

***Follow up to the 2018 IOC Consensus Statement on Paediatric ACL Injuries:
towards a broader vision of care.***

E. Chahidi^{1,2,3}, C. Mouton^{1,2,4}, C. Tooth^{1,2,5}, L. de Garie^{1,6}, C. Arden^{7,8}, L. Engebretsen⁹, G. Ekås^{9,10,11}, H. Moksnes¹⁰, H. Grindem¹², P.M. Tscholl^{1,13}, F. Delvaux^{1,5,14}, R. Seil^{1,2,4}

Affiliations:

¹ ReFORM IOC Research Centre for Prevention of Injury and Protection of Athlete Health

² Luxembourg Institute of Research in Orthopedics, Sports Medicine and Science, Luxembourg

³ CHU HELORA- Hôpital La Louvière, Belgium

⁴ Clinique du sport, Centre Hospitalier de Luxembourg, Luxembourg

⁵ Department of Physical Medicine, Rehabilitation and Sports Traumatology, SportS², FIFA Medical Centre of Excellence, FIMS Collaborative Centre of Sports Medicine, CHU de Liège, Liège, Belgique

⁶ Institut National du Sport du Québec, Montréal, Canada

⁷ Department of Physical Therapy, The University of British Columbia Faculty of Medicine, Vancouver, British Columbia, Canada

⁸ Sport and Exercise Medicine Research Centre, La Trobe University, Melbourne, Victoria, Australia.

⁹ Division of Orthopaedic Surgery, Oslo University Hospital, Oslo, Norway.

¹⁰ Oslo Sports Trauma Research Centre (OSTRC), Norwegian School of Sport Sciences, Oslo, Norway.

¹¹ Institute of Clinical Medicine, University of Oslo, Oslo, Norway.

¹² Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway.

¹³ Department of orthopaedic surgery and traumatology, Geneva University Hospitals, Geneva, Switzerland

¹⁴ Departement of Physical Activity and Rehabilitation Sciences, University of Liege, Liege, Belgium

Correspondence to:

Tooth Camille, PT, PhD, Department of Physical Medicine, Rehabilitation and Sports Traumatology, SportS², FIFA Medical Centre of Excellence, FIMS Collaborative Centre of Sports Medicine, CHU de Liège, Avenue de l'Hôpital 1, 4000 Liège, Belgium. Tel: +32 495363755; E-mail: ctooth@chuliege.be

Funding: No funding has been received for this work.

Competing Interest: Nothing to declare

Ethics approval: Not applicable

Data availability statement: Not applicable

Contributors: EC wrote the paper, in collaboration with CM, RS and CT. The other authors reviewed the synthesis and gave pertinent comments that improved the quality of this work. First author is guarantor. All authors understand that they are accountable for all aspects of the work and ensure the accuracy or integrity of this manuscript.

In 2018, the IOC issued a consensus statement on the prevention, diagnosis, and management of paediatric anterior cruciate ligament (ACL) injuries. It articulated fundamental principles to guide children, parents, and clinicians in making informed decisions, safeguarding long-term knee health, and supporting lifelong activity [1]. Subsequent research has identified previously unaddressed aspects of paediatric ACL injuries and underscored their emergence as a significant public health concern requiring a coordinated and sustainable response. This editorial examines recent advances, current evidence, and persistent challenges in paediatric ACL injury prevention, individualised management decisions, evolving surgical strategies, and long-term holistic care (Table 1).

1. Are effective ACL injury prevention strategies sufficiently implemented in youth sports?

Non-contact ACL injury risk can be reduced by up to 64% in female athletes aged 12–19 [2]. Yet, despite this strong evidence, the incidence of ACL injuries in youth sports continues to rise, reflecting persistent challenges in translating prevention programmes into practice[3].

Effective programs should begin in pre-season and continue through the season, combining at least three components. Plyometric and strength training are most consistently supported by evidence and are most often recommended, particularly when combined with feedback or coaching on technique[2]. Agility, balance, and stretching are also commonly included in ACL injury prevention programmes, although the evidence supporting their independent effectiveness is less robust[2].

