

Original Research

# Parental Awareness and Attitudes Towards ACL Injury Prevention Programs in Youth Athletes

Paola R. Sparagana, BS<sup>1</sup>; Bayley Selee, BS<sup>1</sup>; Henry B. Ellis Jr., MD<sup>1</sup>; Matthew Ellington, MD<sup>2</sup>; Jennifer J. Beck, MD<sup>3</sup>; Sasha Carsen, MD, MBA<sup>4</sup>; Allison Crepeau, MD<sup>5</sup>; Aristides I. Cruz Jr., MD, MBA<sup>6</sup>; Benton Heyworth, MD<sup>7</sup>; Stephanie W. Mayer, MD<sup>8</sup>; Emily L. Niu, MD<sup>9</sup>; Neeraj Patel, MD, MPH, MBS<sup>10</sup>; Andrew Pennock, MD<sup>11</sup>; Curtis Vandenberg, MD<sup>8</sup>; Kelly Vanderhave, MD; Brendan A. Williams, MD<sup>12</sup>; Zachary S. Stinson, MD<sup>13</sup>

<sup>1</sup>Scottish Rite for Children, Dallas, TX; <sup>2</sup>Central Texas Pediatric Orthopedics, Dell Medical School, The University of Texas at Austin, Austin, TX; <sup>3</sup>Boulder Medical Center, Boulder, CO; <sup>4</sup>Children's Hospital of Eastern Ontario, University of Ottawa, Ottawa, Ontario; <sup>5</sup>Connecticut Children's Hospital, Farmington, CT; <sup>6</sup>Department of Orthopaedic Surgery, Brown University, Providence, RI; <sup>7</sup>Boston Children's Hospital, Orthopedic Center, Boston, MA; <sup>8</sup>Children's Hospital Colorado, Department of Orthopaedic Surgery, Aurora, CO; <sup>9</sup>Children's National Hospital, Washington, DC; <sup>10</sup>Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL; <sup>11</sup>Rady Children's Hospital, San Diego, CA; <sup>12</sup>Children's Hospital of Philadelphia, Philadelphia, PA; <sup>13</sup>Nemours Children's Health, Orlando, FL

Correspondence: Zachary S. Stinson, MD, Nemours Children's Health, 13535 Nemours Parkway, Orlando, FL 32827. Email: zachary.stinson@nemours.org

Received: September 14, 2023; Accepted: October 19, 2023; Published: November 15, 2023

DOI: 10.55275/JPOSNA-2023-788

## Abstract

**Background:** The incidence of anterior cruciate ligament (ACL) injuries has steadily increased in young athletes and may have long-term implications for physical function and quality of life. ACL injury prevention programs have been developed and refined over the past several decades and have been shown to reduce the risk of ACL injuries by up to 70%. However, awareness and understanding of these programs among parents of athletes is unknown. This study aims to evaluate knowledge and attitudes toward ACL injury prevention programs for parents of young athletes involved in cutting and pivoting sports at varying levels of competition.

**Methods:** A cross-sectional survey was nationally distributed to a convenience sample of parents of young athletes between the ages of 5 and 18. The survey focused on questions relating to demographic information, history of ACL injury, knowledge of ACL injury prevention programs, and factors influencing program awareness. Descriptive statistics were used to summarize participant characteristics and determine prevalence of program awareness.

**Results:** A total of 244 parents completed the survey with 74% indicating their child's primary sport was soccer. Seventy-seven percent of these athletes began specializing in their primary sport at an average age of 8 years old

(SD = 2.72). Only 18% of parents reported knowledge of ACL injury prevention programs and just 6% reported their child has ever participated in one. Of the 29 (12%) athletes who had experienced an ACL injury, only 17% had participated in an ACL injury prevention program. The most commonly reported barrier to ACL injury prevention program participation was the lack of awareness of where to get such training and it not being readily offered to their child. Sixty-eight percent of all parents would have their child participate in an ACL injury prevention program if offered to them.

**Conclusion:** There is a lack of awareness of ACL injury prevention programs among parents of young athletes involved in high injury-risk sports. However, most parents would be interested in their child utilizing an ACL injury prevention program if it were offered.

**Levels of Evidence:** Level IV

### Key Concepts

- Given the young age at which athletes are specializing in their sport and other contributing factors, ACL injury prevention programs are becoming increasingly important.
- Parents of youth athletes demonstrate a lack of awareness regarding ACL injury prevention programs.
- Barriers to the utilization of ACL injury prevention programs include both a lack of knowledge of their availability and where to access this form of training.
- Many parents are interested in having their child participate in an ACL injury prevention program.
- Spreading awareness of ACL injury prevention programs will require a multi-faceted approach.

## Introduction

There has been a steady increase in youth sports participation in recent years, with three-quarters of U.S. households having children engaged in sports activities.<sup>1-3</sup> This increased participation, along with a trend towards increased early sports specialization and increased volume and intensity of training, has led to a corresponding increase in youth sport injuries, including anterior cruciate ligament (ACL) injuries.<sup>4-6</sup> ACL injuries have a profound impact on young athletes, both physically and psychologically,<sup>7-10</sup> requiring them to withdraw from sports participation and incurring substantial surgical and rehabilitation costs.<sup>11</sup> In addition, ACL injuries result in an increased risk of developing osteoarthritis.<sup>12,13</sup> The success rate of athletes returning to competition after ACL reconstruction has been reported to range between 50 to 95%,<sup>14-18</sup> emphasizing the need for implementing effective preventative measures.

