TACKLING FOOTBALL'S ACHILLES HEEL

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Introduction

Every professional football team can anticipate at least one Achilles tendon injury per season, and, if fortunate, a rupture every few years. Achilles tendinopathies account for 2.5% of all injuries in professional football, with initial injuries resulting in an average absence of 18-23 days[1] and 22% of cases with symptoms lasting more than 4 weeks.[2] However, the recurrence rate is 27%, with an elevated risk if recovery from the initial injury is less than 10 days with older players particularly susceptible.[1] Recurrent Achilles tendinopathies can extend absence times to more than 30 days.[1]

Achilles Tendon Injuries

A tendinopathy is the most prevalent type of Achilles tendon injury in football, occurring at the mid-portion (2-7cm above the heel insertion) and at the heel insertion.[2] Other common mid-portion Achilles tendon injuries include paratenonitis – inflammation of the paratenon – and plantaris-related Achilles tendon pain, which may necessitate additional interventions; the latter accounts for 20% of all cases of mid-portion Achilles pain and often requires surgical removal.[3] In cases of insertional Achilles pain, contributing factors such as retrocalcaneal bursitis, a Haglund's deformity, or enthesitis (inflammation of the bone tissue at the tendon insertion) may also be present. An Achilles tendon rupture typically occurs at the midportion, often with evidence of pre-clinical tendinopathy coupled with an inciting event involving an explosive action and poor control of rapid dorsiflexion.[4,5]

Achilles Tendinopathy

Over the past few decades, the understanding of tendinopathy has evolved from viewing it as an acute inflammatory issue (tendinitis) to recognising it as a tissue degeneration issue (tendinosis). It is now understood to involve a complex interaction between immune cells, tenocytes, and the extracellular matrix, typically resulting from overload or an inability to adapt to regular stress.[6] Some athletes may exhibit a heightened inflammatory response and should be assessed for potential underlying health conditions that could contribute to this injury. Pain at multiple tendon insertion sites may suggest an underlying inflammatory condition, warranting a more holistic treatment plan.[7] Other systemic health factors impacting tendon health include metabolic disorders such as diabetes, cardiovascular disease, hypertension, and haemochromatosis[8]. Medications such as fluoroquinolone antibiotics, statins, and corticosteroids may also affect tendon health.[6]

The pain experienced by patients does not always correlate with structural findings on imaging or functional impairments. It is widely accepted that the release of neuropeptides, such as Substance P and glutamate, stimulates the sprouting of unmyelinated nerve endings, resulting in amplified nociceptive feedback.[6] Biopsychosocial factors may also be present in some patient subgroups;[9] given the stresses of professional sport and the impact of injury, appropriate supplementary support should be considered.

Individual Anatomy Matters

The Achilles tendon comprises subtendon fibres from the soleus, medial, and lateral gastrocnemius muscles. These fibres form a spiral orientation, rotating at the midportion to insert at the calcaneus as illustrated in Figure 1. The deeper fibres from the soleus insert on the anteromedial aspect of the calcaneal tuberosity, while the superficial layers from the lateral gastrocnemius insert

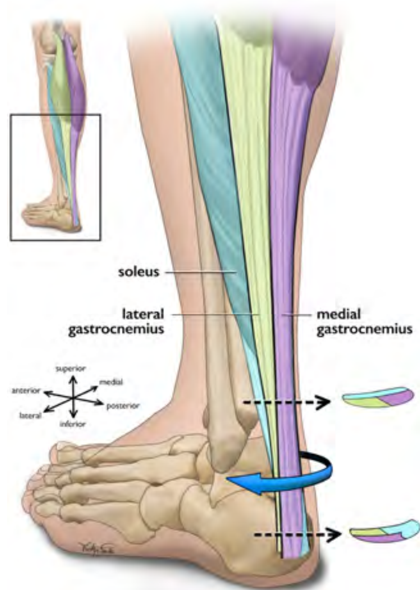


Figure 1: *An illustration of the spiral anatomy of the subtendon fibres from the individual triceps surae muscles. Image designed by Vicky Earle. Reproduced with permission from Merry, K., Napier, C., Waugh, C. M., & Scott, A. (2022)*[17]

on the medial aspect, and the medial gastrocnemius on the posterior aspect, with some individual variations.[10,11] The soleus has the largest muscle volume and force contribution to the Achilles tendon and its deep subtendon fascicles experience the greatest displacement.[12–14] Given the slightly medialised orientation of the AT around the subtalar joint axis, the triceps surae provides an inversion moment.[15] However, variable anatomy at an individual muscle level and torsion of the AT subtendon fascicles, as well as foot posture, may impact this joint moment and AT strain.[16]

