema-control strategies were implemented, with the aim to improve function by decreasing pain, inflammation, and muscle soreness; however, as the likelihood of an isolated plantaris rupture increased and the suspicion of a medial gastrocsoleus strain diminished, it was recognized that rehabilitation should focus on treating the objective clinical symptoms and on functional ability, because healing of the tendon was not the aim. The aggressive use of pneumatic compression was integral, as evidence demonstrates that compression can help decrease edema and allow for early ambulation, while not altering the rate of muscle glycogen resynthesis.[31,32,35,59,60] Likewise, the utilization of specific soft tissue mobilization was thought to improve tissue extensibility and allow for lymph drainage.[5,8,48,66,74] As the player improved, gradual progression of passive, active, and resisted movements was introduced in a manner that accounted for the limits of tissue tolerance, with the intention of distending maturing scar tissue during the plastic phase of healing. He could progressively generate increased resistive force, suggesting that, aside from the complete rupture of the plantaris, the surrounding musculature was able to produce tensile loads.[28] As in any case, cause and effect are difficult to infer, but the ability to progressively load the calf without increased signs of inflammation helped to support the player's readiness to advance. The functional need for the plantaris was considered, but the player's ability to perform was not diminished. It should also be noted that, anatomically, the plantaris is reported to be absent in 5% to 20% of the general population.[1,23,45] Assuming that rehabilitation assisted recovery, it is unclear which intervention contributed to the improvement, because a multimodal approach reflective of clinical practice was implemented.

Other cases report patient progression to graduated strengthening, stretching, and proprioceptive activities.[5,7,8,13,24,47] This athlete could advance to more dynamic activities without incident, and he demonstrated the ability to generate adequate forces to participate in on-court activities that included running and double- and single-leg jumping, without apparent proprioceptive deficit. There is no consensus on guidelines or criteria for return to play for muscle strains, and decision making is based on expert opinion and related to the desire to minimize the risk of recurrence and maximize performance.[49-51,53] In the present case, the evolving clinical diagnosis diminished the risk of "recurrence," because, with the complete rupture of one structure, the related soft tissue did not appear to be aggravated by clinical intervention. The literature suggests that an earlier return to play is possible even if there is a low to moderate risk of injury recurrence, because of improvements in the ability of sports medicine teams to better understand mechanism of injury, prognosis, risk management strategies, and rehabilitation programs.[49-51,53] Also, the player in this case study did not demonstrate cardiorespiratory decline, which is in line with literature that suggests that a detraining effect does not occur until after 2 weeks.[9,12,43,53] He did not require or have the opportunity to participate in advanced return-to-sports activities due to his lack of substantive decline and his ability to return to play. The player competed in postseason professional basketball games during a 7-day span without residual symptoms or a drop in preinjury minutes played, performance, or production.

Preseason Measures

While the preseason FMS score (17) for this athlete was not predictive of the likelihood of injury, the sports medicine team did believe that the screen was of clinical value and offered a good baseline comparison to help determine the player's readiness for return to play. He did present with preseason YBT scores that suggested a predisposition to injury, according to the testing protocol[54] (YBT composite, 84.31%; anterior reach difference, 7.5 cm). Teyhen et al[69] found that there was a relationship between a YBT composite score and Achilles flexibility (r = 0.38, P = .004), which may imply that our player's limitation in weight-bearing ankle dorsiflexion and possible posterior calf inflexibility or stiffness were linked to his plantaris injury.[5,22,28,35,40,44,63] It is important to note that the player did not report to training camp with a history or complaint of left calf dysfunction, and that these preseason findings were identified by the sports medicine team; his program was designed to include corrective exercises and manual therapy to address these limitations accordingly. In

any event, return-to-play functional and YBT testing demonstrated comparatively improved symmetry, total excursion, and composite score (**TABLES 3** and **4**).

CONCLUSION

This case report describes a case in which a professional basketball player returned to competitive play in an accelerated time frame following rupture of the plantaris tendon. The physical therapy management and decision-making framework for this injury incorporated the patient's history, physical examination, diagnostic imaging, and ongoing response to treatment as a basis for the return to play. ◉

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Validity and Responsiveness of the Short Version of the Western Ontario Rotator Cuff Index (Short-WORC) in Patients With Rotator Cuff Repair

STUDY DESIGN: Clinical measurement.

BACKGROUND: Recently, the Western Ontario Rotator Cuff Index (WORC) was shortened, but few studies have reported its measurement properties.

OBJECTIVE: To compare the validity and responsiveness of the short version of the Western Ontario Rotator Cuff Index (Short-WORC) and the WORC (disease-specific measures) with those of the Shoulder Pain and Disability Index (SPADI) and the simple shoulder test (SST) (joint-specific measures); the Disabilities of the Arm, Shoulder and Hand (DASH) (a region-specific measure); and the Medical Outcomes Study 12-Item Short-Form Health Survey version 2 (SF-12v2) (a general health status measure) in patients undergoing rotator cuff repair (RCR).

METHODS: A cohort of patients (n = 223) completed the WORC, SPADI, SST, DASH, and SF-12v2 preoperatively and at 3 and 6 months after RCR. Short-WORC scores were extracted from the WORC questionnaire. The construct validity (Pearson correlations) and internal responsiveness (effect size [ES], standardized response mean [SRM], relative efficiency [RE]) of the Short-WORC were calculated.

RESULTS: The Short-WORC was strongly correlated with the WORC (r = 0.89-0.96) and moderately to strongly correlated with non–disease-specific measures at preoperative and postoperative assessments (r = 0.51-0.92). The Short-WORC and WORC were equally responsive ($RE_{Short\text{-}WORC/WORC}$ = 1) at 0 to 6 months and highly responsive overall at 0 to 3 months ($ES_{Short\text{-}WORC}$, 0.72; ES_{WORC}, 0.92; $SRM_{Short\text{-}WORC}$, 0.75; SRM_{WORC}, 0.81) and 0 to 6 months ($ES_{Short\text{-}WORC}$, 1.05; ES_{WORC}, 1.12; $SRM_{Short\text{-}WORC}$, 0.89; SRM_{WORC}, 0.89). The responsiveness of the comparator measures (SPADI, SST, DASH, SF-12v2) was poor to moderate at 0 to 3 months (ES, 0.07-0.55; SRM, 0.09-0.49) and 0 to 6 months (ES, 0.05-0.78; SRM, 0.07-0.78).

CONCLUSION: The Short-WORC and WORC have similar responsiveness in patients undergoing RCR, and are more responsive than non–disease-specific measures. Future studies should focus on validation of the Short-WORC in samples representing the spectrum of rotator cuff disorders.
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KEY WORDS: *quality of life, rotator cuff repair, shoulder pain, validity, Western Ontario Rotator Cuff Index (WORC)*

Shoulder pain is the third most commonly reported symptom encountered in musculoskeletal practice.[49,52] Rotator cuff disorders (RCDs) account for substantial work loss, sick leave, and poor health-related quality of life (HRQoL).[25,42,47,54,63,64] The main aim of rotator cuff repair (RCR) is to reduce pain and improve functional ability and HRQoL.[23,32,60] Preoperatively and postoperatively, people with RCD may be assessed using disease-specific, joint-specific, region-specific, and general patient-reported outcome measures (PROs).[13] The Western Ontario Rotator Cuff Index (WORC), developed by Kirkley et al,[32] is one of the most validated disease-specific HRQoL questionnaires for patients with RCDs.[11,26,41,49,56] In 2012, Razmjou et al[51] proposed a shorter version of the WORC (Short-WORC) to address concerns about response burden and lack of factor validation.

The developers described the Short-WORC as a tool to evaluate activity limitation rather than HRQoL, and provided preliminary evidence that the responsiveness of the Short-WORC was similar to 2 joint-specific PROs, the Constant-Murley score and American Shoulder and Elbow Surgeons assessment form.[51] We have recently established reproducibility (reliability and agreement statistics) for the Short-WORC.[9] However, further study is required to establish the clinical measurement properties of the Short-WORC.

The primary purpose of this study was to determine the cross-sectional

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and longitudinal construct validity and responsiveness of the Short-WORC and WORC in patients undergoing RCR. A secondary purpose was to compare these psychometric parameters of the Short-WORC and WORC to joint-specific (Shoulder Pain and Disability Index [SPADI], simple shoulder test [SST]), region-specific (Disabilities of the Arm, Shoulder and Hand questionnaire [DASH]), and general health status (Medical Outcomes Study 12-Item Short-Form Health Survey version 2 [SF-12v2]) measures.

METHODS

We conducted a retrospective review of anonymized charts for patients who underwent RCR at St Joseph's Health Care in London, Ontario (Canada) from December 1997 to May 2012. Ethical approval to review the clinic's database registry to extract anonymized data was obtained from the Health Sciences Research Ethics Board of the University of Western Ontario in London, Ontario.

Patients

Patients between 18 and 85 years of age who were slated for RCR (any technique) and completed the WORC were eligible for participation. Those with a history of previous surgery, upper extremity fracture, or concomitant shoulder pathologies were excluded from the study.

Sample Description and Assessment Time Points

Patients (n = 223; 151 men, 72 women; mean ± SD age, 56.70 ± 11.08 years) completed the WORC, DASH, SPADI, SST, and SF-12v2 PROs at baseline (1-2 weeks before surgery) and follow-ups (3 months and 6 months post surgery). The Short-WORC scores were extracted from the completed WORC.

Questionnaires/PROs

The WORC is a reliable and validated disease-specific HRQoL PRO developed for people with RCD.[32] It consists of 21 items presented under 5 domains: physical symptoms (6 items), sports and recreation (4 items), work (4 items), lifestyle (4 items), and emotions (3 items). Each item is scored on a 0-to-100-mm visual analog scale, summing a total score ranging from 0 (best possible score) to 2100 (worst possible score). The raw WORC scores can also be expressed as a percentage. The questionnaire is considered incomplete and no score is generated when 10% of the responses are missing.[32]

The 7-item Short-WORC data were extracted from the WORC.[51] The Short-WORC consists of all items from the work (questions 11-14) and lifestyle (questions 15-18) domains, except 1 lifestyle item related to roughhousing (question 17). The total Short-WORC score varies from 0 (best possible score) to 700 (worst possible score). The raw Short-WORC scores can also be expressed as a percentage. Any missing items render the Short-WORC questionnaire incomplete, and no score can be generated.[51]

The SPADI[53] is a reliable,[3] valid,[5,53,60] and responsive[3,24] joint-specific PRO to assess pain and disability specific to shoulder pathology. The 13-item SPADI[53,62] contains 2 subscales: pain and disability. The SST is a reliable,[20] valid, and responsive[41,55] joint-specific PRO to assess functional disability. It consists of 12 items with a yes/no response format that ask about the function of the involved shoulder. The DASH is a reliable, valid, and responsive region-specific PRO that assesses symptoms and upper extremity function in patients with upper extremity disorders, including RCD.[5,27,33,40] The SF-12v2 is a reliable and valid[7,58] 12-item general health status survey[29] expressed as physical component summary (PCS) and mental component summary (MCS) scores.

Statistical Analysis

All analyses were conducted using SPSS for Windows Version 23 (IBM Corporation, Armonk, NY). The statistical significance was set at an alpha less than .05 at a 95% confidence interval (CI). Descriptive statistics were examined to determine data distributions and floor and ceiling effects. For the Short-WORC and WORC, floor and ceiling effects were deemed to be present when the total score in 15% of the sample fell within 0 to 10 (minimal scores) or 90 to 100 (maximal scores), respectively.[10,43]

Validity and Responsiveness

Construct Validity[34] We assessed construct validity by evaluating the extent to which the PRO demonstrated relationships consistent with theoretically assumed relationships between the attributes of pain, disability, function, and HRQoL.

Known-Group Validity Prior literature suggests that patients with workers' compensation (WC)[2,44,59] and female patients[50] have poorer outcomes after RCR. Hence, we determined cross-sectional and longitudinal known-group validity using the variables of WC status and sex.[26]

Cross-sectional Known-Group Validity Independent *t* tests were used to evaluate whether Short-WORC and WORC scores were different based on WC status or sex.

Longitudinal Known-Group Validity Independent *t* tests were used to test longitudinal differences in Short-WORC and WORC scores from baseline to follow-up assessments (0 to 3 and 0 to 6 months) for known groups.

Convergent Construct Validity Convergent construct validity[16,57] was assessed by correlating the Short-WORC and WORC scores with measures that are expected to evaluate similar constructs.

Cross-sectional Construct Validity Pearson correlation coefficients (*r*) with 95% CIs were calculated to examine the relationship of the Short-WORC and WORC with joint-specific (SPADI, SST), region-specific (DASH), and general health status (SF-12v2) measures at baseline and follow-ups. Correlation coefficients of 0.00 to 0.19 were defined as very weak, 0.20 to 0.39 as weak, 0.40 to 0.69 as moderate, 0.70 to 0.89 as strong, and 0.90 to 1.00 as very strong.[18] We used the

Fisher r-to-z transformation calculator[39] to assess differences in the relationships of the Short-WORC and WORC scores ($r_{difference} = r_{Short\text{-}WORC} - r_{WORC}$) when correlated with scores on joint-specific, region-specific, and general health status PROs at the 3 assessment time points. We tested the following a priori hypotheses: (1) the Short-WORC and WORC would have a strong positive correlation (r>0.70) with each other at baseline and follow-ups, and (2) the Short-WORC and WORC would have a similar and moderate correlation (r = 0.40-0.69) with other joint-specific, region-specific, and general health status questionnaires at baseline and follow-ups.

Longitudinal Construct Validity Also known as external responsiveness,[28] for this measure, Pearson r values with 95% CIs were used to find the relationship between the change scores reported for different measures at baseline and follow-ups. We used the Fisher r-to-z transformation calculator to assess whether there were any significant differences ($r_{difference}$) between the relationship of change in Short-WORC and WORC scores when correlated with change in scores on joint-specific, region-specific, and general health status PROs at baseline and follow-ups. A priori hypotheses were as follows: (1) the change scores on the Short-WORC and WORC from baseline to follow-ups would have a strong correlation (r>0.70), and (2) the change scores on the Short-WORC and WORC from baseline to follow-ups would have a similar and moderate correlation (r = 0.40-0.69) with the change in other joint-specific, region-specific, and general health status PROs.

Internal Responsiveness We used the following responsiveness statistics to assess internal responsiveness of the Short-WORC and WORC:

1. Paired t test. As suggested by Juniper et al[30] and others,[28,31,37] we used paired t test statistics to test the hypothesis that within-subject changes in scores on the Short-WORC and WORC between baseline and follow-ups would be statistically significantly different. As suggested by Liang et al,[36] we used paired t statistics to determine relative efficiency (RE) of the Short-WORC compared to the WORC. Relative efficiency was computed by squaring the ratio of paired t tests for the Short-WORC and WORC ($RE_{Short\text{-}WORC/WORC} = [t_{Short\text{-}WORC}/t_{WORC}]^2$, where t is the mean difference/[SD of mean difference/$\sqrt{n}$]). An RE greater than 1 (or RE less than 1) indicated that the Short-WORC was a more (or less) efficient tool for measuring change than the WORC.[36] Similarly, we also computed the RE of the Short-WORC in comparison to other conventionally used upper extremity measures.
2. Effect size (ES) 1, also known as standardized effect size,[4,17,28] is defined as the ratio of mean change scores ($\delta_X = x2 - x1$) to the standard deviation of baseline scores ($SD_{baseline}$), where δ_X is mean change and $x1$ and $x2$ represent mean scores assessed at baseline and follow-up assessments, respectively.
3. Effect size 2, also known as standardized response mean (SRM), is

TABLE 1 Baseline Characteristics of the Study Population (n = 223)*

Variable	Value	Variable	Value
Age, y†	56.7 ± 11.1	Workers' compensation involved (n = 211)	95
Sex (n = 223)	100	No (n = 136)	64
Male (n = 151)	68	Yes (n = 68)	32
Female (n = 72)	32	Pending (n = 7)	3
Affected shoulder (n = 222)	99	Highest education level (n = 208)	93
Left (n = 93)	42	Some grade school (n = 6)	3
Right (n = 128)	58	Finished grade school (n = 20)	10
Both (n = 1)	0.4	Some high school (n = 45)	22
Hand dominance (n = 220)	99	Finished high school (n = 36)	17
Left (n = 30)	14	Some college/technical/diploma program (n = 33)	16
Right (n = 190)	86	Finished college/technical/diploma program (n = 30)	14
Medication used before surgery (n = 209)	94	Some university (n = 18)	9
Yes (n = 104)	49	Finished university (n = 11)	5
No (n = 105)	50	Some graduate work at university (n = 4)	2
Injections used before surgery (n = 212)	95	Finished graduate work at university (n = 5)	2
Yes (n = 99)	47	Smoker (n = 207)	93
No (n = 113)	53	No (n = 82)	39
Employment status at enrollment (n = 213)	95	Yes (n = 45)	22
Full-time regular duties (n = 62)	29	I quit (n = 80)	39
Part-time regular duties (n = 10)	5	Alcohol (n = 210)	94
Full-time light duties (n = 19)	9	Never (n = 40)	19
Part-time light duties (n = 8)	4	Occasionally (n = 103)	49
Unable to work because of injury (n = 47)	22	1-6 drinks per week (n = 32)	15
Unable to work for other medical reasons (n = 9)	4	7-14 drinks per week (n = 23)	11
Homemaker (n = 2)	1	15+ drinks per week (n = 12)	5
Retired (n = 56)	26		

*Values are percent unless otherwise indicated.
†Values are mean ± SD.

defined as the ratio of mean change scores ($\delta_X = x2 - x1$) to the standard deviation reflecting the variability of change scores ($SD\delta_X$).[28,35] The SRM is the most widely accepted responsiveness statistic, because SRM is not dependent on either the standard deviation of baseline scores (as for ES 1) or the sample size (as for the paired *t* test).[6,28,48] We computed 95% CIs for SRMs by the bootstrap method, using Stata Version 12 software (StataCorp LLC, College Station, TX).[6] For the purpose of clinical decision making, we used Cohen's benchmark to indicate the magnitude of responsiveness indices (ES 1 and ES 2): trivial (less than 0.2), small (0.2 or greater to less than 0.5), moderate (0.5 or greater to less than 0.8), or large (0.8 or greater).[8] We expected the Short-WORC and WORC to have similar magnitudes of responsiveness.

TABLE 2 Floor and Ceiling Effects for the Short-WORC and WORC

Time Point/Measure	Mean ± SD	Median (IQR)	Floor Effect, %	Ceiling Effect, %
Baseline				
Short-WORC (n = 207)	30.2 ± 20.3	28.0 (29.3)	39/207 = 18.8	1/207 = 0.004
WORC (n = 213)	32.3 ± 18.0	30.7 (25.5)	25/213 = 12.0	0/213 = 0
6-month follow-up				
Short-WORC (n = 183)	56.8 ± 28.5	60.4 (48.9)	11/183 = 6.0	26/183 = 14.2
WORC (n = 190)	56.8 ± 27.9	59.9 (46.9)	10/190 = 5.2	26/190 = 13.7

Abbreviations: IQR, interquartile range; Short-WORC, short version of the Western Ontario Rotator Cuff Index; WORC, Western Ontario Rotator Cuff Index.

TABLE 3 Cross-sectional and Longitudinal Known-Group Validity: With and Without WC

Type of Validity/Time Point or Interval/Measure	With WC*	Without WC*	Mean Difference	*P* Value (2 Tailed)
Cross-sectional known-group validity				
Baseline (with WC, n = 66; without WC, n = 129)				
Short-WORC	24.6 ± 18.5	32.9 ± 21.1	8.4	<.01†
WORC	25.5 ± 16.2	35.5 ± 18.7	9.9	<.01†
6-month follow-up (with WC, n = 60; without WC, n = 109)				
Short-WORC	40.4 ± 25.3	66.4 ± 26.4	26.0	<.01†
WORC	40.7 ± 25.1	66.1 ± 25.2	25.3	<.01†
Longitudinal known-group validity				
0-3 months (with WC, n = 54; without WC, n = 107)				
Short-WORC	−6.7 ± 15.4	−18.2 ± 23.6	−11.4	<.01†
WORC	−11.3 ± 14.9	−19.1 ± 24.2	−7.8	.01‡
0-6 months (with WC, n = 58; without WC, n = 103)				
Short-WORC	−15.4 ± 22.6	−33.9 ± 26.6	−18.5	<.01†
WORC	−14.9 ± 21.4	−30.7 ± 25.6	−15.8	<.01†

Abbreviations: Short-WORC, short version of the Western Ontario Rotator Cuff Index; WC, workers' compensation; WORC, Western Ontario Rotator Cuff Index.
**Values are mean ± SD.*
†Statistically significant difference (P≤.001).
‡Statistically significant difference (P<.05).

RESULTS

The baseline characteristics of the study population and sample size for each variable are presented in **TABLE 1**. All patients did not complete all measures at all time points, and the sample size for each evaluation is reported with each analysis.

Floor and Ceiling Effects

The number of patients with minimal or maximal Short-WORC and WORC scores is summarized in **TABLE 2**. No ceiling effects were observed at any time point. No floor effects were observed for the WORC at baseline or 6 months, and for the Short-WORC at 6 months. Floor effects were observed at baseline for 18.8% on the Short-WORC.

Cross-sectional Known-Group Validity

In **TABLE 3**, we show that Short-WORC and WORC scores were significantly different based on WC status ($P<.001$) at both baseline (mean difference [D]: $D_{Short\text{-}WORC}$, 8.4; D_{WORC}, 9.9) and 6 months ($D_{Short\text{-}WORC}$, 26.0; D_{WORC}, 25.3). **TABLE 4** shows that Short-WORC scores were significantly different ($P\leq.01$) among women and men at both baseline ($D_{Short\text{-}WORC}$, 16.4) and 6 months ($D_{Short\text{-}WORC}$, 11.6). In comparison, the WORC could discriminate significant sex differences only at baseline (D_{WORC}, 12.4; $P<.001$) (**TABLE 4**). However, at both baseline and 6 months, patients with WC and women reported lower scores on the Short-WORC and WORC than those without WC and men (**TABLES 3** and **4**).

Longitudinal Known-Group Validity

TABLE 3 summarizes the change in Short-WORC and WORC scores, which were significantly different ($P\leq.01$) among those with or without WC when assessed from baseline to 3 months ($D_{Short\text{-}WORC}$, 11.4; D_{WORC}, 7.8) and 6 months ($D_{Short\text{-}WORC}$, 18.5; D_{WORC}, 15.8) post surgery. As summarized in **TABLE 4**, the changes from baseline scores on the Short-WORC and WORC were significantly different ($P\leq.01$) among women and men at 3

months, but not 6 months, post surgery. At both follow-ups, patients with WC and women showed greater change in scores on the Short-WORC and WORC compared to those without WC and men (**TABLES 3** and **4**).

Cross-sectional Convergent Construct Validity

TABLE 5 presents the Pearson correlation coefficients for the Short-WORC and WORC with respect to each other and to the SPADI, SST, DASH, SF-12v2 PCS, and SF-12v2 MCS, assessed at 3 time points. As hypothesized, the Short-WORC was correlated with the WORC at baseline (preoperative, r = 0.92) and each follow-up (3 months, r = 0.89; 6 months, r = 0.96). Scores on both the Short-WORC and WORC were moderately ($0.40>r<0.69$) to strongly ($r>0.70$) related with joint-specific (SPADI, SST), region-specific (DASH), and general health status (SF-12v2 PCS, SF-12v2 MCS) PROs at all time points, with the exception of weak associations with scores on the SF-12v2 MCS at 3 months (r = 0.20-0.39). Among all PROs evaluated, scores on the Short-WORC and WORC were strongly associated with the region-specific measure (DASH) at baseline, and with a joint-specific measure (SPADI) at 3 and 6 months post surgery. The Short-WORC and WORC showed moderate to strong association with the SST at all time points. In contrast, associations were lowest for the Short-WORC and WORC when compared with the general health status (SF-12v2 MCS) scores at all time points (**TABLE 5**). The relationships between Short-WORC and WORC scores and scores on other PROs were similar (**TABLE 5**), and there were no statistically significant differences in the relationships of the Short-WORC and WORC scores when correlated with scores on joint-specific, region-specific, and general health status PROs at 3 different time points ($r_{difference}$ data available in **APPENDIX TABLE A**, available at www.jospt.org).

Longitudinal Convergent Construct Validity (External Responsiveness)

As hypothesized, changes in Short-WORC and WORC scores demonstrated strong and statistically significant correlations when assessed from baseline to 3 months (r = 0.86) and from baseline to 6 months (r = 0.92) (**TABLE 5**). The change in Short-WORC and WORC scores exhibited similar and moderate correlations (r = 0.40-0.70) with changes from baseline in joint-specific (SPADI, SST), region-specific (DASH), and general health status (SF-12v2 PCS) PROs at 3- and 6-month follow-ups. The exception was the strong correlations ($r>0.70$) with change in SST score from baseline to 6 months for both the Short-WORC and WORC. Changes in Short-WORC and WORC scores showed weak (r = 0.20-0.39) correlations with change in SF-12v2 MCS score from baseline to follow-ups, which reached statistical significance at 6 months (**TABLE 5**). No statistically significant differences were observed in the magnitude of correlation coefficients for changes from baseline in Short-WORC and WORC scores and scores on the comparator PROs at follow-ups ($r_{difference}$ data available in **APPENDIX TABLE B**, available at www.jospt.org).

TABLE 4 Cross-sectional and Longitudinal Known-Group Validity: Women and Men

Type of Validity/Time Point or Interval/Measure	Women*	Men*	Mean Difference	*P* Value (2 Tailed)
Cross-sectional known-group validity				
Baseline (women, n = 69; men, n = 138)				
Short-WORC	19.3 ± 15.4	35.6 ± 20.3	16.4	.001†
WORC	24.0 ± 15.6	36.4 ± 18.1	12.4	.001†
6-month follow-up (women, n = 62; men, n = 120)				
Short-WORC	49.0 ± 32.8	60.7 ± 25.4	11.6	.01‡
WORC	52.1 ± 31.6	59.1 ± 25.3	6.9	.13
Longitudinal known-group validity				
0-3 months (women, n = 58; men, n = 113)				
Short-WORC	−20.7 ± 20.5	−11.9 ± 22.2	8.8	.001†
WORC	−23.8 ± 22.3	−13.2 ± 21.0	10.5	.001†
0-6 months (women, n = 59; men, n = 108)				
Short-WORC	−30.7 ± 28.1	−25.2 ± 25.7	5.5	.20
WORC	−28.1 ± 27.7	−23.0 ± 23.7	5.1	.21

Abbreviations: Short-WORC, short version of the Western Ontario Rotator Cuff Index; WORC, Western Ontario Rotator Cuff Index.
**Values are mean ± SD.*
†Statistically significant difference (P≤.001).
‡Statistically significant difference (P<.05).

Internal Responsiveness

TABLE 6 shows mean change scores for all PROs assessed at baseline and follow-up visits. Both the Short-WORC and WORC detected change over time when comparing preoperative and postoperative scores ($P<.01$). Similarly, all other upper extremity PROs detected change over time in our sample. **TABLE 7** summarizes the calculations performed to determine the RE of the Short-WORC to evaluate change over time, in comparison to the RE of the WORC and the other PROs. The Short-WORC and the WORC evaluated change from baseline to 6 months with similar efficiency. The Short-WORC evaluated change at 3 and 6 months with more efficiency (RE greater than 1) than the joint-specific, region-specific, or general health status PROs.

TABLE 6 summarizes ES 1 and SRM, indicating good responsiveness of the Short-WORC and WORC. At 6 months, both the Short-WORC and WORC exhibited similarly large responsiveness ($ES_{Short-WORC}$,

1.05; ES_{WORC}, 1.12; $SRM_{Short\text{-}WORC}$, 0.89; SRM_{WORC}, 0.89). From 0 to 3 months, the WORC showed large responsiveness (ES_{WORC}, 0.92; SRM_{WORC}, 0.81) in comparison to the moderate responsiveness of the Short-WORC ($ES_{Short\text{-}WORC}$, 0.72; $SRM_{Short\text{-}WORC}$, 0.75). Over both follow-up periods, disease-specific measures (Short-WORC and WORC) were more responsive than joint-specific, region-specific, and general health status PROs.

DISCUSSION

The results of our study support the validity and responsiveness characteristics of the 7-item Short-WORC as being similar to the full-length 21-item WORC. Also, both versions of the WORC were more responsive in comparison to the joint-specific, region-specific, and general health status outcome measures. Razmjou et al[51] evaluated measurement properties of the Short-WORC at a follow-up of 6 months, while we included follow-ups of 3 and 6 months in our study and used more extensive analysis on validity and responsiveness. The lack of studies on measurement properties of the Short-WORC and WORC limited our ability to compare performance to other samples or contexts. Our study provided novel data regarding floor and ceiling effects and determined that the only potential concern for the Short-WORC were the minimal floor effects (18.8%) at baseline in our study sample, which slightly exceeded the common threshold of 15%. While this might suggest caution in using the Short-WORC to evaluate worsening, we did not notice any floor and ceiling effects on the Short-WORC in our recent study[9] evaluating the reproducibility of the Short-WORC in a similar sample. Also, there were no floor and ceiling effects on the translated versions of the 21-item WORC.[10,14,61]

The known-group validity of the Short-WORC reported in our study was consistent with findings in the previous literature that patients with WC[2,44,59] and female patients[50] often report poorer outcomes. This confirms that the Short-WORC is equally able to discriminate these subgroups, but also suggests that Short-WORC scores should be stratified by sex and compensation status in future research.

The high correlation between the Short-WORC and WORC seen in our study was similar to the correlations reported by the developers of the Short-WORC and was not a surprising finding, as the Short-WORC items are a subset of the WORC.[51] The moderate to strong correlations of the Short-WORC and WORC to the other PROs were also consistent

TABLE 5 Cross-sectional and Longitudinal Convergent Construct Validity*

Type of Validity/Time Point or Interval/ Measure	WORC	SPADI	SST	DASH	SF-12v2 PCS	SF-12v2 MCS
Cross-sectional convergent construct validity						
Baseline (n = 88)						
Short-WORC	0.92 (0.88, 0.94)†	−0.63 (−0.73, −0.51)†	0.69 (0.58, 0.77)†	−0.77 (−0.83, −0.68)†	0.51 (0.36, 0.63)†	0.41 (0.25, 0.55)†
WORC	1	−0.63 (−0.73, −0.51)†	0.68 (0.57, 0.76)†	−0.82 (−0.87, −0.75)†	0.53 (0.39, 0.64)†	0.48 (0.33, 0.60)†
3-month follow-up (n = 83)						
Short-WORC	0.89 (0.84, 0.92)†	−0.82 (−0.87, −0.75)†	0.58 (0.44, 0.68)†	−0.73 (−0.80, −0.63)†	0.61 (0.48, 0.71)†	0.38 (0.21, 0.53)†
WORC	1	−0.80 (−0.85, −0.72)†	0.53 (0.38, 0.67)†	−0.69 (−0.77, −0.58)†	0.60 (0.47, 0.70)†	0.35 (0.18, 0.50)†
6-month follow-up (n = 99)						
Short-WORC	0.96 (0.94, 0.97)‡	−0.92 (−0.94, −0.89)†	0.87 (0.82, 0.90)†	−0.86 (−0.89, −0.81)†	0.77 (0.69, 0.83)†	0.52 (0.38, 0.63)†
WORC	1	−0.89 (−0.92, −0.85)†	0.84 (0.78, 0.88)†	−0.84 (−0.88, −0.78)†	0.76 (0.68, 0.82)†	0.58 (0.45, 0.68)†
Longitudinal convergent construct validity (external responsiveness statistics)						
0-3 months (n = 53)						
Short-WORC	0.86 (0.79, 0.91)†	−0.62 (−0.74, −0.46)†	0.58 (0.40, 0.71)†	−0.70 (−0.80, −0.56)†	0.53 (0.34, 0.67)†	0.23 (0.00, 0.43)
WORC	1	−0.51 (−0.66, −0.31)†	0.53 (0.34, 0.67)†	−0.60 (−0.73, −0.43)†	0.55 (0.37, 0.69)†	0.32 (0.09, 0.51)‡
0-6 months (n = 61)						
Short-WORC	0.92 (0.88, 0.95)†	−0.69 (−0.79, −0.56)†	0.77 (0.67, 0.84)†	−0.64 (−0.79, −0.49)†	0.63 (0.48, 0.74)†	0.29 (0.08, 0.47)‡
WORC	1	−0.67 (−0.77, −0.53)†	0.75 (0.63, 0.83)†	−0.63 (−0.74, −0.48)†	0.56 (0.39, 0.69)†	0.39 (0.19, 0.56)†

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MCS, mental component summary; PCS, physical component summary; SF-12v2, Medical Outcomes Study 12-Item Short-Form Health Survey version 2; Short-WORC, short version of the Western Ontario Rotator Cuff Index; SPADI, Shoulder Pain and Disability Index; SST, simple shoulder test; WORC, Western Ontario Rotator Cuff Index.
**Values are Pearson r (95% confidence interval).*
†Statistically significant difference (P≤.001).
‡Statistically significant difference (P<.05).

with previous studies.[14,15,19,32,38,45,51] However, what was more important in this study was the finding that the sizes of these correlations were similar at all time points, regardless of which WORC version was used. The correlations between the Short-WORC and other measures were equivalent or higher than those for the WORC. However, this trend was opposite for the Short-WORC and SF-12v2 MCS (where the Short-WORC was 0.10 lower across all time points). We attribute this to the removal of the emotional constructs from the Short-WORC during its development. This confirms our conceptual concern about whether the Short-WORC should be called a HRQoL measure, as it no longer attempts to cross both the physical and mental domains of health. Also, the developers of the Short-WORC have described the role of the Short-WORC as evaluating activity limitation rather than quality of life.

Our findings are consistent with previous studies and the indications for surgery, in that the physical domains of health are more affected than mental health.[41,56] This is not to say that mental health should not be considered, as it has been shown to worsen in those with poor outcomes following RCR[41] and may be a predictor of outcome.[46] It may best be addressed using relevant and validated scales, rather than a mental or emotional component of the WORC, arguing against the need to retain the original spectrum of content in the WORC. This is especially true in light of the positive measurement characteristics of the Short-WORC.

In the present study, both the Short-WORC and WORC were more responsive than the other measures evaluated. The Short-WORC had a lower ES during the first 3-month interval than the WORC. Perhaps this was due to small floor effects shown at baseline, but we do not want to overinterpret this trend, as the SRMs were similar and the RE did not indicate a cause for concern. Also, this could be because shorter versions are known to be somewhat compromised in content validity, and consequently need a larger sample to detect a change in the outcomes.[37] The Short-WORC was almost as efficient as the WORC, and more efficient (RE greater than 1) than the SPADI, SST, DASH, and SF-12v2 during the first 3-month interval. The measures were less different on this parameter during the 6-month interval, especially when related with the SST and SPADI. As the Short-WORC and the SST are the 2 brief measures, the Short-WORC would be more efficient for early assessment, and this difference is less important for the longer term. Our findings are consistent with a previous study that reported that the WORC (SRM_{WORC}, 2.0)

TABLE 6 Internal Responsiveness Indices: Mean Change, SRM (Bootstrapped), ES

Change Interval/Measure	t_o	Baseline*	Follow-up*	Change*†	SRM†‡	ES§
0-3 months (n = 53)						
Short-WORC	5.5	29.9 ± 23.4	46.9 ± 25.7	16.9 ± 22.5 (10.8, 23.1)‖	0.75 (0.42, 1.20)	0.72
WORC	5.9	32.2 ± 20.9	51.6 ± 25.1	19.4 ± 23.9 (12.8, 25.9)‖	0.81 (0.48, 1.22)	0.92
SPADI	3.5	53.8 ± 26.2	40.6 ± 26.5	13.2 ± 27.5 (5.7, 20.7)‖	0.48 (0.21, 0.81)	0.50
SST	3.4	36.1 ± 24.4	47.1 ± 20.6	10.9 ± 23.6 (4.5, 17.4)‖	0.46 (0.17, 0.84)	0.45
DASH	3.5	47.6 ± 18.7	37.1 ± 20.1	10.4 ± 21.3 (4.6, 16.2)‖	0.49 (0.20, 0.79)	0.55
SF-12v2 PCS	1.4	34.8 ± 9.2	36.5 ± 8.8	1.6 ± 8.6 (−0.7, 4.0)	0.19 (0.08, 0.50)	0.18
SF-12v2 MCS	0.7	48.8 ± 14.0	49.7 ± 12.0	0.9 ± 10.3 (−1.8, 3.8)	−0.08 (−0.34, 0.18)	0.07
0-6 months (n = 61)						
Short-WORC	6.9	30.0 ± 23.0	54.4 ± 31.7	24.4 ± 27.4 (17.4, 31.4)‖	0.89 (0.67, 1.17)	1.05
WORC	6.9	32.7 ± 20.4	55.7 ± 30.8	22.9 ± 25.8 (16.4, 29.6)‖	0.89 (0.66, 1.17)	1.12
SPADI	6.1	57.2 ± 26.2	36.5 ± 31.1	20.7 ± 26.6 (13.9, 27.5)‖	0.77 (0.54, 1.05)	0.78
SST	6.1	35.6 ± 28.2	57.6 ± 31.9	21.9 ± 28.1 (14.8, 29.2)‖	0.78 (0.54, 1.08)	0.78
DASH	4.6	47.9 ± 21.2	35.9 ± 26.6	11.9 ± 20.4 (6.7, 17.2)‖	0.58 (0.37, 0.82)	0.56
SF-12v2 PCS	5.3	34.6 ± 8.2	39.5 ± 10.1	4.9 ± 7.3 (3.0, 6.8)‖	0.67 (0.48, 0.91)	0.59
SF-12v2 MCS	0.5	47.5 ± 12.8	48.2 ± 28.2	0.7 ± 9.7 (−1.8, 3.1)	−0.07 (−0.33, 0.19)	0.05

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; ES, effect size; MCS, mental component summary; PCS, physical component summary; SF-12v2, Medical Outcomes Study 12-Item Short-Form Health Survey version 2; Short-WORC, short version of the Western Ontario Rotator Cuff Index; SPADI, Shoulder Pain and Disability Index; SRM, standardized response mean; SST, simple shoulder test; t_o the observed value of t on paired t test; WORC, Western Ontario Rotator Cuff Index.