ACL Injury Prevention Programs (IPPs) have proven to be effective, with a previous meta-analysis demonstrating a relative risk reduction of 70% and one ACL injury prevented for every 89 athletes who participated in an IPP.<sup>1</sup> In addition, studies that demonstrated higher compliance were associated with improved reduction rates.<sup>19</sup> While many variations of IPPs have been developed and modified over the past several decades, the common underlying principles of these programs is to modify neuromuscular and biomechanical risk factors thought to be associated with ACL tears, such as peak knee valgus moment during landing.<sup>20-24</sup>

Despite the existence of effective injury prevention programs that have been available and easy to incorporate into regular warm-ups since as early as the 1990s<sup>25</sup> there has been a dramatic rise in the incidence

of ACL tears among pediatric athletes,<sup>26</sup> with a 3-fold increase demonstrated by Dodwell et al. between 1990 and 2009. Encouragingly, Brodeur et al. identified a decrease in this trend between 2014 and 2017 and suggested that injury prevention programs may be part of the reason for the improvement.<sup>27</sup>

There is little that is known about the overall implementation and utilization of ACL IPPs among youth athletes in North America. In addition, the level of awareness of ACL IPPs parents of young athletes is unknown. Parents represent the ultimate safety advocate for their child. It is important to identify gaps in knowledge or awareness of IPPs among parents of young athletes so that efforts can be made to address these deficiencies. To our knowledge, there have been no studies evaluating the knowledge and attitudes of parents of young athletes regarding IPPs.

The primary aim of this study was to investigate the knowledge, attitudes, access, and utilization of ACL injury prevention programs among parents of young athletes involved in high-risk sports via cross-sectional survey. A secondary goal of this study was to identify both barriers and facilitators of awareness of IPPs so that actionable steps can be taken to improve the broader implementation of these evidence-based programs.

## Materials & Methods

With Institutional Review Board approval, a Research Electronic Data Capture (REDCap) survey on youth sport injury prevention awareness was developed by members of the Pediatric Orthopaedic Society of North America's Quality, Safety, and Value Initiative (POSNA QSVI) Sports Committee using the Checklist for Reporting Results of Internet E-Surveys (CHERRIES).<sup>28</sup>

The branching logic survey was distributed to athletes, parents of athletes, coaches, athletic trainers, and youth sports professionals (administrators, league organizers, athletic directors, etc.). The survey findings reported in this current study specifically focus on the findings

of survey respondents who reported as being a parent of an athlete involved in a sport considered at high risk for ACL injuries, such as soccer, basketball, football, volleyball, and lacrosse. Each of the eight members of the POSNA QSVI Sports Committee actively recruited voluntary survey participants. The geographic locations represented by the committee members included Central Florida, North Texas, Central Texas, Southern California, Colorado, and Eastern Ontario. The surveys were distributed through multiple avenues, such as fliers posted in the clinic setting with QR codes, active recruitment at school and recreational sporting events, and marketing of the survey on hospital webpages, social media, and text/email messages. Surveys were distributed from February 2021 to February 2023 to capture a diverse representation of youth sports.

To complete the survey on parent awareness of ACL injury prevention programs, respondents had to be adults over the age of 18 years, proficient in English (both speaking and writing), and be a parent to one or more youth athletes. Respondents did not receive compensation upon survey completion.

The survey used branching logic to tailor questions specific to respondents' sports experience. Respondents who identified as a parent of an athlete involved in a cutting or pivoting sport, including soccer, basketball, football, lacrosse, and volleyball, were directed towards questions regarding their awareness and experience with ACL injury prevention programs (Figure 1), in addition to questions about sport specialization, intensity of training, and general attitudes about sports participation.

In the first section of the ACL parent survey, respondents provided information on their child's demographics and level of sport involvement. The second section of the survey focused on parental perceptions regarding their child's involvement in sports. The third section of the survey inquired about the ACL injury history of their child. The subsequent section focused on parent awareness of ACL injury prevention programs. The final section of the survey addressed barriers and future interest in ACL injury prevention programs.

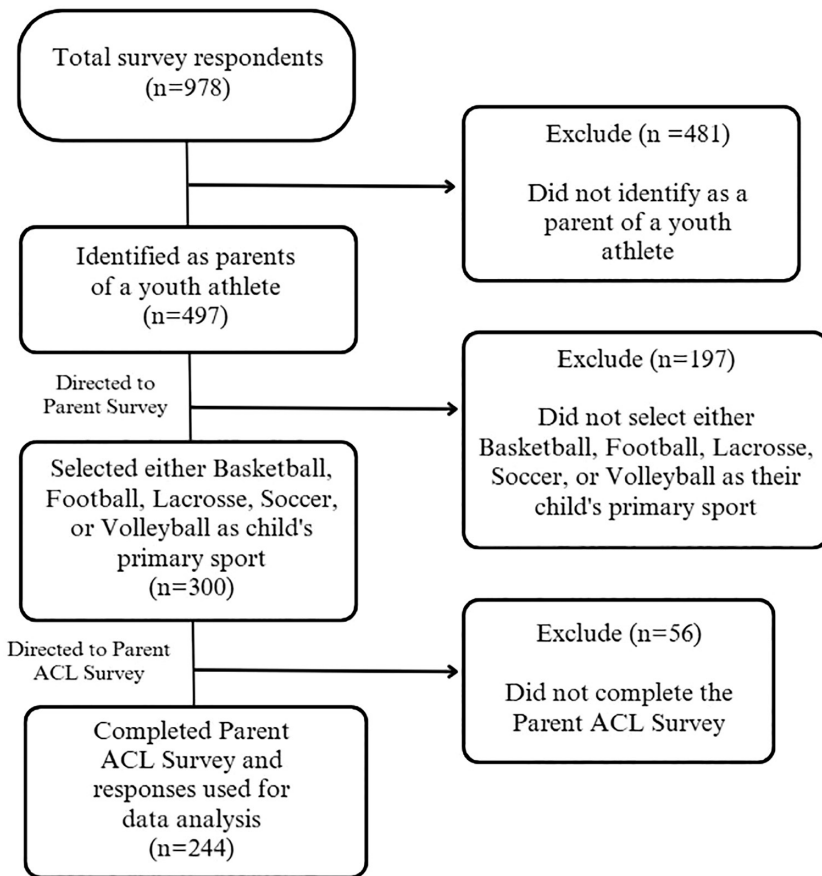


Figure 1. Flow diagram for participant selection.