Given the anatomical variation of the individual triceps surae muscles and classifications of torsion among the subtendon fibres, muscle coordination, foot shape, and rotation will impact tendon strain and stress distributions. During the stance phase, when the tibia internally rotates, the subtendon fibres externally rotate[18] – a mechanism that may be compromised in a stiff cavus foot type. In young, healthy tendons, there is variable sliding between the deep and superficial layers of the tendon, a characteristic that diminishes in older tendons and following tendinopathy.[19] Reduced neural drive and atrophy of the lateral gastrocnemius are commonly observed in Achilles tendinopathy, resulting in altered triceps surae coordination.[20,21] When assessing a patient, it is important to consider the shape of the triceps surae and foot posture.

A Muscle Needs a Good Tendon

The Achilles tendon acts interchangeably to facilitate efficiency, amplify force, or dissipate energy, depending on the task. A tendon with optimal stiffness (the ability to resist elongation in response to applied force) enables the muscle fascicles to operate on their preferred region of the force-length-velocity curve, thus promoting efficient muscle contractions during repetitive movements like running,[22] or effective force transmission and energy return during explosive actions such as jumping or accelerating.[23,24] Therefore an injury to a region of the tendon can alter the function of its muscle origin – more likely due to loss of tension of the subtendon fascicle resulting in reduced neural drive and altered architecture to the muscle.[25,26]

Tendons Like Routine

Tendons are metabolically active and mechanosensitive organs. Some individuals are more sensitive to acute and accumulative changes in training and match loads. When fatigue accumulates, musculotendinous unit (MTU) capacity reduces. The addition of travel, disrupted sleep quality, altered circadian rhythm, and added stress creates an environment conducive to Achilles tendon injuries. This poses a challenge in professional football, where congested match schedules and some high-risk players may require careful monitoring and individualised programming.

Assessments

Diagnostics

Clinical tests can aid in differentiating between Achilles tendinopathy and paratenonitis, as well as other differential diagnoses, but where feasible, imaging provides greater clarity. MRI is the gold standard imaging technique for muscle or tendon injuries, but point-of-care ultrasound (POCUS) can be provide good diagnostic clarity in tendons. Common features of Achilles tendinopathy include fusiform swelling in the anterior-posterior plane. Oedema on the peripheral aspects of the Achilles tendon indicates paratenonitis or plantaris involvement if oedema is visible between the two structures in close proximity. Dynamic ultrasound imaging may be useful to verify plantaris interference and to detect Haglund's deformity or retrocalcaneal bursitis contributing to irritation at the insertion. Other features, such as power Doppler, may suggest regionalised neovascularisation and inflammatory activity. Ultrasound tissue characterisation (UTC) is used to classify tissue quality within the tendon based on echo type, providing a useful screening tool for tendon health and detecting early degeneration in regions of tissue. Other differentials to exclude include sural nerve irritation if the pain is on the lateral side, as well as posterior ankle impingement.