Initiatives like ESSKA-ESMA’s “Prevention for All” aim to embed ACL prevention in youth and adolescent sports across all sports levels, while also highlighting real-world barriers such as coach education, funding, and adherence. Prevention efforts should engage children, parents, coaches, and healthcare providers alike. Anyone can encourage young athletes in high-risk sports involving jumping, landing, and cutting to follow tailored prevention programmes adapted to their context[4]. Achieving this requires broader health campaigns to raise awareness of ACL injury risks, management, and consequences. Such campaigns remain limited and focus almost exclusively on primary prevention, while organised initiatives targeting secondary (reinjury risk) and tertiary (long-term consequences) prevention are largely absent, despite being integral to injury prevention.

2. Tailoring Management Decisions to the Paediatric Patient

In children with ACL injuries, factors including growth status, hormonal changes, neuromuscular development, injury severity, activity level, and patient expectations evolve over time, influencing both reinjury risk and recovery trajectories. Close surveillance of instability, functional limitations, activity restrictions, growth disturbances, and secondary injuries is thus essential, as it informs timely treatment decisions, guides individualised rehabilitation, and allows early detection of complications that could alter the management pathway.

Current evidence increasingly supports early (<12 weeks) surgical stabilisation to preserve long-term knee integrity[5,6] . Non-operative management has been associated with higher rates of pathological laxity, secondary meniscal and chondral damage, and reduced return-to-sport rates, particularly in active children or those who have difficulty adhering to activity restrictions [5,6]. Nonetheless, non-surgical treatment has an important role in carefully selected cases, such as patients with partial ACL tears, preserved meniscal integrity, lower activity demands, or a strong family preference to avoid surgery.

Irrespective of the chosen treatment pathway, strict adherence to paediatric-specific rehabilitation protocols is critical. A recent consensus differentiated pre- from post-pubertal athletes and outlined three criterion-based rehabilitation phases, with a fourth phase dedicated to sustained injury prevention[7]. For pre-pubertal athletes, rehabilitation should place greater emphasis on neuromuscular training, movement quality, and parental involvement, as well as extended rehabilitation timelines often exceeding 12 months. The consensus identified educational requirements during rehabilitation and recommended when psychological support or orthopaedic consultation should be considered. Although certain issues - such as managing concomitant injuries that prolong rehabilitation - remain insufficiently addressed, this framework represents an important step toward improving paediatric ACL care.

Adjunctive strategies, including bracing, remain a subject of debate. While braces can reduce anterior tibial translation, their effects on proprioception are debated, and their use may slow hamstring reaction times [5]. Promising results from bracing to promote biological healing in adults [8] should not be extrapolated uncritically to children, where compliance, muscle atrophy, and short- and long-term outcomes remain uncertain[5].

3. Beyond ‘Traditional’ Isolated ACL Reconstruction

In young, active patients, ACL reconstruction remains preferable to ACL repair. Although repair initially appeared promising - preserving growth plates, avoiding donor-site morbidity, and facilitating high rates of return to sport - it is associated with unacceptably high failure rates, reaching up to 50% in this population[9].

Hamstring tendon (HT) autograft has long been the standard for paediatric ACL reconstruction. However, the quadriceps tendon graft is gaining prominence due to its consistent size, preservation of hamstring function, and lower rupture rates compared with HT grafts[10].

Adjunctive procedures are also shaping contemporary practice. Over the past decade, lateral extra-articular procedures (LEAPs) have been increasingly adopted to enhance rotational stability and reduce graft failure risk in high-demand young athletes, despite ongoing concerns about over-constraint. Furthermore, meticulous attention to concomitant injuries is now central to improving outcomes and

protecting the reconstructed ACL. In particular, preserving meniscal integrity is critical, as meniscal loss compromises joint mechanics and may accelerate long-term joint degeneration[5,11].

When ACL reconstruction and associated injuries are managed appropriately, complications such as leg length discrepancies (>10 mm) and angular deformities remain rare (<2%). Although early (<5 years) post-traumatic osteoarthritis (PTOA) appears uncommon in insurance database studies (<2%), paediatric-specific long-term data remain lacking. These reported rates are likely underestimated, particularly given the strong association between ACL injury and PTOA in adult populations, and may increase over time or in patients requiring subsequent surgery [12,13]. Encouragingly, up to 74% of paediatric patients return to sport, and some progress to elite levels[14]. However, this positive outlook is tempered by secondary ACL injury rates of 25–30% (graft failure or contralateral ACL rupture), underscoring the substantial risk of reinjury.[14].