**Values are mean ± SD.*

†Values in parentheses are 95% confidence interval.

‡Mean change divided by the SD of change scores.

§Mean change divided by the SD of baseline scores.

‖Statistically significant mean change (P≤.001).

and the joint-specific measure (SRM_{SST}, 1.8) were more responsive than the region-specific measure (SRM_{DASH}, 1.6) and the general health status measures ($SRM_{SF\text{-}12v2\ PCS}$, 0.97; $SRM_{SF\text{-}12v2\ MCS}$, 0.05) to detect change at the 6-month follow-up.[41] This is consistent with the narrow focus of disease-specific measures, which are known to capture various aspects of disease better than the measures that are broadly related to the disease condition.[4,21,22] Our results were also consistent with other studies in which general HRQoL measures were least responsive when compared with the region- or joint-specific measures for upper extremity disorders.[1,3,41,42]

Our results contradicted those of other studies of WORC responsiveness.[12,13,49] Ekeberg et al[13] found that the SPADI and Oxford Shoulder Score were more responsive than the WORC. However, they evaluated responsiveness at 2 and 6 weeks post surgery, whereas we performed assessments at 3 and 6 months. In another study[49] done on a small sample population (n = 41) with rotator cuff pathology, it was reported that the WORC was less responsive than the limb- or region-specific measures (SRM_{WORC}, 1.4; $SRM_{Upper\ Extremity\ Functional\ Index}$, 1.5). However, the authors did not report lower limits of SRMs or the follow-up time points at which the postoperative assessments were done. Some variation can relate to time frames tested, populations, procedures, familiarity with the measures, literacy, culture, and other factors. Moreover, the best indicators of outcome measure performance are systematic reviews of the compiled best-quality evidence, and not individual studies. A recent systematic review[56] of PRO performance in patients with RCDs indicated that the WORC is the most responsive.

Strengths, Limitations, and Future Recommendations

Our study was based on a large prospective cohort of patients from a single center, where data were collected by blinded research assistants. However, some limitations should be acknowledged. First, we derived our prospective data from a clinical database and were unable to contact all eligible participants to ensure that the WORC was complete. Furthermore, scores for the Short-WORC were derived from the 7 items completed as part of the 21-item WORC. The additional 14 items may have influenced responses. While we could have administered the WORC and the Short-WORC separately, it would have been difficult to make the time long enough to prevent recall while ensuring their condition remained stable. Thus, using the extracted items is the most pragmatic design choice. Future studies should determine the measurement properties of the Short-WORC when administered independently from the additional 14 items from the full scale. Second, we did not do a priori sample-size calculations. Nevertheless, our sample size was similar to comparator cross-sectional studies of the Short-WORC[49] or WORC[26,32] and longitudinal validity studies of the WORC,[26,49] and our CIs suggest adequate precision. Third, our study population was not homogeneous, and we included patients with wide age ranges and with different surgical procedures, although this might be considered a strength, as it enhances generalizability. Last, we could not evaluate the minimal clinically important difference. Future studies should consider evaluating the minimal clinically important difference of the Short-WORC, compare ease and time required to complete the Short-WORC and WORC questionnaires, and continue to strengthen the cross-cultural translations available to improve access.

Despite the limitations, we were able to provide further insight and evidence regarding validity and responsiveness of the Short-WORC to assess change in outcomes in patients undergoing RCR. Furthermore, short questionnaires such as the Short-WORC might be more acceptable and preferable in both clinical and research settings, due to their comprehensiveness and low response burden.

TABLE 7 Relative Efficiency of the Short-WORC Versus the WORC to Detect Change Over Time*

Change Interval	Short-WORC/ WORC	Short-WORC/ SPADI	Short-WORC/SST	Short-WORC/DASH	Short-WORC/ SF-12v2 PCS	Short-WORC/ SF-12v2 MCS
0-3 months (n = 53)	0.93	1.6	1.6	1.5	3.9	8.0
0-6 months (n= 61)	1.00	1.1	1.1	1.5	1.3	12.9

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MCS, mental component summary; PCS, physical component summary; RE, relative efficiency; SF-12v2, Medical Outcomes Study 12-Item Short-Form Health Survey version 2; Short-WORC, short version of the Western Ontario Rotator Cuff Index; SPADI, Shoulder Pain and Disability Index; SST, simple shoulder test; WORC, Western Ontario Rotator Cuff Index.
**Values are relative efficiency, calculated as the squared ratio of the paired t tests, where t is the mean difference/(SD of mean difference/√n).*

CONCLUSION

The 7-item Short-WORC has proven to be a valid and responsive PRO for evaluation of function in patients undergoing RCR. Both the Short-WORC and WORC showed similar validity and responsiveness characteristics and were more responsive than the SPADI, SST, DASH, and SF-12v2. This suggests that the Short-WORC is a preferable option for evaluation of outcomes in patients undergoing RCR. ◉

KEY POINTS

FINDINGS: Both the 7-item short version of the Western Ontario Rotator Cuff Index (Short-WORC) and 21-item Western Ontario Rotator Cuff Index (WORC) are valid and responsive disease-specific patient-reported outcome measures to

assess change in functional outcome among patients undergoing rotator cuff repair.

IMPLICATIONS: The 7-item Short-WORC can replace the 21-item WORC for assessing outcomes among patients undergoing rotator cuff repair.

CAUTION: A single study in a single tertiary care hospital may not generalize to other contexts.

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APPENDIX

Table A

Cross-sectional Convergent Construct Validity: Differences in the Relationships of the Short-WORC and WORC*

Time Point/Measure	WORC	SPADI	SST	DASH	SF-12v2 PCS	SF-12v2 MCS
Baseline (n = 88)						
Short-WORC	0.92 (0.88, 0.94)†	−0.63 (−0.73, −0.51)†	0.69 (0.58, 0.77)†	−0.77 (−0.83, −0.68)†	0.51 (0.36, 0.63)†	0.41 (0.25, 0.55)†
WORC	1	−0.63 (−0.73, −0.51)†	0.68 (0.57, 0.76)†	−0.82 (−0.87, −0.75)†	0.53 (0.39, 0.64)†	0.48 (0.33, 0.60)†
Difference‡		0 (z = 0, P = .5)	0.01 (z = 0.12, P = .45)	0.05 (z = 0.89, P = .18)	−0.02 (z = −0.18, P = .43)	−0.07 (z = −0.57, P = .28)
3-mo follow-up (n = 83)						
Short-WORC	0.89 (0.84, 0.92)†	−0.82 (−0.87, −0.75)†	0.58 (0.44, 0.68)†	−0.73 (−0.80, −0.63)†	0.61 (0.48, 0.71)†	0.38 (0.21, 0.53)†
WORC	1	−0.80 (−0.85, −0.72)†	0.53 (0.38, 0.67)†	−0.69 (−0.77 ,−0.58)†	0.60 (0.47, 0.70)†	0.35 (0.18, 0.50)†
Difference‡		−0.02 (z = −0.37, P = .35)	0.05 (z = 0.46, P = .32)	−0.04 (z = −0.51, P = .30)	0.01 (z = 0.1, P = .46)	0.03 (z = 0.22, P = .41)
6-mo follow-up (n = 99)						
Short-WORC	0.96 (0.94, 0.97)§	−0.92 (−0.94, −0.89)§	0.87 (0.82, 0.90)§	−0.86 (−0.89, −0.81)§	0.77 (0.69, 0.83)§	0.52 (0.38, 0.63)§
WORC	1	−0.89 (−0.92, −0.85)§	0.84 (0.78, 0.88)§	−0.84 (−0.88, −0.78)§	0.76 (0.68, 0.82)§	0.58 (0.45, 0.68)§
Difference‡		−0.03 (z = −1.16, P = .12)	0.03 (z = 0.78, P = .21)	−0.02 (z = −0.5, P = .3)	0.01 (z = 0.17, P = .43)	−0.06 (z = −0.6, P = .27)

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MCS, mental component summary; PCS, physical component summary; SF-12v2, Medical Outcomes Study 12-Item Short-Form Health Survey version 2; Short-WORC, short version of the Western Ontario Rotator Cuff Index; SPADI, Shoulder Pain and Disability Index; SST, simple shoulder test; WORC, Western Ontario Rotator Cuff Index.

**Values are Pearson r (95% confidence interval) unless otherwise indicated.*

†*Statistically significant difference (P≤.001).*

‡$r_{difference} = r_{Short\text{-}WORC} - r_{WORC}$.

§*Statistically significant difference (P<.05).*

Table B

Longitudinal Convergent Construct Validity: Differences in the Relationships of the Short-WORC and WORC*

Time Interval/Measure	WORC	SPADI	SST	DASH	SF-12v2 PCS	SF-12v2 MCS
0-3 mo (n = 53)						
Short-WORC	0.86 (0.79, 0.91)†	−0.62 (−0.74, −0.46)†	0.58 (0.40, 0.71)†	−0.70 (−0.80, −0.56)†	0.53 (0.34, 0.67)†	0.23 (0.00, 0.43)
WORC	1	−0.51 (−0.66, −0.31)†	0.53 (0.34, 0.67)†	−0.60 (−0.73, −0.43)†	0.55 (0.37, 0.69)†	0.32 (0.09, 0.51)‡
Difference§		−0.11 (z = −0.81, P = .21)	0.05 (z = 0.36, P = .35)	−0.10 (z = −0.87, P = .2)	−0.02 (z = −0.14, P = .44)	−0.09 (z = −0.49, P = .31)
0-6 mo (n = 61)						
Short-WORC	0.92 (0.88, 0.95)†	−0.69 (−0.79, −0.56)†	0.77 (0.67, 0.84)†	−0.64 (−0.79,– 0.49)†	0.63 (0.48, 0.74)†	0.29 (0.08, 0.47)‡
WORC	1	−0.67 (−0.77, −0.53)†	0.75 (0.63, 0.83)†	−0.63 (−0.74,– 0.48)†	0.56 (0.39, 0.69)†	0.39 (0.19, 0.56)†
Difference§		−0.02 (z = −0.2, P = .42)	0.02 (z = 0.26, P = .4)	−0.01 (z = −0.09, P = .46)	0.07 (z = −0.58, P = .28)	−0.10 (z = −0.61, P = .27)

Abbreviations: DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MCS, mental component summary; PCS, physical component summary; SF-12v2, Medical Outcomes Study 12-Item Short-Form Health Survey version 2; Short-WORC, short version of the Western Ontario Rotator Cuff Index; SPADI, Shoulder Pain and Disability Index; SST, simple shoulder test; WORC, Western Ontario Rotator Cuff Index.

**Values are Pearson r (95% confidence interval) unless otherwise indicated.*

†*Statistically significant difference (P≤.001).*

‡*Statistically significant difference (P<.05).*

§$r_{difference} = r_{Short\text{-}WORC} - r_{WORC}$.

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Effectiveness of Manual Therapy for Pain and Self-reported Function in Individuals With Patellofemoral Pain: Systematic Review and Meta-analysis

STUDY DESIGN: Systematic literature review with meta-analysis.

BACKGROUND: Management of patellofemoral pain (PFP) may include the utilization of manual therapy (MT) techniques to the patellofemoral joint, surrounding soft tissues, and/or lumbopelvic region.

OBJECTIVES: To determine the effectiveness of MT, used alone or as an adjunct intervention, compared to standard treatment or sham for reducing pain and improving self-reported function in individuals with PFP.

METHODS: An electronic literature search was conducted in the PubMed, Ovid, Cochrane Central Register of Controlled Trials, and CINAHL databases for studies investigating MT for individuals with PFP. Studies published through August 2017 that compared MT (local or remote to the knee), used alone or in combination with other interventions, to control or sham interventions were included. Patient-reported pain and functional outcomes were collected and synthesized. Trials were assessed via the Cochrane risk-of-bias tool, and a meta-analysis of the evidence was performed.

RESULTS: Nine studies were included in the review, 5 of which were rated as having a low risk of bias. The use of MT, applied to the local knee structure, was associated with favorable short-term changes in self-reported function and pain in individuals with PFP, when compared to a comparison (control or sham) intervention. However, the changes were clinically meaningful only for pain (defined as a 2-cm or 2-point improvement on a visual analog scale or numeric pain-rating scale). The evidence regarding lumbopelvic manipulation was inconclusive for pain improvement in individuals with PFP, based on 3 studies.

CONCLUSION: The data from this review cautiously suggest that MT may be helpful in the short term for decreasing pain in patients with PFP. Several studies integrated MT into a comprehensive treatment program. Changes in self-reported function with the inclusion of MT were shown to be significant, but not clinically meaningful. The limitations in the studies performed to date suggest that future research should determine the optimal techniques and dosage of MT and perform longer follow-up to monitor long-term effects.

LEVEL OF EVIDENCE: Therapy, level 1a.
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KEY WORDS: *anterior knee pain, chondromalacia, manipulation, mobilization, patella*

Patellofemoral pain (PFP) is one of the most commonly reported conditions involving the lower extremity.[20,21,55,62,68,69,78] The clinical presentation of PFP is often described as retropatellar and/or peripatellar knee pain, aggravated by prolonged sitting or loading activities such as stair climbing, squatting, running, jumping, or kneeling.[14,76] Incidence is higher in females.[20,21,71] Proposed etiological factors for PFP include abnormal patellar tracking,[27,31,61] poor hip control leading to altered lower extremity motion and mechanics,[44,54,61,65] and overtraining.[46]

Physical therapy management of PFP often addresses multiple impairments of the lower extremity believed to potentially contribute to the condition. A multimodal approach has been recommended, based on a recent systematic review combined with expert opinion.[5] Knee orthoses have been proposed to address faulty patellar alignment, but there is a lack of evidence to support their effectiveness.[63] Results are mixed for the effects of patellar-taping interventions.[3,9,10,48] A recent Cochrane review concluded that evidence for exercise is of low quality; however, exercise may result in a clinically important reduction in pain and improvement in function.[74] Strengthening exercises for the proximal musculature, with or without the inclusion of quadriceps rehabilitation, were found to be beneficial for pain and function in the short term and medium term.[2,43] Barton et al[5] recommended that treatment of PFP include patient education and activity modification, trunk/hip and distal strengthening, and movement-pattern and gait retraining. Athletes with PFP should monitor training loads, as poorly managed training can increase risk of injury and/or prevent recovery.[45,64]

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While a growing body of literature supports the inclusion of strengthening exercises to target the lateral/posterior hip musculature,[7,22-26,36,40,41,50] some studies have attempted to address PFP symptoms through the inclusion of manual therapy (MT).[6,13,14,16,17,28-30,34,37,47,49,58,66,73] Manual therapy may include techniques that address the patellofemoral joint, tibiofemoral joint, proximal tibiofibular joint, and proximal sites such as the lumbar spine and sacroiliac joint. Patellofemoral joint mobilizations and lateral knee soft tissue mobilization are theorized to decrease peripatellar soft tissue tightness associated with PFP.[18] Manual therapy of the lumbar spine and sacroiliac joint has been shown to decrease quadriceps muscle inhibition.[68,69] The improvements in function and pain following lumbopelvic manipulation in patients with PFP[49] have been theorized to be the result of regional interdependence, a model that suggests an influence of impairment in a remote region.[75] Other possible mechanisms include a neurophysiological response resulting in decreased peripheral and central sensitization.[52] A synthesis of the current evidence is needed to determine the role that MT can play in the rehabilitation of individuals with PFP.

The aim of this systematic review and meta-analysis was to evaluate and summarize the evidence for the effectiveness of MT interventions (used alone or in combination with other interventions), compared to other interventions, placebo, or sham, for pain and self-reported function in individuals with PFP.

METHODS

Search Strategy

To ensure that the current topic had not yet been reviewed in the past 3 years, an initial search of the Cochrane Database of Systematic Reviews, Centre for Reviews and Dissemination, and PubMed databases was conducted in July 2016. This was followed by focused PubMed, Ovid, Cochrane Central Register of Controlled Trials, and CINAHL searches using the search terms outlined in the **APPENDIX** (available at www.jospt.org) and a manual search of the reference lists in the retrieved articles. The search was repeated in August 2017, 2 months before this review was accepted for publication, with 1 additional manuscript identified that met the inclusion criteria and was subsequently included in the review.

Inclusion and Exclusion Criteria

The review aimed to include only full-text articles of randomized controlled trials (RCTs) written in English. In addition, study participants had to have a diagnosis of anterior knee pain or PFP and no other knee pathologies. Studies had to include some form of MT intervention directed to the patellofemoral joint, soft tissues of the lower extremity, or lumbar spine/sacroiliac joint, used alone or in conjunction with other physical therapy interventions, and the outcomes had to include pain and/or self-reported functional questionnaires. For inclusion, the study had to include 10 or more participants, and the dropout rate had to be less than 20%. The cutoff of 10 or more participants was used to decrease the likelihood that findings were relevant only for an idiosyncratic set of individuals. A dropout rate of less than 20% was used to eliminate studies in which the risk of bias due to attrition could be high. The dropout rate of 20% or lower for inclusion in systematic reviews has been established by the National Heart, Lung, and Blood Institute as a quality assessment measure.[51] No limit on publication date was imposed. Studies were excluded if participants had 2 or more comorbidities or were not diagnosed with patellofemoral knee pain.

Study Selection

Titles of identified citations were screened by the primary author to determine whether the title indicated that the study investigated a physical therapy or MT intervention for PFP. Abstracts of studies meeting these criteria were reviewed for appropriateness against the inclusion/exclusion criteria, with 25 full-text articles further assessed for final selection. **FIGURE 1** provides a flow chart of the search and article-selection process.

Data Extraction

Data from retained articles were extracted by 2 investigators (B.J.E. and D.M.K.) and entered into the Systematic Review Data Repository (SRDR) website (http://srdr.ahrq.gov). The online data-extraction template was developed a priori and was used to collect information on participant characteristics, study design, study duration, intervention, outcomes (including results of statistical analyses), and funding sources. Data entry was audited, and any discrepancies were resolved via consensus between the 2 authors (B.J.E. and D.M.K.).

Risk of Bias

Review of study bias was assessed at the individual study level with the Cochrane risk-of-bias[33] tool and recorded in the SRDR. This tool evaluates 7 risk-of-bias dimensions, using a 3-point scale that assigns a score of 0 for high risk, 1 for unclear risk, and 2 for low risk, for a maximum possible score of 14 points. Studies with a total of 11 or more points were given an overall rating of low bias, 7 to 10 points reflected moderate bias, and 6 or fewer points reflected high bias. Three reviewers (B.J.E., D.M.K., J.S.P.) independently assessed bias categories of each study, followed by a discussion of discrepancies to reach a consensus. Factors that were considered for additional bias included incomplete reporting and analysis, group similarity at baseline, different cointerventions across groups, inappropriate compliance, and timing of outcome assessment.

Data Analysis and Synthesis of Results

Compiled data were exported from SRDR into Open Meta-Analyst Version 0.1 (http://www.cebm.brown.edu/open-meta) for the meta-analysis. Continuous random-effects models of standardized mean differences (SMDs) were used for

the analysis of both primary and secondary outcomes. A limitation of the calculation of SMD is that it may not be optimally sensitive to imbalanced sample sizes.

As pain rating was reported with either a visual analog scale (VAS) or numeric pain-rating scale (NPRS), the data were analyzed using SMD. The NPRS has been shown to be a valid and reliable tool for assessing pain intensity.[38,39,56] The minimal clinically important difference (MCID) has been reported to be between 1.5 points[1] and 2 points[59] for chronic musculoskeletal conditions. The VAS has demonstrated good test-retest reliability, with an MCID of 1.4 cm.[70] Excellent correlation between the NPRS and VAS (r = 0.86) has been reported across varying age groups.[32] Where applicable, data for "pain with activity" were utilized in studies that reported multiple measures of pain (ie, worst pain, least pain, resting pain, or pain with activity).

In the studies included in the review, self-reported function was reported with either the Anterior Knee Pain Scale (AKPS) or the Patient-Specific Functional Scale (PSFS). The AKPS consists of 13 questions that assess the difficulty that patients have performing functional lower extremity tasks, with a total score ranging from 0 to 100 and a score of 100 indicating no disability.[42] This outcome has been shown to have high test-retest reliability and is moderately responsive to clinical change in patients with anterior knee pain.[77] The AKPS has a minimal detectable change (MDC) of 13 points.[77]

The PSFS has been shown to be a valid and reliable tool to assess change in patients with knee conditions.[11] Individuals are asked to identify up to 5 important activities that they have difficulty performing or are unable to perform[11] and to rate the level of difficulty on an 11-point scale, ranging from 0 ("unable to perform activity") to 10 ("able to perform activity at same level as before injury or problem"). The MDC for the PSFS in patients with knee dysfunction (PFP, osteoarthritis, postsurgical limitations, etc) has been reported to be 1.5 points.[11]

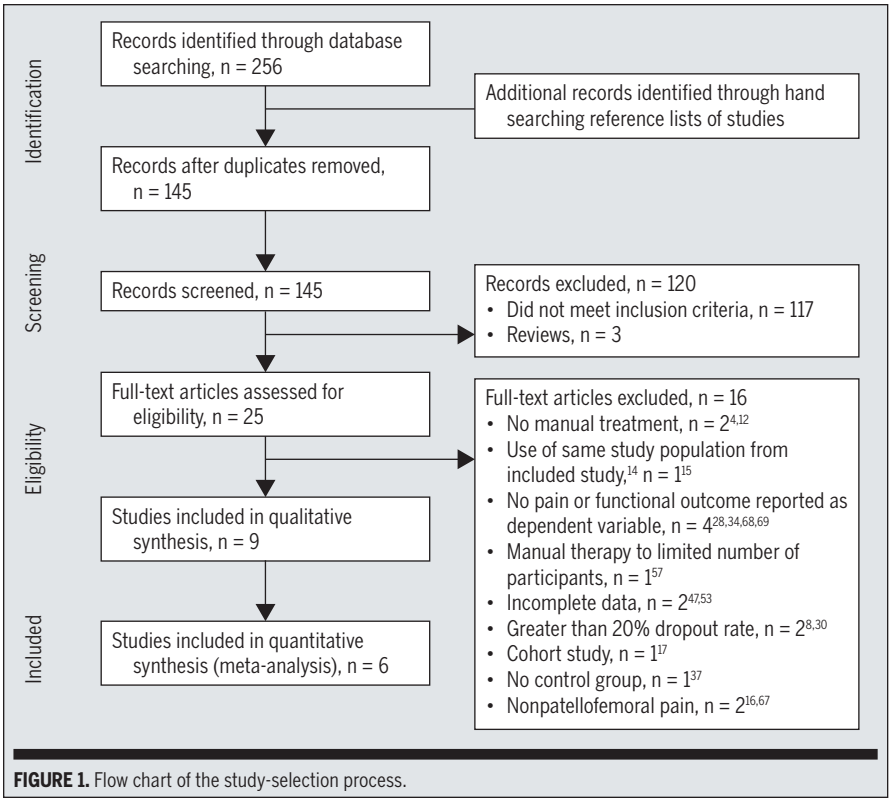

FIGURE 1. Flow chart of the study-selection process.

The AKPS and PSFS outcomes were analyzed using SMD, due to differences between scales. Forest plots included the standardized effect size calculated from the extracted data. Heterogeneity across the studies was quantified via I^2. Huedo-Medina et al[35] suggest that I^2 percentages of around 25%, 50%, and 75% indicate low, medium, and high heterogeneity, respectively.

Studies that reported a self-reported functional outcome score for MT directed to the patella, compared to a control or sham intervention, were included in the analysis. In addition, meta-analyses of self-reported pain were performed for studies that compared MT directed to the patella with a control (no intervention) or sham intervention, and for studies that compared a combined therapy of patellar MT and exercise with an alternative treatment. Qualitative analysis of all articles included risk-of-bias assessment.

RESULTS

Search Results

A total of 145 potentially relevant studies were identified. After excluding 120 articles based on a preliminary review of abstracts for inclusion and exclusion criteria, a total of 25 articles remained for full-text review. Sixteen studies were excluded after review of the full text, leaving 9 studies for the review and meta-analysis (**FIGURE 1**).[6,13,14,29,49,58,66,72,73] Of the included articles, 5 noted dropouts,[13,14,66,72,73] but, of these, only 3 reported an intention-to-treat analysis.[13,14,73]

TABLE 1 provides the study characteristics. The RCTs by van den Dolder and Roberts,[73] Collins et al,[13] Crossley et al,[14] and Rowlands and Brantingham[58] compared MT intervention at the patella for participants with PFP to a sham or control group. Four studies utilized a combination approach of MT directed to the patella and exercise intervention.[13,14,66,72] Three studies investigated the effectiveness of lumbar spine and sacroiliac joint mobilization/manipulation on patients

with PFP.[6,49,66] The outcome assessments of the included studies ranged from immediately to 3 months post intervention, with 1 study[13] providing follow-up data at 1 year.

TABLE 2 reports clinically meaningful change in pain and function. Two studies did not report data sufficient to determine clinically meaningful change.[49,58] Of the remaining 7 studies outlined in **TABLE 2**, 6 demonstrated a clinically meaningful improvement in pain scores where MT was included in the intervention.[6,13,14,29,66,72] Among studies that included MT as part of a comprehensive intervention com-

TABLE 1 Summary of the Included Studies*

Study	Study Design	Participants†	Intervention	Follow-up Period	Outcome Measure	Change‡
van den Dolder and Roberts[73]	RCT	MT: n = 21 (female, 81%; age, 55 ± 11 y); mean symptom duration, 26 wk; dropout rate, 0% Control: n = 17 (female, 62%; age, 52 ± 18 y); mean symptom duration, 39 wk; dropout rate, 1%	MT: transverse friction massage to the lateral retinaculum, PF joint tilt, sustained medial glide during repeated flexion and extension of the knee; 15-20 min of MT over 6 sessions in 2 wk Control: wait list	2 wk	Pain (100-mm VAS) Stair-climb test (number of steps climbed in 60 s)	Within groups • Pain: MT, −10 ± 16 (95% CI: −17.28, −2.72; 20%); control, −2 ± 10 (95% CI: −7.32, 3.33; 4%) • Stair-climb test: MT, 5 ± 3 (95% CI: 3.63, 6.37; 20%); control, −1 ± 5 (95% CI: −3.66, 1.66; −4%) Between groups • Pain: 8 (95% CI: −17, 1; *P* = .08) • Stair-climb test: 5 (95% CI: 2, 8; *P* = .001)
Hains and Hains[29]	RCT	MT (local): n = 27 (female, 74%; age, 25.3 y); symptom duration, 2-8 y; dropout rate, 0% MT (remote): n = 11 (female, 73%; age, 25 y); symptom duration, 2-8 y; dropout rate, 0%	MT (local): ischemic compression therapy to trigger points in the peripatellar region (sustained digital pressure to the areas of elicited pain for between 5 and 15 s) MT (remote): ischemic compression therapy to trigger points in the gluteal region (sustained digital pressure to the areas of elicited pain for between 5 and 15 s)	4 wk	Pain (10-cm VAS)	Within groups • Pain: MT local, −3.57 ± 0.49 (95% CI: −3.76, −3.38; 60%); MT remote, −1.90 ± 0.81 (95% CI: −2.44, −1.35; 28%) Between groups • Pain: −1.67 (95% CI: −2.18, −1.16)
Collins et al[13]	RCT	MT: n = 45 (female, 64.4%; age, 30.9 ± 5.8 y); symptom duration, >6 wk; dropout rate, 7% Sham foot orthotics: n = 44 (female, 45.5%; age, 29 ± 6.0 y); symptom duration, >6 wk; dropout rate, 7% Foot orthotics§: n = 46 (female, 54.3%; age, 27.9 ± 5.3 y); symptom duration, >6 wk; dropout rate, 2% Foot orthotics and MT§: n = 44 (female, 59.1%; age, 29.6 ± 5.6 y); symptom duration, >6 wk; dropout rate, 2%	MT: patellar mobilization and patellar taping, plus quadriceps and hip external rotation strengthening and hamstring and anterior hip stretches; 6 sessions over 6 wk of 20 to 60 min Sham foot orthotics: flat shoe inserts Foot orthotics: prefabricated foot orthotic use Foot orthotics and MT: combined approach; 6 sessions over 6 wk of 20 to 60 min	6 wk, 12 wk, 52 wk	Pain (100-mm VAS) AKPS (0-100)	Within groups for MT versus sham • Pain at 6 wk: MT, −29.2 ± 26.64 (95% CI: −37.61, −20.79; 48%); sham, −8.6 ± 26.40 (95% CI: −17.04, −0.16; 18%) • AKPS at 6 wk: MT, 11.7 ± 14.50 (95% CI: 7.12, 16.28; 16%); sham, 2.7 ± 13.01 (95% CI: −1.46, 6.86; 4%) • Pain at 12 wk: MT, −34.6 ± 27.13 (95% CI: −43.16, −26.04; 56%); sham, −21.6 ± 26.90 (95% CI: −30.44, −12.76; 38%) • AKPS at 12 wk: MT, 13.2 ± 15.02 (95% CI: 8.46, 17.94; 18%); sham, 8.8 ± 13.58 (95% CI: 4.33, 13.26; 12%) • Pain at 52 wk: MT, −39.2 ± 28.37 (95% CI: −48.04, −30.36; 64%); sham, −30.5 ± 28.16 (95% CI: −39.39, −21.61; 54%) • AKPS at 52 wk: MT, 16.2 ± 14.89 (95% CI: 11.56, 20.84; 23%); sham, 14.8 ± 13.43 (95% CI: 10.56, 19.04; 21%) Between groups • Pain at 6 wk: −20.6 (95% CI: −32.15, −9.05) • AKPS at 6 wk: 9.0 (95% CI: 3.00, 15.00) • Pain at 12 wk: −13.0 (95% CI: −24.92, −1.08) • AKPS at 12 wk: 4.4 (95% CI: −1.91, 10.70) • Pain at 52 wk: −8.7 (95% CI: −20.86, 3.46) • AKPS at 52 wk: 1.4 (95% CI: −4.70, 7.50)

Table continues on page 362.

pared to a sham or control intervention, only Crossley et al[14] found a clinically meaningful difference in self-reported pain in the MT group versus the control group. Clinical significance was found in 2 studies that examined the inclusion of local or remote MT as part of a comprehensive intervention for patients with PFP.[29,66] Four of the 7 studies found a clinically significant improvement in function, and groups that included MT with additional interventions achieved clinical meaningfulness.[6,14,66,72] Other key findings germane to variables in the studies included in the meta-analyses are summarized in **TABLE 3.**

Risk of Bias Within Studies

TABLE 4 outlines the ratings for each of the risk-of-bias categories. Five of the 9 studies were determined to have an overall low

TABLE 1 Summary of the Studies Included in the Qualitative and Quantitative Syntheses* (continued)

Study	Study Design	Participants†	Intervention	Follow-up Period	Outcome Measure	Change‡
Crossley et al[14]	RCT	MT: n = 36 (female, 64%; age, 29 ± 8 y); symptom duration, NR; dropout rate, 8% Control: n = 35 (female, 66%; age, 26 ± 8 y); symptom duration, NR; dropout rate, 3%	MT: manual stretching of knee soft tissue structures, patellar taping, VMO and gluteal strengthening; 30 to 60 min, once weekly for 6 wk Control: placebo taping, sham ultrasound, nontherapeutic gel; 30 to 60 min, once weekly for 6 wk	6 wk	Pain (10-cm VAS) AKPS (0-100)	Within groups • Pain: MT, −4.0 ± 2.5 (95% CI: −4.89, −3.11; 57%); control, −2.0 ± 2.9 (95% CI: −3.01, −0.99; 29%) • AKPS: MT, 18.0 ± 11.4 (95% CI: 13.96, 22.04; 26%); control, 9.0 ± 15.0 (95% CI: 3.77, 14.23; 13%) Between groups • Pain: 2.0 (95% CI: 1.0, 3.5; *P*<.05) • AKPS: −10 (95% CI: −14, −5; *P*<.05)
Taylor and Brantingham[72]	RCT	n = 12 (6 in each group; female, 33%; age, 30.17 y); symptom duration, minimum 1 mo; dropout rate, 20%	MT: multidirectional patellar mobilization and HVLA patellar adjustment; 2 times per week for 4 wk MT and exercise: multidirectional patellar mobilization and HVLA patellar adjustment, quadriceps strengthening (WB and NWB), plus hamstring and quadriceps stretching; 2 times per week for 4 wk	5 wk	Pain (NPRS-101) PSFS (0-10)	Within groups • Pain: MT, −35.0 ± 26.74 (95% CI: −63.06, −6.94; 52%; *P* = .043); MT and exercise, −49.17 ± 26.72 (95% CI: −77.21, −21.13; 79%; *P* = .028) • PSFS: MT, 2.5 ± 2.69 (95% CI: −0.32, 5.32; 31%); MT and exercise, 3.0 ± 1.34 (95% CI: 1.59, 4.4; 46%) Between groups • Pain: 14.47 (95% CI: −16.08, 44.42) • PSFS: −0.5 (95% CI: −2.90, 1.90)
Stakes et al[66]	RCT	Knee MT: n = 30 (female, NR; age, 29 y); symptom duration, NR; dropout rate, 13% Multijoint MT: n = 30 (female, NR; age, 32 y); symptom duration, NR; dropout rate, 13%	Knee MT: patellar mobilization and lower extremity strengthening and stretching; 6 visits over 4 wk Multijoint MT: patellar mobilization and lower extremity strengthening and stretching, plus spinal and sacroiliac manipulation; 6 visits over 4 wk	6 wk	Pain (NPRS-101) PSFS (0-10)	Within groups • Pain: MT at patella, −28.54 ± 35.49 (95% CI: −41.79, −15.29; 41%; *P*<.001); MT at patella and sacroiliac joint, −30.93 ± 29.57 (95% CI: −41.97, −19.89; 42%; *P*<.001) • PSFS: MT at patella, 2.28 ± 2.94 (95% CI: 1.18, 3.38; 55%; *P*<.001); MT at patella and sacroiliac joint, 2.77 ± 2.41 (95% CI: 1.87, 3.67; 63%; *P*<.001) Between groups • Pain: 2.39 (95% CI: −14.14, 18.92) • PSFS: −0.49 (95% CI: −1.85, 0.87)
Rowlands and Brantingham[58]	RCT	Knee MT: n = 15 (female, NR; age, NR); symptom duration, NR; dropout rate, 0% Control group: n = 15 (female, NR; age, NR); symptom duration, NR; dropout rate, 0%	Knee MT: 10 min of PF mobilization and HVLA thrust, 3 times, to the patella; 8 visits over 4 wk Control group: sham ultrasound for 5 min; 8 visits over 4 wk	4 wk	Pain (NPRS-101) PSFS (0-10)	Within groups • Pain: MT, −14.83 ± 15.96 (95% CI: −22.91, −6.75); control, −24.67 ± 21.89 (95% CI: −35.75, −13.59) • PSFS: MT, 8.65 ± 1.56 (95% CI: 7.78, 9.51); control, 6.7 ± 2.92 (95% CI: 5.08, 8.31) • No raw mean pre/post data available to calculate percent of mean change Between groups • Pain: −9.84 (95% CI: −23.54, 3.87; *P* = .211) • PSFS: 1.95 (95% CI: 0.27, 3.63; *P* = .06)

Table continues on page 363.

TABLE 1 Summary of the Studies Included in the Qualitative and Quantitative Syntheses* (continued)

Study	Study Design	Participants†	Intervention	Follow-up Period	Outcome Measure	Change‡
Motealleh et al[49]	RCT	Lumbopelvic manipulation: n = 14 (female, 57%; age, 26.9 ± 5.5 y); symptom duration, <6 mo; dropout rate, 0% Sham manipulation: n = 14 (female, 57%; age, 26.1 ± 3.9 y); symptom duration, <6 mo; dropout rate, 0%	Lumbopelvic manipulation: HVLA thrust manipulation technique to lumbopelvic area; 1 session Sham manipulation: nonthrust mobilization technique to lumbopelvic area; 1 session	Immediately post MT	Pain (11-point NPRS) Step-down test (repetitions in 30 s) 1-legged hop test (maximum distance, in centimeters, of 3 trials)	Within groups • Pain: MT, −2.2 ± 2.05 (95% CI: −3.38, −1.02; 40%); sham, 0.6 ± 1.98 (95% CI: −0.54, 1.74; −13%) • Step-down test: MT, 2.9 ± 4.68 (95% CI: 0.20, 5.60; 21%); sham, 0.3 ± 4.04 (95% CI: −2.03, 2.63; 2%) • 1-legged hop test: MT, 4.0 ± 62.23 (95% CI: −31.93, 39.93; 3%); sham, −2.4 ± 63.00 (95% CI: −38.78, 33.98; −2%) Between groups • Pain: −2.6 ± 1.8 (95% CI: −3.5, −1.8; *P*<.001) • Step-down test: 2.4 ± 3.5 (95% CI: 0.8, 3.9; *P* = .004) • 1-legged hop test: 6.80 ± 16.8 (95% CI: −2.0, 15.6; *P* = .125)
Behrangrad and Kamali[6]	RCT	Lumbopelvic manipulation: n = 15 (female, 80%; age, 24.3 ± 1.9 y); symptom duration, at least 6 wk; dropout rate, 0% Knee MT: n = 15 (female, 80%; age, 24.3 ± 1.9 y); symptom duration, at least 6 wk; dropout rate, 0%	Lumbopelvic manipulation: HVLA thrust manipulation technique to lumbopelvic area; 3 visits over 1 wk Knee MT: ischemic compression to trigger points in the VMO (3 repetitions for 90 s each); 3 visits over 1 wk	1 wk, 1 mo, 3 mo	Pain (100-mm VAS) AKPS (0-100)	Within groups • Pain at 1 wk: manipulation, −40.0 ± 8.6 (95% CI: −44.4, −35.6; 61%); knee MT, −53.1 ± 10.1 (95% CI: −58.2, −48.0; 82%) • AKPS at 1 wk: manipulation, 15.6 ± 5.3 (95% CI: 12.8, 18.3; 25%); knee MT, 28.3 ± 4.2 (95% CI: 26.2, 30.4; 45%) • Pain at 1 mo: manipulation, −39.0 ± 13.6 (95% CI: −45.9, −32.1; 59%); knee MT, −53.5 ± 10.5 (95% CI: −58.8, −48.2; 83%) • AKPS at 1 mo: manipulation, 14.8 ± 5.7 (95% CI: 11.9, 17.7; 23%); knee MT, 29.4 ± 4.2 (95% CI: 27.3, 31.5; 47%) • Pain at 3 mo: manipulation, −35.0 ± 8.7 (95% CI: −39.4, −30.6; 53%); knee MT, −51.5 ± 5.2 (95% CI: −54.1, −48.9; 79%) • AKPS at 3 mo: manipulation, 12.9 ± 5.7 (95% CI: 9.8, 15.7; 20%); knee MT, 29.8 ± 4.6 (95% CI: 27.5, 32.1; 48%) Between groups • Pain at 1 wk: 13.10 (95% CI: 6.38, 19.82; *P*<.001) • AKPS at 1 wk: −12.70 (95% CI: −16.14, −9.26; *P*<.001) • Pain at 1 mo: 14.50 (95% CI: 5.79, 23.21; *P*<.001) • AKPS at 1 mo: −14.60 (95% CI: −18.20, −11.00; *P*<.001) • Pain at 3 mo: 16.50 (95% CI: 11.37, 21.63; *P*<.001) • AKPS at 3 mo: −17.00 (95% CI: −20.73, −13.27; *P*<.001)

Abbreviations: AKPS, Anterior Knee Pain Scale; CI, confidence interval; HVLA, high velocity, low amplitude; MT, manual therapy; NPRS, numeric pain-rating scale; NR, not reported; NWB, non–weight bearing; PF, patellofemoral; PSFS, Patient-Specific Functional Scale; RCT, randomized controlled trial; VAS, visual analog scale; VMO, vastus medialis oblique; WB, weight bearing.