Figure 2: *A screening framework for Achilles tendon injuries*

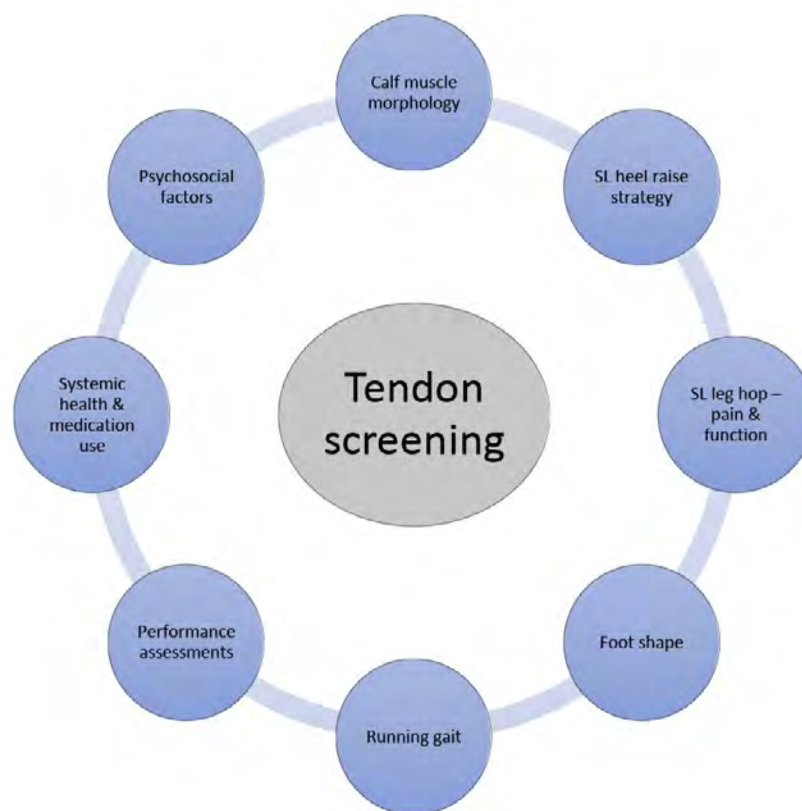
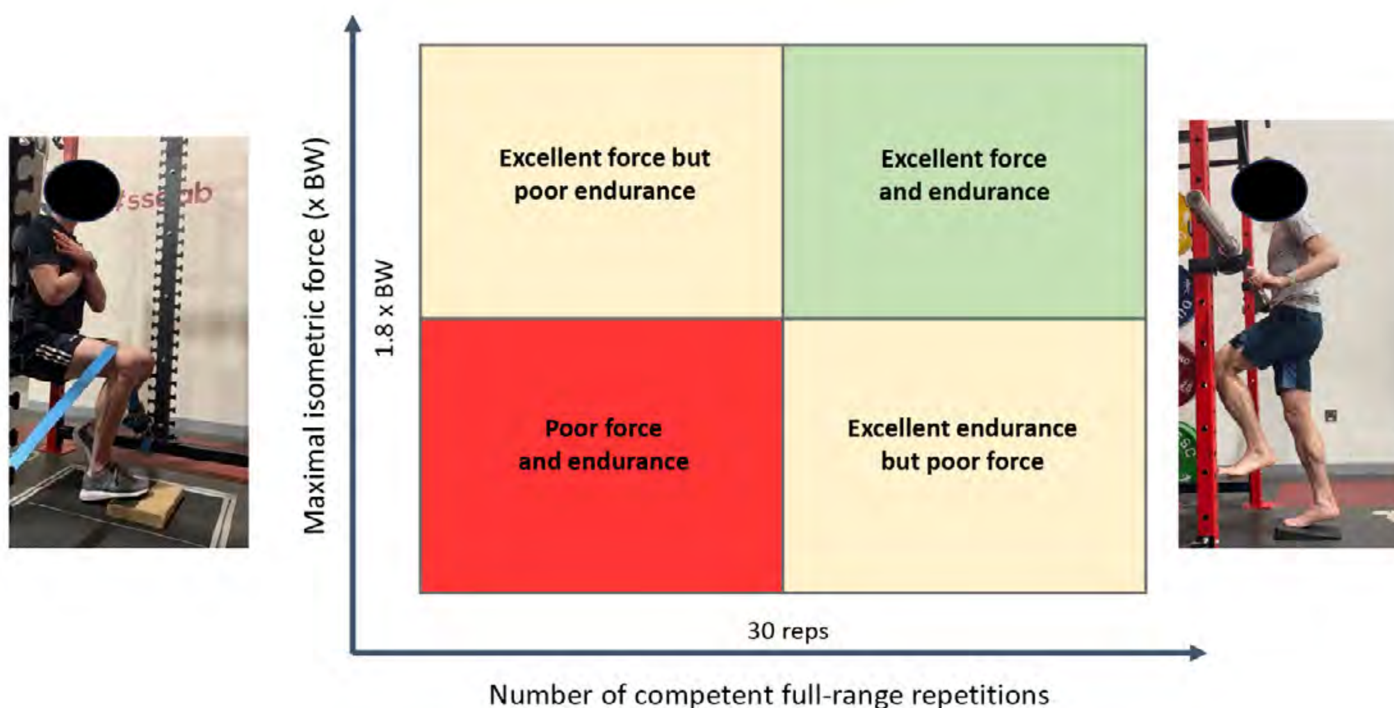