The survey question used to measure parental awareness was, “Are you aware of the availability of ACL injury prevention training (either offered by your own team or in the community)?” We defined beginner competition level as “just learning/play for fun,” intermediate as “regularly involved but not in top 10% of peers,” and elite/super elite as in top 10%/1% of peers, respectively (see Appendix A for pre-survey and parent ACL survey).

Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA) was used for data analysis and standard descriptive statistics were calculated.

## Results

### Overview

Total survey participation included 978 respondents, of which 300 reported as being parents of young athletes.

After completing the demographics portion, 56 of parent respondents dropped out. The remaining 244 (81%) were analyzed for the purposes of this study.

### Youth Athlete Demographics & Sport Involvement

In the first section of the survey, participants provided information on youth athletes’ demographics and level of sport involvement (Table 1).

The average age of respondents’ child athlete at the time of the survey was 12.7 years (SD = 3.00). Most respondents’ child athletes were male (65%), followed by female (34%). The majority of participants identified their race/ethnicity as White (59%). Among those who completed this section, 63 (53%) resided in Florida, with 40 (33%) residing in Texas.

The average age at which youth athletes began playing organized sports was 5.1 years (SD = 2.02), with the

**Table 1. Demographic Data and Sport Involvement of Survey Respondents' Child Athlete**

|  | N (%)    |
|--|----------|
| Gender                                     |          |
| Male                                       | 158 (65) |
| Female                                     | 84 (34)  |
| Prefer not to answer                       | 2 (1)    |
| Race/Ethnicity*                            |          |
| American Indian or Alaska Native           | 2 (3)    |
| Asian                                      | 6 (9)    |
| Black or African American                  | 9 (14)   |
| Hispanic or Latino                         | 15 (23)  |
| Native Hawaiian or Other Pacific Islander  | 1 (2)    |
| White                                      | 38 (59)  |
| Age at Collection (years)                  |          |
| 1-5  | 5 (2)    |
| 6-10                                       | 45 (19)  |
| 11-15                                      | 141 (60) |
| 16-20                                      | 45 (19)  |
| Primary Sport                              |          |
| Soccer                                     | 221 (73) |
| Basketball                                 | 30 (10)  |
| Football                                   | 26 (9)   |
| Volleyball                                 | 13 (4)   |
| Lacrosse                                   | 10 (3)   |
| Weekly hours spent training in their sport |          |
| <5   | 31 (13)  |
| 5-9  | 126 (52) |
| 10-14                                      | 56 (23)  |
| 15-19                                      | 25 (10)  |
| ≥20  | 5 (2)    |
| Competition level                          |          |
| Beginner or casual                         | 13 (5)   |
| Intermediate                               | 95 (39)  |
| Elite & Super Elite                        | 135 (56) |

Note: Respondents were not required to answer every question.  
\*Respondents could select multiple options.

majority (69%) starting in early childhood (ages 2-5). Soccer was reported as the primary sport for most respondents' children (73%), followed by basketball (10%), football (9%), volleyball (4%), and lacrosse (3%). Most (77%) reported their child specialized in their primary sport. The average age at which youth athletes began specializing in their primary sport was 8 years (SD = 2.72), with the majority (55%) specializing during middle childhood (ages 6-9).

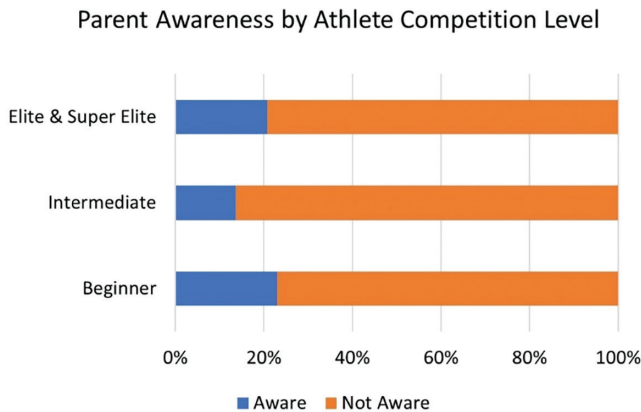
Half of the respondents (52%) reported their child spent an average of 5 to <10 hours per week training or competing in their sport. In terms of competition levels, 135 (56%) respondents reported their child competed at an elite or superelite level, followed by 95 (39%) at an intermediate level, and 13 (5%) at a beginner or casual level.

#### ***Youth Athlete ACL Injury History***

Twenty-nine (12%) reported a history of an ACL tear, with 90% of these injuries occurring while participating in their primary sport. Of those who experienced an ACL injury, 9 (31%) were aware of ACL injury prevention programs but only 5 (17%) had participated in such programs before their ACL tear.