**When not provided in the published articles, values were calculated through Open Meta-Analyst (http://www.cebm.brown.edu/openmeta/).*

†Values for age are mean or mean ± SD.

‡Values are mean ± SD unless otherwise indicated. Percentage values in parentheses are mean change, representing change from baseline score to follow-up for within-group data. A negative value indicates a decrease in mean difference score.

§Data not included in current meta-analysis.

TABLE 2 Clinical Meaningfulness of Changes in Pain and Function*

Study	Group	Within-Group Change in Pain (Time) Post Treatment	Clinically Meaningful?†	Within-Group Change in Function (Time) Post Treatment	Clinically Meaningful?‡
van den Dolder and Roberts[73]	Manual therapy	100-mm VAS: −10 ± 16 (2 wk)	No	Stair-climb test: 5 ± 3 (2 wk)	5.5 reported for patients with knee OA
	Control	100-mm VAS: −2 ± 10 (2 wk)	No	Stair-climb test: −1 ± 5 (2 wk)	Unknown
Hains and Hains[29]	Manual therapy (local to knee)	10-cm VAS: −3.57 ± 0.49 (4 wk)	Yes	NR	NR
	Manual therapy (remote to hip)	10-cm VAS: −1.90 ± 0.81 (4 wk)	Yes	NR	NR
Collins et al[13]	Manual therapy	100-mm VAS: −29.2 ± 26.64 (6 wk)	Yes	AKPS (0-100): 11.7 ± 14.50 (6 wk)	No
	Sham orthotics	100-mm VAS: −8.6 ± 26.40 (6 wk)	No	AKPS (0-100): 2.7 ± 13.01 (6 wk)	No
	Foot orthotics	100-mm VAS: −19.6 ± 26.55 (6 wk)	Yes	AKPS (0-100): 8.9 ± 12.79 (6 wk)	No
	Foot orthotics and manual therapy	100-mm VAS: −36.3 ± 27.72 (6 wk)	Yes	AKPS (0-100): 12.1 ± 13.37 (6 wk)	No
Crossley et al[14]	Manual therapy	10-cm VAS: −4.0 ± 2.5 (6 wk)	Yes	AKPS (0-100): 18.0 ± 11.4 (6 wk)	Yes
	Control	10-cm VAS: −2.0 ± 2.9 (6 wk)	Yes	AKPS (0-100): 9.0 ± 15.0 (6 wk)	No
Taylor and Brantingham[72]	Manual therapy	NPRS-101 (0-100): −35.0 ± 26.74 (5 wk)	Yes	PSFS (0-10): 2.5 ± 2.69 (5 wk)	Yes
	Manual therapy and exercise	NPRS-101 (0-100): −49.17 ± 26.72 (5 wk)	Yes	PSFS (0-10): 3.0 ± 1.34 (5 wk)	Yes
Stakes et al[66]	Knee manual therapy	NPRS-101 (0-100): −28.54 ± 35.49 (6 wk)	Yes	PSFS (0-10): 2.28 ± 2.94 (6 wk)	Yes
	Multijoint manual therapy (including lumbopelvic manipulation)	NPRS-101 (0-100): −30.93 ± 29.57 (6 wk)	Yes	PSFS (0-10): 2.77 ± 2.41 (6 wk)	Yes
Rowlands and Brantingham[58]	Manual therapy	NPRS-101 (0-100): −14.83 ± 15.96 (4 wk)	No	PSFS (0-10): 8.65 ± 1.56 (4 wk)	Yes
	Control	NPRS-101 (0-100): −24.67 ± 21.89 (4 wk)	Yes	PSFS (0-10): 6.7 ± 2.92 (4 wk)	Yes
Motealleh et al[49]	Lumbopelvic manipulation	NPRS-101 (0-100): −2.2 ± 2.05 (immediately post manual therapy)	Yes	Step-down test: 2.9 ± 4.68 (immediately post manual therapy)	NA
	Sham manipulation	NPRS-101 (0-100): 0.6 ± 1.98 (immediately post manual therapy)	No	Step-down test: 0.3 ± 4.04 (immediately post manual therapy)	NA
Behrangrad and Kamali[6]	Lumbopelvic manipulation	100-mm VAS: −39.0 ± 13.6 (4 wk)	Yes	AKPS (0-100): 14.8 ± 5.7 (4 wk)	Yes
	Knee manual therapy	100-mm VAS: −53.5 ± 10.5 (4 wk)	Yes	AKPS (0-100): 29.4 ± 4.2 (4 wk)	Yes

Abbreviations: AKPS, Anterior Knee Pain Scale; MCID, minimal clinically important difference; MDC, minimal detectable change; NA, not assessed; NPRS, numeric pain-rating scale; NR, not reported; OA, osteoarthritis; PSFS, Patient-Specific Functional Scale; VAS, visual analog scale.
**Values are mean ± SD unless otherwise indicated.*
†Clinically meaningful difference values: NPRS MCID, 2 points[59]; VAS MCID, 1.4 cm.[70]
‡Clinically meaningful difference values: AKPS MDC, 13 points[77]; PSFS MDC, 1.5 points.[11]

bias.[6,13,14,29,72] The most common source of bias across studies was nonblinding of personnel/care providers (8 of the 9 studies). All studies included in the meta-analysis had low bias for selective reporting, and 8 of 9 had low selection bias.

Risk of Bias Across Studies

The MT intervention techniques and dosage of the interventions were not consistent across studies. Long-term follow-up was lacking in all studies, except for the study by Collins et al,[13] which included data from a 1-year follow-up. True blinding of both the participants and assessors was not feasible due to the nature of the interventions (**TABLE 4**). **FIGURE 2** illustrates the risk of bias across all studies included in this synthesis, expressed as a percentage.

Meta-analysis

Three studies that compared the inclusion of MT directed at the patella with a control or sham group provided self-reported functional outcomes (**FIGURE 3**).[13,14,58] Two studies utilized the AKPS,[13,14] and 1 study the PSFS.[58] The SMD for the pooled effect size for these studies was 0.68 (95% confidence interval [CI]: 0.38, 0.98; $P<.001$), which is indicative of a favorable improvement at 4 to 6 weeks' follow-up. Collins et al,[13] the only study with a long-term follow-up, found no significant difference in improvement between groups at 1 year. The heterogeneity (I^2) of the studies in **FIGURE 3** was 0% ($P = .929$), indicating that variations in study designs or samples had little impact on the outcomes. The MCID of the AKPS was surpassed at 6 weeks in the study by Crossley et al,[14] but not in the

TABLE 3 Summary of Additional Key Findings From Outcomes Not Included in the Meta-analysis

Study	Group	Outcome	Key Findings
van den Dolder and Roberts[73]	Manual therapy	Patellofemoral Pain Severity Questionnaire	No difference in Patellofemoral Pain Severity Questionnaire average and stairs scores between groups
		Active knee ROM	Increased knee flexion ROM by 10° (95% CI: 4°, 16°; $P = .004$) in manual therapy group
	Control	Step test (number in 60 s)	Increased number of steps in 60 s by 5 (95% CI: 2, 8; $P = .001$) in manual therapy group
Hains and Hains[29]	Manual therapy (local to knee) Manual therapy (remote to hip)	Patella-grind test	The knee manual therapy group had a significant decrease in patella-grind test score from pre to post treatment. There was no significant change for the hip manual therapy group. No between-group comparison was reported
Collins et al[13]	Manual therapy Sham orthotics Foot orthotics	Functional Index Questionnaire Global improvement	At 6 and 12 wk, no significant differences were found in global improvement or Functional Index Questionnaire scores between groups A significant effect favored foot orthotics over sham orthotics at 6 and 12 wk for the outcomes noted
Crossley et al[14]	Manual therapy	Functional Index Questionnaire	There was no significant difference in Functional Index Questionnaire score between treatment groups
	Control	Functional measurement of number of step-ups, step-downs, and squats that participants could perform before pain onset or increase	The manual therapy group was able to perform significantly more step-ups ($P = .01$), step-downs ($P = .03$), and squats ($P = .04$) before pain onset or increase
Taylor and Brantingham[72]	Manual therapy	Short-form McGill Pain Questionnaire	Significant improvements in short-form McGill Pain Questionnaire scores in both groups from baseline to post treatment were found
	Manual therapy and exercise	Pressure pain threshold	Significant improvements in threshold in both groups from baseline to post treatment were found
		Pressure pain tolerance	Significant improvements in tolerance in both groups from baseline to post treatment were found
Stakes et al[66]	Knee manual therapy	Short-form McGill Pain Questionnaire	Significant improvements in short-form McGill Pain Questionnaire scores in both groups from baseline to post treatment were found
		Patellofemoral Joint Evaluation Scale	Significant improvements in Patellofemoral Joint Evaluation Scale scores in both groups from baseline to post treatment were found
	Multijoint manual therapy	Pressure pain threshold	Significant improvements in threshold in both groups from baseline to post treatment were found
		Pressure pain tolerance	Significant improvements in tolerance in both groups from baseline to post treatment were found
Rowlands and Brantingham[58]	Manual therapy	Short-form McGill Pain Questionnaire	No significant difference in short-form McGill Pain Questionnaire scores between groups was found
	Control	Pressure pain threshold	There was a significant improvement in threshold for the manual therapy group from baseline to post treatment
		Pressure pain tolerance	There was a significant improvement in tolerance for the manual therapy group from baseline to post treatment
Motealleh et al[49]	Lumbopelvic manipulation	EMG of VMO, VL, and GM	Onset of EMG activity of the VMO and GM was earlier and higher in the manipulation group compared to the sham group. No significant difference between groups was found for EMG onset of the VL
	Sham manipulation	1-leg hop test for distance	A significant improvement in hop test distance following lumbopelvic manipulation was found
		Step-down test (number of repetitions in 30 s)	No significant change in step-down test performance between groups was found
Behrangrad and Kamali[6]	Lumbopelvic manipulation Knee manual therapy	Pressure pain threshold	Significant improvements in threshold for both groups from baseline to 1 wk, 1 mo, and 3 mo post treatment were found. Improvement in pressure pain threshold was greater in the knee manual therapy group than in the lumbopelvic manipulation group

Abbreviations: CI, confidence interval; EMG, electromyography; GM, gluteus medius; ROM, range of motion; VL, vastus lateralis; VMO, vastus medialis oblique.

TABLE 4 Cochrane Risk-of-Bias Quality Assessment of the Included Trials*

Study	Item† 1	2	3	4	5	6	7	Overall Risk of Bias
Collins et al[13]	2	2	0	2	2	2	1	Low
Crossley et al[14]	2	2	0	2	2	2	1	Low
Hains and Hains[29]	2	2	1	1	2	2	2	Low
Stakes et al[66]	2	2	0	0	0	2	0	High
Rowlands and Brantingham[58]	1	0	0	0	0	2	0	High
Taylor and Brantingham[72]	2	2	2	2	2	2	1	Low
van den Dolder and Roberts[73]	2	2	0	0	2	2	1	Moderate
Motealleh et al[49]	2	1	0	0	2	2	0	Moderate
Behrangrad and Kamali[6]	2	2	1	0	2	2	2	Low

**Adapted from the Cochrane risk-of-bias[33] quality assessment tool. A score of 0 indicates high bias, a score of 1 unclear bias, and a score of 2 low bias.*
†Items: 1, Random sequence generation (selection bias); 2, Allocation concealment (selection bias); 3, Blinding of participants and personnel (performance bias); 4, Blinding of outcome assessment (detection bias); 5, Incomplete outcome data (attrition bias); 6, Selective reporting (reporting bias); 7, Additional bias.

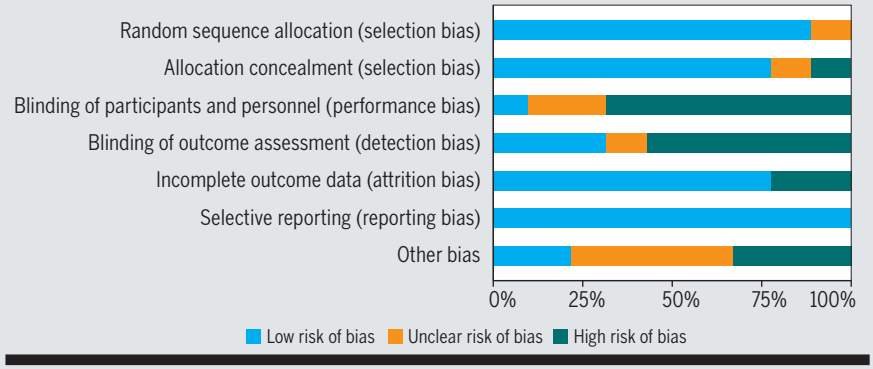

FIGURE 2. Risk-of-bias graph: review authors' assessment of each risk-of-bias item, presented as percentages, across all included studies.

study by Collins et al.[13] Interpretation of the MCID was not possible for the study by Rowlands and Brantingham,[58] due to incomplete reporting of data.

Five studies investigated the change in pain, reported via VAS or NPRS, in participants who received MT directed at the patella compared to a sham intervention or control at 2 to 6 weeks.[13,14,29,58,73] A summary of the pooled effect of the SMD for change in pain is presented in **FIGURE 4**.[13,14,29,58,73] A continuous random-effects model was used to determine the SMD for the measure of association. The SMD for the pooled effect size was −0.61 (95% CI: −0.87, −0.36; $P<.001$) and was significant in support of MT intervention to the patella. The heterogeneity of the studies in **FIGURE 4** was 0% ($P = .766$). Three of the 5 studies reported a change in pain in the MT group that surpassed the MCID for the NPRS or VAS.[13,14,29]

Two of the studies included in the meta-analysis compared a combination of exercise and MT techniques directed at the patella to alternative interventions, reporting pain as an outcome measure (**FIGURE 5**).[66,72] The SMD for the pooled effect size was −0.03 (95% CI: −0.52, 0.46; $P = .902$), and the heterogeneity was 0% ($P = .387$). Stakes et al[66] compared the bundled approach of exercise and MT at the patella to exercise, MT at the patella, and lumbopelvic manipulation, whereas Taylor and Brantingham[72] compared the bundled approach to just MT at the patella. In both studies, changes in pain for both groups surpassed the MCID for the NPRS or VAS.[66,72]

Three studies looked at the effects of lumbopelvic manipulation on PFP.[6,49,66] Stakes et al[66] included sacroiliac manipulation in addition to a comprehensive program, while Motealleh et al[49] compared lumbopelvic manipulation with a sham technique to the lumbopelvic joint. Behrangrad and Kamali[6] compared lumbopelvic manipulation (alone) to an alternative treatment (ischemic compression at the vastus medialis oblique). Due to the differences in study design and experimental groups, a meta-analysis was not performed. Stakes et al[66] reported changes in pain for both groups that met or surpassed the MCID for the NPRS, with no significant between-group differences. Motealleh et al[49] reported a significant improvement in pain, which exceeded the MCID, for the group receiving the true lumbopelvic manipulation, but no differences between groups were noted for a functional step-down test. Behrangrad and Kamali[6] found a significant change in pain and functional score at 1 week, 1 month, and 3 months post intervention in favor of the ischemic compression group.

DISCUSSION

From the results of this systematic review, there is moderate evidence of short-term (6 weeks or less) pain relief following MT directed to the patellar region in individuals with PFP, when compared to a sham or control intervention. In addition, there may be a short-term, added benefit of pain reduction when MT is included in a more comprehensive treatment approach for patients with PFP. While the meta-analysis indicates that inclusion of MT provided benefits in self-reported function,

these benefits were not clinically meaningful. While changes in pain scores following MT directed to the patellar region met or exceeded the MDC and MCID in most studies, this was not the case for self-reported function. Manual therapy directed to the patellar region for individuals with PFP may be better than no intervention, but may not be better than alternative therapies. In studies that compared MT combined with exercise to an alternative treatment, the overall pooled effect showed no significant difference; however, the alternative treatments differed across the 2 studies.[66,72] When MT with exercise was compared to MT at the patella alone[72] or to a sham intervention,[14] there was a significant or clinically meaningful reduction in pain between groups. There was no additional benefit to the addition of MT directed at the lumbopelvic complex for individuals with PFP, based on 3 studies.

The etiology of PFP is generally not well agreed upon, other than it appears to be multifactorial. Consequently, the interventions utilized to address this condition are often variable, with MT interventions described in a number of studies.[6,13,14,29,49,58,66,72,73] While MT was often not the exclusive treatment approach, the limited number of studies showing the benefit of MT directed to the patellar region and other studies showing benefits of other treatment approaches may lend support to the multifactorial etiology of PFP. There may be a specific subgroup of individuals with PFP who show greater benefit in the short term from the inclusion of MT directed to the patellar region, but this has not been defined to date.

Three studies that included spinal manual interventions in this review met criteria for our narrative review.[6,49,66] The treatment provided to the comparison group varied across all studies. Outcomes of these studies were mixed. Motealleh et al[49] found improved pain and function in individuals with PFP who received lumbopelvic manipulation compared with a sham manipulation; however, Stakes et al[66] reported no difference between MT at the knee compared to MT at the knee with lumbopelvic manipulation. When ischemic compression at the vastus medialis oblique was compared to lumbopelvic manipulation, pain and functional outcomes demonstrated greater improvement in the ischemic compression group.[6]

Short-term improvement in quadriceps strength[34] and decreased quadriceps inhibition[68,69] have been described following lumbopelvic manipulation in this population. It has been theorized that neurophysiologic changes or regional interdependence may be responsible for observed changes seen following manipulation.[37] Iverson et al[37] developed a clinical prediction rule for the utilization of lumbar spine and sacroiliac joint manipulative therapy in patients with PFP, which has not yet been validated. Grindstaff and colleagues[28] assessed the quadriceps strength of patients with PFP

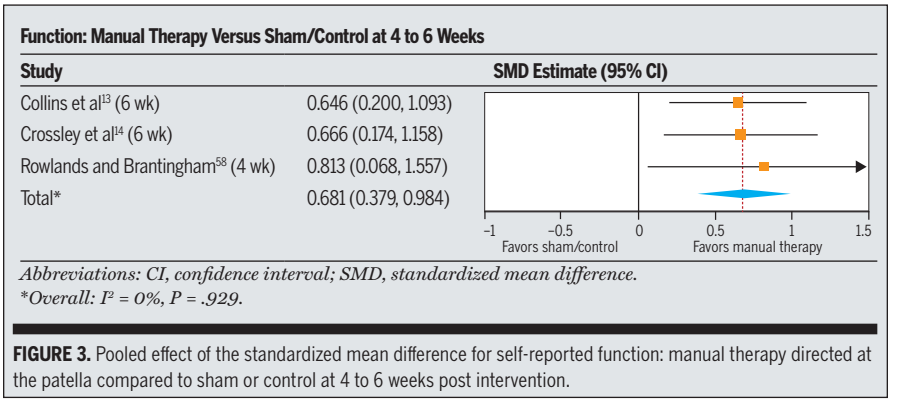

FIGURE 3. Pooled effect of the standardized mean difference for self-reported function: manual therapy directed at the patella compared to sham or control at 4 to 6 weeks post intervention.

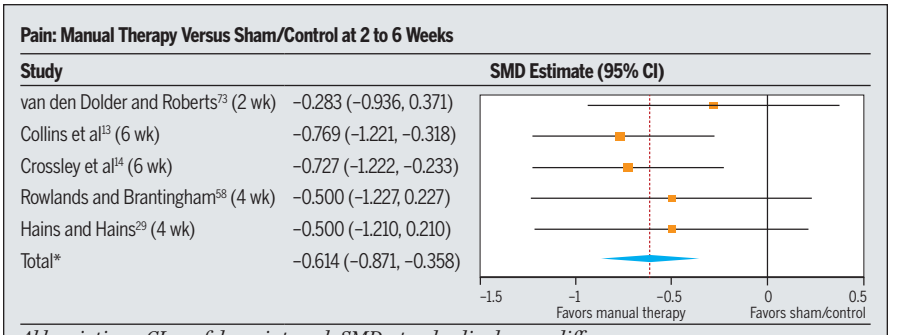

FIGURE 4. Pooled effect of the standardized mean difference for change in pain: manual therapy directed at the patella compared to sham or control at 2 to 6 weeks post intervention.

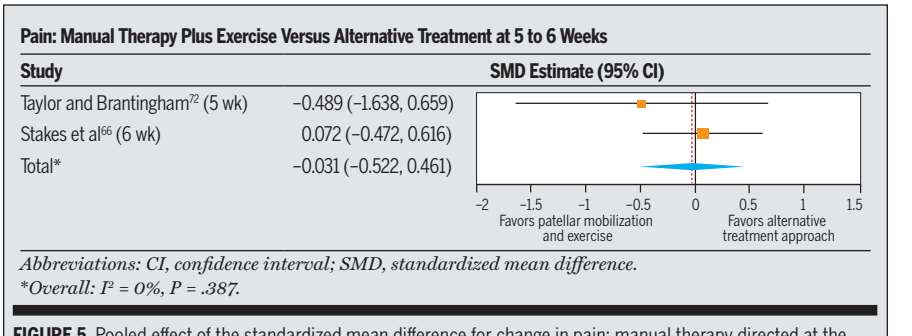

FIGURE 5. Pooled effect of the standardized mean difference for change in pain: manual therapy directed at the patella combined with exercise compared to an alternative treatment approach at 5 to 6 weeks post intervention.

following a lumbopelvic joint manipulation, but found no significant benefit of treatment. Crowell and Wofford[17] performed a nonrandomized study that assessed hip range of motion, hip strength, hop test performance, pain, and global rating of change before and immediately after the application of lumbopelvic manipulation in patients with PFP. They found no clinically meaningful change in hip strength and functional testing variables, with a mean reduction in hip abduction and hip extension strength following the MT intervention at the lumbopelvic joint.[17] While these studies did not meet the inclusion criteria of this review, future investigations may determine whether any added benefit from remote MT interventions would best serve this patient population.

It has been recommended that patellofemoral joint mobilization only be considered in the presence of joint mobility restriction.[5] Application of MT local to this joint has been thought to improve the flexibility of the passive peripatellar structures, which may be contributing to weakness of quadriceps musculature.[14,58] Patellofemoral mobilization and soft tissue techniques to the knee may reduce muscle and fascial tightness of the lateral structures believed to lead to lateral patellar tracking, which seemingly contributes to knee pain.[18] A possible neuroanatomical basis for PFP has been theorized due to a greater distribution of nerve fibers and neural growth factor in the lateral patellofemoral region of patients with PFP.[60] It is possible that MT directed to the patellar region could have neurophysiological benefits.

Optimal management of PFP remains unclear, with patients often developing recurrent or chronic pain complaints.[19] Clinicians may consider MT within the context of a multimodal approach in the management of PFP. A multimodal approach may consist of proximal hip and quadriceps strengthening, movement-pattern retraining, training load management, patient education, distal and core strengthening, MT, stretching based on assessment findings, taping and/or bracing, and foot orthoses.[5] Exercise specifically targeting the proximal hip musculature and quadriceps should be included in the treatment of patients with PFP, based on the conclusions of several systematic reviews.[5,43,74] Only 4 of the 9 studies in the meta-analysis incorporated quadriceps and hip strengthening into their protocols.[13,14,66,72] The addition of MT may be of additional benefit to a comprehensive rehabilitation program for short-term pain reduction.

Limitations

Among the 9 studies identified in this review, there was great variety of interventions, comparison groups, outcome measures, and follow-up time frames. Several limitations were found in the process of this systematic review, primarily with regard to the small number of studies and studies with small samples. The included studies reported a variety of assessment times, many with a short-term follow-up period, making the long-term implications of the study intervention unclear. The study by Taylor and Brantingham[72] was a pilot RCT that did not allow for complete statistical evaluation of the effect or effectiveness of the intervention, but was included because it met the inclusion criteria for this review. Findings should be interpreted with caution, as this study may show a more extreme treatment effect compared to the larger studies.

A variety of outcome measurements, ranging from self-report functional measures to functional testing, were used, with little consistency among studies. Although 1 study[72] had a very small sample size compared to the other studies, it met inclusion criteria for the current review. Data from the Patellofemoral Pain Severity Scale, Functional Index Questionnaire, global improvement, and short-form McGill Pain Questionnaire were not reported in the review due to the limited number of studies that included these measures.

A common issue of bias among all studies was the lack of true blinding of the participants and assessors; however, in some cases, the lack of true blinding did not likely contribute to bias, as participants were likely not aware of which intervention was hypothesized to be more effective. In addition, the high risk of bias in the studies by Stakes et al[66] and Rowlands and Brantingham[58] suggests that interpretation of the pooled effects should be made with caution. Additionally, had we chosen to utilize a different risk-of-bias tool, we might have arrived at conflicting results due to inherent differences in the convergent validity among tools.

The MT techniques described in the studies in this review were quite varied in terms of the type of intervention and length of time for the application of the intervention. Also, some of the studies included supplementary interventions in addition to the MT techniques, which makes the exact mechanism for the results uncertain. In a clinical setting, management of PFP would rarely consist solely of MT interventions. The inclusion of selected strengthening exercises of the quadriceps, hip, and trunk musculature could have potentially accounted for some of the improvement in pain rating.[13,14,66,72]

Implications for Future Studies

Further research and improved consistency on the use of the most appropriate outcome measures for individuals with PFP are warranted. The inclusion of multiple follow-up times to assess the long-term effectiveness of management of PFP is necessary. Further research may consider identifying the characteristics of a potential subgroup of individuals who would most benefit from MT techniques. Additional research is needed on the ideal management of PFP, including whether MT techniques are warranted.

CONCLUSION

There is moderate evidence to support the utilization of MT interventions directed to the local knee structures as part of a comprehensive,

multimodal rehabilitation program to provide short-term, clinically meaningful benefits in pain in patients with PFP. Although the present meta-analysis showed that self-reported function may also improve with the inclusion of MT, whether such changes in self-reported function are clinically meaningful is unclear. No recommendations can be made at this time on the most effective type of MT in terms of dosage or techniques. ◉

KEY POINTS

FINDINGS: Manual therapy interventions directed to the local knee structures may help to decrease pain in patients with patellofemoral pain. The effect on functional outcomes is less clear and not likely to be clinically significant.

IMPLICATIONS: Manual therapy techniques may be a beneficial part of a comprehensive multimodal approach for patients with patellofemoral pain.

CAUTION: Study bias, methodological limitations, and the lack of outcome data beyond 6 weeks should be considered in the interpretation of the results. Optimal dosage and specific techniques are not well defined, with high variability across studies.

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APPENDIX

OVERALL SEARCH STRATEGY

Types: randomized controlled trial
Language: English
Dates: dates of inception to August 2017

Search Strategy for PubMed
((pain AND English[lang])) OR (treatment outcome AND English[lang])
AND
(((“Manipulation, Chiropractic”[Mesh]) OR “Manipulation, Osteopathic”[Mesh]) OR manipulation) OR “Musculoskeletal Manipulations”[Mesh] OR ((mobilization AND English[lang]) OR (mobilisation AND English[lang]) OR (joint mobilization AND English[lang]) OR (joint mobilsation English[lang])))
AND
(((((manual technique AND English[lang])) OR (manual therapy AND English[lang])) OR (manipulation AND English[lang]))) AND (((pain AND English[lang])) OR (treatment outcome AND English[lang]))
AND
((((anterior knee pain) OR patellofemoral pain) AND English[lang])) AND ((((((manual technique AND English[lang])) OR (manual therapy AND English[lang])) OR (manipulation AND English[lang]))) AND (((pain AND English[lang])) OR (treatment outcome AND English[lang])))

Search Strategy for Ovid
exp Pain/ or exp Patellofemoral Pain Syndrome/ or exp Patellofemoral Pain/ exp Musculoskeletal Pain/ or mobilization AND English[lang]) OR (mobilisation AND English[lang]) OR (joint mobilization AND English[lang]) OR (joint mobilsation English[lang]))
AND
exp Manipulation, Orthopedic/ or exp Manipulation, Chiropractic/ or exp Manipulation, Spinal/ or exp Manipulation, Osteopathic/
AND
1 and 2
AND
exp Patellofemoral Pain Syndrome/ or exp Patellofemoral Joint/
3 and 4

Search Strategy for Cochrane Central Register of Controlled Trials
Outcome terms (combine terms with OR)
Pain OR Treatment outcome
AND
Intervention / Exposure / Diagnostic Test (combine with OR)
Musculoskeletal Manipulations OR
OR Manipulation, Chiropractic, OR Manipulation, Osteopathic OR Manipulation, Orthopaedic
AND
Comparator terms (combine terms with OR if more than one). Note, may not be needed if placebo is the comparison or no comparison specified.
Patellofemoral pain (#1 or #2)
AND
Intervention Terms (#4 or #5 or #6 or #7)
AND
Population terms (limits may be used in actual syntax)
Patellofemoral pain
Additional Limits (based on Inclusion/Exclusion Criteria)

Search Strategy for CINAHL
(MM “Pain+”) OR (MM “Knee Pain+”) OR (MM “Patellofemoral Pain Syndrome”) OR (MH “Myofascial Pain Syndromes+”)
AND
(MM “Manipulation, Orthopedic”) OR (MM “ Manipulation, Chiropractic”) OR (MM “Manipulation, Osteopathic”) OR (MM “Manual Therapy+”) OR (mobilization) OR (mobilisation) OR (joint mobilization) or (joint mobilsation)
AND
1 AND 2
Intervention Terms (#4 or #5 or #6 or #7)
AND
((MH “Patellofemoral Pain Syndrome”) OR (MH “Knee Pain”) OR (MH “Myofascial Pain Syndromes”))
Abbreviations: exp, exploded; lang, language; Mesh, medical subject heading; MH, major and minor heading search; MM, major heading search.

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Quality of Life in Symptomatic Individuals After Anterior Cruciate Ligament Reconstruction, With and Without Radiographic Knee Osteoarthritis

STUDY DESIGN: Clinical measurement, cross-sectional.

BACKGROUND: Individuals who have undergone anterior cruciate ligament (ACL) reconstruction commonly experience long-term impairments in quality of life (QoL), which may be related to persistent knee symptoms or radiographic osteoarthritis (ROA). Understanding the impact of knee symptoms and ROA on QoL after ACL reconstruction may assist in the development of appropriate management strategies.

OBJECTIVES: To (1) compare QoL between groups of individuals after ACL reconstruction (including those who are symptomatic with ROA, symptomatic without ROA, and asymptomatic [unknown ROA status]), and (2) identify specific aspects of QoL impairment in symptomatic individuals with and without ROA post ACL reconstruction.

METHODS: One hundred thirteen participants completed QoL measures (Knee injury and Osteoarthritis Outcome Score QoL subscale [KOOS-QoL], Anterior Cruciate Ligament Quality of Life [ACL-QoL], Assessment of Quality of Life-8 Dimensions [AQoL-8D]) 5 to 20 years after ACL reconstruction. Eighty-one symptomatic individuals underwent radiographs, and 32 asymptomatic individuals formed a comparison group. Radiographic osteoarthritis was defined as a Kellgren-Lawrence grade of 2 or greater for the tibiofemoral and/or patellofemoral joints. Mann-Whitney *U* tests compared outcomes between groups. Individual ACL-QoL items were used to explore specific aspects of QoL.

RESULTS: In symptomatic individuals after ACL reconstruction, ROA was related to worse knee-related outcomes on the KOOS-QoL (median, 50; interquartile range [IQR], 38-69 versus median, 69; IQR, 56-81; $P<.001$) and the ACL-QoL (median, 51; IQR, 38-71 versus median, 66; IQR, 50-82; $P = .04$). The AQoL-8D scores showed that health-related QoL was impaired in both symptomatic groups compared to the asymptomatic group. The ACL-QoL item scores revealed greater limitations and concern surrounding sport and exercise and social/emotional difficulties in the symptomatic group with ROA.

CONCLUSION: Osteoarthritis is associated with worse knee-related QoL in symptomatic individuals after ACL reconstruction. Diagnosing ROA in symptomatic individuals after ACL reconstruction may be valuable, because these individuals may require unique management. Targeted strategies to facilitate participation in satisfying activities have potential to improve QoL in symptomatic people with ROA after ACL reconstruction. *J Orthop Sports Phys Ther 2018;48(5):398-408. doi:10.2519/jospt.2018.7830*

KEY WORDS: *pain, physical activity, psychological, radiology/medical imaging, sport*

Osteoarthritis of the knee is a leading cause of disability worldwide.[5] Individuals who experience symptomatic radiographic osteoarthritis (ROA) may endure chronic pain and physical activity limitations that can impact quality of life (QoL).[1,5,31] Although knee ROA is most prevalent among older adults,[5] young individuals participating in competitive sport who rupture their anterior cruciate ligament (ACL) are at high risk of developing knee ROA within 10 years of injury.[22,28] The desire to continue participation in high-impact sports, combined with work and parenting responsibilities inherent in these young adults, may contribute to the impaired QoL described in some individuals 5 to 20 years after ACL reconstruction.[9,10] However, the impact of symptomatic ROA on QoL after ACL reconstruction is poorly understood. Consequently, the clinical importance of diagnosing ROA in symptomatic individuals after ACL reconstruction is unclear, and information to guide strat-

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egies to improve QoL in this population is limited.

After ACL reconstruction, QoL was similar between individuals with and without tibiofemoral ROA (defined as a Kellgren-Lawrence grade of 2 or above[14]).[6,20,24] However, QoL was worse in people with severe tibiofemoral ROA after ACL reconstruction (Kellgren-Lawrence grade 4) compared to those without ROA.[24] The impact of patellofemoral ROA on QoL is unclear, due to disagreement in the literature.[6,21,23] To date, all studies investigating the relationship between QoL and ROA after ACL reconstruction have not considered symptomatic status. Consequently, the complex relationship between knee symptoms, ROA, and QoL following ACL reconstruction has not been investigated. Additionally, the relevance of ROA findings in symptomatic individuals after ACL reconstruction is uncertain. An exploration of QoL among symptomatic individuals after ACL reconstruction, with and without ROA, could provide new insights.

The aims of this study were (1) to compare QoL between individuals after ACL reconstruction who were (*a*) symptomatic with ROA, (*b*) symptomatic without ROA, and (*c*) asymptomatic (unknown ROA status); and (2) to identify specific aspects of QoL impairment in symptomatic individuals with and without ROA after ACL reconstruction.

METHODS

Study Design

This cross-sectional study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cross-sectional studies. Ethical approval for this study was obtained from the University of Queensland Medical Research Ethics Committee (approval number 2012001240).