Figure 3: *Performance assessments*

Anatomy and Muscle Morphology
It is important to develop a comprehensive understanding of the player and identify all plausible factors that may be impacting the injury. This begins with assessing their foot shape and tibia alignment. A rigid cavus foot type can prove challenging for players with a Haglund's deformity, where a calcaneal varus with limited ability to rotate may exacerbate the issue. In these cases, it is worth assessing ankle eversion strength and addressing any deficiencies in the peroneal muscles. Muscle morphology may also suggest patterns of loading and de-conditioning. Football players often exhibit external rotation of the foot when kicking and passing, favouring the medial gastrocnemius muscle. Reduced neural drive to the lateral gastrocnemius muscle and increased demand on the soleus muscle is a common pattern detected in Achilles tendinopathy. These features may influence regional strains within the Achilles tendon due to an imbalance in individual muscle recruitment.[25]

Strength and Capacity
Assessing peak strength from the calf complex and muscle endurance provides a comprehensive profile the athlete's calf capacity (see Figure 4). Isokinetic dynamometry, isometric force plate testing, or repetition maximum testing using external loads lifted on a Smith machine or leg press will provide a measure of peak strength. The most widely used test is a seated calf isometric test, where a peak force of around twice bodyweight is a target. An isokinetic strength test with the knee extended at slower speeds of 30°/sec enables relative torque values of more than 100% bodyweight to be produced, with values in excess of 160% bodyweight desirable. A single leg heel raise test on a 10° incline board or off a step to a metronome of 60 beats per minute to fatigue or technical failure is a simple clinical test to measure calf endurance. This can be objectified by using the Calf Raise app, where total work done or decline in output can be measured.[27] If time allows, including a measure of kinetic chain and synergist muscle strength may be useful. The synergist muscles should include the ankle invertors, evertors, and toe flexors, which can be measured with a handheld dynamometer or on the ForceFrame. Surface EMG can be used to measure activation patterns among the individual triceps surae muscles, and in vivo ultrasound can measure tendon strain in response to external load on calf strength exercises to individualise exercise prescription. A full battery of performance assessments are outlined in Figure 3.

Figure 4: *A calf capacity quadrant to profile an athlete based on their calf peak strength and endurance*