#### ***Parent Awareness of ACL Injury Prevention Programs***

Among the 244 respondents, 199 (82%) were unaware of the availability of these programs. Out of the 45 (18%) who were aware, only 14 (6%) had participated in one. A series of questions was then prompted to the 14 respondents whose children had participated in an ACL injury prevention program. Among these, 50% reported receiving their training from someone other than their team coach or trainer (personal or athletic trainer), while the remaining 50% received training from their sport coach or trainer either pre-season and/or during the season. In terms of reasons for participation, 7 (50%) reported voluntary participation, 4 (29%) indicated mandatory participation, and the remaining 3 (21%) cited other reasons. Of the 4 who reported mandatory participation, 75% expressed that they would have their child participate even if it were not mandatory. Regarding



**Figure 2.** Parent awareness by youth athlete competition level.

cost of participation in ACL injury prevention programs, 9 (64%) reported no additional costs. Of the 5 (36%) who reported extra costs, 3 (60%) of these respondents reported costs greater than \$500 per year, and the remaining 2 reported they were unsure of actual costs.

Among parents of beginner athletes, 23% (3 out of 13) were aware of the programs, followed by awareness reported by 21% (28 out of 135) of the elite and super elite athletes, and 14% (13 out of 95) of intermediate level athletes (Figure 2). Similarly, awareness varied based on gender, with 25% (21 out of 89) of female youth athletes' parents being aware compared to only 15% (23 out of 152) of male youth athletes' parents.

Additionally, when comparing awareness by primary sport involvement, football had the highest level of parent awareness at 25% (5 out of 20), followed by basketball with 24% (5 out of 21), volleyball and lacrosse at 22% (2 out of 9), and soccer with the lowest awareness among primary sports at 17% (30 out of 177). The awareness levels also varied across states, with 17% (7 out of 39) of parents from Texas and only 9% (6 out of 62) of parents from Florida reporting awareness of ACL injury prevention programs.

### **Parent Perception of Youth Athlete**

Seventy-five parents (31%) reported they encouraged sports participation with the hope of their child securing a college scholarship or pursuing a professional career

in sports. Within this subgroup, the average age at which their children began participating in organized sports was 5 years (SD = 2.56), and the average age of sport specialization was 7.6 years (SD = 2.85). Of these respondents, only 13/75 (17%) were aware of ACL injury prevention programs. Fifty-six of the 75 respondents in this subgroup (75%) reported soccer as their child's primary sport. Among parents of these 56 soccer players, the average age at which their children began participating in organized sports was 4.7 years (SD = 2.55), with an average age of specialization of 7.2 years (SD = 2.86).

### **Barriers & Interest in ACL Injury Prevention Programs**

Among the 45 parents aware of ACL injury prevention programs, 31 (69%) reported their child had never participated in such a program. The most frequently reported barriers to their lack of participation were, "I'm not sure where to get this type of training" (n=12), and "It is not offered to me" (n=11). Among parents who reported being unaware of ACL injury prevention training, 68% (149) responded "yes" to future interest in having their children participate in an ACL injury prevention program if offered, while 27% (60) were unsure, and 5% (11) would not have their child participate.

### **Discussion**

ACL injury prevention programs have existed in various formats for many years and have proven to be effective.<sup>20-23,29-34</sup> Given the escalation in the number of these devastating injuries that occur in young athletes,<sup>26</sup> it is imperative that every possible preventative solution is utilized to ensure sports safety. This cross-sectional survey study of parents of young athletes involved in high injury-risk sports found that only 18% of parents report some level of awareness of ACL injury prevention training and that only 6% had a child athlete who had ever participated in one.

Other studies assessing awareness of ACL injury prevention programs around the world have identified similarly low levels of awareness among both coaches

and athletes. A recent study out of Saudi Arabia identified only 17% awareness of IPPs among athletes.<sup>35</sup> In addition, a study of German amateur soccer coaches identified that over half of the respondents were unaware of IPPs.<sup>36</sup> However, there are no studies in the literature that have investigated parental awareness of IPPs.

In terms of factors that may influence parental awareness of ACL injury prevention programs, this study identified that the subset of parents who classified their athlete as “beginner or casual” were the most likely to have awareness of injury prevention training at 23%. This potentially indicates that parents at this level may be more receptive to guidance and information, including IPPs. This may be due to their child’s limited experience in the sport and parental interest in ensuring their child’s safety in their new athletic pursuit. However, this finding was not statistically significant ( $p = 0.2091$ ), and 23% awareness is still extremely low for such an important topic. Regarding awareness by sport, parents of soccer players represented the lowest rate of awareness at 17% even though soccer is one of the highest risk sports for ACL tears, especially among females.<sup>34,37-41</sup> Overall, awareness of injury prevention programs remained low, regardless of age, gender, ethnicity, level of competition or type of sport, indicating that there is a general lack of parental awareness for all types of athletes in all sports.

In addition to a lack of general awareness, additional barriers to the utilization of ACL injury prevention programs include both a lack of knowledge of their availability and where to receive training. Of the parents who reported knowledge of ACL injury prevention training, less than a third reported their child participated in a program, and the primary reason for those who had not participated was not knowing where or how to get involved in one. Cost was not cited as a factor interfering with utilization, as most parents (60%) who had a child participate in these programs reported no added cost. Interestingly, in contrast to our survey’s findings, a previous survey of female soccer coaches in the United States raised concerns about costs of implementing an IPP.<sup>42</sup> Furthermore, most parents (68%) who reported not

being aware of ACL injury prevention training indicated they would be interested in their child participating if it were available, which indicates that improved education efforts could have a dramatic impact on utilization. If parents learned that these programs are easy to implement and have proven effectiveness to reduce the risk of significant injury, then at the very least they would be more likely to inquire if coaches are utilizing these programs. More likely, they would demand that they be utilized.

