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Adolescence is a critical time for patellar tendon development: it is time to rethink our current approach to patellar tendinopathy

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Patellar tendinopathy interventions have primarily focused on adult athletes with equivocal success,[1] rather than targeting potential prevention strategy(s) during the adolescent growth spurt; a period where the tendon is more susceptible to patellar tendon structural changes. This editorial focuses on the adolescent athlete and how diagnostic imaging using ultrasound tissue characterisation (UTC) can be used to understand patellar tendon structural changes.

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WHERE DOES IMAGING FIT IN HIGHLY LOADED ADOLESCENT ATHLETES?

Patellar tendinopathy is the clinical presentation of focal patellar tendon pain and a loss of functional capacity.[2] This condition presents a significant burden to jump-landing athletes and those who change direction. In the adolescent athlete, patellar tendinopathy is the most prevalent lower limb tendinopathy[3] and is associated with high morbidity, interference with sporting performance, limited participation and premature ending of careers.

Tendon imaging is not recommended or needed for the diagnosis of tendinopathy,[2] including patellar tendinopathy. However, diagnostic imaging has been used in assessing patellar tendon structural alterations to identify athletes at potential risk of developing patellar tendinopathy (ie, asymptomatic athletes with patellar tendon pathological structural changes).[4] The specific structural changes observed on diagnostic imaging are the presence of a hypoechoic area and/or focal tendon thickening (>7 mm) identified at the proximal insertion of the tendon.[5] Structural changes in asymptomatic athletes are a risk factor for the development of patellar tendon pain, with a ninefold[6] increased risk of future symptoms of patellar tendinopathy. Prevalence of athletes who develop

structural changes varies considerably from 3%[3] to 36%[4] in adolescence due to differences in population, imaging modality used and diagnostic criteria of structural changes.

CONSIDERING MATURATION NOT JUST CHRONOLOGICAL AGE

Patellar tendon structural changes develop differently to other tendons.[7] The rotator cuff and Achilles tendons have age-related (load accumulation) increases in the prevalence of structural tendon changes.[8] Whereas structural changes in the patellar tendon occur during adolescence and their prevalence does not increase with age.[9] This suggests that adolescence is the critical window where the patellar tendon may be susceptible to the development of structural tendon changes, as the athlete undergoes rapid skeletal growth and the formation of the proximal tendon attachment to the patella, especially in a high-loading environment. This distinct prevalence pattern suggests that the timing of preventative intervention strategies (targeting prevention of the development of adverse pathology) may differ from that of other tendinopathy strategies.

UTC is one approach that assesses, quantifies and monitors tendon structural changes over time. This reliable method measures the stability of the echopattern and[10] overcomes the limitations of greyscale ultrasound that provides little information on subtle changes in tendon structure and MRI lack of portability and higher cost. Quantification of the UTC echotypes allows for an enhanced understanding of the amount of load bearing tissue of the tendon (ie, aligned fibrillar structure). The UTC echotypes enable the detection of subtle changes in response to acute and chronic load[11] and quantification of the extent of pathological changes, which have been histologically validated.[10] It is hypothesised that changes in echotype II are subtle, more transient, reversible changes in structure (increases in bound water and large proteoglycans) where echotype III/IV represent fibrillar disorganisation that may not be completely reversible. Pilot UTC research offers insight into patellar tendon structural changes occurring during adolescence.[12] This suggests that adolescence may be a critical window for the development of the patellar tendon attachment.

Building on this research is our 2.5-year longitudinal UTC study of adolescent athletes in jump-land sports.[13] In this UTC study,[13] adolescent athletes (undergoing skeletal maturation) showed a linear increase in echotype I (representing aligned tendon bundles) and a decrease in echotype II (representing a slightly less stable echotype with tendon bundles becoming more discontinuous in comparison). This reversible change indicates an improvement in proximal patellar tendon structure. Interestingly, this process occurred irrelevant of whether the athlete developed structural changes or not,[13] highlighting the reversibility in tendon structure between ecotypes I and II. What is of importance for clinicians is that this longitudinal assessment of patellar tendon structure in the adolescent athlete showed a stronger linear association with skeletal maturation as opposed to chronological age alone. These findings reinforce adolescence as a critical window in the patellar tendon development and that practitioners should incorporate measures of maturation status to monitor structural changes within this window as part of their prevention strategy.