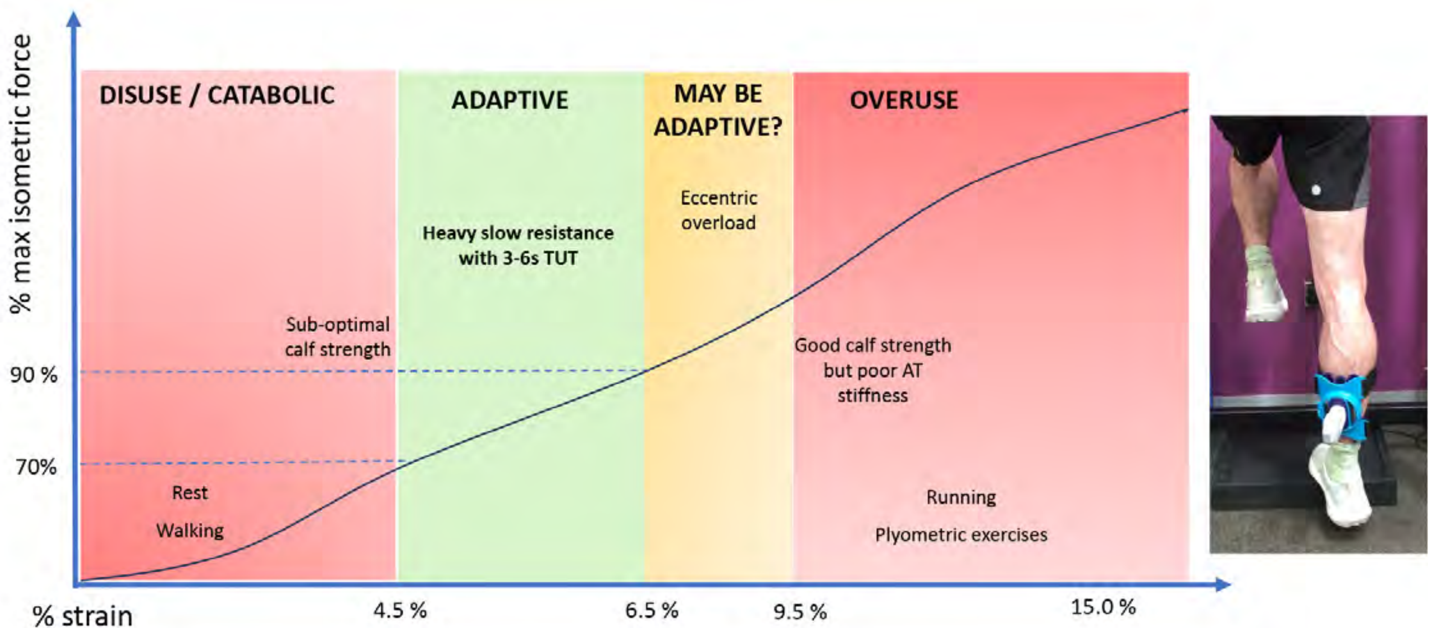


***Figure 5:** Tendon strain of between 4.5-6.5% with at least 3 seconds time under tension has been found to be the sweet spot to improve tendon mechanical properties*

Power and Reactive Strength
While calf muscle strength and capacity, as well as synergists and kinetic chain function, are critical, it is also important to measure stretch-shortening cycle (SSC) capacity through jumping and hop testing. The tendon tensile loading rates in these tasks closely replicate the demands of moderate-to-high speed running.[28-30] These tests can include double and single leg drop jumps, a single leg horizontal plyometric task, a repeated hop test such as a 10-5, and a countermovement jump. Aside from performance outcome metrics such as RSI and jump height or hop distance, it is useful to assess the player's strategy by looking at the force trace and using complementary video analysis to identify any relevant kinematic features. Relative symmetry in performance metrics and a smooth force trace with sound kinematics are key targets.

Rehab
Tendons require tension and adequate strain (4.5-6.5%) to adapt and minimise negative adaptations[31-34] as illustrated in figure 5. Therefore, complete rest should be avoided when managing a tendinopathy without co-existing partial tears or paratenonitis. In the presence of paratenonitis, it is important to offload movements that cause friction in the tendon until the oedema subsides, often requiring anti-inflammatory medication. The objective is to identify the appropriate entry level of calf and Achilles loading exercises and progress through a graded rehabilitation pathway. For a player with a very painful tendinopathy, this may involve low load, long duration isometrics or a modified calf raise that does not provoke symptoms beyond a tolerable level. Others may enter at more advanced calf exercises and include plyometric exercises early on.[35] An individualised approach is key, informed by initial assessments. Many players will present with calf muscle strength deficiencies, and often the lateral gastrocnemius experiences reduced neural drive and appears atrophied. As well as building global calf strength and capacity, targeting individual muscles such as the lateral gastrocnemius may be prudent. A healthy tendon experiences non-uniform strain between the sub-tendons from the individual muscles and between the deep and superficial layers – a mechanism that is compromised in older tendons and in tendinopathies.[19,36] Therefore, targeting the individual muscles may help restore that non-uniformity to ensure stresses are more evenly distributed across the tendon.[37]

Plyometric exercises should initially focus on smooth ground contacts through active dorsiflexion during the flight phase to generate pre-tensioning of the MTU and more favourable tendon loading during the early stance phase.[38] Once skill and capacity have been developed bilaterally and unilaterally, and in multiple planes, plyometric exercises can be intensified. For players who are naturally plyometric and less robust, caution needs to be applied with their plyometric loading. Players who fit this profile may benefit from keeping their plyometric loading submaximal and focusing more on building capacity and robustness.

Running can be introduced or progressed when a player is tolerant to consecutive plyometric sessions and demonstrates minimally acceptable calf strength and capacity, such as >1.6 x BW on a seated calf isometric test and >25 single leg calf raises through range. For players with milder symptoms and timely intervention at the reactive stage, removing running from their program may not be necessary. This may also provide an opportunity to work on running technique and coordination. Running can be progressed to the point where the player covers consecutive sessions of >3000m volume at moderate speeds, 400m of high-to-maximal speed running, and a club-agreed number of accelerations, decelerations, tackles, and other game-specific tasks. Once the player is pain-free, maintaining some calf and Achilles loading in their program and treating it like an ongoing injury is important.