4. Extending Care Beyond Physical Recovery

Recent approaches to paediatric ACL recovery extend beyond symptoms and functional outcomes to encompass emotional and social dimensions. The inability to participate in sport can be particularly distressing during adolescence, a critical period for identity formation, social development, and self-esteem. Young athletes may experience anxiety, depression, loneliness, or loss of identity, which can hinder rehabilitation and increase reinjury risk[15]. In this context, families and healthcare providers (including psychologists) must act as guardians of the child's overall well-being. Their role extends beyond physical rehabilitation to include recognising emotional challenges, providing tailored guidance, managing expectations, and encouraging balanced participation in sport. In cases where treatment results are suboptimal, transitioning to lower-risk activities should be discussed with the child and their guardians to support social, physiological, and mental resilience. Embedding this holistic perspective into clinical practice and care pathways is essential not only to improve recovery but also to foster resilience, safeguard long-term health, and reduce the burden of repeat injuries.

Conclusion

To ensure that every child has a fair opportunity to remain active and healthy throughout life, care must begin from the moment they first participate in physical activity. Public awareness of ACL injury risks should be strengthened, alongside promoting healthy behaviours in environments that actively support children. Paediatric ACL injuries are inherently complex and demand a multifaceted, patient-centred approach. While advances in understanding the injury and its management have been considerable, important gaps persist, particularly in large-scale prevention initiatives and in integrating psychological support. Beyond restoring knee function, the child's overall well-being must remain central to treatment and rehabilitation. Sustainable and evidence-based strategies are needed to support children, minimise

139 reinjury risk, and improve quality of life. Ultimately, a broader vision of care - one that embraces
140 prevention, education, and long-term health -will best promote resilience and lifelong well-being.

141 **Table 1:** Progress and future directions in paediatric ACL injury care

Domain	Recent Advances	Ongoing Challenges and Unmet Needs
Injury Prevention	• Evidence-based prevention programs reduce non-contact ACL injury risk. • Core components should include plyometric and strength training, combined with feedback and coaching on technique.	• Barriers to large-scale implementation: coaches' education, funding, adherence, and lack of broad public health campaigns. • Lack of secondary and tertiary prevention initiatives.
Individualised Management	• Consensus on paediatric-specific, criterion-based rehabilitation. • Early surgical stabilisation (<12 weeks) is favoured for active children to preserve knee integrity.	• Insufficient guidance for managing concomitant injuries. • Debate persists on bracing usage. • Need for clearer criteria to guide surgical vs. non-surgical decision-making.
Surgical Strategies	• Shift away from ACL repair due to high failure rates (up to 50%). • Increased use of quadriceps tendon autografts. • Increased use of lateral extra-articular procedures (LEAPs) to enhance rotational stability and decrease graft failure. • Increase awareness on the need to treat associated injuries. • Growth-related complications (leg length discrepancy, angular deformities) remain rare but require vigilance. • Up to 74% return to sport, with some reaching elite levels.	• Limited long-term outcome data for newer techniques. • Limited paediatric specific data on post-treatment osteoarthritis incidence and influencing factors.
Holistic Care	• Growing awareness of psychosocial impact (anxiety, depression, identity loss) during adolescence. • Role of families and psychologists in supporting emotional well-being and rehabilitation adherence.	• Psychosocial support not yet standard in clinical pathways. • Training gaps for healthcare providers and coaches in recognising and addressing mental health challenges.