An additional study finding includes that the majority (77%) specialized in their primary sport with specialization starting at an average age of 8 years old. It has been well-documented that increased volume and intensity of training,<sup>43</sup> as well as early sport specialization, are correlated with a higher risk of injury.<sup>44-47</sup> In addition, a lack of sports sampling or exposure to multiple different types of sports may hinder an overall well-rounded athletic development, also imparting a higher risk of injury. Many (31%) of the parents in this study reported a primary reason for their child’s sport participation was with the hopes of a college scholarship or future professional sports participation. This is a revealing finding that further supports the notion that parents are their child’s greatest advocate, and that there is great interest in opportunities to maximize their success and well-being. While the benefits of early sports specialization are unclear, we do have evidence that injury prevention programs work, and this information must be strongly and clearly delivered to all parents who sign their child up for an organized sports activity.

There are several limitations of this study, most of which are inherent to survey methodology. Most respondents came from two states, Texas and Florida, which may not fully represent the diverse experiences and perspectives of parents from other regions. Additionally, despite the large sample size of parent respondents, the lack of socioeconomic status and limited collection of race and ethnicity data may limit the generalizability of this convenience sample to a broader population of youth athletes and their parents.

Previous studies have identified that socioeconomic status is directly correlated with participation in private sports clubs, sport specialization, and general attitudes towards youth sports.<sup>48-50</sup> Future studies should focus on how socioeconomic status affects the availability and utilization of injury prevention programs. Another limitation was that most respondents were parents of male athletes. The majority of respondents also reported their child's primary sport to be soccer. In addition, other cutting and pivoting sports, like field hockey, were not specifically included as a survey option for primary sport. This does not accurately represent the full diversity of youth sport participation or the gender distribution of youth sports athletes, thus hindering the study's generalizability.

This survey was also potentially subject to further selection bias as willing participants may have been parents with a specific interest in sports or injury prevention. Despite these limitations, our survey findings provide valuable insights into the current use and awareness of ACL injury prevention programs among parents of youth athletes. Moving forward, these results can inform the development of targeted awareness campaigns, address barriers to participation, and improve the effectiveness of ACL injury prevention programs.

It will require a multi-faceted approach to improve the implementation and utilization of injury prevention programs. This study shows there is a lack of parental awareness, but parental involvement and advocacy represent only one of the many components involved in ensuring the safety of youth sports. This includes a coordinated involvement of coaches, healthcare providers, and policymakers. Coaches must be properly educated on this topic and need the appropriate tools and resources. Those who provide direct healthcare to young athletes, such as athletic trainers and sports medicine physicians, should ensure that efforts are in place to maximize the effectiveness of education and research on this topic. Finally, policymakers should ensure that evidence-based guidelines for sports safety are continually evaluated and adjusted to maximize the

public's well-being. As sports medicine professionals and researchers, our next step in this process is to study different methods of disseminating information on injury prevention programs and the effects that it has on implementation, utilization, and rates of injury. Future research could explore the potential benefits of partnering with sports organizations to share educational materials about ACL IPPs. A video demonstration of an ACL IPP has been included in Appendix B, which we encourage to be shared with anyone interested in learning how to implement this type of program.

In conclusion, this study highlights the need for increased efforts to raise awareness about ACL injury prevention programs among parents of youth athletes. By addressing barriers to participation and continuously refining program effectiveness based on feedback, we can work towards reducing the incidence of ACL injuries and promoting safer sports participation among young athletes.

### Additional Links

- American Academy of Orthopaedic Surgeons (AAOS): [Appropriate Use Criteria for ACL Prevention Programs](#)
- *Journal of the Pediatric Society of North America (JPOSNA<sup>®</sup>)*: [Safe Return to Play Following ACL Reconstruction in Young Athletes](#)
- *Journal of the Pediatric Society of North America (JPOSNA<sup>®</sup>)*: [Raising the Young Athlete: Training and Injury Prevention Strategies](#)

### Disclaimer

A POSNA Micro Grant for \$1,000 was received. The authors report no conflicts of interest related to this manuscript.

### References

1. Grindstaff TL, Hammill RR, Tuzson AE, et al. Neuromuscular control training programs and noncontact anterior cruciate ligament injury rates in female athletes: a numbers-needed-to-treat analysis. *J Athl Train.* 2006;41(4):450-456.
2. Donnell-Fink LA, Klara K, Collins JE, et al. Effectiveness of knee injury and anterior cruciate ligament tear prevention programs: a meta-analysis. *PLoS One.* 2015;10(12):e0144063.