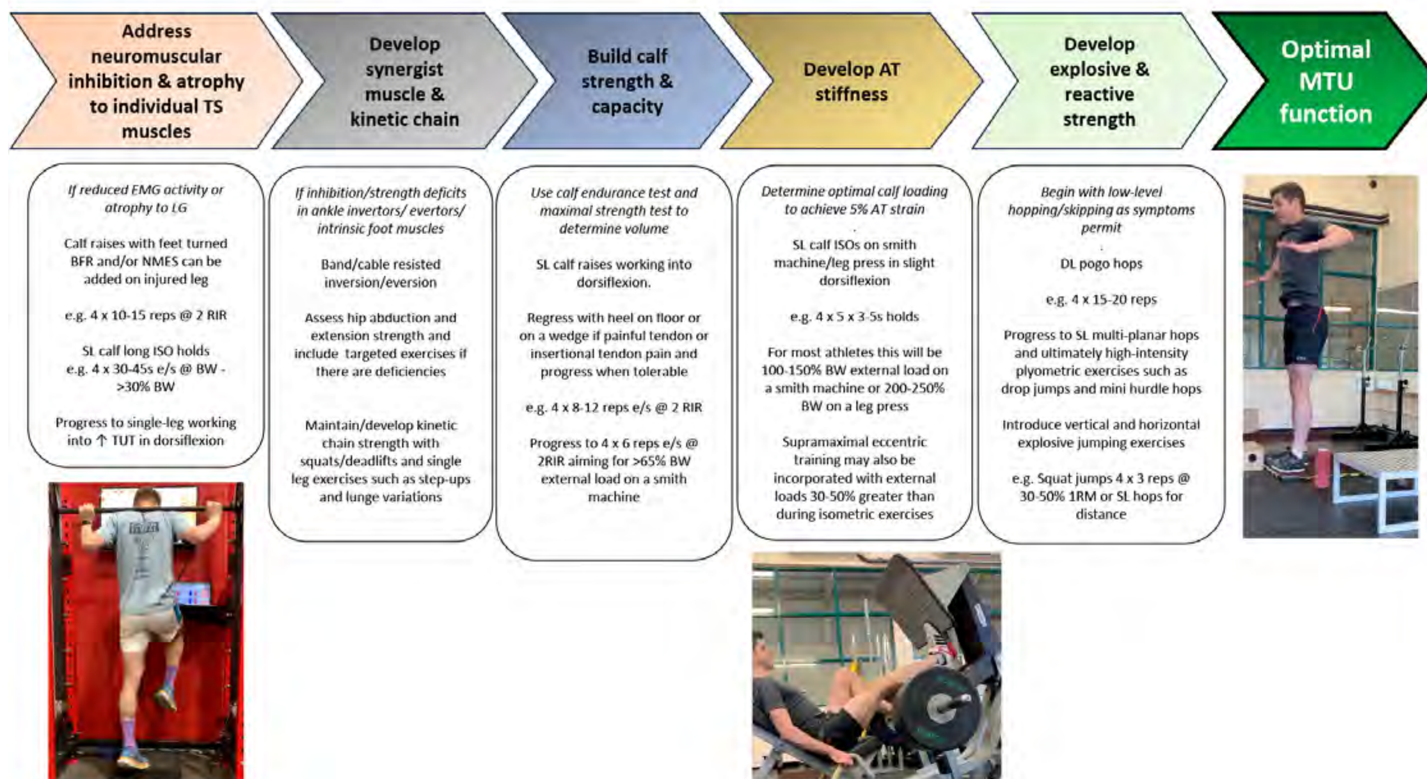


Figure 6: *A rehab framework for Achilles tendinopathy*

Conclusion

- Effective management of Achilles tendinopathies require a thorough assessment of individual anatomy, muscle morphology, strength, capacity, and biomechanics, as well as medical history to identify contributing factors and guide personalised rehabilitation.
- Rehabilitation should be tailored to the specific needs of the player, considering the severity of the tendinopathy and individual deficiencies. A graded approach that incorporates appropriate loading on the tendon and plyometric exercises is essential for optimal recovery.
- Due to the high recurrence rate, ongoing monitoring of training loads, fatigue, and biomechanics is necessary to prevent future injuries. Maintaining calf and Achilles loading in the player's program, even after they are pain-free, is crucial for long-term tendon health and performance.

Abbreviations

MTU: musculotendinous unit
TUT: time-under-tension
SL: single-leg
DL: double-leg
e/s: each side
SSC: stretch-shortening cycle
EMG: electromyography

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