- 143 1 Ardern CL, Ekås GR, Grindem H, *et al.* 2018 International Olympic Committee consensus
144 statement on prevention, diagnosis and management of paediatric anterior cruciate ligament
145 (ACL) injuries. Published Online First: 1 April 2018. doi: 10.1136/bjsports-2018-099060
- 146 2 Mattu AT, Ghali B, Linton V, *et al.* Prevention of Non-Contact Anterior Cruciate Ligament
147 Injuries among Youth Female Athletes: An Umbrella Review. *International Journal of*
148 *Environmental Research and Public Health*. 2022;19:4648. doi: 10.3390/ijerph19084648
- 149 3 Kooy CEVW, Jakobsen RB, Fenstad AM, *et al.* PIncrease in Incidence of Pediatric ACL
150 Reconstructions From 2005 to 2021: A Study From the Norwegian Knee Ligament Register. *Am J*
151 *Sports Med*. 2023;51(11):2891-2899. doi:10.1177/03635465231185742
- 152 4 Benjaminse A, Verhagen E. Implementing ACL Injury Prevention in Daily Sports Practice-It's
153 Not Just the Program: Let's Build Together, Involve the Context, and Improve the Content. *Sports*
154 *Med*. 2021;51:2461–7. doi: 10.1007/s40279-021-01560-4
- 155 5 Bixby EC, Heyworth BE. Management of Anterior Cruciate Ligament Tears in Skeletally
156 Immature Patients. *Curr Rev Musculoskelet Med*. 2024;17:258–72. doi: 10.1007/s12178-024-
157 09897-9
- 158 6 James EW, Dawkins BJ, Schachne JM, *et al.* Early Operative Versus Delayed Operative Versus
159 Nonoperative Treatment of Pediatric and Adolescent Anterior Cruciate Ligament Injuries: A
160 Systematic Review and Meta-analysis. *Am J Sports Med*. 2021;49:4008–17. doi:
161 10.1177/0363546521990817
- 162 7 van Melick N, Dietvorst M, van Oort MIAM, *et al.* Anterior Cruciate Ligament Rehabilitation for
163 the 10- to 18-Year-Old Adolescent Athlete: Practice Guidelines Based on International Delphi
164 Consensus. *Orthopaedic Journal of Sports Medicine*. 2023;11:23259671231172454. doi:
165 10.1177/23259671231172454
- 166 8 Filbay SR, Dowsett M, Chaker Jomaa M, *et al.* Healing of acute anterior cruciate ligament rupture
167 on MRI and outcomes following non-surgical management with the Cross Bracing Protocol. *Br J*
168 *Sports Med*. 2023;57:1490–7. doi: 10.1136/bjsports-2023-106931
- 169 9 Gagliardi AG, Carry PM, Parikh HB, *et al.* ACL Repair With Suture Ligament Augmentation Is
170 Associated With a High Failure Rate Among Adolescent Patients. *Am J Sports Med*.
171 2019;47:560–6. doi: 10.1177/0363546518825255
- 172 10 Rangasamy K, Baburaj V, Gopinathan NR, *et al.* Quadriceps tendon autograft is promising with
173 lower graft rupture rates and better functional Lysholm scores than hamstring tendon autograft in
174 pediatric ACL reconstruction. A systematic review and meta-analysis. *J Orthop*. 2023;49:156–66.
175 doi: 10.1016/j.jor.2023.12.014
- 176 11 Matava MJ, Gibian JT, Hutchinson LE, *et al.* Factors Associated With Meniscal and Articular
177 Cartilage Injury in the PLUTO Cohort. *Am J Sports Med*. 2023;51:1497–505. doi:
178 10.1177/03635465231164952
- 179 12 Moran J, Gouzoulis MJ, Kunze KN, *et al.* Incidence and Risk Factors for Posttraumatic
180 Osteoarthritis After Primary ACL Reconstruction in Pediatric Patients: A National Database
181 Study. *Orthop J Sports Med*. 2025;13:23259671251313754. doi: 10.1177/23259671251313754
- 182 13 Fury MS, Paschos NK, Fabricant PD, *et al.* Assessment of Skeletal Maturity and Postoperative
183 Growth Disturbance After Anterior Cruciate Ligament Reconstruction in Skeletally Immature
184 Patients: A Systematic Review. *Am J Sports Med*. 2022;50:1430–41. doi:
185 10.1177/03635465211008656

- 186 14 Thorolfsson B, Winkler PW, Piuksi R, *et al.* The Chance to Become an Elite Athlete After
187 Pediatric And Adolescent Anterior Cruciate Ligament Reconstruction. *Am J Sports Med.*
188 2025;3635465251320415. doi: 10.1177/03635465251320415
- 189 15 Matsuzaki Y, Chipman DE, Hidalgo Perea S, *et al.* Unique Considerations for the Pediatric
190 Athlete During Rehabilitation and Return to Sport After Anterior Cruciate Ligament
191 Reconstruction. *Arthrosc Sports Med Rehabil.* 2022;4:e221–30. doi: 10.1016/j.asmr.2021.09.037
- 192