3. Swart E, Redler L, Fabricant PD, et al. Prevention and screening programs for anterior cruciate ligament injuries in young athletes: a cost-effectiveness analysis. *J Bone Joint Surg Am.* 2014;96(9):705-711.
4. Post EG, Trigsted SM, Riekena JW, et al. The association of sport specialization and training volume with injury history in youth athletes. *Am J Sports Med.* 2017;45(6):1405-1412.
5. Pasulka J, Jayanthi N, McCann A, et al. Specialization patterns across various youth sports and relationship to injury risk. *Phys Sportsmed.* 2017;45(3):344-352.
6. Post EG, Biese KM, Schaefer DA, et al. Sport-specific associations of specialization and sex with overuse injury in youth athletes. *Sports Health.* 2020;12(1):36-42.
7. Christino MA, Fantry AJ, Vopat BG. Psychological aspects of recovery following anterior cruciate ligament reconstruction. *J Am Acad Orthop Surg.* 2015;23(8):501-509.
8. Wu HH, Liu M, Dines JS, et al. Depression and psychiatric disease associated with outcomes after anterior cruciate ligament reconstruction. *World J Orthop.* 2016;7(11):709-717.
9. Ohji S, Aizawa J, Hirohata K, et al. Athletic identity and sport commitment in athletes after anterior cruciate ligament reconstruction who have returned to sports at their pre-injury level of competition. *BMC Sports Sci Med Rehabil.* 2021;13(1):37.
10. Piussi R, Krupic F, Senorski C, et al. Psychological impairments after ACL injury – Do we know what we are addressing? Experiences from sports physical therapists. *Scand J Med Sci Sports.* 2021;31(7):1508-1517.
11. Filbay SR, Skou ST, Bullock GS, et al. Long-term quality of life, work limitation, physical activity, economic cost and disease burden following ACL and meniscal injury: a systematic review and meta-analysis for the OPTIKNEE consensus. *Br J Sports Med.* 2022;56(24):1465-1474.
12. Luc B, Gribble PA, Pietrosimone BG. Osteoarthritis prevalence following anterior cruciate ligament reconstruction: a systematic review and numbers-needed-to-treat analysis. *J Athl Train.* 2014;49(6):806-819.
13. Lohmander LS, Englund PM, Dahl LL, et al. The long-term consequence of anterior cruciate ligament and meniscus injuries: osteoarthritis. *Am J Sports Med.* 2007;35(10):1756-1769.
14. Feller JA, Webster KE. A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. *Am J Sports Med.* 2003;31(4):564-573.
15. Marder RA, Raskind JR, Carroll M. Prospective evaluation of arthroscopically assisted anterior cruciate ligament reconstruction. Patellar tendon versus semitendinosus and gracilis tendons. *Am J Sports Med.* 1991;19(5):478-484.
16. Matsumoto A, Yoshiya S, Muratsu H, et al. A comparison of bone-patellar tendon-bone and bone-hamstring tendon-bone autografts for anterior cruciate ligament reconstruction. *Am J Sports Med.* 2006;34(2):213-219.
17. O'Neill DB. Arthroscopically assisted reconstruction of the anterior cruciate ligament. A follow-up report. *J Bone Joint Surg Am.* 2001;83(9):1329-1332.
18. Shaieb MD, Kan DM, Chang SK, et al. A prospective randomized comparison of patellar tendon versus semitendinosus and gracilis tendon autografts for anterior cruciate ligament reconstruction. *Am J Sports Med.* 2002;30(2):214-220.
19. Sugimoto D, Myer GD, Bush HM, et al. Compliance with neuromuscular training and anterior cruciate ligament injury risk reduction in female athletes: a meta-analysis. *J Athl Train.* 2012;47(6):714-723.
20. Cerulli G, Benoit DL, Caraffa A, et al. Proprioceptive training and prevention of anterior cruciate ligament injuries in soccer. *J Orthop Sports Phys Ther.* 2001;31(11):655-660; discussion 661.
21. Daneshjoo A, Mokhtar A, Rahnama N, et al. The effects of injury prevention warm-up programmes on knee strength in male soccer players. *Biol Sport.* 2013;30(4):281-288.
22. Hewett TE, Lindenfeld TN, Riccobene JV, et al. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. *Am J Sports Med.* 1999;27(6):699-706.
23. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med.* 2005;33(7):1003-1010.
24. Thompson JA, Tran AA, Gatewood CT, et al. Biomechanical effects of an injury prevention program in preadolescent female soccer athletes. *Am J Sports Med.* 2017;45(2):294-301.
25. Arundale AJH, Silvers-Granelli HJ, Myklebust G. ACL injury prevention: where have we come from and where are we going? *J Orthop Res.* 2022;40(1):43-54.
26. Dodwell ER, Lamont LE, Green DW, et al. 20 years of pediatric anterior cruciate ligament reconstruction in New York State. *Am J Sports Med.* 2014;42(3):675-680.
27. Brodeur PG, Licht AH, Modest JM, et al. Epidemiology and revision rates of pediatric ACL reconstruction in New York state. *Am J Sports Med.* 2022;50(5):1222-1228.
28. Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). *J Med Internet Res.* 2004;6(3):e34.
29. Gilchrist J, Mandelbaum BR, Melancon H, et al. A randomized controlled trial to prevent noncontact anterior cruciate ligament injury in female collegiate soccer players. *Am J Sports Med.* 2008;36(8):1476-1483.
30. Myklebust G, Engebretsen L, Braekken IH, et al. Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. *Clin J Sport Med.* 2003;13(2):71-78.
31. Myklebust G, Engebretsen L, Braekken IH, et al. Prevention of noncontact anterior cruciate ligament injuries in elite and adolescent female team handball athletes. *Instr Course Lect.* 2007;56:407-418.
32. Silvers-Granelli H, Mandelbaum B, Adeniji O, et al. Efficacy of the FIFA 11+ injury prevention program in the Collegiate Male Soccer player. *Am J Sports Med.* 2015;43(11):2628-2637.
33. Soligard T, Myklebust G, Steffen K, et al. Comprehensive warm-up programme to prevent injuries in young female footballers: cluster randomised controlled trial. *BMJ.* 2008;337:a2469.
34. Kiani A, Hellquist E, Ahlqvist K, et al. Prevention of soccer-related knee injuries in teenaged girls. *Arch Intern Med.* 2010;170(1):43-49.
35. Alyami AH, Darraj H, Hamdi S, et al. Awareness of anterior cruciate ligament injury—preventive training programs among Saudi Athletes. *Clin Pract.* 2023;13:656-665.
36. Wilke J, Niederer D, Vogt L, et al. Is the message getting through? Awareness and use of the 11+ injury prevention programme in amateur level football clubs. *PLoS One.* 2018;13(4):e0195998.
37. Hewett TE, Myer GD, Ford KR. Anterior cruciate ligament injuries in female athletes: part 1, mechanisms and risk factors. *Am J Sports Med.* 2006;34(2):299-311.
38. Huston LJ, Greenfield ML, Wojtys EM. Anterior cruciate ligament injuries in the female athlete. Potential risk factors. *Clin Orthop Relat Res.* 2000(372):50-63.
39. Hutchinson MR, Ireland ML. Knee injuries in female athletes. *Sports Med.* 1995;19(4):288-302.
40. Lal S, Hoch AZ. Factors that affect the young female athlete. *Phys Med Rehabil Clin N Am.* 2007;18(3):361-383, vii.
41. Zech A, Hollander K, Junge A, et al. Sex differences in injury rates in team-sport athletes: a systematic review and meta-regression analysis. *J Sport Health Sci.* 2022;11(1):104-114.
42. Dix C, Logerstedt D, Arundale A, et al. Perceived barriers to implementation of injury prevention programs among collegiate women's soccer coaches. *J Sci Med Sport.* 2021;24(4):352-356.
43. Brenner JS; Council on Sports Medicine and Fitness. Sports specialization and intensive training in young athletes. *Pediatrics.* 2016;138(3):e20162148.
44. Mosher A, Till K, Fraser-Thomas J, et al. Revisiting early sport specialization: What's the Problem? *Sports Health.* 2022;14(1):13-19.