Participants

Individuals were recruited from a larger cross-sectional study investigating QoL in people with knee difficulties 5 to 20 years following ACL reconstruction.[9] Details of the recruitment procedure and eligibility criteria for the larger study have been published previously.[9] In brief, to be eligible for the cross-sectional study, individuals had to be 18 to 55 years of age, have had a hamstring or patellar tendon autograft ACL reconstruction 5 to 20 years previously, report no substantial comorbidities likely to impact QoL, and report knee difficulties. Considering no validated criteria exist for categorizing individuals post ACL reconstruction as "symptomatic," we adapted published criteria for the purposes of this study.[9,26] Symptomatic knee status was defined as reporting impairment on at least 2 Knee injury and Osteoarthritis Outcome Score (KOOS) subscales. Impairment was determined by a 1-step decrease from the best response to at least 50% of items within a subscale, which determined the following cutoffs: pain less than or equal to 86.1, symptoms less than or equal to 85.7, activities of daily living less than or equal to 86.8, sport and recreation less than or equal to 85.0, and QoL less than or equal to 87.5. Thirty-two of the 194 individuals who completed the questionnaire did not meet the KOOS cutoff criteria and were categorized as asymptomatic. These individuals were not invited for a knee radiograph, but their questionnaire data were used for comparison with symptomatic individuals post ACL reconstruction. Study information and an invitation to receive a knee radiograph were sent to all 162 individuals who met the KOOS cutoff criteria. **FIGURE 1** describes the recruitment

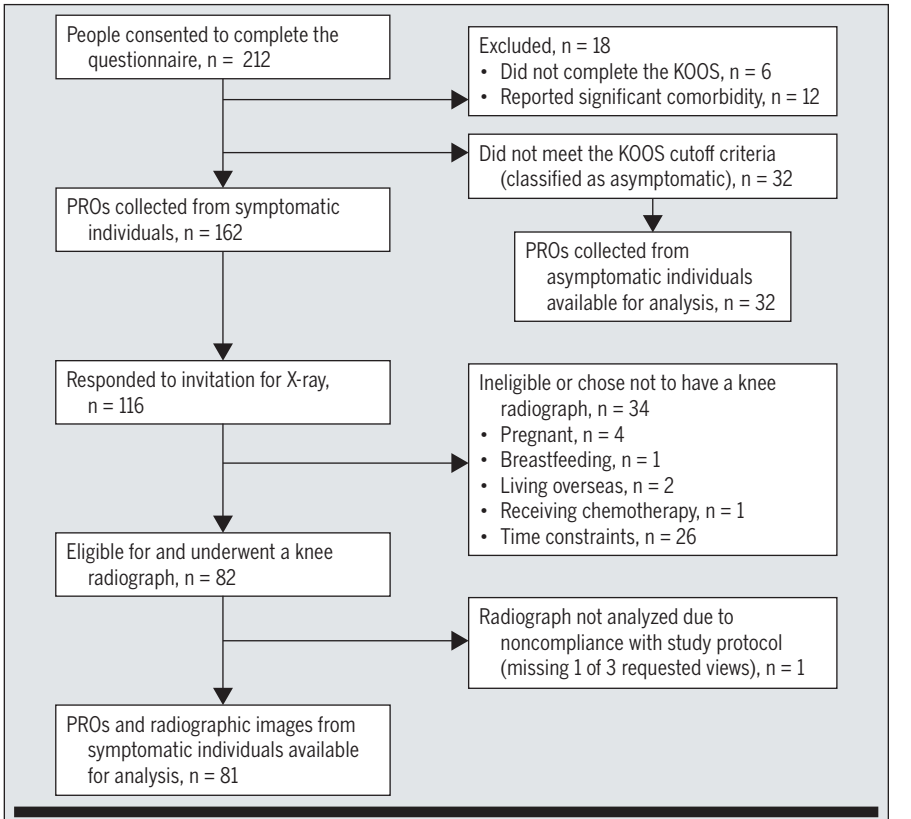

FIGURE 1. Participant recruitment flow chart. The KOOS cutoff criteria for symptomatic knee status were determined by applying a cutoff that equates to a 1-step decrease from the best response for at least 50% of items within 2 or more subscales (resulting in the following cutoffs: pain, 86.1 or lower; symptoms, 85.7 or lower; activities of daily living, 86.8 or lower; sport/recreation, 85.0 or lower; and quality of life, 87.5 or lower). Abbreviations: KOOS, Knee injury and Osteoarthritis Outcome Score; PRO, patient-reported outcome.

process for the present study, which included radiographs from 81 individuals for grading and analysis.

Radiographic Assessment

Radiographic clinics across Australia were contacted prior to receiving a referral and informed of the study protocol and procedure. Three views of the ACL-reconstructed knee(s) were requested to enable radiographic grading of the tibiofemoral and patellofemoral joints: weight-bearing posteroanterior erect in 15° of knee flexion, weight-bearing lateral in 30° of knee flexion, and non–weight-bearing skyline in 45° of knee flexion. All radiographs were graded by an experienced radiologist (S.D.) using the Kellgren-Lawrence criteria for defining ROA,[14] by which osteophytes, narrowing of joint cartilage, sclerotic or pseudocystic subchondral bone, and an altered shape of the tibial or femoral condyles were considered signs of ROA. A Kellgren-Lawrence score of grade 0 represents no radiographic changes, grade 1 minimal changes, grade 2 definite but minimal changes, grade 3 moderate changes, and grade 4 severe radiographic changes.[14] A Kellgren-Lawrence score of grade 2 or greater for the tibiofemoral or patellofemoral joint was used to define the presence of ROA.[14] Radiographic osteoarthritis was further classified by the following involved compartments: medial tibiofemoral, lateral tibiofemoral, and patellofemoral. All knee radiographs were performed between September 2014 and August 2015, at a median of 9 months (interquartile range [IQR], 8-11 months) after questionnaire completion.

Although symptomatic osteoarthritis can be diagnosed without imaging,[27] the presence of knee symptoms without structural changes cannot be confidently attributed to osteoarthritis.[15] Therefore, we assumed that the symptomatic group with ROA would have more symptoms related to the ROA disease process than would the symptomatic group without ROA.

Participant Characteristics

A range of information regarding participant characteristics and demographics was collected as part of the parent study. This included age, body mass index, time since last ACL reconstruction, time from injury to ACL reconstruction (dichotomized to 6 months or shorter versus longer than 6 months), contact mechanism of injury, additional surgery (additional knee surgery to an ACL-reconstructed knee not including revision ACL reconstruction or concomitant surgery performed at the time of primary or revision ACL reconstruction), and revision ACL reconstruction (yes/no). Return to sport was also assessed using the following question: "Please tick the most appropriate statement regarding your level of sport participation after injuring your ACL by selecting 1 of the following 3 options: 'I returned to competitive sport at the same or higher level than before ACL injury,' 'I returned to competitive sport at a lower level than before ACL injury,' or 'I did not return to competitive sport after my ACL reconstruction.'" The proportion of participants receiving current knee treatment was assessed ("Do you currently receive treatment for your knee?"), and participants were asked, "How would you rate your current knowledge of osteoarthritis?" with responses on a 5-point Likert scale (very good, good, average, poor, very poor). Due to potential difficulty recalling information surrounding the ACL injury and surgery, "unsure" response options were given (ie, questions on mechanism of ACL injury and time from injury to ACL reconstruction).

Patient-Reported Measures

All patient-reported measures used for this study were collected as part of the larger cross-sectional study. The psychometric properties for these instruments have been previously described.[9]

Knee-Related QoL The Anterior Cruciate Ligament Quality of Life (ACL-QoL) was chosen as the primary measure to evaluate knee-related QoL, because this is the only ACL-specific QoL measure[18] and contains items of clear relevance to individuals with ACL injuries.[29] A unique attribute of the ACL-QoL is use of terminology that enables the responder to consider the personal impact that pain or physical deficits have on their life (eg, "How troubled are you by pain or stiffness?" and "How much of a concern is it for you to miss days from work?"). The ACL-QoL contains 31 items that fall under 5 separate domains: symptoms and physical complaints, work-related concerns, recreational activities and sport participation or competition, lifestyle, and social and emotional.[18] Each item is scored on a visual analog scale ranging from 0 (severe impairment) to 100 (no impairment). Item scores are averaged to calculate the overall ACL-QoL score (range, 0-100). The ACL-QoL scores are valid for use in individuals with ACL injuries and with chronic knee difficulties,[18] and have high internal consistency (Cronbach $\alpha \geq .93$) at 6, 12, and 24 months following ACL reconstruction.[16] The ACL-QoL has been found to be responsive (using anchor-based methods) to self-rated knee improvement before and more than 2 years following ACL reconstruction.[16]

The KOOS was used as a secondary measure of QoL, because this is the most commonly used measure of longer-term QoL in populations with ACL reconstruction,[10] enabling comparisons with previous studies. The KOOS-QoL subscale comprises 4 questions addressing knee awareness, knee-related lifestyle modifications, knee confidence, and knee-related difficulties.[26] The KOOS items are scored on a 5-point ordinal scale, from which subscale scores are calculated ranging from 0 (severe impairment) to 100 (no impairment).

Health-Related QoL The Assessment of Quality of Life-8 Dimensions (AQoL-8D) instrument is a general health-related QoL measure with strong content, construct, and discriminative validity in populations with osteoarthritis.[12,13,25,30] The AQoL-8D includes

8 dimensions (independent living, happiness, mental health, coping, relationships, self-worth, pain, senses). The AQoL-8D can provide both unweighted summary scores and weighted utility scores. Utility scores were calculated for this study. The AQoL-8D utility scores are scaled such that 0.00 represents the worst health state and 1.00 represents the best health state.

Statistical Analysis

The assumption of normality was not met for several variables; consequently, nonparametric tests were chosen, and data are reported as medians and IQRs or frequencies and percentages, as appropriate. To minimize the total number of group comparisons, we used the Kruskal-Wallis test to compare outcomes between the 3 groups. The distribution of scores was not homogeneous between groups (due to higher scores in the asymptomatic group); therefore, Kruskal-Wallis tests were performed with mean ranks rather than median scores. Differences accompanied by *P* less than .05 were analyzed post hoc using Mann-Whitney *U* tests to determine which groups were statistically different.

To assess whether people volunteering to undergo a knee radiograph were representative of the larger cross-sectional study sample, Mann-Whitney *U* and chi-square tests were used, as appropriate. Due to the small amount of missing data (KOOS, no missing data; ACL-QoL, n = 1 missing data [asymptomatic group]; AQoL-8D, n = 2 missing data [asymptomatic group]), analyses were performed where complete data were available (ie, data from the 3 questionnaires that were incomplete were not included in the analysis).

RESULTS

Sample Characteristics

Participant characteristics are described in **TABLE 1**. Symptomatic participants were older than asymptomatic participants (median, 40 years; IQR, 34-49 years versus median, 34 years; IQR, 29-45 years; *P* = .04), more symptomatic participants had undergone additional knee surgery (54% versus 19%, *P* = .001), and fewer symptomatic participants had returned to a preinjury level of sport compared with asymptomatic participants (37% versus 63%, *P* = .01).

Compared to symptomatic participants without ROA, symptomatic participants with ROA were older (median age, 42 years; IQR, 36-49 years versus 37 years; IQR, 32-43 years; *P* = .02) and more overweight or obese (70% versus 45%, *P* = .03), and had more time since their ACL reconstruction (median, 9 years; IQR, 7-11 years versus 8 years; IQR, 6-8 years; *P* = .01). Symptomatic participants with ROA were also more likely to have reported a delay of greater than 6 months from ACL injury to reconstruction (41% versus 10%, *P* = .003), were more likely to have undergone additional knee surgery (66% versus 35%, *P* = .007), and were less likely to have reported a contact mechanism of ACL injury (27% versus 52%, *P* = .03). A similar proportion of symptomatic participants with and without ROA received current knee treatment (20% and 19%, respectively). Before undergoing a knee radiograph, 30% of symptomatic participants rated their osteoarthritis knowledge as good/very good (34% with ROA, 23% without

TABLE 1 Sample Characteristics*

	All Symptomatic (n = 81)	Asymptomatic (Unknown ROA Status) (n = 32)	*P* Value†	Symptomatic With ROA (n = 50)	Symptomatic Without ROA (n = 31)	*P* Value†
Age, y	40 (34-49)	34 (29-45)	.04	42 (36-49)	37 (32-43)	.02
Sex (male), n (%)	42 (52)	17 (53)	.90	27 (54)	15 (48)	.62
BMI (overweight or obese), n (%)‡	49 (61)	18 (56)	.31	35 (70)	14 (45)	.03
Years since last ACL reconstruction, y	8 (7-11)	8 (7-11)	.82	9 (7-11)	8 (6-8)	.01
>6-mo ACL reconstruction delay, n (%)§	23 (28)	8 (25)	.69	20 (41)	3 (10)	.003
Additional knee surgery, n (%)	44 (54)	6 (19)	.001	33 (66)	11 (35)	.007
Revision ACL reconstruction, n (%)	12 (15)	2 (6)	.21	9 (18)	3 (10)	.31
Contact mechanism of injury, n (%)‖	29 (36)	12 (40)	.75	13 (27)	16 (52)	.03
RTS at preinjury/higher level, n (%)	30 (37)	20 (63)	.01	17 (34)	13 (42)	.47
RTS at a lower level, n (%)	22 (27)	6 (19)	.20	12 (24)	10 (32)	.42
Did not RTS, n (%)	29 (36)	6 (19)	.08	21 (42)	8 (26)	.14

Abbreviations: ACL, anterior cruciate ligament; BMI, body mass index; ROA, radiographic osteoarthritis; RTS, return to sport.
**Values are median (interquartile range) unless otherwise indicated.*
†Calculated using Mann-Whitney U (continuous variables) or chi-square tests (binary variables).
‡Converted to a binary variable (normal weight versus overweight or obese), with reference to international classification guidelines (normal weight, 18.9-24.9 kg/m²; overweight, 25.0-29.9 kg/m²; obese, 30.0 kg/m² or greater).[19]
§"Unsure" responses were removed, resulting in 1 missing response (from the symptomatic group with ROA).
‖"Unsure" responses were removed, resulting in 4 missing responses (2 from the symptomatic group with ROA and 2 from the asymptomatic group).

ROA), 30% as average (34% with ROA, 23% without ROA), and 41% as poor/very poor (32% with ROA, 55% without ROA).

There were no statistical differences in sex, body mass index, time since ACL reconstruction, proportion having additional surgery, dissatisfaction with knee function, KOOS pain score, KOOS symptoms score, or ACL-QoL score between those who underwent radiographs (n = 81) and symptomatic individuals without radiographs from the parent study (n = 81) (P>.05 for all analyses). The only statistical difference between these groups was age, such that individuals who underwent radiographs were younger than symptomatic individuals who did not undergo a knee radiograph (median age, 36 years versus 40 years; IQR, 34-49 years; P = .01).

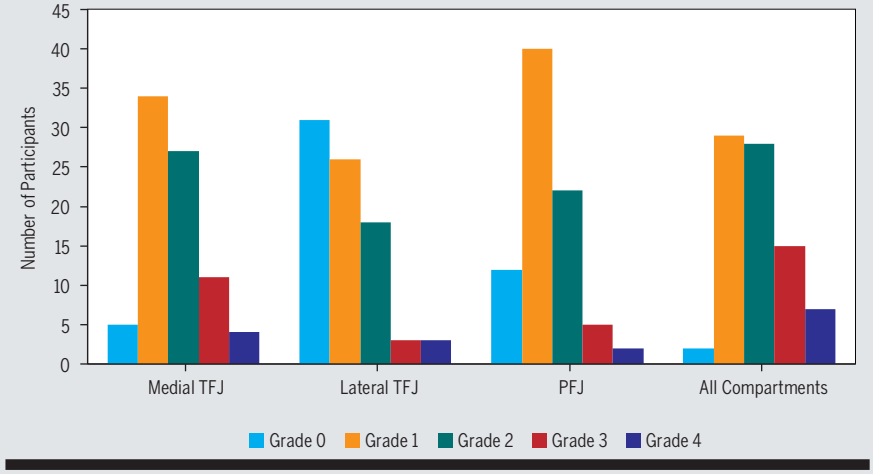

FIGURE 2. Knee ROA prevalence by compartment and severity (n = 81). "All compartments" presents the highest grade of ROA from any compartment for each participant. A Kellgren-Lawrence grade of 0 represents no radiographic changes, grade 1 represents minimal changes, grade 2 represents definite but minimal changes, grade 3 represents moderate changes, and grade 4 represents severe radiographic changes.[14] If both knees were reconstructed, the highest severity of ROA in either knee was reported for each compartment. Abbreviations: PFJ, patellofemoral joint; ROA, radiographic osteoarthritis; TFJ, tibiofemoral joint.

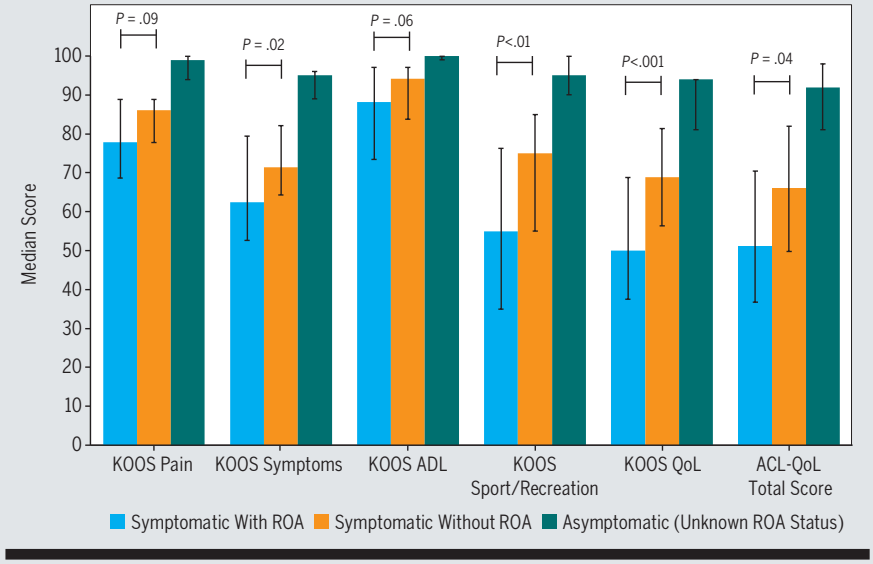

FIGURE 3. Comparison of KOOS subscale scores and total ACL-QoL scores in symptomatic people after ACL reconstruction (with and without ROA) and asymptomatic participants. All outcomes were reported as medians, and error bars represent interquartile ranges. A score of 100 represents the best possible score for each outcome. P values were obtained using Mann-Whitney U tests and are reported for symptomatic with ROA (blue) versus symptomatic without ROA (orange). Abbreviations: ACL, anterior cruciate ligament; ACL-QoL, Anterior Cruciate Ligament Quality of Life questionnaire; ADL, activities of daily living; KOOS, Knee injury and Osteoarthritis Outcome Score; QoL, quality of life; ROA, radiographic osteoarthritis.

Radiographic Findings

The prevalence of ROA by knee compartment and radiographic severity score is presented in **FIGURE 2**. When all compartments were considered together, 2 (2.5%) participants had grade 0 (no) ROA, 29 (36%) had grade 1 (minimal) ROA, 28 (34.5%) had grade 2 (definite) ROA, 15 (18.5%) had grade 3 (moderate) ROA, and 7 (8.5%) had grade 4 (severe) ROA.

Comparisons in QoL

Knee-Related QoL Symptomatic participants with ROA reported worse QoL on the KOOS-QoL subscale (median, 50; IQR, 38-69 versus 69; IQR, 56-81; P<.001) and the ACL-QoL (median, 51; IQR, 38-71 versus 66; IQR, 50-82; P = .04) compared to symptomatic participants without ROA (**FIGURE 3**). Asymptomatic participants reported better KOOS and ACL-QoL scores compared with symptomatic participants with and without ROA (all, P<.001).

Health-Related QoL No statistical differences were observed in overall AQoL-8D scores between symptomatic participants with and without ROA (**FIGURE 4**). However, all AQoL-8D domains and utility scores were impaired in symptomatic participants with and without ROA compared to asymptomatic individuals (all, P<.03), with the exception of the self-worth domain, which was not statistically different between symptomatic participants without ROA and asymptomatic participants (P = .12).

Specific Aspects of QoL Impairment

Symptoms and Physical Complaints Pain, stiffness, and knee weakness were common among symptomatic participants, but trouble with giving-way

episodes was rare (**TABLE 2**). There were no statistical differences in the impact of symptoms and physical complaints on QoL of symptomatic individuals with and without ROA (**TABLE 2**). Symptoms and physical complaints were more impaired in symptomatic participants with ROA (all items, $P \leq .003$) and without ROA (all items, $P \leq .001$) compared to asymptomatic individuals.

Work-Related Concerns Symptomatic participants reported trouble with squatting motions at work, and ceiling effects were evident for other items (**TABLE 2**). There were no statistical differences in work-related concerns between symptomatic individuals with and without ROA (**TABLE 2**). All work-related concerns were worse in symptomatic participants with ROA (all items, $P < .02$) compared to asymptomatic individuals. The only item that did not differ between the groups was concern regarding loss of time from work due to knee treatment.

Recreational Activities and Sport Participation Compared to participants without ROA, participants with ROA reported worse athletic performance compared with preinjury performance, were more likely to play sport under caution, were more concerned with environmental conditions, found it difficult to go full out during sport, were more fearful of playing sport, and reported greater difficulties taking part in their second most important sport or activity (all, $P < .05$). Sport and recreational impairments had a greater impact on QoL for symptomatic participants with ROA (all items, $P < .001$) and without ROA (all items, $P < .04$) compared to asymptomatic individuals. Asymptomatic participants expressed concern that sport or recreational activity might result in worsening of their knee status (question 10 median, 64; IQR, 50-100), although they were less concerned than symptomatic individuals (with ROA: median, 27; IQR, 2-53; without ROA: median, 27; IQR, 12-65).

Lifestyle All items related to lifestyle factors were worse in symptomatic individuals with ROA, including concern with general safety issues, limitations in exercising and maintaining fitness, reduced enjoyment of life, more awareness of knee problems, greater knee concerns during family activities, and more lifestyle modifications. All lifestyle items were more impaired in symptomatic participants with ROA ($P < .001$) and without ROA ($P < .05$) compared to asymptomatic individuals.

Social and Emotional Social and emotional items were more impaired in symptomatic people with ROA, including concern that competitive needs were not being met, being apprehensive, difficulty coming to grips with knee problems, and worse knee confidence (**TABLE 2**). Social and emotional impairments were greater in symptomatic participants with ROA ($P < .001$) and without ROA ($P < .03$) compared to asymptomatic individuals.

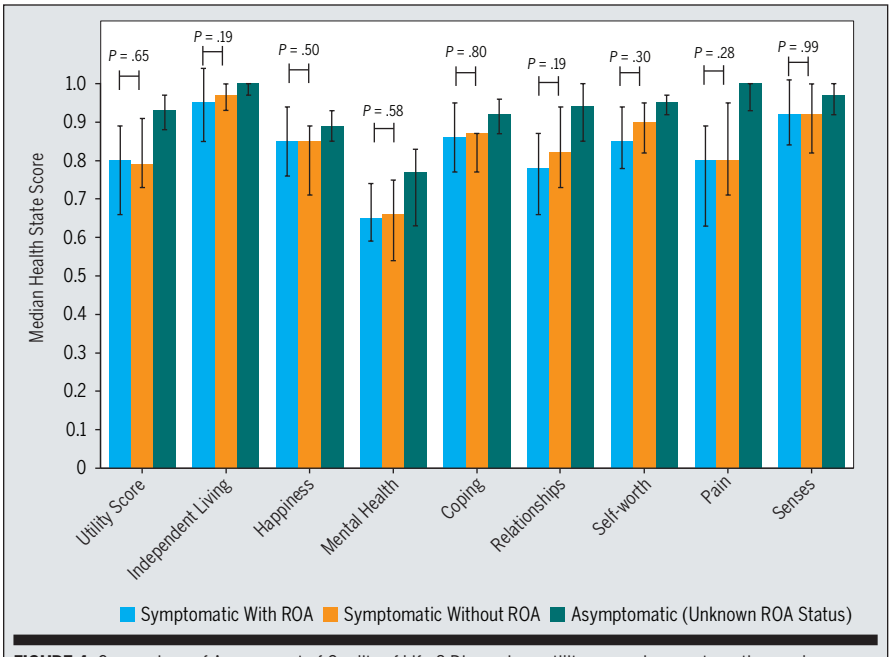

FIGURE 4. Comparison of Assessment of Quality of Life-8 Dimensions utility scores in symptomatic people after ACL reconstruction (with and without ROA) and asymptomatic participants. All outcomes were reported as medians, and error bars represent interquartile ranges. A score of 1.0 represents the best possible score. *P* values were obtained using Mann-Whitney *U* tests and are reported for symptomatic with ROA (blue) versus symptomatic without ROA (orange). Abbreviations: ACL, anterior cruciate ligament; ROA, radiographic osteoarthritis.

DISCUSSION

In individuals with knee symptoms more than 5 years after ACL reconstruction, ROA in the tibiofemoral and/or patellofemoral joint was related to worse knee-related QoL. Although health-related QoL was similar between symptomatic people with and without ROA, this was impaired compared to an asymptomatic ACL-reconstructed group. Exploring specific ACL-QoL items revealed aspects of QoL that were more impaired in symptomatic individuals with ROA, including sport and recreation limitations, lifestyle factors, and social/emotional difficulties.

Concerns about sport limitations were common for both symptomatic groups, and to a greater degree in people with ROA. Items that were more impaired in those with ROA included reduced sports performance, playing sport under caution, concern with sports environment, difficulty going full out, fear of contact sports, and limitations in preferred activities. Our previous study found that not returning to sport after ACL reconstruction was associated with worse QoL 5 to 20 years after ACL reconstruction in

people with knee symptoms.[9] Furthermore, ACL-QoL items surrounding sport have been rated of highest importance by a group of patients after ACL reconstruction.[29] Our qualitative research in this area also found that maintaining a satisfying, physically active lifestyle was a critical component of longer-term QoL after ACL reconstruction.[11] However, this is the first study to demonstrate the importance of sport participation among symptomatic people with ROA after ACL reconstruction.

Participants with ROA reported difficulty exercising and maintaining fitness due to their knee. Exercise and strength training are recommended as core treatments for reducing pain and improving function in people with knee osteoarthritis.[17] Of concern is that 41% of participants with knee symptoms reported their osteoarthritis knowledge as poor or very poor (including 1 in 3 individuals with ROA), and only 20% were receiving treatment for their knee. The rehabilitation period provides an important opportunity for physical therapists to deliver osteoarthritis education and develop a long-term physical activity plan. While return to sport is a common goal of ACL rehabilitation, it is not known whether physical therapists discuss strategies for maintaining an active lifestyle across the lifespan. Additionally, symptomatic individuals with ROA commonly experienced poor knee confidence and reinjury fears. Addressing these potential barriers to physical activity may have positive impacts on QoL. There is a need to develop effective strategies to reduce fear of reinjury and improve knee confidence in symptomatic individuals after ACL reconstruction.

It is possible that difficulty exercising and maintaining fitness in symptomatic individuals with ROA after ACL reconstruction is greater for those with a strong preference for participation in competitive sports. Notably, people with ROA were more likely to express concern that their competitive needs were no

TABLE 2 ACL-QoL Item Scores and Comparison Between ACL-Reconstructed Groups*

ACL-QoL Item	Symptomatic With ROA (n = 50)	Symptomatic Without ROA (n = 31)	Asymptomatic (Unknown ROA Status) (n = 31)†
Symptoms and physical complaints			
1. With respect to your overall knee function, how troubled are you by giving-way episodes?			
a. Severity of giving-way episodes	99 (83-100)	96 (90-100)	100 (100-100)
b. Frequency of giving-way episodes	98 (88-100)	96 (90-100)	100 (100-100)
2. With any kind of prolonged activity (ie, >30 min), how much pain or discomfort do you get in your knee?	68 (44-87)	83 (54-87)	100 (90-100)
3. With respect to your overall knee function, how much are you troubled by stiffness or loss of motion in your knee?	77 (43-92)	79 (58-88)	96 (86-100)
4. Consider the overall function of your knee and how it relates to the strength of your muscles. How weak is your knee?	64 (38-84)	72 (48-85)	93 (86-100)
Work-related concerns			
5. How much trouble do you have, because of your knee, with turning or pivoting motions at work?	92 (75-100)	100 (89-100)	100 (100-100)
6. How much trouble do you have, because of your knee, with squatting motions at work?	57 (26-90)	75 (50-97)	100 (96-100)
7. How much of a concern is it for you to miss days from work due to problems or reinjury to your knee?	100 (53-100)	100 (86-100)	100 (100-100)
8. How much of a concern is it for you to lose time from "school" or work because of the treatment of your ACL-reconstructed knee?	99 (53-100)	100 (88-100)	100 (100-100)
Recreational activities and sport participation or competition			
9. How much limitation do you have with sudden twisting and pivoting movements or changes in direction?	63 (31-97)	72 (53-90)	99 (88-100)
10. How much of a concern is it for you that your sporting or recreational activities may result in the status of your knee worsening?	27 (2-53)	27 (12-65)	64 (50-100)
11. How does your current level of athletic or recreational performance compare with your preinjury level?	32 (11-75)‡	61 (48-80)	95 (78-100)
12. With respect to activities/sports that you desire to be involved with, how much have your expectations changed because of your knee?	29 (6-71)	50 (25-74)	97 (81-100)
13. Do you have to play your recreation or sport under caution?	18 (0-49)§	47 (3-90)	86 (54-100)
14. How fearful are you of your knee giving way when playing recreation or sport?	30 (6-74)	61 (13-100)	94 (63-100)

Table continues on page 405.

longer being met due to their knee problem than were symptomatic people without ROA. We recently found that individuals with a strong preference to be active through competitive sport risked adopting an inactive lifestyle and experiencing reduced QoL if their knee limited them from pursuing sports activities.[11] Current osteoarthritis treatment recommendations largely target older patients[3,7] and, as such, may not address all aspects of importance to a symptomatic population with ROA after ACL reconstruction. Specifically, prioritizing sport participation, fulfilling competitive needs, and fear of reinjury may be largely unique to individuals after ACL reconstruction. For symptomatic individuals with ROA after ACL reconstruction who express a strong preference to be active through competitive sports, discovering activities that meet their competitive needs and do not exacerbate their knee symptoms or function could positively impact QoL. Modifications of team sports, such as walking football and walking netball, could provide appropriate alternatives to high-impact sports. Further research is needed to explore this possibility.

Our findings do not necessarily support the use of radiographs to diagnose knee osteoarthritis. Rather, they highlight the value in diagnosing ROA in symptomatic individuals after ACL reconstruction. Symptoms due to osteoarthritis should be managed differently from those unrelated to osteoarthritis. For example, recommended osteoarthritis management includes osteoarthritis education, physical activity pacing (small amounts often), weight loss, specialized footwear, walking aids, and joint replacement surgery for severe osteoarthritis.[3,7] These treatments may be inappropriate for symptomatic individuals without ROA after ACL reconstruction, further highlighting the value in diagnosing

TABLE 2 ACL-QoL Item Scores and Comparison Between ACL-Reconstructed Groups* (continued)

ACL-QoL Item	Symptomatic With ROA (n = 50)	Symptomatic Without ROA (n = 31)	Asymptomatic (Unknown ROA Status) (n = 31)†
15. Are you concerned about environmental conditions, such as a wet playing field or a hard court, when involved in your recreation or sport?	20 (6-68)§	53 (18-90)	90 (50-100)
16. Do you find it frustrating to have to consider your knee with respect to your recreation or sport?	15 (0-49)	35 (4-90)	94 (79-100)
17. How difficult is it for you to "go full out" at your recreation or sport?	13 (0-50)§	47 (11-92)	90 (56-100)
18. Are you fearful of playing contact sports?	10 (0-47)§	45 (9-84)	90 (46-100)
19. How limited are you in playing the number "1" sport or activity?	39 (1-82)	70 (36-90)	96 (85-100)
20. How limited are you in playing the number "2" sport or activity?	34 (0-75)§	71 (22-94)	96 (81-100)
Lifestyle			
21. Do you have to concern yourself with general safety issues (eg, carrying small children, working in the yard) with respect to your knee?	85 (50-100)‡	100 (82-100)	100 (100-100)
22. How much has your ability to exercise and maintain fitness been limited by your knee problem?	47 (22-81)‡	84 (50-95)	100 (94-100)
23. How much has your enjoyment of life been limited by your knee problem?	70 (48-92)‡	94 (83-100)	100 (98-100)
24. How often are you aware of your knee problem?	22 (2-75)‡	53 (22-80)	95 (89-98)
25. Are you concerned about your knee with respect to lifestyle activities that you and your family do together?	53 (29-90)‡	91 (66-100)	100 (90-100)
26. Have you modified your lifestyle to avoid potentially damaging activities to your knee?	37 (15-75)‡	75 (45-94)	96 (81-100)
Social and emotional			
27. Does it concern you that your competitive needs are no longer being met because of your knee problem?	47 (20-82)‡	87 (42-100)	100 (91-100)
28. Have you had difficulty being able to psychologically "come to grips" with your knee problem?	82 (50-97)§	95 (79-100)	100 (100-100)
29. How often are you apprehensive about your knee?	51 (34-88)§	81 (50-98)	96 (84-100)
30. How much are you troubled with lack of confidence in your knee?	55 (31-88)§	80 (50-100)	98 (92-100)
31. How fearful are you of reinjuring your knee?	36 (5-75)	45 (17-86)	86 (40-100)
Total ACL-QoL score	51 (37-71)§	66 (50-82)	92 (81-98)

Abbreviations: ACL, anterior cruciate ligament; ACL-QoL, Anterior Cruciate Ligament Quality of Life questionnaire; ROA, radiographic osteoarthritis.
**Values are median (interquartile range). P values were obtained from the Mann-Whitney U test. The wording for some questions was shortened due to space limitations (see Mohtadi[18] for precise wording).*
†One person from the asymptomatic group did not complete the ACL-QoL.
‡P<.01.
§P<.05.

ROA in this population. Ideally, symptomatic osteoarthritis can be diagnosed through clinical assessment rather than by obtaining a knee radiograph, in line with European League Against Rheumatism guidelines.[27] However, imaging is recommended to help confirm alternative diagnoses, and there is a shortage of studies investigating the added benefit of imaging over clinical findings for diagnosing knee osteoarthritis.[27] Importantly, recommendations regarding use of imaging to diagnose osteoarthritis have not been made specifically for individuals after ACL reconstruction who may present with different knee symptoms compared with the typical population without ACL injury. Further research is needed to evaluate whether clinical assessment can accurately diagnose osteoarthritis in people with knee symptoms after ACL reconstruction.

We found less QoL impairment in the asymptomatic group (irrespective of ROA status) compared to symptomatic patients with and without ROA. This suggests that more knee symptoms may have a negative impact on QoL. To provide further information regarding whether pain and symptom severity alone could explain the difference in QoL between symptomatic groups with and without ROA, we performed a post hoc analysis. The ACL-QoL scores stratified by KOOS pain and KOOS symptoms severity are presented in the **APPENDIX** (available at www.jospt.org). Symptomatic individuals with ROA appeared to have worse QoL, with similar degrees of knee pain and symptoms, compared to symptomatic individuals without ROA. Notably, we could not determine the significance of any between-group difference due to insufficient power. Exploring differences in QoL between ROA and non-ROA groups, stratified by knee pain and symptom severity, could be an important area for future research.

Although sport limitations appear to be related to ROA 5 to 20 years after ACL reconstruction, few studies have investigated the relationship between return to preinjury sport (at any time after ACL reconstruction) and the development of ROA.[2] We found similar return-to-sport rates in symptomatic people with and without ROA after ACL reconstruction, and our previous investigations found that return to sport was not related to ROA in this sample.[8] While this provides some evidence that returning to sport after ACL reconstruction may not be associated with ROA development, additional prospective research is required to explore this relationship further.

Strengths and Limitations

This is the first study to explore specific aspects of QoL in symptomatic individuals with and without ROA after ACL reconstruction, providing clinically applicable information that may be used to guide the development of strategies to improve longer-term QoL after ACL reconstruction. Additional strengths of this study include radiographing both the tibiofemoral and patellofemoral joints and including symptomatic and asymptomatic groups. Although the ACL-QoL contains many items of importance to individuals after ACL reconstruction and its psychometric properties have been previously evaluated,[16] it was designed to address aspects of QoL relevant for ACL-deficient people with knee difficulties.[18] Consequently, validity of this measure for use in individuals with knee difficulties 5 to 20 years after ACL reconstruction is unclear. We found that using the ACL-QoL in this sample resulted in potential item redundancy (very similar participant scores for items assessing similar aspects of QoL (eg, items 13 and 17, and items 29 and 30) and a ceiling effect for 5 items (1a, 1b, 5, 7, and 8), which suggests that these items may be inappropriate for use in people with knee symptoms more than 5 years after ACL reconstruction.

A limitation of this study was that only 50% of individuals from the parent study elected to undergo a knee radiograph. Despite similar characteristics between radiographed and nonradiographed individuals, the proportion of individuals choosing not to undergo a radiograph might impact the generalizability of results. For instance, these results may be less applicable to older individuals (ie, those who did not undergo radiographs were older on average) or those with less time to undergo a knee radiograph (not enough time was the most common reason for rejecting the invitation for knee radiography). Assuming a pooled standard deviation of 16 units on the ACL-QoL,[16] we required 28 participants per group to achieve a power of 80% and a level of significance of 5% (2 sided) for detecting a true difference between groups of 12 units on the ACL-QoL. Due to the nature of recruitment, we were underpowered to detect true differences between groups of fewer than 12 units on the ACL-QoL.

Unfortunately, it was not practical for participants to complete the questionnaire at the time of radiography. Consequently, participants' pain and symptoms could have changed between questionnaire completion and radiography (median, 9 months). To assess this, a proportion of symptomatic participants (n = 56, 34%) recompleted the KOOS a mean ± SD of 12 ± 1 months (range, 10-18 months) after completing the previous questionnaire. Wilcoxon signed-rank tests indicate that KOOS pain, symptoms, and function subscale scores were all similar between these 2 time points ($P \geq .05$ for all analyses), with no clinically relevant differences identified according to the minimal important change for this instrument.[4] Notably, no validated criteria exist to define knee difficulties in individuals after ACL reconstruction, so we adapted criteria from a prior study. A limitation of using this approach was that individuals who did not meet these criteria (forming the "asymptomatic group") could have experienced some knee difficulties (ie, impairment in 1 of the 5 KOOS subscales or slight impairment in more than 1 KOOS subscale). Additionally, the cross-sectional design only allowed us to examine associations rather than causal inferences.

CONCLUSION

Symptomatic individuals with ROA after ACL reconstruction experienced greater knee-related QoL impairment than symptomatic individuals without ROA. Health-related QoL was impaired in all symptomatic individuals after ACL reconstruction, irrespective of ROA status. We identified specific aspects of QoL that were impaired in symptomatic people with ROA, highlighting greater limitations and concern surrounding sport and exercise and social/emotional difficulties in this subgroup of individuals. It may be important to extend focus beyond return to sport, to include maintenance of a physically active lifestyle across the lifespan following ACL reconstruction. There may be benefit in diagnosing ROA in symptomatic individuals after ACL reconstruction, as these individuals may require different management from symptomatic individuals without ROA. Additionally, symptomatic individuals after ACL reconstruction with osteoarthritis may have unique needs that are not addressed in current osteoarthritis management guidelines. ◉

KEY POINTS

FINDINGS: Symptomatic individuals after anterior cruciate ligament (ACL) reconstruction with radiographic osteoarthritis (ROA) experienced worse knee-related quality of life (QoL) than did symptomatic individuals after ACL reconstruction without ROA. Health-related QoL was impaired to a similar degree in people with knee symptoms compared to an asymptomatic group after ACL reconstruction. Specific aspects of QoL that were more impaired in symptomatic people with ROA included sport and exercise limitations, reduced enjoyment of life, family-related activity limitations, and emotional troubles.

