Pediatric Anterior Cruciate Ligament Injuries: We Need to Do Better for Our Most Vulnerable Patients

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Secular trends over the past 2 decades indicate that an increasing number of younger patients (10–19 years) are being diagnosed with an anterior cruciate ligament (ACL) injury and seeking ACL reconstruction compared with adults.^{1–4} These ACL injuries typically begin to occur around age 11 and then increase steadily until ages 17 to 19.⁵ Such trends are particularly concerning for young females, who are more likely to injure their ACL earlier in life (the peak is at approximately 14–18 years old) versus similarly trained males (whose peak is around 19–25 years old)⁶ and subsequently are more likely to suffer a secondary ACL injury and injury-related disability early in the lifespan.^{7,8}

Despite these well-established and concerning trends, a current PubMed search revealed that only 15% of papers published on *ACL injury (nonsurgical)* focused on the pediatric population. This begs the question: if the adolescent years are such a critical time for injuring the ACL, why do we continue to preferentially focus our efforts on studying adult ACL-injured populations?

A CALL FOR MORE RESEARCH FOCUS ON THE PEDIATRIC ATHLETE

Primary injury risk assessment and timely prevention remain paramount if we are to lessen the long-term effects of ACL injury. Although we know that many of the physical risk factors associated with ACL injury develop or change (both within and between sexes) during physical maturation, we have yet to identify at the individual level *who* is likely to become injured, *how* the injury is likely to occur, and *when* that risk first develops. Moreover, our previous focus has been primarily on physical risk factors, and we are just beginning to understand the role of neurocognitive factors in primary injury risk and prevention. Addressing these knowledge gaps is crucial if we are to take more of a precision medicine approach to ACL injury-prevention programs (IPPs) for the pediatric athlete, which have been slow to evolve over the past several years.

Despite evidence of greater effectiveness of IPPs when administered earlier in life,⁹ the literature indicates that the vast majority of randomized controlled trials of ACL IPPs to date have focused on late adolescent or young adult populations (14+ years of age).¹⁰ If we are to "get ahead" of the onset of injury, shouldn't we be evaluating the effectiveness of implementing IPPs at younger ages? Many researchers from 1995 through 2015 concentrated on ACL IPPs, yet few advances have been published in the last 6 to 7 years. Have we solved the problem, or have we become complacent in thinking that the current programs are sufficiently effective?

For those who sustain an ACL injury, surgical and rehabilitation approaches continue to evolve. It is important that we pursue the most relevant physiological and patientreported outcomes to assess treatment effectiveness and return to sport in the pediatric athlete. More information about these outcomes will enable us to safely return youngsters to sport and lessen their potential for secondary injury and long-term complications.

OVERCOMING THE BARRIERS TO STUDYING PEDIATRIC ACL INJURY

Although data on ACL injury risk development and the outcomes after pediatric ACL injury are critically needed, we recognize the considerable barriers to properly studying this population that often lead us to focus our research efforts on adult ACL injuries. We must consider research models that extend beyond our laboratories and engage community partners (eg, schools, athletic programs, pediatric clinics) to facilitate periodic longitudinal assessments of a large volume of children and adolescents with minimal burden to parents and participants.

It is also important that we properly consider and define standardized approaches for characterizing the maturity status of study participants. The current literature characterizes the maturity status of pediatric patients in multiple ways, including chronological age, sexual maturational status, and skeletal age and growth. Even within a method (eg, Tanner stage), phases are often collapsed into prepubertal, pubertal, and postpubertal, but these categorizations are not defined consistently. The predominant use of chronological age is problematic given the range in ages and pace at which individuals proceed through puberty, both within and between sexes. We recognize that the inconsistent characterization of maturity status may result, in part, from study purposes and designs (ie, maturity designations may not be a primary purpose of the research) or the greater complexity in determining sexual or skeletal maturation as opposed to chronological age. However, we must also acknowledge that these inconsistencies lead to a muddled sense of the individual and sex-dependent maturational biopsychosocial factors that contribute to primary and secondary ACL injury and positively or negatively affect both short- and long-term joint health. Until we take a more standardized approach to defining maturity status, this will remain a logistical hurdle that

OUR GOAL FOR THIS SPECIAL ISSUE ON PEDIATRIC ACL INJURY

We are grateful to the leadership of the Journal of Athletic Training for the opportunity to directly address the need to comprehensively study ACL injury in the pediatric athlete. We are excited to dedicate the current special issue to this subject and to incorporate a novel cohort of studies that tackle the problem of pediatric ACL injury from a variety of angles. Specifically, this special issue's authors evaluated primary risk and prevention with a focus on sex-dimorphic development of risk factors during the maturation process and speak to the need for future longitudinal designs in which outcomes are stratified by maturation stage (the primary driver of these physical changes) rather than chronological age. Other researchers address the potential barriers to and facilitators of implementing prevention programs in youth sports, our understanding of the role that central processes play in injury risk biomechanics, and the response to training interventions. Also included are basic science and orthopaedic studies describing recent updates on ACL maturation and trends in reconstruction and operative techniques. Finally, several authors discuss rehabilitation considerations after ACL injury, and others speak to the latest advances and perceived challenges in return-to-sport criteria.

In this issue, you will also find the proceedings from ACL Research Retreat IX: the Pediatric Athlete. The Retreat was held March 17–19, 2022, in High Point, North Carolina, and brought together clinicians and scientists to present and examine recent research developments in pediatric ACL injury across the ACL injury continuum (see the "Summary Statement" for more information on the findings from and conversations during the meeting). We have organized the 42 podium presentations around similar themes as the fulllength articles so that the reader can gain a more complete picture of the emerging work in each area.

OUR HOPE FOR THE FUTURE

We appreciate the many outstanding researchers and clinicians who have contributed to this special issue, which demonstrates some of the best current work on pediatric ACL injuries. We realize there is still an incredible amount of work to do in this area, and we hope that the attention given here to pediatric ACL injuries will act as a catalyst to fill critical knowledge gaps and lead to significant clinical advancements that protect our young athletes. The current clinical need is clear: we must decrease the primary risk of ACL injury in pediatric patients and develop evidence-based treatments to reduce secondary risk and improve joint health across the lifespan. Our vision is an updated special issue 10 years from now that directly responds to the call to action sounded as part of this special issue and ACL Research Retreat IX. Specifically, we expect that this future issue will include studies that identify the earliest markers of risk development and provide advanced, evidence-based screening and IPPs targeting our younger athletes while their risks may still be modifiable. For our pediatric patients who sustain an ACL injury, new and innovative maturation-specific interventions to maximize function and lifelong joint health will have been designed and tested. As a scientific community, we have made tremendous strides in understanding ACL injury risk and prevention in collegiate and professional athletes. It is now time to turn our attention to our most vulnerable population, pediatric athletes, which will also pay great dividends for the populations we have more traditionally studied.

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