45. Jayanthi N, Pinkham C, Dugas L, et al. Sports specialization in young athletes: evidence-based recommendations. *Sports Health*. 2013;5(3):251-257.
46. Jayanthi NA, LaBella CR, Fischer D, et al. Sports-specialized intensive training and the risk of injury in young athletes: a clinical case-control study. *Am J Sports Med*. 2015;43(4):794-801.
47. Bell DR, Post EG, Trigsted SM, et al. Parents' awareness and perceptions of sport specialization and injury prevention recommendations. *Clin J Sport Med*. 2020;30(6):539-543.
48. Tandon PS, Kroshus E, Olsen K, et al. Socioeconomic inequities in youth participation in physical activity and sports. *Int J Environ Res Public Health*. 2021;18(13):6946.
49. Powell LM, Slater S, Chaloupka FJ, et al. Availability of physical activity-related facilities and neighborhood demographic and socioeconomic characteristics: a national study. *Am J Public Health*. 2006;96(9):1676-1680.
50. Jayanthi NA, Holt DB, Jr., LaBella CR, et al. Socioeconomic factors for sports specialization and injury in youth athletes. *Sports Health*. 2018;10(4):303-310.

## Appendices

### Appendix A: ACL Pre-Survey Questions & Parent ACL Injury Prevention Survey

#### I. Pre-Survey Questions

1. Select the option that best describes your role in youth sports
  - a. Athlete
  - b. Parent of an Athlete
  - c. Coach
  - d. Athletic Trainer
  - e. Athletic Director
  - f. Team Manager
  - g. Personal Trainer
  - h. Other (describe)
  - i. Not involved
  
2. (If athletic trainer selected in #1) Please select the organizations for which you are an athletic trainer.
  - a. High School
  - b. Club Sports Organization
  - c. Academic Institution
  - d. Sports Medicine Clinic
  - e. Other
  
3. (If athlete selected in #1) Please select the sports that you play regularly (select all that apply).
  - a. Baseball
  - b. Softball
  - c. Soccer
  - d. Football
  - e. Basketball
  - f. Volleyball
  - g. Lacrosse
  - h. Wrestling
  - i. Tennis
  - j. Gymnastics
  - k. Swimming
  - l. Diving
  - m. Water Polo
  - n. Track and Field
  - o. Cross country
  - p. Cheerleading
  - q. Golf
  - r. Other (free text)
  
4. Of the sports selected above, which one would you consider your primary sport?
 

List of options is populated base on the selections above:

  - If baseball or softball selected as primary, then the athlete throwing guidelines survey is generated
  - If soccer, basketball, football, volleyball, or lacrosse selected as primary, then athlete ACL injury prevention survey is generated
  - If any other sport selected as primary, then athlete sport participation survey generated
  
5. (If parent selected in #1) Please select all of the sports that your child plays regularly. (You may elect to fill out this survey multiple times if you have more than one child who is active in youth sports. Please select answers that best correspond to one child per survey completed.)
  - a. Baseball
  - b. Softball
  - c. Soccer

- d. Football
  - e. Basketball
  - f. Volleyball
  - g. Lacrosse
  - h. Wrestling
  - i. Tennis
  - j. Gymnastics
  - k. Swimming
  - l. Diving
  - m. Water Polo
  - n. Track and Field
  - o. Cross country
  - p. Cheerleading
  - q. Golf
  - r. Other (free text)
6. Of the sports selected above, which one would you consider to be your child's primary sport?
- List of options is populated base on the selections above:
- If baseball or softball selected as primary, then the parent throwing guidelines survey is generated
  - If soccer, basketball, football, volleyball, or lacrosse selected as primary, then parent ACL injury prevention survey is generated
  - If any other sport selected as primary, then parent sport participation survey generated
7. (If c, d, e, f, g, h selected in #1) Please select the sports where you have direct or indirect involvement with young athletes (select all that apply).
- a. Baseball (direct to coach/trainer throwing survey)
  - b. Softball (direct to coach/trainer throwing survey)

- c. Soccer (direct to coach/trainer ACL prevention survey)
- d. Football (direct to coach/trainer ACL prevention survey)
- e. Basketball (direct to coach/trainer ACL prevention survey)
- f. Volleyball (direct to coach/trainer ACL prevention survey)
- g. Lacrosse (direct to coach/trainer ACL prevention survey)