For adolescent athletes, sport programme categorisation is determined by chronological age and not the maturation status of the athlete (ie, athletes of the same chronological age can present with different levels of skeletal maturation).[13] This presents as a practical challenge for practitioners (eg, physical therapists and strength and conditioning coaches) in the use of maturation status for prescription of external workload in injury prevention or return to play programmes. Further complications may arise as many adolescent athletes at any given time compete across multiple teams and/or sport programme, participate in school-based physical activity and/or play for fun, making it difficult for practitioners to manage their athlete's total workload at critical time points during maturation.

CAN WE PREVENT?

Prevention of structural changes and tendinopathy is a clinical challenge. For practitioners who identify structural changes in their adolescent athletes (ie, hypoechoic area and/or tendon thickening) and who present with higher proportions of echotypes III and IV possibly representing irreversible tendon changes of increased structural disorganisation. Evidence suggests that these areas of structural disorganisation remain relatively stable in proportions as the adolescent athlete undergoes skeletal maturation,[13] suggesting irreversible changes. Based on current evidence, it cannot be ascertained whether these structural changes are part of a highly adaptive process as the tendon increases in anteroposterior diameter and maintains adequate levels of aligned fibrillar structure. This tendon structure adaptation may explain why echotypes III and IV remained stable in proportions over the 2.5-year longitudinal study and did not appear to worsen or improve despite continued exposure to high external workload environment.[13]

Limited evidence may allude to potential sex differences in the timing of onset of structural changes during adolescence. It is difficult to draw any definitive conclusions due to the small proportion of athletes who developed structural changes in this study.[13] However, as part of their prevention strategy, practitioners should identify when in the maturation process their athlete develops structural changes (ie, male adolescent athletes after the peak growth spurt vs female adolescent athletes before the peak growth spurt). Once structural changes develop, this may remain in the adult tendon. For practitioners, this reinforces that repeat imaging is likely of little importance to the clinical management of the athlete. This is why applying the continuum model of tendon pathology framework is important as the reactive phase (ie, increase in echotype II) offers practitioners an opportunity to implement an intervention targeting structure through load management, strength-based interventions and progressive loading before they remain in the adult tendon.[14] Interventions postmaturation should focus on clinical symptoms and function as opposed to alteration of the tendon's structural properties.

Practitioners are encouraged to consider three suggestions in their prevention and management of patellar tendinopathy in adolescence. (1) Consider the athlete's stage in the maturation process, rather than only age, and carefully evaluate the need for imaging to identify if potential patellar tendon structural change(s). (2) Recognise that once an athlete develops patellar tendon structural change(s), it may remain in the adult tendon and repeated imaging is likely of little importance to the clinical management (or diagnosis) of the athlete. (3) Prioritise postmaturation treatment to focus on addressing clinical symptoms and improving functional capacity of the tendon, rather than attempting to alter its structural properties.

Acknowledgements The authors of this manuscript declare that the results are presented clearly, honestly and without fabrication, falsification or inappropriate data manipulation. The authors would like to thank Mr Kim Colyvas (Statistical Consulting Unit, Faculty of Science; The University of Newcastle) for his statistical support in preparation of this manuscript.

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Contributors JLC, EKR, SE and SD was responsible for the conception and design of the study. MH and SE were involved in the drafting of the manuscript; and all authors contributed to the interpretation of the data for the work and revising it critically for important intellectual content. All authors have read and agreed to the published version of the manuscript. SE approved the final manuscript. SE is the guarantor.

Funding This research received funding from the GE HealthCare and National Basketball Association Orthopaedics and Sports Medicine Collaboration.

Competing interests The authors were financially supported with an Australian Government Research Training Program (PhD) scholarship and the GE HealthCare and National Basketball Association Orthopaedics and Sports Medicine Collaboration. EKR was supported by an NHMRC early career fellowship. The authors certify that they have no affiliations or financial involvement with any entity that has a direct financial interest in the subject matter of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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Check for updates

To cite Edwards S, Harris M, Docking S, *et al*. *Br J Sports Med* 2026;**60**:95–97.

Accepted 16 August 2025

Published Online First 3 December 2025

Br J Sports Med 2026;**60**:95–97.
doi:10.1136/bjsports-2024-109586

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