IMPLICATIONS: There may be value in diagnosing osteoarthritis in symptomatic individuals after ACL reconstruction, as these individuals may require different management than symptomatic individuals after ACL reconstruction without osteoarthritis. Current osteoarthritis treatment recommendations may not address all aspects of importance to symptomatic individuals after ACL reconstruction with osteoarthritis. Personalized strategies to increase participation in preferred forms of exercise and enhance knee confidence may have potential to improve longer-term QoL in symptomatic people with osteoarthritis following ACL reconstruction.

CAUTION: The Anterior Cruciate Ligament Quality of Life instrument was designed to address aspects of QoL relevant for people with ACL injury and knee difficulties; as such, the instrument may not address all aspects of QoL relevant to individuals following ACL reconstruction with longer-term knee difficulties. The cross-sectional design only allowed us to examine associations rather than causal inferences.

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APPENDIX

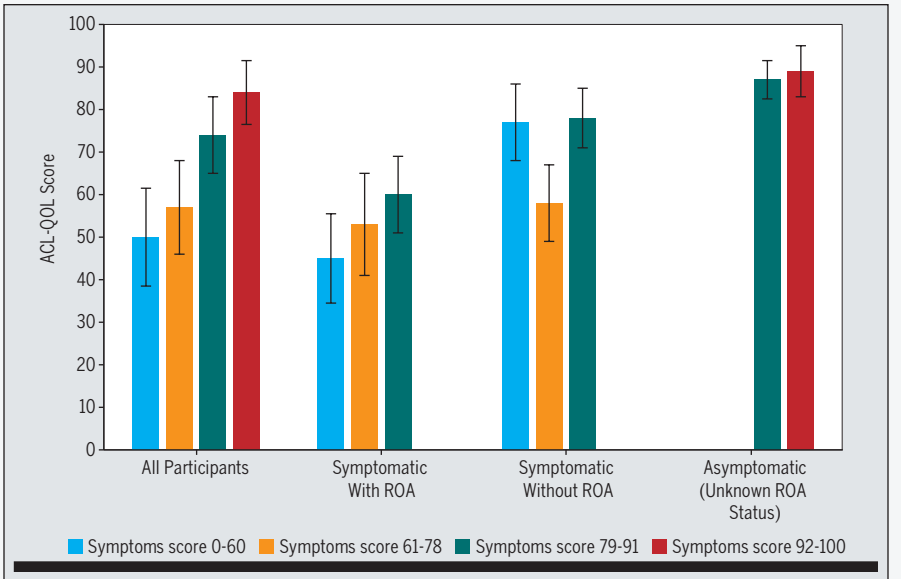

FIGURE 1. ACL-QoL mean scores stratified by KOOS symptoms subscale quartiles. Error bars represent standard deviations. Quartiles were determined according to the distribution of KOOS symptoms subscale scores for all participants. The ACL-QoL and KOOS symptoms subscale are scored from 0 (worst) to 100 (best). Abbreviations: ACL-QoL, Anterior Cruciate Ligament Quality of Life questionnaire; KOOS, Knee injury and Osteoarthritis Outcome Score; ROA, radiographic osteoarthritis.

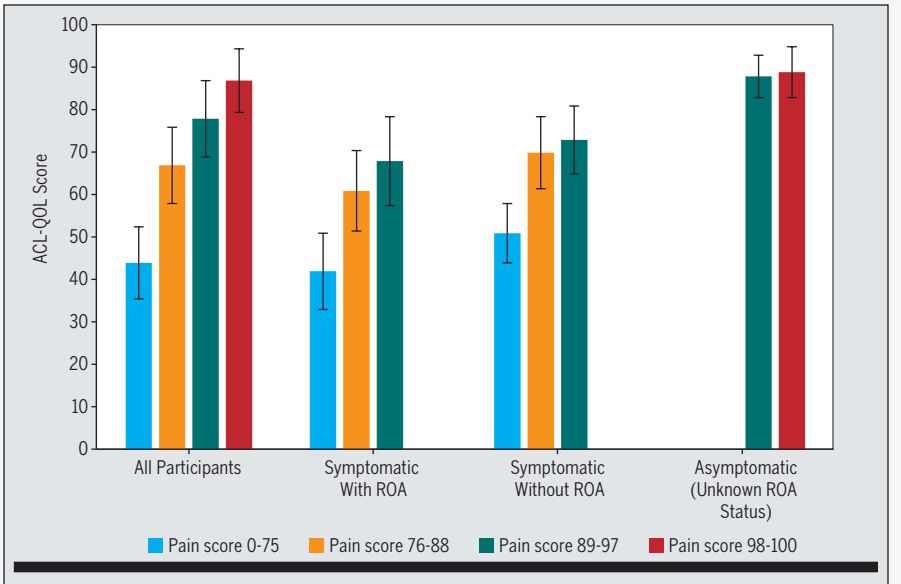

FIGURE 2. ACL-QoL mean scores stratified by KOOS pain subscale quartiles. Error bars represent standard deviations. Quartiles were determined according to the distribution of KOOS pain subscale scores for all participants. The ACL-QoL and KOOS pain subscale are scored from 0 (worst) to 100 (best). Abbreviations: ACL-QoL, Anterior Cruciate Ligament Quality of Life questionnaire; KOOS, Knee injury and Osteoarthritis Outcome Score; ROA, radiographic osteoarthritis.

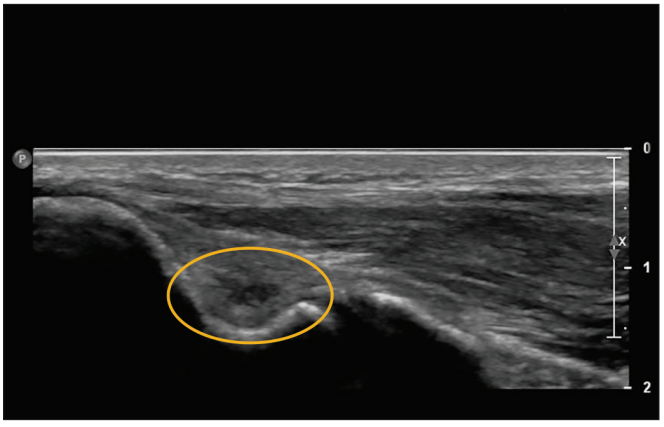

FIGURE 1. Diagnostic ultrasound: long-axis view of the left medial elbow demonstrating a hypoechoic area (orange circle) along the undersurface (deep fibers) of the ulnar collateral ligament, concerning for partial-thickness tearing.

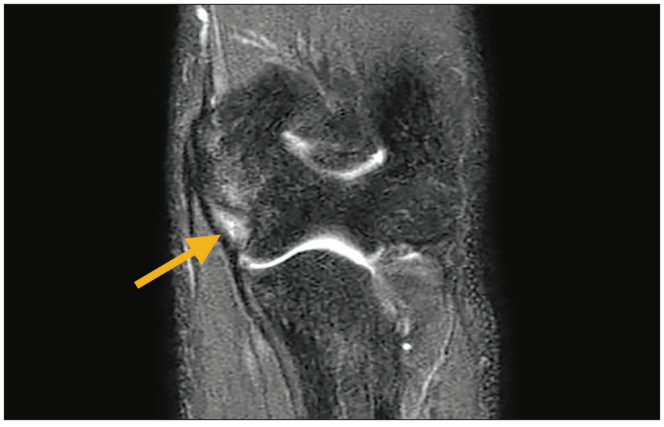

FIGURE 2. Fat-saturated, T2-weighted, coronal magnetic resonance image of the left elbow showing ulnar collateral ligament sprain/inflammation and reactive marrow edema (arrow) along the incompletely fused medial apophysis.

Refractory Ulnar Nerve Symptoms in an Adolescent Pitcher With Medial Apophysitis

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A 16-year-old high school baseball pitcher with a 3-week history of acute-onset pain in his medial elbow during throwing presented to physical therapy. The patient denied having symptoms of paresthesia. Examination revealed a 5° loss of elbow extension, normal grip strength, positive valgus stress test, and positive Tinel sign over the cubital tunnel. Physical therapy was initiated and the patient was referred for imaging, with suspicion of ulnar collateral ligament (UCL) injury.

Radiographs were noncontributory. Ultrasound imaging, however, was performed by a physiatrist and was suggestive of a partial-thickness tear of the UCL (**FIGURE 1**) and ulnar nerve enlargement. The physiatrist ordered magnetic resonance imaging (MRI) to more accurately delineate the potential extent of the UCL injury. The MRI confirmed a medial apophyseal stress reaction, commonly known as Little League elbow, a mild UCL sprain, and reactive ulnar nerve edema (**FIGURE 2**) (**FIGURE 3**, available at www.jospt.org). A physical therapy intervention designed to address medial elbow stability with ulnar nerve mobility and protection guidelines was prescribed. A return-to-throw program was also initiated. After 6 weeks, the patient resumed pitching from 18.3 m (60 ft) without pain, but experienced intermittent ulnar nerve paresthesia during activities of daily living. The patient was referred for repeat diagnostic ultrasound to assess for focal nerve entrapment, subluxating/dislocating ulnar nerve, and snapping triceps in the absence of functional elbow instability.

Follow-up ultrasound (**FIGURE 4**, available at www.jospt.org) revealed ulnar nerve enlargement at the medial epicondyle consistent with ulnar neuritis.[2] Iontophoresis with dexamethasone was added to the treatment plan to address nerve edema.[1]

The patient's symptoms fully resolved after 5 treatments over 2 weeks, which included iontophoresis and exercise. Ulnar neuritis is difficult to diagnose solely on clinical grounds.[2] Continued neurogenic symptoms warranted further imaging. Diagnostic ultrasound is a cost-effective, dynamic, and valid approach to assess ulnar neuritis and supported an alteration in treatment and subsequent resolution of symptoms.[2] *J Orthop Sports Phys Ther 2018;48(5):419. doi:10.2519/jospt.2018.7359*

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Assessing Outcomes in People With Chronic Ankle Instability: The Ability of Functional Performance Tests to Measure Deficits in Physical Function and Perceived Instability

STUDY DESIGN: Laboratory-based, cross-sectional study.

BACKGROUND: Functional performance tests (FPTs) assess short bouts of unilateral hops for either distance or speed. More research is needed to identify specific FPTs that may be useful for measuring asymmetry outcomes related to functional performance and perceived instability deficits in individuals with chronic ankle instability (CAI).

OBJECTIVES: To identify FPTs that are sensitive to subjective and objective deficits associated with CAI.

METHODS: Twenty-four subjects with unilateral CAI (10 male, 14 female; mean ± SD age, 20.7 ± 3.0 years) and 24 healthy, matched controls (10 male, 14 female; age, 20.1 ± 2.6 years) completed 5 unilateral FPTs in random order. Mean FPT scores and functional symmetry percentages were calculated and compared between groups using 2 separate 1-way multivariate analyses of variance (MANOVAs). Perceived instability symmetry percentages were compared between groups using a Mann-Whitney *U* analysis.

RESULTS: There were no differences in the mean FPT scores (P>.05) or functional symmetry percentages (P>.05) between groups for any of the 5 FPTs. However, participants with CAI perceived greater instability when using their involved limb during the side hop (P = .02), 6-meter crossover hop (P = .003), lateral hop (P = .007), and figure-of-eight hop (P = .008).

CONCLUSION: There were no differences in mean functional scores between groups for all 5 FPTs, and each group performed symmetrically. Regardless, administering a visual analog scale following the completion of the side hop, 6-meter crossover hop, lateral hop, and figure-of-eight hop tests captures subjective reports of perceived instability in the involved limb that can be compared bilaterally throughout treatment. *J Orthop Sports Phys Ther 2018;48(5):372-380. Epub 30 Mar 2018. doi:10.2519/jospt.2018.7514*

KEY WORDS: *limb symmetry, outcomes, return to play*

Acute lateral ankle sprain has been documented as the most common musculoskeletal injury in physically active individuals,[50] with an incidence rate of 2.15 per 1000 person-years in the United States.[45] Research suggests that individuals who sustain an ankle sprain are more susceptible to reinjury, which can result in a cascade of long-term issues.[39] Chronic ankle instability (CAI) is a term used clinically to define patients who experience prolonged functional deficits and subjective reports of instability following an acute ankle sprain. Over time, patients with CAI can show a reduction in physical activity, decreased health-related quality of life, and increased risk of developing ankle osteoarthritis compared to healthy individuals.[3,33]

Finding an effective means of minimizing the long-term sequelae of CAI remains a paramount issue in the field of sports medicine. Recent efforts have been made to establish rehabilitation protocols specific to CAI patient populations to help prevent repetitive injury and diminish long-term deficits.[10,12,13,19,20,28,32,34,42,46,47] The ultimate goal in developing these rehabilitation programs is to reduce both subjective and objective deficits associated with CAI. Subjectively, individuals with CAI typically report ongoing symptoms of "giving way," or a temporary uncontrollable sensation of instability in the affected ankle.[7,23,26] Objectively, patients with CAI experience a decrease in strength and range of motion, impaired functional performance, compromised proprioception, and poor neuromuscular control.[5,8,9,36,43]

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Although researchers and clinicians tend to agree on the target symptoms of CAI, there are large discrepancies between the outcome measures used to evaluate the success of rehabilitation programs. A detailed review of previous literature found 19 separate dependent variables that researchers have implemented to evaluate the success of the rehabilitation protocols. Such variables include laboratory-based measures (eg, center of pressure,[20] time to stabilization,[42] strength via an isokinetic dynamometer,[28] electromyography amplitude[12]), clinical measures (eg, Balance Error Scoring System [BESS],[19] Star Excursion Balance Test [SEBT],[19,20,34] strength via a handheld dynamometer[10]), and self-reported questionnaires with corresponding sport subscales (eg, Foot and Ankle Disability Index,[19,20,34] Foot and Ankle Ability Measure[13,32,47]). While many of these dependent variables are used to measure improvements in balance and self-reported function, not a single outcome measure has been implemented to assess improvement in patients' perceived instability over the course of a rehabilitation protocol. This seems surprising, given that symptoms of perceived instability during functional activity are used to detect the presence of CAI in the first place.[17] Perhaps previous studies have failed to report perceived-instability outcomes because research has yet to identify an effective means of capturing such information in patients with CAI in a controlled environment.

Functional performance tests (FPTs) offer a potential opportunity to assess perceived instability. Traditionally, FPTs have been used to assess patients' ability to complete short bouts of single-leg hopping tasks for either distance or speed.[29] When the patient completes these hopping tests bilaterally, the results of each extremity can be compared to determine whether asymmetry exists between the injured and uninjured limbs.[29,38] Over the past few years, CAI research appears to have moved away from implementing FPTs to measure CAI treatment outcomes, due to inconsistent research findings. The majority of past research has found that single-limb hop tests lack sensitivity to detect lower extremity deficits in subjects with a history of ankle sprains,[8,36,49] while other studies found that individuals with CAI perform significantly worse on FPTs with the affected limb compared to the uninvolved limb and compared to healthy control subjects.[5]

Despite the conflicting evidence surrounding the validity of functional outcomes obtained from FPTs, functional tasks present an opportunity for clinicians and researchers to measure perceived instability. To our knowledge, only 2 studies have evaluated symptoms of instability in subjects with CAI using unilateral hop tests.[4,5] These studies found that individuals with CAI who answered yes to the question, "Did you feel unstable during the test?" demonstrated worse performance on these tests than individuals with CAI who responded no.[4,5] Unfortunately, asking a simple yes/no question following a particular hopping task provides little help for clinicians looking to monitor fluctuations in symptoms over the course of rehabilitation. Patient-reported outcome instruments, such as the visual analog scale (VAS), allow patients to rate their perceived instability on a scale from 0 to 100, which provides a visual aid of how a chosen intervention might have altered subjective symptoms over time.[44] After performing the hop test on 1 limb, the patient can complete a VAS, and, similar to any functional outcome such as distance or speed, the perceived instability ratings can be compared bilaterally to determine whether asymmetry exists.

Surprisingly, there has been no research to identify specific FPTs that can detect asymmetries in both functional performance and perceived instability among individuals with CAI. The purpose of this study was to find FPTs that (1) can differentiate individuals with unilateral CAI from healthy control subjects based on functional performance outcomes, and (2) can accurately identify functional and perceived instability asymmetries in subjects with unilateral CAI. Given the results from previous studies, we hypothesized that the involved limb of those with unilateral CAI would perform symmetrically with the uninvolved limb and would perform similarly to the dominant limb of healthy control subjects. However, despite the functional similarities, we hypothesized that the FPTs would identify asymmetries in perceived instability between the involved and uninvolved limbs of individuals with CAI, making FPTs a potential assessment technique for measuring improvements following rehabilitation interventions.

METHODS

Participants

Twenty-four healthy control subjects (10 male, 14 female; mean ± SD age, 20.1 ± 2.6 years; height, 171.5 ± 9.2 cm; weight, 69.1 ± 12.0 kg) and 24 subjects with unilateral CAI (10 male, 14 female; age, 20.7 ± 3.0 years; height, 168.1 ± 8.0 cm; weight, 65.2 ± 11.2 kg) were recruited from a large Midwest university by posting advertisements around campus. The participants in the control group were matched to those with CAI according to sex, height (±10 cm), mass (±10 kg), and limb length (±8 cm). All subjects were physically active and participated in at least 120 minutes of exercise per week at moderate intensity. Subjects were included in the CAI group if (1) 1 limb scored an 11 or greater on the Identification of Functional Ankle Instability questionnaire, (2) the contralateral limb had no history of instability or giving way, and (3) the subject's last ankle sprain occurred more than 3 months prior to enrollment. Subjects were included in the control group if they had no history of ankle sprains or ankle instability. Subjects were excluded if they had a history of displaced fractures or lower extremity surgeries, a neuromuscular disease such as multiple sclerosis or Parkinson's disease, answered yes to 1 of the questions on the Physical Activity Readiness Questionnaire, as recommended by the

American College of Sports Medicine,[1] or were unable to perform the functional tests. All procedures were approved by the university's Institutional Review Board for the Protection of Human Subjects. All participants consented prior to starting the study, and the rights of the subjects were protected.

Procedures

Functional Performance Subjects completed a 5-minute bike warm-up and additional stretching if needed, followed by 5 unilateral hopping tests (the FPTs). Three of the tests were completed for speed and measured in seconds (side hop, 6-meter crossover hop, figure-of-eight hop), while the other 2 tests were completed for distance and measured in centimeters (triple crossover hop and lateral hop). All subjects were allowed 1 to 4 practice trials before completing 3 successful trials for each FPT. If an error occurred, then the subject was notified and instructed to attempt the trial again. An error included losing balance, placing the contralateral limb down, hitting a line or a cone used to outline the FPT, or not landing on the test leg. The number of failed trials was recorded for each test. For the timed tests, an electronic timer (Speed Trap 2; Brower Timing Systems, Draper, UT) captured the data, while a standard tape measure captured the data for distance hopping tests. The order for each test and limb was counterbalanced at random for all participants.

Timed FPTs For the side hop test, subjects hopped on the test limb laterally over a 30-cm distance and back 10 times, as fast as possible (**FIGURE 1A**). For the 6-meter crossover hop, subjects hopped a distance of 6 m as quickly as possible, crossing diagonally over a 15-cm-wide line with each hop (**FIGURE 1B**). For the figure-of-eight hop test, subjects hopped in a figure-of-eight fashion around 2 cones placed 5 m apart, 2 consecutive times (**FIGURE 1C**). All timed FPTs were determined to have good to excellent reliability (intraclass correlation coefficient [$ICC_{2,1}$] = 0.84-0.96).[5]

Distance FPTs The triple crossover hop test for distance was performed using the same 15-cm-wide line that was used for the 6-meter crossover hop test; however, instead of crossing over the line for speed, the subjects hopped 3 times as far as possible, crossing the 15-cm-wide line with each hop (**FIGURE 1D**). For the lateral test for distance (**FIGURE 1E**), subjects hopped laterally 3 times as far as possible. All distance FPTs were determined to have excellent reliability ($ICC_{2,1}$ = 0.93-0.96).[31,41]

Perceived Ankle Instability Perceived ankle instability was measured using a 0-to-100 VAS. Subjects were asked, "How unstable did your ankle feel during the test?" Stability was defined as the ability to perform the FPT without feeling concern/fear of injury to the ankle. A higher value indicated more instability while performing the test. The VAS was completed following 3 successful trials for each FPT and limb.

Data Processing

First, mean functional performance scores were calculated for each FPT and limb, using scores from 3 successful trials. Second, symmetry values were calculated to assess (1) physical function symmetry and (2) perceived instability symmetry. The equations used to calculate symmetry values are described below.

Physical Function Symmetry Values Physical function symmetry values for each FPT were calculated using mean scores from 3 trials. We used the equation (nondominant limb/dominant limb) × 100 to calculate physical function symmetry for the control group. The definition of limb dominance was the leg the subject would use to kick a soccer ball. We used the equation (involved limb/uninvolved limb) × 100 to calculate physical function symmetry for the CAI group. For timed FPTs, a final symmetry value greater than 100% indicated that the involved or nondominant side performed worse, while a symmetry value less than 100% indicated that the involved or nondominant limb performed better. For distance FPTs, a final symmetry value greater than 100% indicated that the involved or nondominant side performed better, while a symmetry value less than 100% indicated

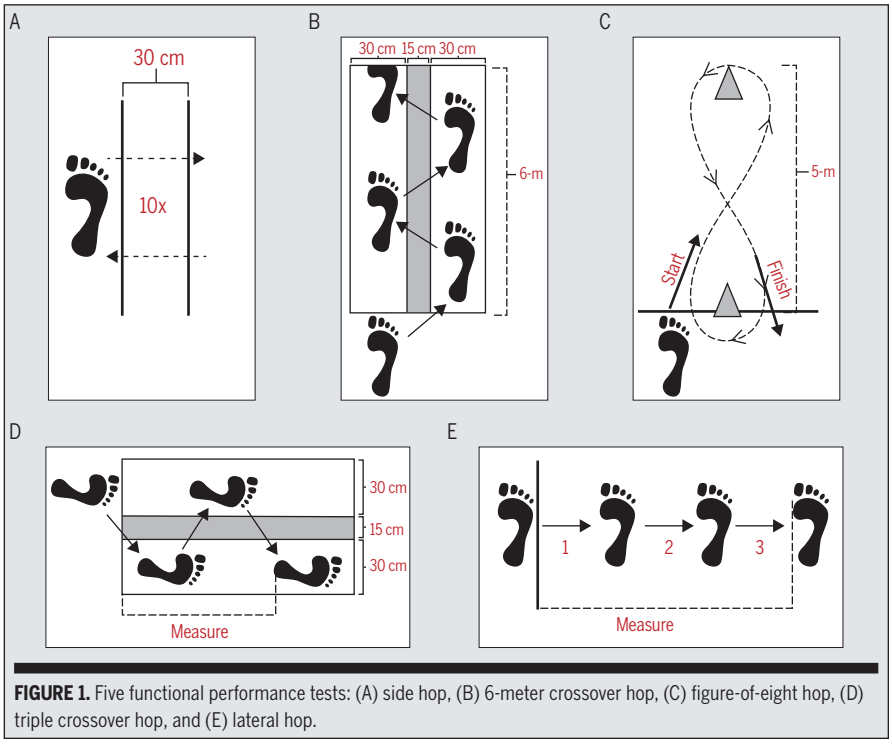

FIGURE 1. Five functional performance tests: (A) side hop, (B) 6-meter crossover hop, (C) figure-of-eight hop, (D) triple crossover hop, and (E) lateral hop.

that the involved or nondominant limb performed worse.

Perceived Instability Symmetry Values Using VAS instability scores, perceived instability symmetry values for each FPT were calculated as VAS nondominant limb – VAS dominant limb for the control group and VAS involved limb – VAS uninvolved limb for the CAI group. A score of zero reflected equal perceived instability between the limbs, a negative value indicated more instability in the uninvolved or dominant side, and a positive value indicated more instability in the nondominant or involved side.

Statistical Analysis

To estimate the appropriate sample size, we conducted a power analysis before the study. An alpha level of $P = .05$ was set a priori, and power was set at 80%. The effect size was estimated at 0.43, which was calculated based on previous VAS and functional performance literature.[5,21] Results of a power analysis in G*Power (Version 3.0.10; Heinrich-Heine Universität, Düsseldorf, Germany) indicated that 23 participants per group would provide sufficient power.

Functional Performance Two separate 1-way multivariate analyses of variance (MANOVAs) were completed to compare physical function between the CAI and control groups for all 5 FPTs. The first MANOVA was performed to identify statistical differences in mean performance scores between the dominant limb in the control group and the involved limb in the CAI group. The second MANOVA compared physical function symmetry values (percent) between the CAI group and the control group. Frequencies were also calculated for the number or failed trials while performing each test. Prior to performing the 2 MANOVAs, the physical function data were evaluated to ensure that all assumptions were met. First, we inspected box plots and found no evidence of univariate outliers, and there were no multivariate outliers in the data according to our calculated Mahalanobis distance values ($P>.001$). Second, normality was confirmed, based on the results from Shapiro-Wilk tests ($P>.05$) and z scores calculated from skewness and kurtosis values (z score, ±2.58). Third, an absence of multicollinearity was determined by performing Pearson correlations, which found that the dependent variables were moderately correlated but did not exceed 0.80. Fourth, there was a linear relationship between each FPT for both the CAI and control groups, as assessed by scatter plots. Finally, Box's M test of equality of covariance matrices indicated homogeneity of variance-covariance matrices for the performance scores ($P = .045$) and the functional symmetry percentages ($P = .013$).

Perceived Instability Visual analog scale instability symmetry values were not normally distributed and warranted a nonparametric statistical analysis. Therefore, 5 separate Mann-Whitney U tests were run to determine whether there were differences in perceived instability symmetry between the CAI group and control group. All statistical analyses were conducted using IBM SPSS Version 24 (IBM Corporation, Armonk, NY), and an a priori alpha level was set at $P<.05$.

RESULTS

On average, both healthy and CAI groups reported participating in 180 to 239 minutes of weekly exercise, at an average intensity of 6 on a Likert scale of 0 to 10 (0 indicating "sedentary" and 10 indicating "very high intensity"). All subjects in the CAI group were right limb dominant, and only 2 of the healthy subjects were left limb dominant. The CAI group had an average Identification of Functional Ankle Instability questionnaire score of 17.9 ± 4.5 for the involved limb. The involved limb was on the dominant side for 23 of the 24 subjects with CAI.

Functional Performance

The results of the first 1-way MANOVA found no significant difference in mean performance scores between the dominant limb of the control group and the involved limb of the CAI group (Wilks' $\lambda = .90$, $F_{5,42} = 0.93$, $P = .48$, partial $\eta^2 = 0.10$) (**FIGURE 2**). The results of the second 1-way MANOVA found no significant difference in physical function symmetry values between the control and CAI groups (Wilks' $\lambda = .81$, $F_{5,42} = 2.0$, $P = .10$, partial $\eta^2 = 0.19$). **TABLE 1** provides mean physical function symmetry values for each test and each group. **TABLE 2** shows a frequency chart whereby subjects are grouped according to the limb that failed more times for each FPT.

Perceived Instability Symmetry

Our results found that the control group perceived ankle instability more symmetrically between the dominant and nondominant limbs compared to the CAI group. The CAI group perceived

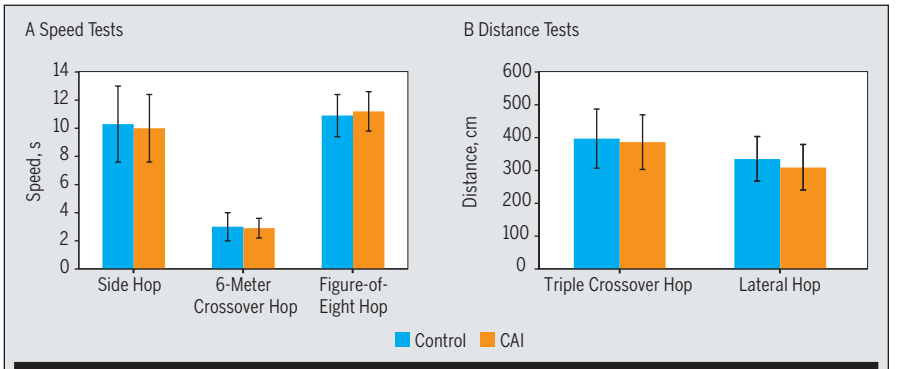

FIGURE 2. Mean functional performance outcomes between the control group's dominant limb and the CAI group's involved limb for all 5 functional performance tests. Error bars represent standard deviation values. Abbreviation: CAI, chronic ankle instability.

more instability in the involved limb when completing the side hop (U = 177.0, z = −2.3, P = .02), 6-meter crossover hop (U = 148.5, z = −2.9, P = .003), lateral hop (U = 162.5, z = −2.7, P = .007), and the figure-of-eight hop (U = 160.5, z = −2.7, P = .008). However, there was no difference in perceived instability symmetry for the triple crossover hop between groups (U = 204.5, z = −1.8, P = .07). **TABLE 3** shows the median VAS symmetry values and interquartile ranges for each group and test.

DISCUSSION

Our results indicate that subjects with unilateral CAI perceive significantly more instability (according to higher VAS scores) in their involved limb when performing the side hop, 6-meter crossover hop, figure-of-eight hop, and lateral hop tests. When interpreted alone, the instability outcomes presented here may seem intuitive. One might expect subjects with a history of giving way at the ankle to report instability when jumping and cutting on the involved limb. However, despite feeling unstable, our subjects with CAI produced similar physical function outcomes bilaterally and compared to healthy controls. These findings provide further justification that individuals with CAI may not experience functional deficits at all.[8,36,48] Instead, the long-term deficits of CAI may stem from subjective reports of instability and giving way. Patients with CAI feel unstable, are in constant fear of reinjury, and thus refrain from regular physical activity, resulting in a decreased health-related quality of life.[27]

While the cause of "feeling unstable" during functional activity remains speculative, researchers believe that sensorimotor control deficits contribute to symptoms of perceived instability.[24,30,37] Previous studies have found that subjects with CAI have diminished eversion force sense,[2] altered motoneuron pool excitability,[35] delayed reaction time of peroneal muscles,[15] and poor dynamic balance.[18] These past results imply that clinicians should begin treating sensorimotor deficits following acute ankle sprains, but the only way to accurately measure improvements of the aforementioned outcomes is via laboratory equipment such as force plates, electromyographic recordings, and nerve stimulators. Unfortunately, clinicians rarely have access to such equipment, making it impossible to measure certain sensorimotor deficits in a clinical environment.

Some studies have evaluated the effectiveness of noninstrumented techniques, including the BESS[11] and SEBT,[18,25] to identify deficits in static and dynamic postural control, respectively. These functional-assessment techniques are affordable to implement and have been shown to detect deficits in balance associated with poor sensorimotor control in subjects with CAI.[11,18] However, the SEBT and BESS do not mimic functional activities often performed during sport participation. Clinicians may implement treatment strategies to improve SEBT outcomes only to discover that subjective reports of instability continue to persist during physical activity. We propose that implementing FPTs to measure ankle instability and functional performance simultaneously saves time for the clinician and provides a more meaningful outcome for evaluating symptoms of CAI during sport-specific movements.

Functional Outcomes Using FPTs

Return-to-play protocols often encourage the use of FPTs to determine when an athlete is ready to participate in competitive sports without restrictions. Functional performance test outcomes (distance hopped or time to completion) of the involved limb are often compared to those of the uninvolved limb to determine whether unilateral deficits persist. According to current guidelines, return to play following acute lower extremity injuries should be granted only if the pa-

TABLE 1 Physical Function Symmetry Values for 5 Functional Performance Tests

Test/Group	Symmetry Value*
Side hop†	
Control	93.0 ± 16.0 (87.3, 98.8)
CAI	101.9 ± 11.4 (96.1, 107.6)
6-meter crossover hop†	
Control	99.7 ± 8.2 (96.2, 103.3)
CAI	100.2 ± 9.1 (96.6, 103.7)
Figure-of-eight hop†	
Control	101.0 ± 4.6 (98.9, 103.1)
CAI	100.8 ± 5.5 (98.4, 102.6)
Triple crossover hop‡	
Control	104.3 ± 14.5 (99.5, 109.1)
CAI	100.4 ± 8.0 (95.6, 105.2)
Lateral hop‡	
Control	99.7 ± 6.8 (96.5, 103.7)
CAI	99.2 ± 8.3 (96.1, 102.3)

Abbreviation: CAI, chronic ankle instability.
**Values are mean ± SD percent (95% confidence interval). A mean symmetry value of 100% indicates that both limbs performed identically.*
†Timed functional performance tests: a mean symmetry value greater than 100% indicates that the involved or nondominant limb performed worse. A mean symmetry value less than 100% indicates that the involved or nondominant limb performed better.
‡Distance functional performance tests: a mean symmetry value greater than 100% indicates that the involved or nondominant limb performed better. A mean symmetry value less than 100% indicates that the involved or nondominant limb performed worse.

tient reports no pain,[40] exhibits normal joint kinematics,[22] and the performance of the injured limb during hopping tasks is at least 80% that of the healthy limb.[6,16,29] However, these guidelines were established according to expert opinion alone. Our results highlight the potential risk of granting full return to sport even when athletes appear to be functionally symmetrical.

Depending on the FPT used, healthy people may appear to have asymmetrical limb performance, due to limb dominance or training habits that strengthen one side of the body. On average, the healthy control group completed the side hop test 7% faster using the nondominant limb and jumped 4% farther on the triple crossover hop using the nondominant limb. The CAI group displayed, at most, 2% asymmetry between limbs for all 5 FPTs. These side-by-side symmetry results raise questions about whether asymmetrical limb performance on any single hop test technique should be considered a standard return-to-play outcome. Perhaps the sensorimotor control deficits experienced by individuals with CAI cause more symmetrical physical function outcomes rather than obvious bilateral differences. Future research should obtain normative symmetry values from a variety of different physically active cohorts to determine normal physical function symmetry outcomes for each FPT. These normative values could then be used for comparison purposes during return-to-play decisions.

Instability Outcomes Using FPTs

To our knowledge, the present study is the first to implement a VAS to measure subjective reports of perceived instability following completion of FPTs. One previous study[14] administered a VAS to subjects with CAI to evaluate how "difficult" the test was to complete. We consider the assessment of "difficulty" associated with the performance of a task to be subjective and to provide little insight to help evaluate the severity of instability symptoms or to monitor

TABLE 2 Frequency Chart Showing the Distribution of Failed Tests Between Limbs for the CAI and Control Subjects*

Test/Group	−4	−3	−2	−1	0	+1	+2	+3	+4
Figure-of-eight hop									
Control	0	0	0	0	24	0	0	0	0
CAI	0	0	0	2	21	1	0	0	0
Lateral hop									
Control	1	1	0	4	13	3	1	0	1
CAI	0	1	1	1	18	1	0	0	2
6-meter crossover hop									
Control	0	0	1	4	14	3	1	1	0
CAI	0	0	3	6	12	1	1	0	1
Triple crossover hop									
Control	1	0	2	4	12	3	0	1	1
CAI	0	1	3	5	9	4	2	0	0
Side hop									
Control	0	0	0	4	15	4	1	0	0
CAI	0	0	0	3	16	4	1	0	0

Abbreviation: CAI, chronic ankle instability.
**Values are n. Subjects in the 0 column failed an equal number of times bilaterally over the course of 3 trials. A negative value indicates that the subject failed that many times using the uninvolved or dominant side, while a positive value means that the subject failed that many times using the nondominant or involved side. According to this frequency chart, the majority of subjects failed an equal number of times bilaterally for all 5 functional performance tests.*

TABLE 3 Instability Symmetry Values for 5 Functional Performance Tests

Test/Group	Median VAS Symmetry Value*	Interquartile Range	Mann-Whitney *U*	*P* Value
Side hop			177.0	.020
Control	0.0	3.0		
CAI	15.5	34.0		
6-meter crossover hop			148.5	.003
Control	0.0	2.0		
CAI	10.0	28.0		
Figure-of-eight hop			160.5	.008
Control	0.0	3.0		
CAI	9.0	28.0		
Triple crossover hop			204.5	.077
Control	0.0	1.0		
CAI	4.5	30.0		
Lateral hop			162.5	.007
Control	0.0	0.0		
CAI	5.0	24.0		

Abbreviations: CAI, chronic ankle instability; VAS, visual analog scale.
**Any VAS instability score lower than zero indicates more instability for the uninvolved or dominant side, and scores greater than zero indicate more instability for the nondominant or involved side.*

improvements in physical impairments. Using a VAS, we found that subjects with CAI reported significantly higher levels of instability in the involved limb, despite demonstrating similar functional outcomes bilaterally. This result highlights the consequence of neglecting patient-reported outcomes when deciding when to return an athlete to competition. In the short term, athletes recovering from an acute ankle sprain injury may appear to have functionally symmetrical limb performance, but remain fearful of reinjury due to perceived instability, likely caused by an irregular and unpredictable motor error. Accordingly, FPTs may be used to safely exacerbate feelings of ankle instability in a clinical setting. Similar to performance measures, subjective reports of instability during functional activity can be compared bilaterally to identify the presence of sensorimotor deficits in the involved limb.

Among the 4 tests that produced significant instability asymmetry among subjects with CAI, the median difference in VAS scores between the involved and uninvolved limbs was relatively low. An important distinction of these results is that the VAS values presented in this paper represent a comparison between limbs. In many instances, the subjects with CAI reported feelings of instability in their uninvolved limb as well as their involved limb, which may indicate deficient motor control mechanisms occurring within the central nervous system rather than damaged peripheral mechanoreceptors of the injured limb alone.[24] Repetitive injury to one limb alters the central processing of motor control and causes problems on both sides of the body.[37]

The triple crossover hop was the only test in which the CAI group did not perceive significantly higher feelings of instability in the involved limb. However, the triple crossover hop test caused the greatest number of subjects with CAI to report feelings of instability bilaterally. More specifically, 17 of the 24 subjects with CAI reported some level of instability when using the uninvolved limb to complete the triple crossover hop. While the triple crossover hop test caused feelings of instability in the subjects with CAI, the symmetry values were not significant, due to possible sensorimotor deficits occurring bilaterally. Given these results, we recommend that clinicians take into account feelings of instability in both limbs and apply interventions bilaterally to address these deficits.