## ***II. Parent ACL Injury Prevention Survey***

1. What state do you live in?  
(State drop down list)
2. What is the current age of your child athlete?  
(Enter numeric value in years)
3. What is your child's gender?
  - a. Female
  - b. Male
  - c. Other or prefer not to answer
4. At what age did your child begin playing organized sports?  
(Enter numeric value in years)
5. Does your child specialize in his or her primary sport? This is best defined as playing that sport greater than 8 months out of the year or excluding involvement in other sports in order to focus on their primary sport.
  - a. Yes
  - b. No
6. (If yes to #5) At what age did your child begin to specialize in his or her primary sport?  
(Enter numeric value in years)

7. How many hours per week do you estimate that your child spends both training and competing in their sport?
- <5
  - 5 to 10
  - 10 to 15
  - 15 to 20
  - >20
8. Does your child play their sport for more than one team?
- Yes
  - No
9. How many months out of the year does your child rest from organized sports?  
(Enter numeric value in months)
10. What level of competition best describes your child's involvement in their primary sport?
- Beginner or Casual involvement (Just learning the sport and playing for fun)
  - Intermediate (They are regularly involved in the sport, but I would not consider them among the top 10% of competitors)
  - Elite (I would consider them at or above the top 10% of skill level or ability among their peers)
  - Super Elite (They have been a state level or higher champion or competed on a national championship level, and I would consider them to be in the top 1% of their peers)
11. What types of teams do your children compete with, either part of the year or during the entire year?  
(select all that apply)
- Middle School (grades 6 through 8)
  - High School (grades 9 through 12)
  - Recreational or community league (such as YMCA or similar)
  - Private league or club team
  - All Star team
  - Travel team
  - National team
  - Other (describe)
12. Which of the following best describe why you encourage your child to participate in sports? (select all that apply)
- I hope they get a college scholarship
  - I hope they eventually play professionally
  - They choose to play for fun
  - I just have them play just for the exercise
  - I let them play because they get to be around friends
  - The choice to play is entirely their decision
  - It gives them something to do; otherwise I think they would be bored
  - Other (explain)
13. Has your child ever had an anterior cruciate ligament (ACL) injury?
- Yes
  - No (If no, skip to 16)
14. (If yes to 13) Did the ACL injury occur while playing their primary sport?
- Yes
  - No
15. (If 13A selected) Did your child participate in ACL injury training prior to having an ACL tear?
- Yes (go to 19)
  - No
  - I am not sure

16. Are you aware of the availability of ACL injury prevention training (either offered by your own team or in the community)?
- Yes
  - No (If no, skip to 29)
17. Have any of your children recently (within the past year) participated in ACL injury prevention training?
- Yes (go to 19)
  - No
  - I am not sure
18. (If 17B or C Selected) Have any of your children *ever* participated in ACL injury prevention training?
- Yes
  - No
  - I am not sure
19. (If 15A, 17A or 18A selected) Was the ACL injury prevention program for your child voluntary or mandatory?
- It was voluntary, but everyone on the team participated
  - It was voluntary, and some people on the team participated
  - It was mandatory
  - I am not sure if it was voluntary or mandatory
  - Other (describe)
20. (If 15A, 17A or 18A selected) How has the injury prevention training been provided to your child? (select all that apply)
- Their coach or trainer provides the injury prevention training prior to the start the season for 6 weeks or less
  - Their coach or trainer provides the injury prevention training prior to the start of the season for greater than 6 weeks
  - Their coach or trainer provides the training during the season
  - They receive additional training from someone other than their team's coach or trainer
  - I am not sure
  - Other (describe)
21. (If 15A, 17A or 18A selected) Does the injury prevention training require an extra cost?
- Yes
  - No
  - I am not sure
22. (If 21A selected) What is the approximate extra cost of participating in an injury prevention program per year, per child?
- <\$50
  - \$51 to \$100
  - \$101 to \$250
  - \$251 to \$500
  - >\$500
  - I am not sure
23. (If 15A, 17A or 18A selected) Have you found the injury prevention training to be helpful?
- Yes
  - No
  - I am not sure
24. Do you feel the amount of time or focus spent on injury prevention is adequate?
- Yes

- b. No
- c. I am not sure
25. (If 19C selected) Would you choose to have your child participate in an injury prevention program if it was not mandatory?
- a. Yes
- b. No
- c. I am not sure
26. Is there something that you would like to see changed or improved about how ACL injury prevention is offered to your child?
- a. Yes, the injury prevention training could be improved.
- b. No, the injury prevention training does not need to be changed. I think it helps prevent injuries.
- c. No, I think injuries would happen at the same rate with or without prevention training.
27. (If 26A selected) Please describe the changes that you would like to see made to ACL injury prevention training.
- (Free text)
28. (If 17B or 18B selected) What reasons or barriers best describe why your child does not participate in an ACL injury prevention program? (select all that apply)
- a. It is too expensive
- b. It requires too much additional time
- c. I do not think it is necessary or helpful for preventing injuries
- d. It is not offered to me
- e. I am not sure where to get this type of training
- f. I am not sure what an ACL injury program is
- g. Other (free text)
29. (If 16 B or 29 D, E or F selected) Would you be interested in having your child participate in an ACL injury prevention program if one were offered?
- a. Yes
- b. No
- c. I am not sure
30. In your estimation, what percentage of your child's teammates have an ACL injury each year?
- a. <1%
- b. 1 to 5%
- c. 6 to 10%
- d. 11 to 20%
- e. 21 to 30%
- f. >30%
31. Does your child participate in any type of pre-season screening to identify if they are at increased risk for an ACL tear?
- a. Yes
- b. No
- c. I am not sure
32. Do you believe involvement in sports has had an overall positive or negative impact on your child's quality of life?
- a. Positive
- b. Negative
- c. I am not sure

### **Appendix B: Example of ACL Injury Prevention Program Training**

General Dynamic Warm-Up – 3-5 Minutes