Limitations

This study had limitations. First, some subjects might have suffered from fatigue during the functional assessment because the tests were performed in a single testing session. To avoid fatigue, we implemented strategies consistent with previous FPT research,[5,9,48] such as requiring a mandatory 30-second rest between trials, encouraging participants to take as many breaks as needed, and counterbalancing the order of the tests. Second, the psychometric properties of the VAS assessment have yet to be established for measuring perceived instability at the ankle. Future research should evaluate the reliability and responsiveness of the VAS as clinicians monitor perceived instability over the course of rehabilitation. Third, our study did not discriminate against the type of physical activity frequently performed by both control subjects and those with CAI. Future research would do well to match the control and CAI groups according to whether the subjects frequently participate in proprioceptive exercises that may mimic the skills required to complete the FPTs.

CONCLUSION

Our results indicate that subjects with CAI experience significant feelings of instability when performing unilateral hopping tests, even if the involved limb appears functionally normal. This finding is of considerable importance for clinicians who treat patients with a history of recurrent ankle sprains. Determining the success of rehabilitation protocols by evaluating functional improvements alone may prove insufficient. Instead, clinicians should consider implementing a VAS upon completion of the side hop, 6-meter crossover hop, figure-of-eight hop, and lateral hop tests to determine whether symptoms of perceived instability persist. In doing so, specific interventions aimed at improving subjective reports of instability can be prescribed in a timely manner in an effort to prevent chronic deficits at the ankle. ◉

KEY POINTS

FINDINGS: Participants with unilateral chronic ankle instability experienced greater feelings of instability in the involved limb while performing unilateral hopping tests, despite the lack of functional deficits.

IMPLICATIONS: Clinicians should consider administering a visual analog scale following functional performance testing to measure perceptions of instability in patients with a history of ankle sprains.

CAUTION: Results should be interpreted with caution due to the lack of generalizability of our patient population.

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Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy Revision 2018

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Orthopaedic Section of the American Physical Therapy Association

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Summary of Recommendations*

DIAGNOSIS/CLASSIFICATION

C In addition to the arc sign and Royal London Hospital test, clinicians can use a subjective report of pain located 2 to 6 cm proximal to the Achilles tendon insertion that began gradually and pain with palpation of the midportion of the tendon to diagnose midportion Achilles tendinopathy.

EXAMINATION – OUTCOME MEASURES: ACTIVITY LIMITATIONS/ SELF-REPORTED MEASURES

A Clinicians should use the Victorian Institute of Sport Assessment-Achilles (VISA-A) to assess pain and stiffness, and either the Foot and Ankle Ability Measure (FAAM) or the Lower Extremity Functional Scale (LEFS) to assess activity and participation in patients with a diagnosis of midportion Achilles tendinopathy.

EXAMINATION – ACTIVITY LIMITATIONS/PHYSICAL PERFORMANCE MEASURES

B Clinicians should use physical performance measures, including hop and heel-raise endurance tests, as appropriate, to assess a patient's functional status and document findings.

EXAMINATION – PHYSICAL IMPAIRMENT MEASURES

B When evaluating physical impairment over an episode of care for those with Achilles tendinopathy, one should measure ankle dorsiflexion range of motion, subtalar joint range of motion, plantar flexion strength and endurance, static arch height, forefoot alignment, and pain with palpation.

INTERVENTIONS – EXERCISE

A Clinicians should use mechanical loading, which can be either in the form of eccentric exercise, or a heavy-load, slow-speed (concentric/eccentric) exercise program, to decrease pain and improve function for patients with midportion Achilles tendinopathy without presumed frailty of the tendon structure.

F Patients should exercise at least twice weekly within their pain tolerance.

INTERVENTIONS – STRETCHING

C Clinicians may use stretching of the ankle plantar flexors with the knee flexed and extended to reduce pain and improve satisfaction with outcome in patients with midportion Achilles tendinopathy who exhibit limited ankle dorsiflexion range of motion.

INTERVENTIONS – NEUROMUSCULAR RE-EDUCATION

F Clinicians may use neuromuscular exercises targeting lower extremity impairments that may lead to abnormal kinetics and/or kinematics, specifically eccentric overload of the Achilles tendon during weight-bearing activities.

INTERVENTIONS – MANUAL THERAPY

F Clinicians may consider using joint mobilization to improve mobility and function and soft tissue mobilization to increase range of motion for patients with midportion Achilles tendinopathy.

INTERVENTIONS – PATIENT EDUCATION: ACTIVITY MODIFICATION

B For patients with nonacute midportion Achilles tendinopathy, clinicians should advise that complete rest is not indicated and that they should continue with their recreational activity within their pain tolerance while participating in rehabilitation.

INTERVENTIONS – PATIENT COUNSELING

E Clinicians may counsel patients with midportion Achilles tendinopathy. Key elements of patient counseling could include (1) theories supporting use of physical therapy and role of mechanical loading, (2) modifiable risk factors, including body mass index and shoewear, and (3) typical time course for recovery from symptoms.

INTERVENTIONS – HEEL LIFTS

D Because contradictory evidence exists, no recommendation can be made for the use of heel lifts in patients with midportion Achilles tendinopathy.

INTERVENTIONS – NIGHT SPLINTS

C Clinicians should not use night splints to improve symptoms in patients with midportion Achilles tendinopathy.

INTERVENTIONS – ORTHOSES

D Because contradictory evidence exists, no recommendation can be made for the use of orthoses in patients with midportion Achilles tendinopathy.

INTERVENTIONS – TAPING

F Clinicians should not use therapeutic elastic tape to reduce pain or improve functional performance in patients with midportion Achilles tendinopathy.

F Clinicians may use rigid taping to decrease strain on the Achilles tendon and/or alter foot posture in patients with midportion Achilles tendinopathy.

INTERVENTIONS – LOW-LEVEL LASER THERAPY

D Because contradictory evidence exists, no recommendation can be made for the use of low-level laser therapy in patients with midportion Achilles tendinopathy.

INTERVENTIONS – IONTOPHORESIS

B Clinicians should use iontophoresis with dexamethasone to decrease pain and improve function in patients with acute midportion Achilles tendinopathy.

INTERVENTIONS – DRY NEEDLING

F Clinicians may use combined therapy of dry needling with injection under ultrasound guidance and eccentric exercise to decrease pain for individuals with symptoms greater than 3 months and increased tendon thickness.

*These recommendations and clinical practice guidelines are based on the scientific literature published prior to November 2017.

List of Abbreviations

APTA: American Physical Therapy Association
BMI: body mass index
CI: confidence interval
CPG: clinical practice guideline
DECT: dual-energy computed tomography
ESWT: extracorporeal shockwave therapy
FAAM: Foot and Ankle Ability Measure
HVIGI: high-volume image-guided injection
ICD: International Classification of Diseases
ICF: International Classification of Functioning, Disability and Health
JOSPT: *Journal of Orthopaedic & Sports Physical Therapy*
LEFS: Lower Extremity Functional Scale
LLLT: low-level laser therapy
LOINC: Logical Observation Identifiers Names and Codes
MRI: magnetic resonance imaging
mRNA: messenger ribonucleic acid
MSU: monosodium urate
NPRS: numeric pain-rating scale
PRP: platelet-rich plasma
US: ultrasound
VAS: visual analog scale
VISA-A: Victorian Institute of Sport Assessment-Achilles

Introduction

AIM OF THE GUIDELINES

The Orthopaedic Section of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based clinical practice guidelines (CPGs) for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International Classification of Functioning, Disability and Health (ICF).

The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of the individual
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient, the available evidence, available diagnostic and treatment options, and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

Methods

Content experts with relevant physical therapy, medical, and surgical expertise were appointed by the Orthopaedic Section, APTA to conduct a review of the literature and to develop an updated Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy CPG as indicated by the current state of the evidence in the field. The aims of the revision were to provide a concise summary of the evidence since publication of the original guideline and to develop new recommendations or revise previously published recommendations to support evidence-based practice. The authors of this guideline revision worked with the CPG Editors and medical librarians for methodological guidance. The research librarians were chosen for their expertise in systematic review and rehabilitation literature search and to perform systematic searches for concepts associated with classification, examination, and intervention strategies for Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy.[22] Briefly, the following databases were searched from 2009 to November 2017: MEDLINE, CINAHL, Cochrane Library, and PEDro (see **APPENDIX A** for full search strategies and **APPENDIX B** for search dates and results, available at www.orthopt.org).

The authors declared relationships and developed a conflict management plan, which included submitting a Conflict of Interest form to the Orthopaedic Section, APTA, Inc. Articles that were authored by a reviewer were assigned to an alternate reviewer. Funding was provided to the CPG development team for travel and expenses for CPG development training by the Orthopaedic Section, APTA, Inc. The CPG development team maintained editorial independence.

Articles contributing to recommendations were reviewed based on specified inclusion and exclusion criteria with the goal of identifying evidence relevant to physical therapist clinical decision making for adults with Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy. The title and abstract of each article were reviewed independently by 2 members of the CPG development team for inclusion (see **APPENDIX C** for inclusion and exclusion criteria, available at www.orthopt.org). Full-text review was then similarly conducted to obtain the final set of articles for contribution to recommendations. The team leader (R.L.M.) provided the final decision for discrepancies that were not resolved by the review team (see **APPENDIX D** for flow chart of articles and **APPENDIX E** for articles included in recommendations by topic, available at www.orthopt.org). For selected relevant topics that were not appropriate for the development of recommendations, such as incidence and imaging, articles were not subject to a systematic review process and were not included in the flow chart. Evidence tables for this CPG are available on the Clinical Practice Guidelines page of the Orthopaedic Section of the APTA website: www.orthopt.org.

This guideline was issued in 2018 based on the published literature up through November 2017. This guideline will be considered for review in 2022, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Orthopaedic Section of the APTA website: www.orthopt.org.

LEVELS OF EVIDENCE

Individual clinical research articles were graded according to criteria adapted from the Centre for Evidence-Based Medicine, Oxford, United Kingdom for diagnostic, prospective, and therapeutic studies.[149] In teams of 2, each reviewer independently assigned a level of evidence and evaluated the quality of each article using a critical appraisal tool (see **APPENDICES F** and **G** for Levels of Evidence table and details on procedures used for assigning levels of evidence, available at www.orthopt.org). The evidence update was organized from highest level of evidence to lowest level. An abbreviated version of the grading system is provided below.

I	Evidence obtained from systematic reviews, high-quality diagnostic studies, prospective studies, or randomized controlled trials
II	Evidence obtained from systematic reviews, lesser-quality diagnostic studies, prospective studies, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

GRADES OF EVIDENCE

The strength of the evidence supporting the recommendations was graded according to the previously established methods for the original guideline and those provided below. Each team developed recommendations based on the strength of evidence, including how directly the studies addressed the question of Achilles Pain, Stiffness, and Muscle Power Deficits: Midportion Achilles Tendinopathy. In developing their recommendations, the authors considered the strengths and limitations of the body of evidence and the health benefits, side effects, and risks of tests and interventions.

Methods *(continued)*

GRADES OF RECOMMENDATION		STRENGTH OF EVIDENCE
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies
E	Theoretical/ foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/ principles, or from basic science/bench research support this conclusion
F	Expert opinion	Best practice based on the clinical experience of the guidelines development team

GUIDELINE REVIEW PROCESS AND VALIDATION

Identified reviewers who are experts in Achilles tendinopathy management and rehabilitation reviewed the CPG draft for integrity, accuracy, and to ensure that it fully represented the current evidence for the condition. The guideline draft was also posted for public comment and review on www.orthopt.org, and a notification of this posting was sent to the members of the Orthopaedic Section, APTA, Inc. In addition, a panel of consumer/patient representatives and external stakeholders, such as claims reviewers, medical coding experts, academic educators, clinical educators, physician specialists, and researchers, also reviewed the guideline. All comments, suggestions, and feedback from the expert reviewers, public, and consumer/patient representatives were provided to the authors and editors for consideration and revisions. Guideline development methods, policies, and implementation processes are reviewed at least yearly by the Orthopaedic Section, APTA's ICF-Based Clinical Practice Guideline Advisory Panel, including consumer/patient representatives, external stakeholders, and experts in physical therapy practice guideline methodology.

DISSEMINATION AND IMPLEMENTATION TOOLS

In addition to publishing these guidelines in the *Journal of Orthopaedic & Sports Physical Therapy* (*JOSPT*), these guidelines will be posted on CPG areas of both the JOSPT and the Orthopaedic Section, APTA websites, which are free-access website areas, and submitted to be available free access on the Agency for Healthcare Research and Quality's website (www.guideline.gov). The implementation tools planned to be available for patients, clinicians, educators, payers, policy makers, and researchers, and the associated implementation strategies, are listed in **TABLE 1**.

TABLE 1 Planned Strategies and Tools to Support the Dissemination and Implementation of This Clinical Practice Guideline

Tool	Strategy
"Perspectives for Patients"	Patient-oriented guideline summary available on www.jospt.org and www.orthopt.org
Mobile app of guideline-based exercises for patients/clients and health care practitioners	Marketing and distribution of app using www.orthopt.org
Clinician's quick-reference guide	Summary of guideline recommendations available on www.orthopt.org
Read-for-credit continuing education units	Continuing education units available for physical therapists and athletic trainers through JOSPT
Educational webinars for health care practitioners	Guideline-based instruction available for practitioners on www.orthopt.org
Mobile and web-based app of guideline for training of health care practitioners	Marketing and distribution of app using www.orthopt.org
Physical Therapy National Outcomes Data Registry	Support the ongoing usage of data registry for common musculoskeletal conditions of the foot and ankle region
Logical Observation Identifiers Names and Codes mapping	Publication of minimal data sets and their corresponding Logical Observation Identifiers Names and Codes for the foot and ankle region on www.orthopt.org
Non-English versions of the guidelines and guideline implementation tools	Development and distribution of translated guidelines and tools to *JOSPT*'s international partners and global audience via www.jospt.org

Methods *(continued)*

CLASSIFICATION

The terminology used to describe Achilles tendon disorders varies, with "tendinitis," "tendonitis," or "paratenonitis" commonly being used and therefore suggestive of an inflammatory condition. Because inflammation and degeneration are usually not mutually exclusive,[99,111,119,150,152] "midportion Achilles tendinopathy" will be the focus of this clinical guideline unless otherwise stated.

The International Classification of Diseases (ICD-10) code associated with Achilles tendinopathy is **M76.6 Achilles tendinitis/Achilles bursitis**. The corresponding primary ICD-9-CM code, commonly used in the United States, is **726.71 Achilles bursitis or tendinitis**.

The primary ICF body function codes associated with Achilles tendinopathy are **b28015 Pain in lower limb, b7300 Power of isolated muscles and muscle groups**, and **b7800 Sensation of muscle stiffness**.

The primary ICF body structures codes associated with Achilles tendinopathy are **s75012 Muscles of lower leg** and **s75028 Structure of ankle and foot**, **specified as Achilles tendon**.

The primary ICF activities and participation codes associated with Achilles tendinopathy are **d4500 Walking short distances**, **d4501 Walking long distances**, **d4552 Running**, **d4553 Jumping**, and **d9201 Sports**.

A comprehensive list of codes was published in the previous guideline.[22]

ORGANIZATION OF THE GUIDELINE

For each topic, the summary recommendation and grade of evidence from the 2010 guideline are presented, followed by a synthesis of the recent literature with the corresponding evidence levels. Each topic concludes with the 2018 summary recommendation and its updated grade of evidence.

CLINICAL GUIDELINES

Impairment/Function-Based Diagnosis

PREVALENCE

2010 Summary

Disorders of the Achilles tendon rank among the most frequently reported overuse injuries in the literature.[30,116,128,130] The majority of those suffering from Achilles tendinopathy are active individuals, often involved in recreational or competitive sports.[114] Estimates of the annual incidence of Achilles tendinopathy in runners range between 7% and 9%.[101,114] However, cases have been reported in sedentary groups as well.[92,164] Although runners appear to be the most commonly affected cohort,[114,116,118,145] Achilles disorders have been reported in a wide variety of sports.[64,68,114,116,207] Athletes are more likely to become symptomatic when training as opposed to during competitive events.[101,207] While there is an increased prevalence of Achilles injury as age increases,[64,113] the mean age of those affected by Achilles disorders is between 30 and 50 years.[130,148,167] While sex has not been directly studied, data from multiple works suggest that males are affected to a greater extent than females.[116,145,167]

Evidence Update

I The prevalence of Achilles tendinopathy in elite male soccer players during 1 season ranged from 2.1% to 5.1%.[76]

I In a large prospective cohort of novice runners, 7% went on to develop Achilles tendinopathy.[140]

II A systematic review by Sobhani et al[183] found Achilles tendinopathy to be one of the most common overuse foot and ankle injuries in sports. In a separate systematic review, the reported prevalence of Achilles tendinopathy in the general running and ultramarathon populations ranged from 6.2% to 9.5% and 2.0% to 18.5%, respectively.[122]

II Achilles tendinopathy was diagnosed in 1.8% of adolescent athletes at a pre–sports participation annual health examination.[23]

II The incidence of Achilles tendinopathy was found to be 1.85 per 1000 patients[43] and 2.16 per 1000 person-years[3] in Dutch general practice populations.

II A review of more than 20 million patient records found that individuals between 40 and 59 years of age were most commonly diagnosed as having Achilles tendinopathy, with a significantly higher incidence than that seen in those between 20 and 39 and between 60 and 69 years of age. No difference in the incidence of Achilles tendinopathy was found between males and females.[211]

III Achilles tendinopathy was found to occur in 12.5% of rock climbers.[19]

2018 Summary

Midportion Achilles tendinopathy continues to be a relatively common overuse lower extremity soft tissue injury for individuals who are active and participate in sports.

PATHOANATOMICAL FEATURES

2018 Summary and Update

The major complaint of those with midportion Achilles tendinopathy is pain that limits activity. Pain is preceded by an excessive mechanical stressor, such as tensile loading and/or shearing, which initiates pathological changes in the tendon.[123,129] These pathological changes can include tenocyte proliferation with tendon thickening,[12,23,55] neovascularity,[44,151] collagen fibril thinning and disorganization,[129] increase of noncollagenic and fibrocartilage matrix,[20,47] fat deposition,[67,73,78,91] altered fluid movement,[84] and overproduction of nitric acid with tissue apoptosis.[146] Failure to control hyperthermia that results during exercise, as tendons convert some of the stored energy to heat, can also contribute by causing local cell death.[129] Tendon changes associated with the pathological process weaken the mechanical and material properties of the tendon. These changes lead to a decrease in tendon stiffness and strength,[8,9,83,84] ineffective force transfer,[28,96,141] thereby affecting central nervous system motor control.[25] This may provide a rationale for the use of mechanical loading to potentially increase tendon stiffness. Inflammation and degeneration are usually not mutually exclusive but can coexist to a varying extent throughout this process.[35,99,111,119,150,152]

The extent and/or severity of tendon abnormalities are not consistently related to the severity of clinical presen-

tation.[31,33,42,44,45,48,54,56,63,79,84] Also, presymptomatic tendon thickening has been documented,[31,100] and bilateral tendon changes have been found in those with unilateral symptoms.[56,84] The plantaris tendon may be involved in those with chronic Achilles tendinopathy.[21,129,142,154,185] The plantaris tendon and associated peritendinous nerve structures may cause impingement on the medial aspect of the thickened Achilles tendon, contributing to pain and activity limitations.[129,185,186]

Systematic reviews have identified genetic variants as important factors in the pathogenesis of tendinopathy.[37,129] An abnormal neuronal phenotype can disrupt normal tendon homeostasis and healing after injury.[37] The neuronal response to tendon injury involves nerve ingrowth, increased sensitivity to neuronal pain mediators, and receptor activation for these mediators.[15,29,37,82,100] Neuronal changes activate the nociceptive pathways to higher centers and are responsible for the perception of pain. Therefore, altered central nervous system pain processing may also be an important factor in persistent tendon pain.[38,89,98,182,195] However, a recent study found that those with Achilles tendinopathy did not display significant features of central sensitization.[153] Genetic variants, such as those associated with mRNA stability, can predispose individuals to abnormalities in collagen production.[2,46,62,75,88,155,171,173,179,180] This abnormal collagen may negatively affect the mechanical and material properties of the tendon, leading to ineffective force transfer.[46,61,155] The relationship between genotype, abnormal collagen, mechanical stress, and symptom presentation is multifactorial and not well understood.[11,72,156,163,172]

RISK FACTORS

2010 Summary

For specific groups of individuals, clinicians should consider abnormal ankle dorsiflexion range of motion, abnormal subtalar joint range of motion, decreased ankle plantar flexion strength, increased foot pronation, and abnormal tendon structure as intrinsic risk factors associated with Achilles tendinopathy. Obesity, hypertension, hyperlipidemia, and diabetes are medical conditions associated with Achilles tendinopathy. Clinicians should also consider training errors, environmental factors, and faulty equipment as extrinsic risk factors associated with Achilles tendinopathy.

Evidence Update

I A systematic review by Dowling et al[58] investigating dynamic foot function as a risk factor for lower-limb overuse injuries included only 1 study related to Achilles tendinopathy. This prospective study found altered posterior/anterior force displacement and an increase in laterally directed force distribution underneath the forefoot as risk factors for developing Achilles tendinopathy in runners who were noted to be "heel-strikers."[200] A prospective cohort study not included in this review found that runners who displayed more medial pressure during stance phase were at risk for injury.[18]

II Franceschi et al[69] identified obesity as a risk factor for developing tendinopathies in their systematic review.

II A systematic review by McAuliffe et al[134] found that tendon abnormalities visualized using ultrasound imaging in asymptomatic tendons were predictive of future tendinopathy. Specifically, in athletes, increased tendon thickness[100] and sonographic abnormalities (moderate or severe hypoechoic defects)[31] were identified as risk factors for the development of Achilles tendinopathy.

II A retrospective study investigated injuries in military recruits who were given either a rigid (n = 1416) or shock-absorbing (n = 1338) insole when issued combat boots. The recruits issued a shock-absorbing insole had a 50% reduction in Achilles tendinopathy rate, with an incidence of 4% compared to 8% with the rigid insoles.[93]

III A systematic review identified intrinsic risk factors for Achilles tendinopathy to include increasing age, male sex, increased body weight, poor tendon temperature regulation, presence of systemic diseases, decreased muscle strength, decreased flexibility, previous injuries, poor blood supply, and genetic variants.[129] One study in this review found those with a family history of tendinopathy to have 5 times the risk of developing Achilles tendinopathy.[110]

III Systematic reviews found that gene variants influenced the development of Achilles tendinopathy.[108,202] Specifically, genes associated with the collagen-production pathway may functionally affect tendon strength and stiffness, leading to an abnormal tendon response to loading. This was supported by other studies not included in this review.[75,157]

III A systematic review by Lorimer and Hume[123] found a posterior-directed center of force when landing, combined with reduced eccentric strength, as potential risk factors for Achilles injury, while having a high arch and generating high propulsion forces were found to be protective against injury.

III Reviews have noted limited evidence for hip muscle performance as risk factors when generally looking at leg, ankle, and foot injuries.[138,188] However, another review by Semciw et al[177] found neuromuscular deficits

in gluteus medius function in those with Achilles tendinopathy. A study not included in this review found weakness in the hip abductors, external rotators, and extensors bilaterally in recreational male athletes with chronic midportion Achilles tendinopathy.[86] Other studies have specifically identified neuromuscular deficits in the gluteus maximus,[70] rectus femoris,[214] tibialis anterior,[214] lateral gastrocnemius,[214] and triceps surae muscle complex[204]; altered hip, knee, and ankle moments[105]; altered hip biomechanics[34]; increased lower-limb stiffness[39]; balance deficits[175]; and abnormal lower extremity kinematics during dancing push-off maneuvers[115] as intrinsic risk factors.

III In a sample of 24 elite, female soccer players, a sport-specific proprioception training program performed over a 2.5-year duration decreased the rate of Achilles tendinopathy and days lost from play due to injury.[109]

III One study in the review by Franceschi et al[69] identified a potential interaction between age and obesity with degenerative tendon changes.[176] Those with dyslipidemia and fat deposition in the Achilles tendon may be at risk for developing tendon pain.[73] This finding is consistent with a systematic review that found that elevated adiposity was frequently associated with general tendon injuries.[74]

III A study of master track-and-field athletes did not find any influence of age, sex, weight, height, or participation in high- versus low-impact activities on the development of Achilles tendinopathy.[121] However, elderly individuals with diabetes who participated in sports were found to be at increased risk for Achilles tendinopathy.[1]

III The review by Magnan et al[129] also identified extrinsic factors in the development of Achilles tendinopathy to include environmental conditions, shoes, equipment, surfaces, and physical activity/sport participation. One study of professional ballet dancers noted overuse injuries to be more common in females and in more technically demanding ballet techniques.[184]

III Systematic reviews have specifically identified an increased risk of tendon injury with use of fluoroquinolone antibiotic therapy.[117,120,129,189]

IV A study included in above reviews found mitochondrial damage to tenocytes during fluoroquinolone treatment to be potentially involved in tendon pathology.[124]

2018 Summary

The risk of developing midportion Achilles tendinopathy is multifactorial and likely related to an interaction of intrinsic and extrinsic factors that lead to tendon overloading. The body's response to loading will be influenced by health conditions, drugs, and genetic factors. Consequently, many studies of eccentric loading have excluded patients with presumed tissue frailty (**TABLE 2**). While these conditions are believed to increase risk during eccentric activity, the interactions between physical loads and tendon symptoms are poorly understood for these patients. Clinicians should consider these risk factors in the patient's differential diagnosis.

TABLE 2 SUMMARY OF EXCLUSION CRITERIA FROM STUDIES OF ECCENTRIC EXERCISES DUE TO PRESUMED FRAILTY OF THE PLANTAR FLEXOR MECHANISM AND LOCAL AREA

Exclusion	Example
Surgery	Tendon rupture repair
Connective tissue diseases	
Systemic diseases/disorders	Rheumatic diseases, diabetes
Genetic diseases	Marfan's syndrome
Medications	Local steroid injection, systemic fluoroquinolones
Pregnancy	
Age	Youths and adolescents
Fracture	
Other local disease states	Peripheral vascular disease

An individual with any number of lower extremity impairments that lead to abnormal kinetics and/or kinematics that specifically produce an eccentric overload of the Achilles tendon may be at risk for Achilles tendon injury. The use of shock-absorbing insoles may help prevent midportion Achilles tendinopathy.

CLINICAL COURSE

2010 Summary

No summary.

Evidence Update

I In elite male soccer players, missed participation because of symptoms related to Achilles tendinopathy was relatively brief (median, 10 days; average, 23 days). However, recurrence rate was high (27%), with a greater risk of reinjury for players resting less than 10 days. In those with severe tendinopathies (more than 28 days lost), 38% required surgical intervention.[76]

I In a large prospective cohort of runners, the median time to recovery was 82 days (minimum, 21; maximum, 479).[140]

II The lack of uniformity in Achilles tendon structure on ultrasonography (hyperechogenicity/hypoechogenicity) is not a consistent predictor for outcome.[12,42]

II Sex may influence response to treatment with eccentric exercise, as females with Achilles tendinopathy perceived more pain and less of an improvement in function compared to males following 12 weeks of eccentric training.[107]

II Good long-term outcomes were noted in 4.2-year[79] and 5-year[199] follow-up studies of individuals who completed a 3-month heavy-load eccentric calf muscle training program. However, mild pain persisted in some individuals,[199] and there was considerable variability in treatment outcomes.[71,130,168]

III A study of National Basketball Association players found that there was an association between Achilles tendinopathy and a decline in performance, with younger players having a better chance of returning to competition.[6]

III Conflicting evidence related to body mass index (BMI) was identified. The systematic review by Franceschi et al[69] found that greater BMI played a role in the development of Achilles tendinopathy. However, a study in this review revealed that BMI did not influence response to nonsurgical treatment.[106]

IV A case series by Silbernagel et al[182] found that 80% (27/34) of participants who completed a 12-week to 6-month progressive Achilles tendon–loading strengthening program were fully recovered at 5-year follow-up.

2018 Summary

In athletes with midportion Achilles tendinopathy, missed participation can be expected to be brief. However, a decline in performance may occur in older athletes, and symptoms may return if not properly treated immediately after injury. Recovery time can vary from brief to many months and is probably dependent on the severity of the injury. Recovery may be influenced by intrinsic factors, such as sex. While most patients will improve, mixed levels of recovery can be anticipated.

DIAGNOSIS/CLASSIFICATION

2010 Recommendation

C Self-reported localized pain and perceived stiffness in the Achilles tendon following a period of inactivity (eg, sleep, prolonged sitting) lessen with an acute bout of activity and may increase after the activity. Symptoms are frequently accompanied by Achilles tendon tenderness, a positive arc sign, and positive findings on the Royal London Hospital test. These signs and symptoms are useful clinical findings for classifying a patient with ankle pain into the ICD category of Achilles bursitis or tendinitis and the associated ICF impairment-based category of Achilles pain (**b28015 Pain in lower limb**), stiffness (**b7800 Sensation of muscle stiffness**), and muscle power deficits (**b7301 Power of muscles of lower limb**).

Evidence Update

II Hutchison et al[94] examined 21 participants with and without Achilles tendinopathy who underwent an ultrasound scan followed by 10 clinical tests for midportion Achilles tendinopathy. Subjective reporting of pain 2 to 6 cm proximal to the Achilles insertion, extending to the calcaneus (sensitivity, 84%; specificity, 73%; κ = 0.74-0.96), and pain with palpation of the midportion of the tendon (sensitivity, 78%; specificity, 77%; κ = 0.75-0.81) was found to be accurate and reliable in diagnosing midportion Achilles tendinopathy.

III Reiman and colleagues[160] performed a systematic review and meta-analysis of the utility of current clinical measures for the diagnosis of Achilles tendon injuries. Because only 2 studies met the inclusion criteria, the authors determined that further high-quality studies are needed.

2018 Recommendation

C In addition to the arc sign and Royal London Hospital test,[127] clinicians can use a subjective report of pain located 2 to 6 cm proximal to the Achilles tendon insertion that began gradually and pain with palpation of the midportion of the tendon to diagnose midportion Achilles tendinopathy.

DIFFERENTIAL DIAGNOSIS

2010 Recommendation

See slightly modified recommendation below.

Evidence Update

IV Using ultrasound scans in patients with pain in the Achilles tendon region, Morton and colleagues[137] identified tears in fascial tissue that divide the leg into its compartments.

IV The plantaris tendon may play a role in chronic midportion Achilles regional pain. A recent retrospective study examined the incidence of plantaris

injuries in track-and-field athletes and found that plantaris injury occurred with an annual incidence of 3.9% to 9.3%.[154]

V Dalbeth and colleagues[36] reported on the frequency and patterns of monosodium urate (MSU) crystal deposition in tendons and ligaments of patients with gout using dual-energy computed tomography (DECT). Ninety-two people with tophaceous gout had DECT scanning of both feet, with the Achilles tendon being the most common site of MSU crystal deposition.

2010 and 2018 Summary

Clinicians should consider diagnostic classifications other than midportion Achilles tendinopathy, including involvement of the plantaris tendon,[154] when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis, Classification, and Clinical Course sections of this updated guideline, or when the patient's symptoms are not resolving with interventions aimed at normalization of the patient's impairments of body function.

The following conditions should be considered in the differential diagnosis of patients presenting with posterior ankle pain:

- Acute Achilles tendon rupture[4,166]
- Partial tear of the Achilles tendon[24,104]
- Retrocalcaneal bursitis[102]
- Posterior ankle impingement[170]
- Irritation or neuroma of the sural nerve[4]
- Os trigonum syndrome[132]
- Accessory soleus muscle[125]
- Achilles tendon ossification[161]
- Systemic inflammatory disease[5]
- Plantaris tendon involvement[154]
- Fascial tears[137]
- Insertional Achilles tendinopathy

IMAGING

2010 Summary

When a diagnosis of Achilles tendinopathy is not clear from the history and physical examination, imaging studies are warranted. Ultrasound and magnetic resonance imaging (MRI) are of assistance when clinical exam results are not sufficient to arrive at a diagnosis.

2018 Update and Summary

Ultrasound imaging and MRI may be useful in assessing for differential diagnoses and identifying coexisting pathology, such as partial ruptures, bursitis, paratendonitis, plantaris involvement, and/or fascial tears.[53,60,133,137] Research studies on patients with midportion Achilles tendinopathy commonly use imaging techniques to examine the severity of tendinopathy, with signs including increased tendon thickness (eg, anterior/posterior diameter or cross-sectional area), altered composition (eg, echogenicity on ultrasound and signal intensity on MRI), and/or neovascularization (eg, location and extent of activity on Doppler ultrasound).[9,78,143,151,191,201,208] However, there is conflicting evidence on the level of association between severity of tendon abnormalities and symptoms.[12,16,42,44,51,56,63,67,80,85,143,144,162,178,187,193,201,209,210] There are techniques currently being developed using ultrasound elastography to estimate tissue mechanical properties (eg, strain and stiffness), which may provide greater insight into tendon pathology in the future.[77,90]

Decision Tree Model

A pathoanatomical/medical diagnosis of midportion Achilles tendinopathy can provide valuable information in describing tissue pathology and may assist in planning treatment and predicting prognosis. The proposed model for examination, diagnosis, and treatment planning for patients with Achilles pain, stiffness, and muscle power deficits associated with midportion Achilles tendinopathy uses the following components: (1) medical screening, (2) classification of the condition through evaluation of clinical findings suggestive of musculoskeletal impairments of body functioning (ICF) and associated tissue pathology/disease (ICD, 3) determination of irritability stage, (4) determination of evaluative outcome measures, and (5) intervention strategies for patients in acute and nonacute stages. This model is depicted in the **FIGURE.**

Component 1

Medical screening incorporates the findings from the history and physical examination to determine whether the patient's symptoms originate from a condition that requires referral to another health care provider. Acute Achilles tendon rupture and systemic inflammatory disease would be examples of conditions that would require referral to another health care provider.

Component 2

Evaluation of physical examination findings, as outlined in the **FIGURE**, should be consistent with the diagnosis of midportion Achilles tendinopathy. The diagnosis and management of the patient's condition should be appropriately modified if the evaluation of clinical findings related to the musculoskeletal impairments of body functioning (ICF) and associated tissue pathology/disease (ICD) suggest other foot or ankle conditions in a differential diagnosis list, symptoms from the lumbopelvic region, or systemic or medical disease.

Component 3

Irritability is a term used by rehabilitation practitioners to reflect the tissue's ability to handle physical stress,[135] and is

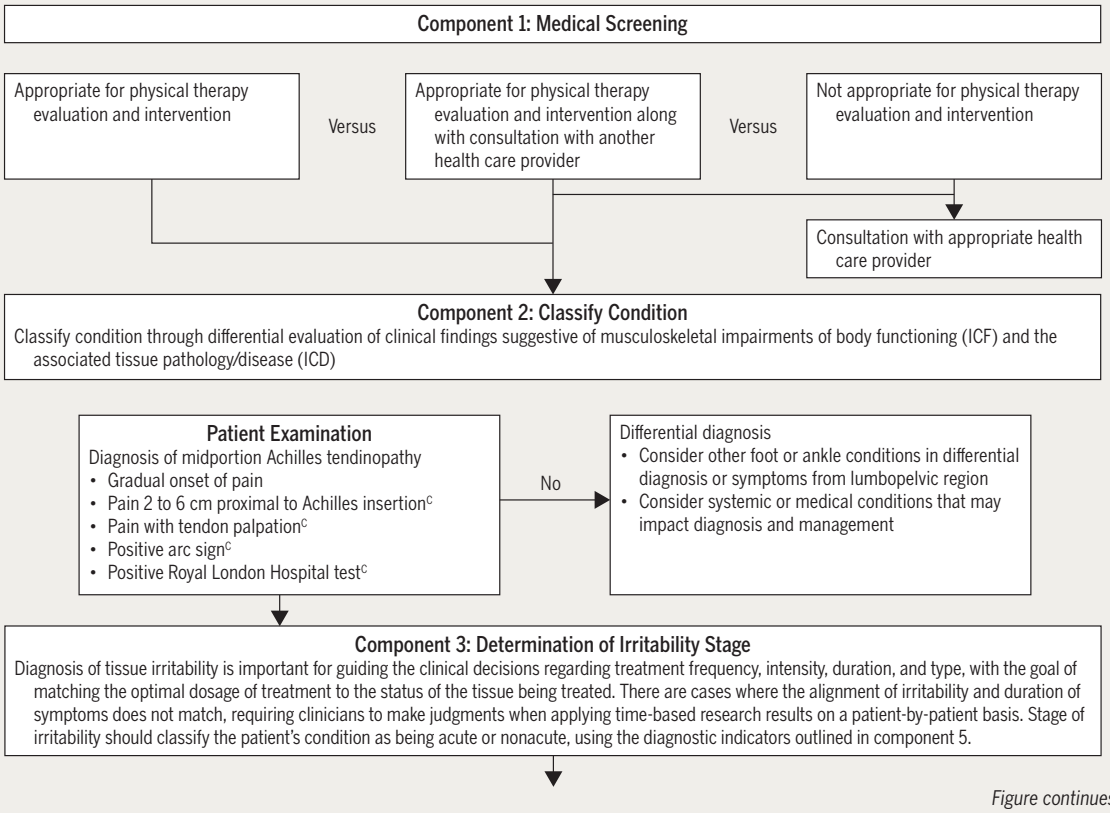

Figure continues on page A13.

FIGURE. Model of diagnosis, examination, and treatment of Achilles pain, stiffness, and muscle power deficits. Superscript letters indicate that the guidelines are based on (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, or (F) expert opinion.

presumably related to physical status and the extent of injury and inflammatory activity that is present. Diagnosis of tissue irritability as acute or nonacute, according to the signs, symptoms, and duration of the condition, is important in guiding the clinical decisions regarding the intervention strategies as outlined in component 5.

Component 4

Outcome measures include an assessment of the patient's functional level and associated physical impairments as outlined in the **FIGURE**. Standardized tools, such as the VISA-A, FAAM, and LEFS, can be used for measuring a specific domain, whether it is a body structure or function, activity limitation, or participation restriction. Outcome measures are important in direct management of individual patient care, and they provide the opportunity to collectively compare care and determine effectiveness through the repeated application of standardized measurement.

Component 5

Intervention strategies outline criteria for treatment selection based on diagnostic indicators and clinical examination findings and allow for treatment planning based on re-evaluation. Interventions are grouped based on the following categories: therapeutic exercise (exercise, stretching, neuromuscular education), manual therapy, education (patient education, patient counseling), home use of medical supplies (bracing), and clinical use of medical devices (iontophoresis). A higher level of evidence indicates greater scientific support for the recommendation, not necessarily the intervention itself. For example, there is a relatively high-level of evidence for the recommendation *not* to use night splints for patients with midportion Achilles tendinopathy. Interventions outside of the scope of physical therapy, including corticosteroid injection, extracorporeal shockwave therapy (ESWT), and platelet-rich plasma (PRP) injections, are included as education for patients who are seeking additional treatment options. Of note, the majority of studies include patients with chronic midportion Achilles tendinopathy. Therefore, treatment of a patient with acute Achilles tendinopathy may depend more on clinical judgment and expert opinion.

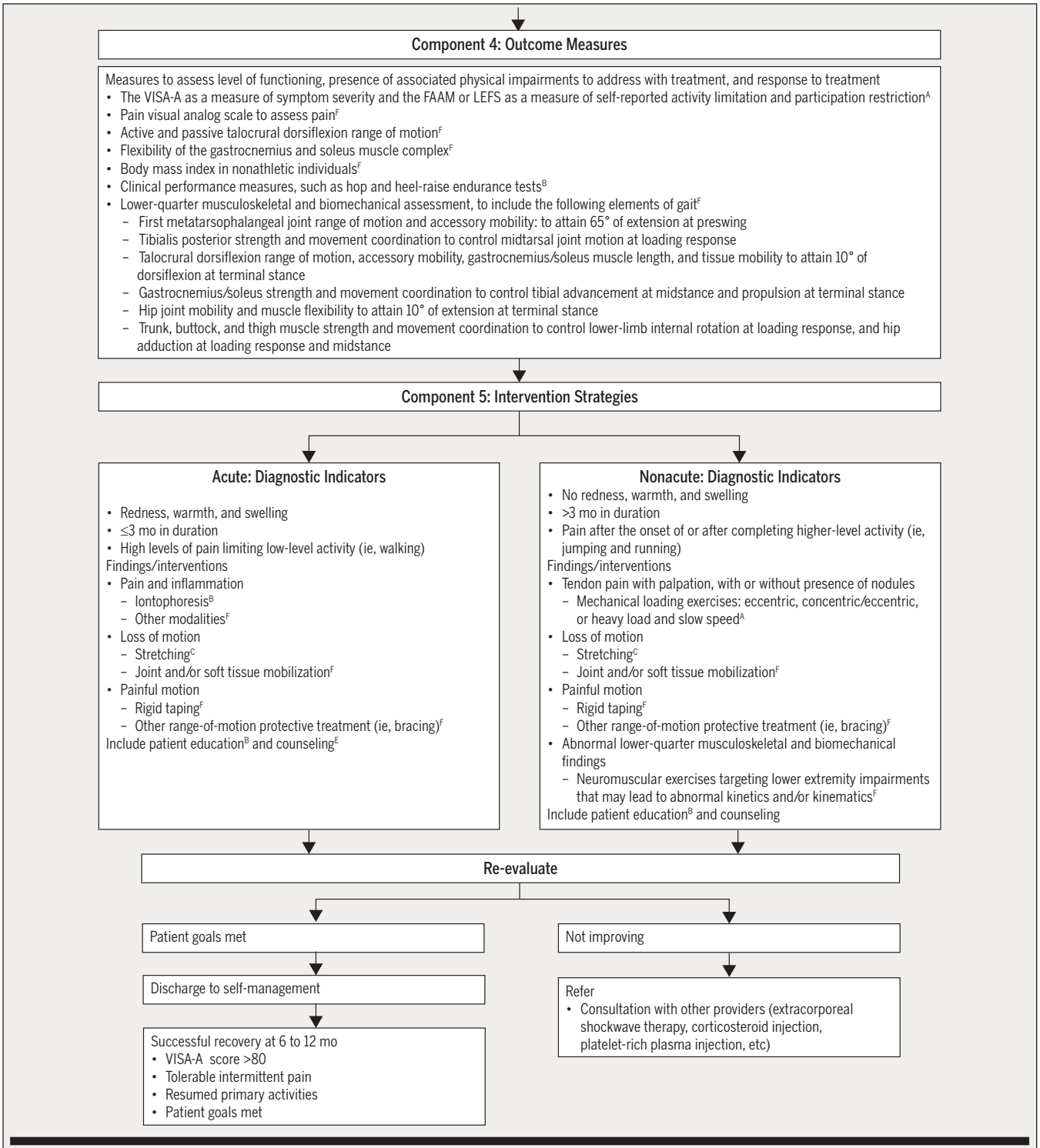

FIGURE (CONTINUED). Model of diagnosis, examination, and treatment of Achilles pain, stiffness, and muscle power deficits. Superscript letters indicate that the guidelines are based on (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, or (F) expert opinion.

CLINICAL GUIDELINES

Examination

OUTCOME MEASURES – ACTIVITY LIMITATIONS/ SELF-REPORTED MEASURES

2010 Recommendation

A Clinicians should incorporate validated functional outcome measures, such as the Victorian Institute of Sport Assessment-Achilles (VISA-A) and the Foot and Ankle Ability Measure (FAAM). These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with Achilles tendinopathy.

Evidence Update

I Iversen et al[97] provided evidence of validity and reliability for the VISA-A questionnaire in Danish-speaking individuals.

II The VISA-A has been validated for patients with Achilles tendinopathy who speak Turkish[57] and French.[103] The validity and reliability findings in these studies are consistent with the results reported in the previously published Achilles tendinopathy guideline.[22]

II Systematic reviews have assessed the evidence to support outcome measures for those with lower-leg, ankle, and foot conditions.[136,181] The Lower Extremity Functional Scale (LEFS) and FAAM were found to be most commonly used, with the FAAM receiving the highest quality assessment score for responsiveness.[181] A separate systematic review found evidence of reliability, validity, and responsiveness to support the LEFS for individuals with lower-limb musculoskeletal conditions.[136]

2018 Recommendation

A Clinicians should use the VISA-A to assess pain and stiffness, and either the FAAM or the LEFS to assess activity and participation in patients with a diagnosis of midportion Achilles tendinopathy.

ACTIVITY LIMITATIONS/PHYSICAL PERFORMANCE MEASURES

2010 Recommendation

B When evaluating functional limitations over an episode of care for those with Achilles tendinopathy, measures of activity limitation and participation restriction can include objective and reproducible assessment of the ability to walk, descend stairs, perform unilateral heel raises, single-limb hop, and participate in recreational activity.

Evidence Update

V A review by MacDermid and Silbernagel[126] summarized physical performance measures for selected upper and lower extremity tendinopathies. They recommended the hop tests and the heel-raise endurance test in the evaluation of functional performance in patients with Achilles tendinopathy.

2018 Recommendation

B Clinicians should use physical performance measures, including hop and heel-raise endurance tests as appropriate, to assess a patient's functional status and document findings.

PHYSICAL IMPAIRMENT MEASURES

Recommended impairment measures and their properties are provided in the 2010 CPG.[22] See the **FIGURE** in the 2010 CPG for the summary of recommended physical impairment measures.

2010 and 2018 Recommendation

B When evaluating physical impairment over an episode of care for those with Achilles tendinopathy, one should measure ankle dorsiflexion range of motion, subtalar joint range of motion, plantar flexion strength and endurance, static arch height, forefoot alignment, and pain with palpation.

CLINICAL GUIDELINES

Interventions

A systematic search of the literature did not reveal articles to alter the 2010 recommendations for iontophoresis, manual therapy, or heel lifts in the treatment of midportion Achilles tendinopathy. Updated recommendations are provided for exercise, which includes eccentric, eccentric/concentric, and heavy-load, slow-speed protocols; stretching; night splints; low-level laser therapy (LLLT); orthoses; taping; neuromuscular re-education; and dry needling. Although corticosteroid injection, ESWT, and PRP injections are used as interventions for those with Achilles tendinopathy, they are outside the scope of physical therapy practice, and therefore only summaries are provided for patient education purposes.

EXERCISE

2010 Recommendation

A Clinicians should consider implementing an eccentric loading program to decrease pain and improve function in patients with midportion Achilles tendinopathy.

Evidence Update

I In a systematic review by Sussmilch-Leitch et al,[192] 9 randomized controlled trials, all published before 2009, directly studied eccentric exercise. This systematic review supported the use of eccentric exercise for midportion Achilles tendinopathy.

I Beyer et al[14] found similar outcomes for a heavy-load, slow-speed exercise and an eccentric training protocol. The heavy-load, slow-speed exercise protocol included 3 bilateral full-range-of-motion heel-raise exercises performed at a speed of 6 seconds per repetition as follows: (1) flexed knee on a seated calf-raise machine, (2) extended knee with the barbell on shoulders, and (3) extended knee on a leg-press machine. The 12-week program included increasing weight with progressively decreasing repetitions. The dosages per week were as follows: week 1, 3 sets of 15 repetitions; weeks 2 and 3, 3 sets of 12 repetitions; weeks 4 and 5, 4 sets of 10 repetitions; weeks 6 to 8, 4 sets of 8 repetitions; and weeks 9 to 12, 4 sets of 6 repetitions. Notable findings at 52-week follow-up included lower visual analog scale (VAS) pain scores during running in both groups (mean VAS change from 0 to 52 weeks: eccentric training group, −38 [95% confidence interval (CI)]: −49.9, −25.6; heavy, slow resistance group, −49 [−62.8, −35.5]), lower VISA-A in both groups (mean VISA-A change from 0 to 52 weeks: eccentric training group, −27.0 [−35.6, −18.0]; heavy, slow resistance group, −34.0 [−41.8, −26.5]), decreased anterior-to-posterior tendon width, and decreased Doppler signal. Although at 52 weeks patients in both groups continued to have pain with running (mean VAS running: eccentric exercise group, 12 [95% CI: 3.2, 19.8]; heavy, slow resistance group, 5 [−0.5, 9.8]), patients in both groups expressed high levels of satisfaction (eccentric exercise group, 76%; heavy, slow resistance group, 98%).

II Although several systematic reviews supported eccentric exercises, heterogeneity across exercise protocols was identified, including factors such as maximum load, speed of contraction, and frequency of sessions not being adequately controlled.[71,87,130,168] Malliaras et al[131] noted that trials often did not isolate eccentric from concentric contractions, and therefore questioned the need for an eccentric-only exercise protocol. However, Frizziero et al[71] found eccentric training to be more effective than concentric exercises, general therapeutic exercise, and ESWT. It should be noted that compliance with eccentric training (27%-72%)[87] and outcomes were found to vary considerably across studies.[71,87,130,168]

II A randomized controlled trial (n = 80, 20 per group) examined daily eccentric exercise (twice per day, 7 days per week) compared to twice weekly eccentric exercise (once per day, twice per week).[196] At 12 weeks, the differences in the VISA-A score between the daily exercise and twice-weekly eccentric exercise groups were not significant.

II Stevens and Tan[190] compared 2 intensities of the Alfredson eccentric protocol in a small sample (13-15 per group) of patients. Those in the "do as tolerated" group completed an average of 112 repetitions daily, while those in the "protocol" group averaged 166 repetitions. No significant differences between groups were found on pain VAS or VISA-A scores at 6 weeks.

IV The case series study by Ram et al[158] evaluated the responses of 16 of 20 participants with chronic midportion Achilles tendinopathy who had tried at least 1 other treatment to a 12-week eccentric training program. Despite experiencing improved scores on the VISA-A, pain VAS, and Tegner activity scale, only 2 participants were satisfied with treatment. Compared to other studies, the low satisfaction may have to do with the fact that patients had a chronic condition and had tried other treatments.[14]

IV de Vos et al[48] examined changes in tendon structure using a specific ultrasonic tissue characterization approach before and after a 16-week eccentric exercise program. The changes defined by the ultrasonic tissue characterization approach found no association between collagen type and VISA-A scores at any time point.

IV Several randomized controlled trials compared eccentric exercise combined with other interventions to eccentric exercise alone.[41,49,50,147,165,196,197,212,215] The observed changes in the control groups (eccentric exercise alone) provide useful information. Improvement in symptom severity (VISA-A) across studies varied in these control groups from 2.4% at 8 weeks,[215] 13% at 12 weeks,[147] 22.6% at 16 weeks,[165] 20.5% at 24 weeks,[50] to 25% to 30% at 52 weeks.[41,197] When eccentric exercise was combined with PRP,[41,49,50] autologous blood injections,[147] or prolotherapy,[212] the results were equivalent to eccentric exercise alone. However, when eccentric exercise was combined with LLLT,[196] ESWT,[165] or acupuncture,[215] studies favored the combined treatments.

It should be noted that studies have excluded participants with presumed frailty of the tendon structure because of metabolic or genetic diseases and drugs. Therefore, little is known about risks and benefits of eccentric exercise for these patients.

Because specific factors (eg, frequency, load, and speed) are not standardized across studies, the optimum parameters for exercise are yet to be formulated.

2018 Recommendation

A Clinicians should use mechanical loading, which can be either in the form of eccentric or a heavy-load, slow-speed (concentric/eccentric) exercise program, to decrease pain and improve function for patients with midportion Achilles tendinopathy without presumed frailty of the tendon structure.

F Patients should exercise at least twice weekly within their pain tolerance.

STRETCHING

2010 Recommendation

C Clinicians may use plantar flexor stretching with the knee flexed and extended to reduce pain and improve satisfaction with outcome in patients with midportion Achilles tendinopathy who exhibit limited dorsiflexion range of motion.

Evidence Update

IV A study by Verrall et al[203] evaluated a single cohort of patients performing a 6-week stretching program that was described as an "eccentric stretching" protocol. One set required participants to perform 9 plantar flexor stretches (6 with knee straight and 3 with knee bent) off the end of a step. Each "heel drop" stretch was held for 15 to 20 seconds. Participants increased from 1 set to 3 and from bilateral to the involved side over a 6-week period. Pain decreased on a 0-to-10 VAS scale from 7.2 at baseline to 2.9 at 12 weeks. Eighty-two percent of participants reported a level of satisfaction of 7/10 or greater with treatment.

2018 Recommendation

C Clinicians may use stretching of the ankle plantar flexors with the knee flexed and extended to reduce pain and improve satisfaction with outcome in patients with midportion Achilles tendinopathy who exhibit limited ankle dorsiflexion range of motion.

NEUROMUSCULAR RE-EDUCATION

2010 Recommendation

No recommendation.

Evidence Update

IV Neuromuscular control among runners with midportion Achilles tendinopathy has been examined in several case-control studies.[10,13,70] Running studies identified patterns of decreased lower extremity muscle activity in participants with midportion Achilles tendinopathy compared to a control group.[10,13,70] However, it is unclear whether decreased muscle activity is a cause or a result of midportion Achilles tendinopathy, and whether an intervention targeting these altered patterns of muscle activity improve outcomes.

2018 Recommendation

F Clinicians may use neuromuscular exercises targeting lower extremity impairments that may lead to abnormal kinetics and/or kinematics, specifically eccentric overload of the Achilles tendon during weight-bearing activities.

MANUAL THERAPY

2010 Recommendation

F Clinicians may use joint and soft tissue mobilization to reduce pain and improve mobility and function in patients with midportion Achilles tendinopathy.

Evidence Update

V

Cheatham et al[27] looked at the efficacy of soft tissue mobilization in a systematic review. Although there were no studies specific to those with midportion Achilles tendinopathy, there appeared to be some evidence supporting instrument-augmented soft tissue mobilization for improving motion in a limited number of studies.

2018 Recommendation

F

Clinicians may consider using joint mobilization to improve mobility and function and soft tissue mobilization to increase range of motion for patients with midportion Achilles tendinopathy

PATIENT EDUCATION: ACTIVITY MODIFICATION

2010 Recommendation

No recommendation.

Evidence Update

I

Silbernagel et al[182] compared the effects of continued sports activity (eg, running and jumping activities below a specified pain intensity) to active rest while patients completed an exercise program for midportion Achilles tendinopathy. Patients in the active rest group could choose to swim, run in deep water, bike, or walk as a daily activity. The specific guideline was for patients to maintain pain levels below a 5/10 on a VAS for all activities. All participants performed a standardized exercise program. Both groups significantly improved on the VISA-A at 5-year follow-up, with the mean VISA-A scores greater than 90 for both groups.[182]

2018 Recommendation

B

For patients with nonacute midportion Achilles tendinopathy, clinicians should advise that complete rest is not indicated and that they should continue with their recreational activity within their pain tolerance while participating in rehabilitation.

PATIENT COUNSELING

2010 Recommendation

No recommendation.

Evidence Update

V

There is no direct evidence that patient counseling benefits patients with Achilles tendinopathy. However, patient education and counseling are both considered important for patient care.[168,182]

2018 Recommendation

E

Clinicians may counsel patients with midportion Achilles tendinopathy. Key elements of patient counseling could include (1) theories supporting use of physical therapy and role of mechanical loading; (2) modifiable risk factors, including BMI and shoewear; and (3) typical time course for recovery from symptoms.

HEEL LIFTS

2010 and 2018 Recommendation

D

Because contradictory evidence exists, no recommendation can be made for the use of heel lifts in patients with midportion Achilles tendinopathy.

NIGHT SPLINTS

2010 Recommendation

C

Night splints are not beneficial in reducing pain when compared to eccentric exercise in patients with Achilles tendinopathy.

Evidence Update

I

A systematic review by Sussmilch-Leitch et al[192] found 2 studies with conflicting results on the additional effect of night splints added to an eccentric exercise program. A pooled meta-analysis found that a night splint provided no significant additional improvement in patient-reported symptoms (VISA-A) at 12 weeks.

II

A 1-year follow-up randomized controlled trial found no additional benefit of a night splint to eccentric exercise.[40] There were no significant differences in symptom severity (VISA-A) between groups at baseline or 3-month and 1-year follow-ups. There were also no significant differences between groups in morning stiffness or patient satisfaction at 1-year follow-up.

2018 Recommendation

C

Clinicians should not use night splints to improve symptoms in patients with midportion Achilles tendinopathy.

ORTHOSES

2010 Recommendation

C

A foot orthosis can be used to reduce pain and alter ankle and foot kinematics while running in patients with Achilles tendinopathy.

Evidence Update

II Two systematic reviews noted no effect of orthoses for patients with midportion Achilles tendinopathy.[130,168]

I Munteanu et al[139] examined the effects of a custom orthosis compared with a sham orthosis. All participants also performed an eccentric exercise program. No difference was found in VISA-A scores at baseline and at 1, 3, 6, and 12 months between the 2 groups.

2018 Recommendation

D Because contradictory evidence exists, no recommendation can be made for the use of orthoses in patients with midportion Achilles tendinopathy.

TAPING

2010 Recommendation

F Taping may be used in an attempt to decrease strain on the Achilles tendon in patients with Achilles tendinopathy.

Evidence Update

IV A systematic review noted that 1 of 2 low-level studies supported taping for midportion Achilles tendinopathy.[168]

IV A case-control study[66] examined the immediate effects of therapeutic elastic tape applied to the Achilles tendon and found application of tape did not improve hop distance or decrease pain.

2018 Recommendation

F Clinicians should not use therapeutic elastic tape to reduce pain or improve functional performance in patients with midportion Achilles tendinopathy.

F Clinicians may use rigid taping to decrease strain on the Achilles tendon and/or alter foot posture in patients with midportion Achilles tendinopathy.

LOW-LEVEL LASER THERAPY

2010 Recommendation

B Clinicians should consider the use of LLLT to decrease pain and stiffness in patients with Achilles tendinopathy.

Evidence Update

II Tumilty and colleagues[197] compared LLLT to placebo laser treatment while both groups concurrently participated in an eccentric exercise program. The laser parameters were set at 810 nm, 100-mW infrared probe, at 3.0 J per point (18 J per session). The LLLT group did not have clinically or statistically greater improvement in the numeric pain-rating scale or symptom severity (VISA-A) at baseline and at 4, 12, and 52 weeks.

II Hutchison et al[95] compared LLLT to a placebo laser treatment using a laser probe, with a spectrum of 530 nm to 1100 nm, to administer a single pulse of 39 J. There were no differences between groups in symptom severity (VISA-A), pain (VAS), or function (LEFS) at baseline and at 6 or 12 weeks. In addition, at 12 weeks, neither group demonstrated a significant difference from baseline in patient-reported outcome measures (95% CI of difference from baseline: VISA-A, −7.2, 7.2; VAS, −15.8, 9.6; LEFS, −4.44, 7.33).

II A randomized trial (n = 80, 20 per group) examined 2 different exercise regimens and the ability of laser to supplement these programs.[196] The 4 arms of the study included placebo plus daily exercise, LLLT plus daily exercise, placebo plus twice-weekly exercise, and LLLT plus twice-weekly exercise. The key significant finding at 12 weeks was that the combination of LLLT plus twice-weekly exercise resulted in the greatest improvement in symptom severity over the 12-week period, as measured by the VISA-A (mean improvement, 18.5% [95% CI: 9.1%, 27.9%]), achieving an average score near the ceiling of the VISA-A (score, 99). In addition, differences between placebo plus daily exercise and LLLT plus daily exercise, although not significant, favored LLLT plus daily exercise by an average of 8.2% (95% CI: −1.3%, 17.7%). Although only the results for LLLT plus twice-weekly exercise were significant, the study was underpowered to determine whether laser was better than no laser. This leaves open the possibility that laser may have significant effects not just for specific exercise protocols but across different exercise protocols.

2018 Recommendation

D Because contradictory evidence exists, no recommendation can be made for the use of LLLT in patients with midportion Achilles tendinopathy.

IONTOPHORESIS

2010 and 2018 Recommendation

B Clinicians should use iontophoresis with dexamethasone to decrease pain and improve function in patients with acute midportion Achilles tendinopathy.

DRY NEEDLING

2010 Recommendation

No recommendation.

Evidence Update

III In a recent prospective cohort study,[206] comparisons were made between high-volume image-guided injection (HVIGI) with and without dry needling. Participants in the HVIGI-only group improved an average of 33.4 points on the VISA-A, while the participants in the HVIGI and dry needling group on average only improved by 6.9 points.

IV In a case series study by Yeo et al,[213] participants received tendon injection of marcaine (tendon decompression) followed by dry needling in conjunction with a 4-week eccentric exercise program. Pain VAS scores (0-100) during rest and activity decreased by 24% and 39.1%, respectively, at 6 weeks post procedure. At 12 and 24 months, 77% and 76% of participants, respectively, had high or very high satisfaction levels.

2018 Recommendation

F Clinicians may use combined therapy of dry needling with injection under ultrasound guidance and eccentric exercise to decrease pain for individuals with symptoms greater than 3 months and increased tendon thickness.

INTERVENTIONS OUTSIDE THE SCOPE OF PHYSICAL THERAPY

Summaries were not provided in 2010 for corticosteroid injection, ESWT, and PRP injections.

CORTICOSTEROID INJECTION

2018 Summary

A systematic review of randomized controlled trials of corticosteroid injections for all types of tendinopathy concluded that an initial short-term benefit is not maintained at intermediate and long-term follow-up.[32] Although the risk of a tendon rupture is low, other minor complications are more common, including postinjection pain, subcutaneous atrophy, and skin depigmentation.[32] Patients with Achilles tendinopathy who did not respond to exercises alone received up to 3 glucocorticosteroid injections (76% received at least 1 injection) in this observational study (midportion tendinopathy, n = 75; insertional tendinopathy, n = 18).[205] Patients managed with either exercise alone or a combination of exercise and glucocorticosteroid injections had good outcomes in this cohort at 6 months (94% reported improvement and 77% reported an excellent or good result).[59,205] Similarly, in a recent randomized controlled study and systematic review, participants who received high-volume corticosteroid injections coupled with eccentric exercises demonstrated an improvement of 29 points in their VISA-A at 24 weeks, while those in the exercise-only group improved 11 points.[17,26]

EXTRACORPOREAL SHOCKWAVE THERAPY

2018 Summary

Extracorporeal shockwave therapy, when combined with eccentric exercise for chronic midportion Achilles tendinopathy, is supported in some systematic reviews with improvement in VISA-A score, pain, and function.[71,81,130,168,192] The only systematic review to perform a meta-analysis noted no effect favoring ESWT alone. However, qualitative evidence favors ESWT when combined with eccentric exercise.[192] Two case series also provide low-level evidence in support of the use of ESWT.[174,194] Saxena et al[174] demonstrated significant improvement with ESWT on a ranking of daily and recreational activities at 1-year follow-up, with a total of 78% of the patients considering themselves improved. Taylor et al[194] studied ESWT in patients with midportion Achilles tendinopathy who did not respond to initial therapy (average length of symptoms of 20 months). At 2-year follow-up, patients demonstrated an improvement in the VISA-A from 40 at baseline to 66.[194] However, there was no difference in pain VAS between baseline and the 2-year follow-up. In summary, there is evidence that ESWT benefits patients with chronic midportion Achilles tendinopathy when combined with eccentric exercise. Evidence supporting ESWT alone and optimal dosage (eg, high versus low energy) is unclear.

PLATELET-RICH PLASMA INJECTION

2018 Summary

Many systematic reviews determined that high-level evidence does not support the use of PRP injections for a variety of outcomes, including VISA-A, return to sport, ultrasound measures, and function (eg, FAAM), for individuals with midportion Achilles tendinopathy. [7,52,65,112,159,169,198]

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APPENDIX A

SEARCH STRATEGIES FOR ALL DATABASES SEARCHED

Limits: 2009 to present (05/11/2015); human; English (published CPG search included articles published from February 1, 2009 to present)

PubMed

History: 05/12/2015

Search	Add to Builder	Query	Items Found, n	Time
#21	Add	Search (#18 not #2) Filters: Publication date from 2009/01/01; English	601	12:50:43
#19	Add	Search (#18 not #2)	1424	12:50:43
#18	Add	Search (#16 or #17)	1515	12:49:05
#17	Add	Search ("achilles tendon"[MeSH Terms] OR ("achilles"[All Fields] AND "tendon"[All Fields]) OR "achilles tendon"[All Fields] OR "achilles"[All Fields]) AND ("tendinopathy"[MeSH Terms] OR "tendinopathy"[All Fields])	1425	11:31:17
#16	Add	Search ("achilles tendon"[MeSH Terms] OR ("achilles"[All Fields] AND "tendon"[All Fields]) OR "achilles tendon"[All Fields] OR "achilles"[All Fields]) AND ("tendinopathy"[MeSH Terms] OR "tendinopathy"[All Fields] OR "tendinitis"[All Fields])	1515	11:30:50
#2	Add	Search (animal not human)	3735987	09:46:42

Cochrane

Search Name: Achilles CPG Cochrane 05122015

Date Run: 12/05/15 16:09:42.256

Description: ID

Search hits: #1. achilles and (tendinitis or tendino* or tendono* or paratendino* or paratendono* or pantendino* or Pantendono*):ti,ab,kw
Publication Year from 2009 to 2015 (Word variations have been searched)

CINAHL

Tuesday, May 12, 2015 11:48:18 AM

Number	Query	Limiters/Expanders	Last Run Via
S4	S1 OR S2	Limiters - Published Date: 20090101-; English Language; Human Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S3	S1 OR S2	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S2	achilles AND tendono* OR tendino* OR pantendino* OR pantendono* OR para-tendino* OR paratendono*	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL
S1	(MH "Achilles Tendinopathy")	Search modes - Find all my search terms	Interface - EBSCOhost Research Databases Search Screen - Advanced Search Database - CINAHL

APPENDIX A

PEDro

Achilles AND tend* from 2009 forward
"Update" search strategies (May 15, 2015-April 12, 2016)
PEDro search run on 4/12/2016 and Update searches from 4/12/2016 to 11/18/2017
Achilles AND tend* from 5/13/2015 forward
Achilles AND tend* from 4/12/2016 forward

PubMed Search

Run 4/12/2016

Search	Query
#5	Search (#2 NOT #1) AND 2015/05/12:2016 [edat] Filters: English
#4	Search (#2 NOT #1) Filters: English
#3	Search (#2 NOT #1)
#2	Search (("achilles tendon"[MeSH Terms] OR ("achilles"[All Fields] AND "tendon"[All Fields]) OR "achilles tendon"[All Fields] OR "achilles"[All Fields]) AND ("tendinopathy"[MeSH Terms] OR "tendinopathy"[All Fields] OR "tendinitis"[All Fields]))
#1	Search animal NOT human

Update searches from 4/12/2016 to 11/18/2017

PubMed

Search	Query	Items Found, n
#5	Search (#2 NOT #1) Filters: Publication date from 2016/04/01 to 2017/11/18; English	245
#4	Search (#2 NOT #1) Filters: English	1617
#3	Search (#2 NOT #1)	1816
#2	Search (("achilles tendon"[MeSH Terms] OR ("achilles"[All Fields] AND "tendon"[All Fields]) OR "achilles tendon"[All Fields] OR "achilles"[All Fields]) AND ("tendinopathy"[MeSH Terms] OR "tendinopathy"[All Fields] OR "tendinitis"[All Fields]))	1930
#1	Search animal NOT human	4167941

CINAHL Search

Run on 4/12/2016

Number	Query	Limiters/Expanders
S3	(S1 OR S2) AND EM 20150513-	Limiters - English Language; Human Search modes - Find all my search terms
S2	achilles AND (tendono* OR tendino* OR pantendino* OR pantendono* OR paratendino* OR paratendono*)	Search modes - Find all my search terms
S1	(MH "Achilles Tendinopathy")	Search modes - Find all my search terms

CINAHL

(Updated Searches From 4/12/2016 to 11/18/2017)

Search	Query	Items Found, n
S3	(S1 OR S2) Limiters - Published Date: 20160401-20171131; Language: English Search modes - Find all my search terms	87
S2	achilles AND (tendono* OR tendino* OR pantendino* OR pantendono* OR paratendino* OR paratendono*) Search modes - Find all my search terms	874
S1	(MH "Achilles Tendinopathy") Search modes - Find all my search terms	544

APPENDIX A

Cochrane Search

Run on 4/12/2016
achilles and (tendinitis or tendino* or tendono* or paratendino* or paratendono* or pantendino* or Pantendono*):ti,ab,kw Publication Year from 2015 to 2016

Cochrane

(Updated Searches From 4/12/2016 to 11/18/2017)

Search	Query	Items Found, n
	achilles and (tendinitis or tendino* or tendono* or paratendino* or paratendono* or pantendino* or Pantendono*):ti,ab,kw Publication Year from 2016 to 2017	1 review, 35 trials

APPENDIX B

SEARCH RESULTS

Database	Platform	Original Date Conducted	Original Results, n	2016 Update Date Conducted	2016 Update Results, n	2017 Update Date Conducted	2017 Update Results, n
MEDLINE	PubMed	5/12/2015	601	4/12/2016 (from Entrez date 5/13/2015)	112	11/18/2017 (from Entrez date 4/12/2017)	245
Cochrane Library	Wiley	5/12/2015	69 Cochrane reviews (4) Other reviews (12) Trials (52) Economic evaluations (1)	4/12/2016	10	11/18/2017 (year 2016-2017)	1 review 35 trials
CINAHL	EBSCO	5/12/2015	392	4/12/2016	9	11/18/2017	87
PEDro	CEBP	5/12/2015	45	4/12/2016 (new records added from May 13, 2015 to current)	9	11/18/2017	9
Total			1107		140		377
Total with duplicates removed			993 (duplicates, 114)		129 (duplicates, 11)		287 (duplicates, 90)

APPENDIX C

ARTICLE INCLUSION AND EXCLUSION CRITERIA

I. Article Characteristics

Include:

- English
- Published from 2009 to present (published CPG search included articles published up to February 1, 2009)
- Articles reporting analysis of data: systematic reviews, meta-analyses, experimental and quasi-experimental, cohort, case series (n≥10), and cross-sectional studies

Exclude:

- Study protocols
- Abstracts, press reports, newsletters, editorial letters
- Articles published in non–peer-reviewed publications (eg, theses)
- Case reports (1 patient per case) and case series with fewer than 10 patients

II. Patient/Participant Characteristics

Include:

- Studies using data from humans
- Participants over 16 years of age (if mixed, the mean should be over 16 years)
- Participants with Achilles tendinitis, tendinopathy, tendinosis
- If the article reports on Achilles tendinopathy along with other conditions, then there must be at least enough patients (greater than 15 in each group) with Achilles tendinopathy AND the results must be reported for Achilles tendinopathy separately

Exclude:

- Articles on healthy/normal participants

III. Topics Included

A. For evidence update

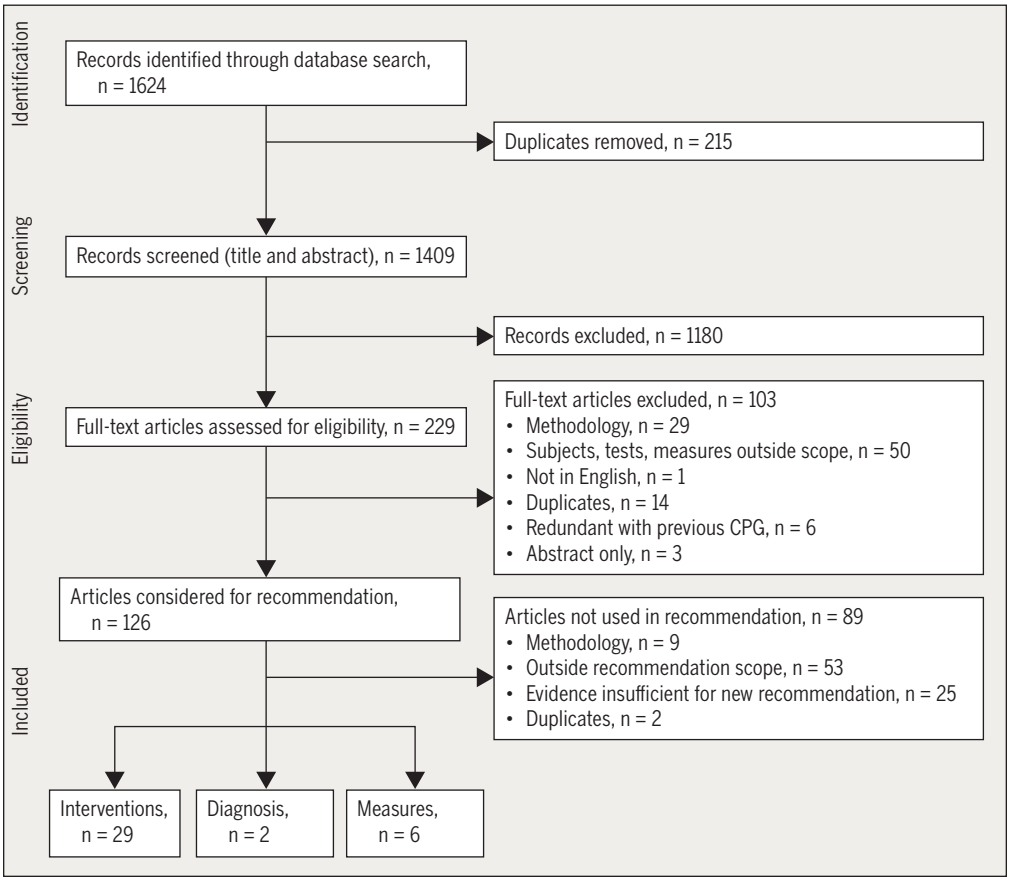
- Prevalence
- Pathoanatomic features: the functional anatomy of the ankle and foot relevant to Achilles tendinopathy
- Risk factors
  - Intrinsic (eg, decreased dorsiflexion range of motion, subtalar motion, plantar flexion strength, pronation, and health conditions/comorbidities such as obesity, hypertension, hyperlipidemia, and diabetes)
  - Extrinsic (eg, training characteristics, environmental factors, equipment-related factors)
- Prognosis
- Imaging studies

B. For formal systematic review

- Classification systems, including but not limited to Curwin and Stanish, Nirschl Pain Phase Scale of Athletic Overuse Injuries, and Puffer and Zachazewski scale
- Tests and measures for diagnosis of Achilles tendinopathy within the scope of physical therapist practice, including but not limited to Achilles tendon palpation test, plantar flexion range of motion, unilateral heel-raise test, the arc sign, Victorian Institute of Sport Assessment-Achilles, Foot and Ankle Ability Measure, Royal London Hospital test
- Differential diagnosis, including but not limited to acute Achilles rupture, partial Achilles tear, retrocalcaneal bursitis, posterior ankle impingement, sural nerve neuroma or irritation, os trigonum syndrome, accessory soleus, Achilles tendon ossification, systemic inflammatory disease, and insertional Achilles tendinopathy
- Measurement properties of outcome measures relevant for Achilles tendinopathy, including but not limited to measures assessing:
  - Body structures and function
    - Truncated arch height ratio
    - Arc sign
    - Royal London Hospital test
    - Forefoot alignment
    - Achilles tendon palpation test
    - Pain
    - Range of motion (dorsiflexion, plantar flexion, inversion, eversion)
    - Plantar flexion strength
    - Plantar flexion endurance
  - Activity (eg, the Silbernagel battery)
  - Participation
- Interventions within the scope of practice of physical therapists, including but not limited to:
  - Eccentric loading or other exercise
  - Low-level laser therapy
  - Iontophoresis
  - Stretching
  - Foot orthoses
  - Manual therapy
  - Taping
  - Heel lifts
  - Shockwave

APPENDIX D

FLOW DIAGRAM OF ARTICLES LEADING TO RECOMMENDATIONS



APPENDIX E

ARTICLES INCLUDED IN RECOMMENDATIONS BY TOPIC

Diagnosis

Hutchison AM, Evans R, Bodger O, et al. What is the best clinical test for Achilles tendinopathy? *Foot Ankle Surg*. 2013;19:112-117. https://doi.org/10.1016/j.fas.2012.12.006

Reiman M, Burgi C, Strube E, et al. The utility of clinical measures for the diagnosis of Achilles tendon injuries: a systematic review with meta-analysis. *J Athl Train*. 2014;49:820-829. https://doi.org/10.4085/1062-6050-49.3.36

Examination

Outcome Measures – Activity Limitations/Self-Reported Measures

Dogramaci Y, Kalaci A, Kücükkübaş N, Inandı T, Esen E, Yanat AN. Validation of the VISA-A questionnaire for Turkish language: the VISA-A-Tr study. *Br J Sports Med*. 2011;45:453-455. https://doi.org/10.1136/bjsm.2009.060236

Iversen JV, Bartels EM, Jørgensen JE, et al. Danish VISA-A questionnaire with validation and reliability testing for Danish-speaking Achilles tendinopathy patients. *Scand J Med Sci Sports*. 2016;26:1423-1427. https://doi.org/10.1111/sms.12576

Kaux JF, Delvaux F, Oppong-Kyei J, et al. Validity and reliability of the French translation of the VISA-A questionnaire for Achilles tendinopathy. *Disabil Rehabil*. 2016;38:2593-2599. https://doi.org/10.3109/09638288.2016.1138553

Mehta SP, Fulton A, Quach C, Thistle M, Toledo C, Evans NA. Measurement properties of the Lower Extremity Functional Scale: a systematic review. *J Orthop Sports Phys Ther*. 2016;46:200-216. https://doi.org/10.2519/jospt.2016.6165

Shultz S, Olszewski A, Ramsey O, Schmitz M, Wyatt V, Cook C. A systematic review of outcome tools used to measure lower leg conditions. *Int J Sports Phys Ther*. 2013;8:838-848.

Activity Limitations – Physical Performance Measures

MacDermid JC, Silbernagel KG. Outcome evaluation in tendinopathy: foundations of assessment and a summary of selected measures. *J Orthop Sports Phys Ther*. 2015;45:950-964. https://doi.org/10.2519/jospt.2015.6054

INTERVENTIONS

Exercise

Beyer R, Kongsgaard M, Hougs Kjaer B, Øhlenschlæger T, Kjaer M, Magnusson SP. Heavy slow resistance versus eccentric training as treatment for Achilles tendinopathy: a randomized controlled trial. *Am J Sports Med*. 2015;43:1704-1711. https://doi.org/10.1177/0363546515584760

de Jonge S, de Vos RJ, Weir A, et al. One-year follow-up of platelet-rich plasma treatment in chronic Achilles tendinopathy: a double-blind randomized placebo-controlled trial. *Am J Sports Med*. 2011;39:1623-1629. https://doi.org/10.1177/0363546511404877

de Vos RJ, Heijboer MP, Weinans H, Verhaar JA, van Schie JT. Tendon structure's lack of relation to clinical outcome after eccentric exercises in chronic midportion Achilles tendinopathy. *J Sport Rehabil*. 2012;21:34-43. https://doi.org/10.1123/jsr.21.1.34

de Vos RJ, Weir A, Tol JL, Verhaar JA, Weinans H, van Schie HT. No effects of PRP on ultrasonographic tendon structure and neovascularisation in chronic midportion Achilles tendinopathy. *Br J Sports Med*. 2011;45:387-392. https://doi.org/10.1136/bjsm.2010.076398

de Vos RJ, Weir A, van Schie HT, et al. Platelet-rich plasma injection for chronic Achilles tendinopathy: a randomized controlled trial. *JAMA*. 2010;303:144-149. https://doi.org/10.1001/jama.2009.1986

Frizziero A, Trainito S, Oliva F, Nicoli Aldini N, Masiero S, Maffulli N. The role of eccentric exercise in sport injuries rehabilitation. *Br Med Bull*. 2014;110:47-75. https://doi.org/10.1093/bmb/ldu006

Habets B, van Cingel RE. Eccentric exercise training in chronic midportion Achilles tendinopathy: a systematic review on different protocols. *Scand J Med Sci Sports*. 2015;25:3-15. https://doi.org/10.1111/sms.12208

Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med*. 2009;19:54-64. https://doi.org/10.1097/JSM.0b013e31818ef090

Malliaras P, Barton CJ, Reeves ND, Langberg H. Achilles and patellar tendinopathy loading programmes: a systematic review comparing clinical outcomes and identifying potential mechanisms for effectiveness. *Sports Med*. 2013;43:267-286. https://doi.org/10.1007/s40279-013-0019-z

Pearson J, Rowlands D, Highet R. Autologous blood injection to treat Achilles tendinopathy? A randomized controlled trial. *J Sport Rehabil*. 2012;21:218-224. https://doi.org/10.1123/jsr.21.3.218

Ram R, Meeuwisse W, Patel C, Wiseman DA, Wiley JP. The limited effectiveness of a home-based eccentric training for treatment of Achilles tendinopathy. *Clin Invest Med*. 2013;36:E197-E206.

Rompe JD, Furia J, Maffulli N. Eccentric loading versus eccentric loading plus shock-wave treatment for midportion Achilles tendinopathy: a randomized controlled trial. *Am J Sports Med*. 2009;37:463-470. https://doi.org/10.1177/0363546508326983

Rowe V, Hemmings S, Barton C, Malliaras P, Maffulli N, Morrissey D. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning. *Sports Med*. 2012;42:941-967. https://doi.org/10.2165/11635410-000000000-00000

Stevens M, Tan CW. Effectiveness of the Alfredson protocol compared with a lower repetition-volume protocol for midportion Achilles tendinopathy: a randomized controlled trial. *J Orthop Sports Phys Ther*. 2014;44:59-67. https://doi.org/10.2519/jospt.2014.4720

Sussmilch-Leitch SP, Collins NJ, Bialocerkowski AE, Warden SJ, Crossley KM. Physical therapies for Achilles tendinopathy: systematic review and meta-analysis. *J Foot Ankle Res*. 2012;5:15. https://doi.org/10.1186/1757-1146-5-15

APPENDIX E

Tumilty S, Mani R, Baxter GD. Photobiomodulation and eccentric exercise for Achilles tendinopathy: a randomized controlled trial. *Lasers Med Sci*. 2016;31:127-135. https://doi.org/10.1007/s10103-015-1840-4

Tumilty S, McDonough S, Hurley DA, Baxter GD. Clinical effectiveness of low-level laser therapy as an adjunct to eccentric exercise for the treatment of Achilles' tendinopathy: a randomized controlled trial. *Arch Phys Med Rehabil*. 2012;93:733-739. https://doi.org/10.1016/j.apmr.2011.08.049

Yelland MJ, Sweeting KR, Lyftogt JA, Ng SK, Scuffham PA, Evans KA. Prolotherapy injections and eccentric loading exercises for painful Achilles tendinosis: a randomised trial. *Br J Sports Med*. 2011;45:421-428. https://doi.org/10.1136/bjsm.2009.057968

Zhang BM, Zhong LW, Xu SW, Jiang HR, Shen J. Acupuncture for chronic Achilles tendnopathy: a randomized controlled study. *Chin J Integr Med*. 2013;19:900-904. https://doi.org/10.1007/s11655-012-1218-4

Stretching

Verrall G, Schofield S, Brustad T. Chronic Achilles tendinopathy treated with eccentric stretching program. *Foot Ankle Int*. 2011;32:843-849. https://doi.org/10.3113/FAI.2011.0843

Neuromuscular Re-education

Azevedo LB, Lambert MI, Vaughan CL, O'Connor CM, Schwellnus MP. Biomechanical variables associated with Achilles tendinopathy in runners. *Br J Sports Med*. 2009;43:288-292. https://doi.org/10.1136/bjsm.2008.053421

Baur H, Müller S, Hirschmüller A, Cassel M, Weber J, Mayer F. Comparison in lower leg neuromuscular activity between runners with unilateral mid-portion Achilles tendinopathy and healthy individuals. *J Electromyogr Kinesiol*. 2011;21:499-505. https://doi.org/10.1016/j.jelekin.2010.11.010

Franettovich Smith MM, Honeywill C, Wyndow N, Crossley KM, Creaby MW. Neuromotor control of gluteal muscles in runners with Achilles tendinopathy. *Med Sci Sports Exerc*. 2014;46:594-599. https://doi.org/10.1249/MSS.0000000000000133

Manual Therapy

Cheatham SW, Lee M, Cain M, Baker R. The efficacy of instrument assisted soft tissue mobilization: a systematic review. *J Can Chiropr Assoc*. 2016;60:200-211.

Patient Education: Activity Modification

Silbernagel KG, Brorsson A, Lundberg M. The majority of patients with Achilles tendinopathy recover fully when treated with exercise alone: a 5-year follow-up. *Am J Sports Med*. 2011;39:607-613. https://doi.org/10.1177/0363546510384789

Patient Counseling

Rowe V, Hemmings S, Barton C, Malliaras P, Maffulli N, Morrissey D. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning. *Sports Med*. 2012;42:941-967. https://doi.org/10.2165/11635410-000000000-00000

Silbernagel KG, Brorsson A, Lundberg M. The majority of patients with Achilles tendinopathy recover fully when treated with exercise alone: a 5-year follow-up. *Am J Sports Med*. 2011;39:607-613. https://doi.org/10.1177/0363546510384789

Night Splints

de Jonge S, de Vos RJ, Van Schie HT, Verhaar JA, Weir A, Tol JL. One-year follow-up of a randomised controlled trial on added splinting to eccentric exercises in chronic midportion Achilles tendinopathy. *Br J Sports Med*. 2010;44:673-677. https://doi.org/10.1136/bjsm.2008.052142

Sussmilch-Leitch SP, Collins NJ, Bialocerkowski AE, Warden SJ, Crossley KM. Physical therapies for Achilles tendinopathy: systematic review and meta-analysis. *J Foot Ankle Res*. 2012;5:15. https://doi.org/10.1186/1757-1146-5-15

Orthoses

Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion Achilles tendinopathy: a systematic review. *Clin J Sport Med*. 2009;19:54-64. https://doi.org/10.1097/JSM.0b013e31818ef090

Munteanu SE, Scott LA, Bonanno DR, et al. Effectiveness of customised foot orthoses for Achilles tendinopathy: a randomised controlled trial. *Br J Sports Med*. 2015;49:989-994. https://doi.org/10.1136/bjsports-2014-093845

Rowe V, Hemmings S, Barton C, Malliaras P, Maffulli N, Morrissey D. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning. *Sports Med*. 2012;42:941-967. https://doi.org/10.2165/11635410-000000000-00000

Taping

Firth BL, Dingley P, Davies ER, Lewis JS, Alexander CM. The effect of kinesiotape on function, pain, and motoneuronal excitability in healthy people and people with Achilles tendinopathy. *Clin J Sport Med*. 2010;20:416-421. https://doi.org/10.1097/JSM.0b013e3181f479b0

Rowe V, Hemmings S, Barton C, Malliaras P, Maffulli N, Morrissey D. Conservative management of midportion Achilles tendinopathy: a mixed methods study, integrating systematic review and clinical reasoning. *Sports Med*. 2012;42:941-967. https://doi.org/10.2165/11635410-000000000-00000

Low-Level Laser Therapy

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APPENDIX E

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APPENDIX F

LEVELS OF EVIDENCE TABLE*

Level	Intervention/ Prevention	Pathoanatomic/Risk/ Clinical Course/ Prognosis/Differential Diagnosis	Diagnosis/Diagnostic Accuracy	Prevalence of Condition/Disorder	Exam/Outcomes
I	Systematic review of high-quality RCTs High-quality RCT†	Systematic review of prospective cohort studies High-quality prospective cohort study‡	Systematic review of high-quality diagnostic studies High-quality diagnostic study§ with validation	Systematic review, high-quality cross-sectional studies High-quality cross-sectional study‖	Systematic review of prospective cohort studies High-quality prospective cohort study
II	Systematic review of high-quality cohort studies High-quality cohort study‡ Outcomes study or ecological study Lower-quality RCT¶	Systematic review of retrospective cohort study Lower-quality prospective cohort study High-quality retrospective cohort study Consecutive cohort Outcomes study or ecological study	Systematic review of exploratory diagnostic studies or consecutive cohort studies High-quality exploratory diagnostic studies Consecutive retrospective cohort	Systematic review of studies that allows relevant estimate Lower-quality cross-sectional study	Systematic review of lower-quality prospective cohort studies Lower-quality prospective cohort study
III	Systematic reviews of case-control studies High-quality case-control study Lower-quality cohort study	Lower-quality retrospective cohort study High-quality cross-sectional study Case-control study	Lower-quality exploratory diagnostic studies Nonconsecutive retrospective cohort	Local nonrandom study	High-quality cross-sectional study
IV	Case series	Case series	Case-control study		Lower-quality cross-sectional study
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion	Expert opinion

Abbreviation: RCT, randomized clinical trial.

Adapted from Phillips et al[149] (http://www.cebm.net/index.aspx?o=1025). See also* **APPENDIX G.

†*High quality includes RCTs with greater than 80% follow-up, blinding, and appropriate randomization procedures.*

‡*High-quality cohort study includes greater than 80% follow-up.*

§*High-quality diagnostic study includes consistently applied reference standard and blinding.*

‖*High-quality prevalence study is a cross-sectional study that uses a local and current random sample or censuses.*

¶*Weaker diagnostic criteria and reference standards, improper randomization, no blinding, and less than 80% follow-up may add bias and threats to validity.*

APPENDIX G

PROCEDURES FOR ASSIGNING LEVELS OF EVIDENCE

- Level of evidence is assigned based on the study design using the Levels of Evidence table (**APPENDIX F**), assuming high quality (eg, for intervention, randomized clinical trial starts at level I)
- Study quality is assessed using the critical appraisal tool, and the study is assigned 1 of 4 overall quality ratings based on the critical appraisal results
- Level of evidence assignment is adjusted based on the overall quality rating:
  - High quality (high confidence in the estimate/results): study remains at assigned level of evidence (eg, if the randomized clinical trial is rated high quality, its final assignment is level I). High quality should include:
    - Randomized clinical trial with greater than 80% follow-up, blinding, and appropriate randomization procedures
    - Cohort study includes greater than 80% follow-up
    - Diagnostic study includes consistently applied reference standard and blinding
    - Prevalence study is a cross-sectional study that uses a local and current random sample or censuses
  - Acceptable quality (the study does not meet requirements for high quality and weaknesses limit the confidence in the accuracy of the estimate): downgrade 1 level
    - Based on critical appraisal results
  - Low quality: the study has significant limitations that substantially limit confidence in the estimate: downgrade 2 levels
    - Based on critical appraisal results
  - Unacceptable quality: serious limitations: exclude from consideration in the guideline
    - Based on critical appraisal results

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Physical Therapists' Role in Solving the Opioid Epidemic

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In this Viewpoint, we highlight the challenges of the current opioid epidemic and outline strategies that the physical therapy profession may adopt to be part of the solution. These strategies include facilitating and providing patient education, early access to physical therapy services, and the promotion of health, wellness, and prevention.

The Problem

An estimated 116 million Americans suffer from chronic pain, at a cost of over $600 billion per year, or roughly $2000 per person per year.[2,3] One of the biggest predictors of chronic pain is the severity of acute pain.[4,31]

Appropriate management of acute pain is key to preventing the progression to persistent pain.[26] In a misguided attempt to manage acute pain, The Joint Commission in the United States created new pain management standards in 2001, which led to the adoption of pain as a "fifth vital sign."[37] These new standards required all health care providers to ask patients about their pain. The medical-industrial complex (private corporations engaged in the business of supplying health care products and services to patients for a profit),[44] specifically the pharmaceutical industry, capitalized on this and initiated a massive marketing and educational campaign designed to promote the use of opioid pain medications.[51] Prescription opioids are often used to relieve moderate to severe pain following a severe injury or surgery. In 1980, a 1-paragraph letter published in the *New England Journal of Medicine* fueled the opioid epidemic by stating, "Despite the widespread use of narcotic drugs in hospitals, the development of addiction is rare . . ."[42] In 1995, the US Food and Drug Administration approved OxyContin (Purdue Pharma LP, Stamford, CT) as a sustained-release opioid medication that was purported to have a lower potential for addiction and abuse due to its slow-release properties.[7] Pharmaceutical companies aggressively promoted and marketed these drugs, while reassuring the medical community that addiction to opioids was rare.[51] This led to a widespread increase in prescription of opioids to manage pain.[33] This increase in prescription rates led to easy availability, diversion, and misuse of these medications.[51] Unfortunately, the medical community failed to realize that these medications were highly addictive[7] and this has led to a public health crisis, with rampant opioid misuse and overdoses.

Vowles et al,[52] in a systematic review on the rates of opioid misuse, abuse, and addiction, defined addiction as a "pattern of continued use with experience of, or demonstrated potential for, harm." Opioid-related harm has reached epidemic levels.[38] The quantity of opioid prescriptions in the United States is staggering, with the Centers for Disease Control and Prevention (CDC) reporting 259 million prescriptions written in 2012, enough for every single American adult to have a bottle of pills.[41] In a survey of more than 51 000 civilian, noninstitutionalized American adults, more than one third reported prescription opioid use in 2015.[22] Based on this survey, the authors estimated that almost 92 million (37.8%) Americans used prescription opioids in 2015. The majority of the individuals (63.4%) took the opioids to relieve physical pain. In many cases, addiction starts with an opioid prescription for the treatment of pain. A 2005 analysis of 2797 heroin users reported that 75% of those

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who began abusing heroin indicated that their first opioid was a prescription drug.[7] It is estimated that 15 million people worldwide are addicted to opioids, and 69 000 people die from opioid overdose each year.[40] Death from opioid overdose in the United States increased almost 5-fold from 2001 to 2013.[40] The CDC estimates that the misuse of opioids is responsible for more than 1000 emergency department visits and 91 deaths every single day in the United States.[45]

A recent Gallup poll of 6200 Americans revealed that 78% of those surveyed would prefer drug-free pain management over opioids.[1] This poll explored Americans' perceptions about the opioid epidemic and treatments for pain. Almost one third of those polled viewed prescription opioid medications as "not very safe" or "not safe at all." The respondents cited multiple causes for the opioid problem.[1] Almost half (44%) of those surveyed saw the overprescription of opioids as a "crisis" or "very serious problem" in their area, and 55% placed significant blame on the pharmaceutical industry for encouraging and incentivizing physicians to prescribe opioids. Over half (53%) placed "a lot" of blame on physicians for overprescribing painkillers to their patients. While not assessed in this poll, the blame does not lie wholly with the pharmaceutical and health care industries. Misuse, abuse, and addiction to opioids can lead to drug-seeking behavior and "doctor shopping," and the street value of opioids has been estimated to be greater than that of marijuana and heroin.[27]

What Can Physical Therapists Do?

The results of the Gallup poll[1] signal a demand for a new health care strategy that includes more drug-free treatments for pain management. While the respondents believed that physical therapy was the safest and most effective drug-free pain management approach, those surveyed would seek care for neck or back pain from a physician (53%), chiropractor (28%), or massage therapist (7%) before seeking a physical therapist (6%).[1] Herein lies the problem. If physical therapists are viewed more favorably than other providers for safe and effective drug-free pain management, then why aren't individuals in pain seeking our care more frequently? Unfortunately, there is a lack of public awareness about what physical therapy has to offer.[24] As of 2015, Americans are able to seek some level of treatment from a licensed physical therapist in all 50 states without a prescription or referral from a physician. Many Americans are not aware that direct access to physical therapy services is available, and in many instances, third-party payers require referral for reimbursement. Also, in the United States, many insurers require a "copayment," which is a payment defined in an insurance policy and paid by an insured person each time a medical service is accessed. Copayments can run as high as $75 per physical therapy visit, even with health insurance. Finally, many health insurance plans discourage patient autonomy and health-seeking behavior, which means that there is a segment of the population that actually needs more care than they receive.[3,8] As physical therapists, it is important to educate our patients on the appropriate use of health care services.

Education Physical therapists need to improve society's knowledge and awareness of physical therapy as a nonpharmaceutical, nonsurgical alternative for the management of pain.[14,24] Confronting the chronic pain epidemic will require the physical therapy profession to step out of its comfort zone. As conscientious health care providers, we must clearly discuss the risks of opioid medications with our patients and their families. In a recent randomized clinical trial that included 240 patients with moderate to severe chronic back pain or hip or knee osteoarthritis pain, treatment with opioids was not superior to treatment with nonopioid medications for improving pain-related function, and had higher adverse medication-related symptoms over 12 months.[25] The CDC now recommends nonpharmaceutical approaches such as physical therapy over opioid medications for chronic pain.[14]

Physical therapists also need to expand their educational efforts to physicians and other referral sources who continue to overprescribe opioids and underprescribe physical therapy. Zheng et al[54] estimated that 170 million individuals consulted a primary care provider for low back pain between 1997 and 2010. Only 10% of these individuals received a referral for physical therapy services, while up to 45% received an opioid prescription. The most current clinical practice guidelines from the American College of Physicians recommend nonpharmacologic treatment approaches consisting of a variety of manual therapies, modalities, and exercise approaches for the treatment of acute, subacute, and chronic low back pain.[43] Physical therapists have a duty to discuss safe, evidence-based alternatives to opioids for managing pain.

Next, we must clearly communicate to patients why they hurt, from a modern pain science perspective.[29,35] Moseley[36] argued in 2003 that we need to reconceptualize the problem of chronic pain, because both patients and health care providers may have poor knowledge of currently accurate information about pain. We need to educate our patients that the biology of pain is never straightforward and that pain does not provide a window into the state of the tissues and is frequently modulated by psychosocial and somatic factors.[34] As pain becomes persistent, the relationship between the tissues and pain is less predictable, and pain becomes an output based on the brain's perception of tissue danger.[35] A recent systematic review by Louw et al[30] concluded that education about pain biology may reduce pain and disability, improve knowledge of pain, improve function and movement, reduce psychosocial factors, and minimize health care utilization in individuals with chronic musculoskeletal conditions. Finally, there is emerging evidence that educating our youth about pain, with a short 30-minute lecture, may change beliefs about pain

and, ultimately, how individuals respond to it.[28]

Promotion of Early Access to Physical Therapy Physical therapists need to educate referral sources that early access to physical therapy decreases costs and health care utilization, including advanced imaging, drugs, and surgery.[6,17-19] Thackeray et al[49] reported that referral to physical therapy and subsequent physical therapy participation were associated with reduced opioid prescriptions during follow-up in individuals with a new onset of low back pain. Virginia Mason Medical Center set up a low back pain clinic that offered same-day access for physical therapy, which led to faster recovery, lower costs, and less sick leave.[20] Direct access to physical therapy has been shown to reduce medical costs, lost time from work, number of visits per episode of care, and episodes of recurrence.[13,15,21,32,39]

Our profession needs to engage in dialog with small, medium, and large businesses in our community and point out that they are in the health care business. We need to explain that the current model of pain management is actively harming their employees, and we need to provide them alternative pathways to nonpharmacological, noninvasive, and nonsurgical care as the "first-line" treatment of pain. For example, the *New York Times* recently reported that Amazon, Berkshire Hathaway, and JPMorgan Chase will focus on an initiative for providing simplified, high-quality health care for their employees that is free from profit-making incentives and constraints.[53] Jamie Dimon of JPMorgan Chase stated, "The three of our companies have extraordinary resources, and our goal is to create solutions that benefit our U.S. employees, their families and, potentially, all Americans."[53] Opportunities such as this may allow physical therapists to leverage opportunities outside of the traditional health care system to provide early, cost-effective, first-line management of pain conditions.[6,16,18,39,48]

Prevention Physical therapists are in a unique position to promote innovative health, wellness, and prevention strategies and promote positive lifestyle changes.[11,12] Physical therapists possess advanced knowledge and strategies across key domains of prevention and health promotion, such as sleep,[46,47] physical activity,[12] and nutrition,[50] that have been shown to contribute to acute and chronic pain syndromes. Lifestyle changes and increased physical activity may lead to health benefits in those with chronic disease, may prevent or manage a number of health conditions, and may lead to an increased quality of life.[10,12] The American Physical Therapy Association advocates for an annual checkup to provide broad health screenings, to assess health status, and to identify potential health risks in their community.[2] The physical therapy profession can take a leading role in health care and health promotion, with the ultimate goal being a reduction in the need for more dangerous health interventions like opioid medications and surgery.[9] The knowledge and skill of physical therapists, combined with the amount of time we spend with patients, place our profession in an ideal position to not only pluck individuals from the river of chronic pain, but to also prevent them from falling into the river in the first place.

Conclusion

The persistent focus on pain by health care providers needs to be re-examined, as it is now well understood that pain is not a vital sign that can be measured objectively, like heart rate and blood pressure. Rather, pain is a multifactorial perception of the current state of physical and emotional well-being, and it can successfully be treated with drug-free management strategies.[5]

A century ago, our profession rallied together following the carnage of World War I. We saw that no matter how burned, broken, or shattered our patients were, there was within each individual the transformative power of the human spirit to overcome. It is now time for that same passion and belief to be reignited and focused on the physical therapist's role to heal a society in the midst of pain. People in pain are crying out for our help. It is time to be of some use.

Key Points

- It is estimated that 15 million people worldwide are addicted to opioids, and 69 000 people die from opioid overdose each year.
- Seventy-eight percent of Americans surveyed prefer drug-free pain management over opioids, and they view physical therapy as the safest and most effective alternative to drugs for the treatment of pain.
- A recent report by the CDC recommends nonpharmacological approaches, such as physical therapy, over opioid medications for chronic pain.
- Physical therapists can play a key role in treating as well as preventing chronic pain. ◉

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Can We Reduce the Epidemic of Elbow Injuries in Youth Throwers?

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As participation in youth sports continues to increase across the Nation, more adolescents are participating in Little League baseball in the United States than ever before.[10] Accompanying this increased participation is an epidemic of upper extremity injuries in young throwers. Recent investigations have demonstrated that as many as 30% to 40% of 7- to 18-year-old baseball players experience elbow and shoulder pain during the baseball season.[15,16] This is particularly important because a high percentage (46%) of injured adolescents report being encouraged to keep playing despite having arm pain.[16]

Initiating play at a participatory level likely contributes to early signs of overuse injuries. Demographic factors such as age, weight, and height also play a role in elbow injury, as do performance factors such as number of pitches thrown during a season and playing outside of the league.[15] Increased year-long play and specialization have been identified as significant contributors to the high number of young throwers presenting with late sequelae of overuse injuries,[20] such as full-thickness ulnar collateral ligament (UCL) ruptures. A recent epidemiological assessment of UCL injuries in New York State demonstrated that the incidence of UCL reconstructions in patients 17 to 20 years old is rising significantly, greater than for any other age group.[11]

Early detection of overuse injuries may be able to prevent further progression. Because throwers are told frequently to keep playing despite painful symptoms,[16] the importance of early and complete evaluation of elbow pain in the young thrower is paramount. The assessment of elbow pain in young throwers should include analysis of level of play, extent of participation (including year-long play), a thorough history intake and physical examination, collection of appropriate patient-reported outcomes, and imaging as indicated. Education regarding the importance of adherence to rehabilitation protocols is crucial. The purpose of this Viewpoint was to discuss the impetus behind the youth thrower elbow injury epidemic and how to best evaluate these patients.

Youth Sports Specialization

Identification of the impetus driving this throwing injury epidemic is critical to curb this concerning trend. It is likely that a confluence of factors, including intrinsic desire for success, participation in multiple leagues, and external pressure from parents and coaches, contributes to longitudinal overuse. Recently, early sports specialization has received enhanced coverage as a driver of youth overuse injuries. Young athletes who played a single sport for more than 9 months in a year and who had higher levels of weekly participation exhibited a 36% increase in risks associated with severe overuse injuries compared to healthy controls.[13] The relative risk of injury was significantly higher in ultracompetitive regions known to produce high-level collegiate prospects.[18,19]

As health care providers become increasingly aware of the epidemic of elbow injuries in young baseball players, accurate distribution of preventative information to the baseball community is necessary. This begins with expanding the role of clinicians from a focus on treatment to a focus on preventative education. Currently, half of high school baseball players and more than 25% of players, coaches, and media members answered that they believe that UCL reconstruction, also known as Tommy

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John surgery, was required to enhance the strength of healthy players' elbows.[1,5] Physicians, physical therapists, and athletic trainers must eradicate these myths and counsel parents, players, and coaches regarding the risks of youth sports specialization.[3,6] Additionally, assessment instruments validated in youth throwers should be used by all health care providers to screen for at-risk players and help to monitor recovery in injured players.[2]

When high-grade injuries to the UCL complex have occurred, and surgery is the selected option of the athlete and his or her care management team, referral to experienced, high-volume surgeons is critical to optimize these athletes' return-to-play prospects. Experience is necessary because UCL reconstruction is a complex operation with exceedingly low levels of incidence. Among Major League Baseball team physicians, only 6 surgeons stated that they perform 50 or more UCL reconstructions annually.[7]

Prevention

Addressing the increasing incidence of serious elbow injuries must begin with identifying causative factors and establishing evidence-based preventative measures. Significant research conducted over the past 20 years has attempted to isolate the causative factors of elbow overuse injuries in throwers. Despite these efforts, the numbers of both early- and late-stage overuse injuries continue to increase. Strict evidence-based guidelines must be instituted to best address this trend. Furthermore, enforcement of pitch counts for young players, the number of leagues players participate in, and the number of months of participation per year in a single sport is required.

Total-body conditioning, including hip, back, and lower extremity strengthening, may be able to help optimize a player's biomechanics to reduce strain on the upper extremity. Additionally, playing in a variety of sports to augment athletic dexterity, rather than engaging in early sports specialization, may protect these players while enhancing athleticism. Last, stringent adherence to throwing rehabilitation protocols, including taking adequate time off from throwing and not accelerating the stage of rehabilitation, will aid secondary prevention of repeat injuries and exacerbations of existing injuries. Despite these advances, players who sustain severe injuries, such as full-thickness UCL ruptures and large osteochondral defects, should be referred to experienced surgeons to discuss operative management.

Clinical Assessment

When an adolescent experiences an injury, a thorough examination of the elbow is critical. The crux of the assessment of the youth thrower with elbow pain remains a thorough history intake and physical examination. A holistic approach incorporating the observations of parents and coaches can assist clinicians with gaining a complete clinical picture. Suspicion for severe overuse injury should be raised for highly specialized, single-sport athletes. Throwers with early symptoms of an overuse injury will often endorse subtle changes in velocity, accuracy, and delivery,[14] whereas later-stage pathology may preclude them from throwing altogether. The timing and location of the pain and overall symptomatology, in addition to provocative movements, can help guide the physician down established diagnostic algorithms.[23]

Physical examination should begin with inspection and comparison to the contralateral extremity. Following a standardized physical exam of the upper extremity, thrower-specific diagnostic maneuvers must be performed. In addition to assessing for physeal injuries and rotator cuff–related shoulder pain, the elbow requires careful examination, given its anatomic complexity. Specifically, the integrity of the UCL must be determined to differentiate partial- or full-thickness rupture. Appropriate use of special tests, such as the moving valgus test, or milking test, may provide clinical insight on the condition of the UCL. This test has exhibited 100% sensitivity and 75% specificity in 21 athletes with varied ages (range, 16-56 years) in the diagnosis of UCL damage.[17]

Patient-Reported Outcomes

Patient-reported outcomes have become prevalent in the clinical assessment of musculoskeletal injuries. While the Kerlan-Jobe Orthopaedic Clinic shoulder and elbow score is often used for throwers of all ages, the instrument was designed for and validated in an adult population. The instrument utilizes some items that make it suboptimal for pediatric evaluation, such as an item asking about the player's relationship with agents. Instead, assessors should consider the use of the recently published Youth Throwing Score,[2] which was generated for and validated in youth baseball players. Written for young athletes (third-grade reading level) and rapidly completed, this instrument can be administered in the clinician's office, after practice, or at home.

Imaging

Clinicians should utilize imaging conservatively. One study reported that more than 80% of young baseball players demonstrated elbow radiographic abnormalities at preseason evaluation, the majority of whom were asymptomatic.[12] Additional prospective investigations have demonstrated that abnormalities at routine preseason magnetic resonance imaging examinations are found in 35% to 48% of young baseball players, with abnormalities more often found in those players who receive private coaching and who play year round.[21,22]

Patients with persistent pain who have failed a thorough nonsurgical rehabilitation approach, including a graded return to throwing,[24] and who have additional specific examination findings, such as a positive valgus or moving valgus stress test, are candidates for advanced imaging. After imaging, the authors assert that the patient's symptoms and clinical presentation must be carefully integrated in evaluating radiological results. Positive

imaging findings in the setting of painless play should not be treated operatively.

Treatment Options

When speaking with adolescents, discussion of the diagnosis and treatment recommendations requires great care and the inclusion of the parents. Patients and parents alike are often taken aback by even the idea of "shutting down" a player by stopping all throwing for an extended period, or by receiving surgery as an avenue to allow for recovery. These discussions must be conducted gradually to avoid alienating the thrower or parent. Nonoperative treatment must be taken seriously in young athletes, as increasing evidence suggests its potential for success. Intrasubstance damage is rare in young athletes, and partial UCL ruptures can be treated successfully using nonsurgical treatment, even in the majority (84%) of Major League Baseball players.[8]

In addition to the physiologic health of young athletes, mental health must be closely evaluated. Specialized athletes often possess high athletic identities and may suffer significant psychosocial trauma after receiving the recommendation that they not play. Psychology research in athletes with anterior cruciate ligament injuries has demonstrated that special attention should be given to the impact the diagnosis has on the patient, as sadness and even depression may impact the player immediately and the player's chance of returning to play at a high level in the future.[4,9] Referral to experienced physical therapists during recovery and referral to sports psychologists for patients who are not coping well assist in both close monitoring and empathic counseling.

With or without surgery, many overuse injuries require players to take a hiatus from throwing before entering an organized throwing rehabilitation protocol. While players and parents are often eager to advance to the next phase of recovery, pre-emptively engaging in activity prior to full healing of an injury carries the inherent risk of further progression of the injury. While returning a young athlete to play is important, overly aggressive rehabilitation progression risks exacerbating a sprain, which may be treated nonoperatively, into a rupture, which may require operative procedures. Thoroughly educating patients, parents, and coaches regarding the importance of adherence is crucial to optimizing the chances for a successful recovery, regardless of surgical intervention.

Further Research

Despite persistent, multidisciplinary efforts, one third to one half of youth baseball players experience elbow and shoulder pain in a given season. Prospective studies contrasting differing pitch-count protocols can assist with providing evidence-based guidelines for players and coaches to follow. Additionally, specialization studies with longer follow-up would help provide physicians more detailed information to educate parents and players regarding the risks of playing a single sport at an early age.

Key Points

- The crux of reducing an emerging prevalence of youth elbow injuries will be in implementing effective, evidence-based preventative measures.
- When initially evaluating the youth thrower, assessing the level of specialization and year-round play should raise suspicion for serious overuse injury.
- Validated patient-reported outcomes, such as the Youth Throwing Score, should supplement clinical evaluation and help monitor recovery.
- Advanced imaging should be reserved for players with significant physical exam findings, such as a positive moving valgus stress test, due to the high rate of incidental findings.
- Nonsurgical treatment, including relative rest, and graduated return to play often allow for successful return to play in athletes with partial UCL ruptures. ◉

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2017 *JOSPT* Award Recipients

GUY G. SIMONEAU, *PT, PhD, ATC, FAPTA*
Interim Editor-in-Chief

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During the American Physical Therapy Association's Combined Sections Meeting in New Orleans, LA in February 2018, JOSPT recognized the authors of the most outstanding research and clinical practice manuscripts published by JOSPT during 2017.

The following annual awards, presented for 15 years by the *Journal of Orthopaedic & Sports Physical Therapy*, recognize the most outstanding articles published in the last calendar year. An award committee of 5 (2 from the Orthopaedic Section, 2 from the Sports Physical Therapy Section, and 1 from the Editorial Board) selected the award recipients from a strong field of eligible articles.

The *Journal of Orthopaedic & Sports Physical Therapy*'s 2017 George J. Davies–James A. Gould Excellence in Clinical Inquiry Award

The George J. Davies–James A. Gould Excellence in Clinical Inquiry Award recognizes the best article published in the *Journal* during a calendar year among the categories of clinical research reports (ie, articles that carry a "Level of Evidence" at the end of the abstract), clinical commentaries, case reports, and resident's case problems.

The 2017 George J. Davies–James A. Gould Excellence in Clinical Inquiry Award was presented to Noa Ben-Ami, PT, PhD; Gabriel Chodick, MHA, PhD; Yigal Mirovsky, MD; Tamar Pincus, MPhil, MSc, PhD; and Yair Shapiro, MD, PhD, for their February 2017 article "Increasing Recreational Physical Activity in Patients With Chronic Low Back Pain: A Pragmatic Controlled Clinical Trial."[1]

The *Journal of Orthopaedic & Sports Physical Therapy*'s 2017 JOSPT Excellence in Research Award

The JOSPT Excellence in Research Award recognizes the best article published in the *Journal* during a calendar year within the category of nonclinical research reports or brief reports (ie, articles that do not carry a "Level of Evidence" at the end of the abstract) and clinical commentaries on research topics.

The 2017 JOSPT Excellence in Research Award was presented to Sanneke Don, PT, MPT; Margot de Kooning, PT, PhD; Lennard Voogt, PT, MT, PhD; Kelly Ickmans, PT, PhD; Liesbeth Daenen, PT, PhD; and Jo Nijs, PT, MT, PhD, for their March 2017 article "The Effect of Visual Feedback of the Neck During Movement in People With Chronic Whiplash-Associated Disorders: An Experimental Study."[2]

These articles were selected from among many high-quality publications that have high potential for impact on the fields of musculoskeletal and sports-related injury, rehabilitation, and health.

Congratulations to these 2017 award recipients for their outstanding work. We look forward to JOSPT continuing to publish and highlight excellent research with clinical implications for practitioners.

The 2017 *JOSPT* Excellence in Clinical Inquiry Award was presented to Dr. Noa Ben-Ami (center) and Dr. Yair Shapiro (right) by Interim Editor-in-Chief Guy Simoneau (left).

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