

Awareness of Anterior Cruciate Ligament Injury-Preventive Training Programs Among Female Collegiate Athletes

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Context: Neuromuscular training programs can reduce the rate of noncontact anterior cruciate ligament (ACL) injuries, particularly in female athletes.

Objective: To assess the awareness of, experience with, and factors associated with participation in preventive training programs (PTPs) among female collegiate athletes and their knowledge of ACL injuries.

Design: Cross-sectional study.

Setting: National Collegiate Athletic Association (NCAA) sports programs.

Patients or Other Participants: A total of 440 female NCAA athletes (age = 20 ± 1 years) representing 20 sports during the 2017–2018 academic year.

Main Outcome Measure(s): We used a 12-item survey to collect data on each participant's age, sport, position, college, NCAA division, and awareness of and experience with PTPs. We performed descriptive statistics and used odds ratios (ORs) to assess relationships between demographic data and awareness of or interest in PTPs.

Results: Of the 440 respondents, 85% (n = 373) knew that female athletes were at higher risk for sustaining ACL injuries

than male athletes, and 89% (n = 391) knew that ACL injuries were preventable. Thirty-three percent (n = 143) were familiar with the concept of ACL PTPs. Only 15% (n = 64) had ever performed PTPs, but 89% (n = 391) reported they would perform a daily PTP if it could prevent ACL injuries. Fifty-two of the 64 respondents (81%) who had performed PTPs said athletic trainers or coaches oversaw the PTPs. Participants were more likely to be familiar with ACL PTPs if they (OR = 3.5; 95% confidence interval [CI] = 2.0, 5.8) or a teammate (OR = 4.6; 95% CI = 2.1, 9.8) had sustained an ACL injury. Respondents were more willing to perform PTPs if they (OR = 2.3; 95% CI = 0.80, 6.6) or a teammate (OR = 3.4; 95% CI = 1.8, 6.6) had sustained an ACL injury.

Conclusions: Although 89% of respondents expressed interest in performing daily ACL PTPs, only 15% had performed such programs, and only 33% were familiar with the concept of ACL PTPs.

Key Words: female athletes, sex, knee, neuromuscular training

Key Points

- Most female collegiate athletes were interested in performing daily anterior cruciate ligament injury-preventive training programs, but awareness and performance of them was not widespread among these athletes.
- Further studies are needed to determine the most effective methods of implementing and monitoring compliance with anterior cruciate ligament injury-preventive training programs in this at-risk population.

Anterior cruciate ligament (ACL) injuries are a common problem in female athletes. These athletes are 2 to 9 times more likely to sustain ACL injuries than their male counterparts,^{1–3} and the prevalence of ACL reconstructions in women has continued to rise.^{4,5} The lifetime cost to U.S. society for a patient's ACL reconstruction is estimated to be \$38 000,⁶ leading to an aggregate health care cost of \$7.6 billion per year. In addition to the financial costs associated with ACL injuries, the typical time until an athlete can return to play is 12 months,⁷ and time loss can be critical, particularly for female athletes, who have fewer opportunities for professional sports careers than male athletes. Furthermore, return-to-play rates after ACL surgery have been shown to be lower in female than in male athletes, at 39% versus 52% and 18% versus 37% in age groups 25 and under, and 26–35 years old, respectively.⁷ In a recent 20-year

longitudinal study of 90 patients who underwent ACL reconstruction, Thompson et al⁸ reported that, compared with men, women had lower International Knee Documentation Committee scores (90 versus 83; $P = .03$), had more activity-related pain (20% versus 57%; $P = .02$), and were less likely to participate in strenuous activities (66% versus 35%; $P = .009$).

Many factors may influence this increased risk for injury in women, including joint morphology, such as femoral notch width and tibial slope; family history; hormones; and differences in neuromuscular control.^{9–16} Up to 85% of ACL injuries in female athletes were noncontact injuries,¹ with sex-based differences in neuromuscular control described as the most modifiable risk factor.^{15,17,18} The concept of preventive training programs (PTPs) to address ACL injuries was developed during the past 20 years, and researchers^{15,19–22} have reported great success with ACL

PTPs for injury risk reduction. Swart et al²³ demonstrated that universal PTP implementation could reduce the incidence of ACL injury in young athletes from 3% to 1.1% per season. Using a decision-analysis model, they determined that universal PTP implementation produced better outcomes and cost less than screening and implementation in only high-risk populations. Grindstaff et al²⁴ analyzed the numbers of noncontact ACL injuries per event exposure or hours of playing time and found that 89 athletes needed to perform a PTP to prevent 1 ACL injury during 1 competitive season. The authors estimated that implementing a universal PTP could save \$100 per player per season because of the low cost and ease of implementation.

Although PTPs can be a cost-effective strategy to reduce the risk of ACL injuries in female athletes, their current application has not been described. No reports exist on the rates of program implementation, which are critical to optimizing injury-reduction rates and planning targeted outreach efforts. Therefore, the primary purpose of our study was to assess the status of PTP implementation among female collegiate athletes by determining the prevalence of athletes who have performed PTPs or were aware that such programs existed. The secondary aims were to assess female collegiate athletes' willingness to perform PTPs and factors associated with willingness to perform them.

METHODS

Study Design

We designed a 12-item, self-report survey to assess the awareness of and interest in female athletes about ACL PTPs (Table 1). Questions were designed to target potential factors relating to performance rates of PTPs, including awareness of and interest in PTPs. True and false questions were used to assess whether respondents believed that ACL injuries were more common in women than men, believed that ACL injuries were preventable, had heard of an ACL PTP, had been educated about PTPs, and currently performed a PTP. A 7-point Likert scale was used to assess respondents' levels of interest in performing a daily PTP, with 1 representing *no interest* and 7 representing *very strong interest*. Respondent demographics, including age, sport, position, college, and National Collegiate Athletic Association (NCAA) division, were collected.

Participants

Using Qualtrics Survey Software (Qualtrics, Seattle, WA), we distributed the survey to current NCAA female athletes during the 2017–2018 academic year. They were contacted via their athletic trainers (ATs) through e-mails that described the purpose of the study and requested that the ATs share the electronic survey link with their women's teams. All NCAA Division I institutions were contacted. The schools were identified through the NCAA Web site, and each athletic department's contact information was identified through a search of the schools' Web sites. All institutions that participate in the NCAA Injury Surveillance Program were also contacted to request the participation of their women's teams. These programs were identified through the NCAA Sports Science Institute Web site.

Table 1. The 12-Item Survey Sent to Current Female National Collegiate Athletic Association Athletes^a

Question No.	Question
1	Do you know what an anterior cruciate ligament (ACL) injury is?
2	Have you ever sustained an ACL injury?
3	Do you know of any teammates who have sustained an ACL injury?
4	(True/False) Female athletes are at increased risk for sustaining ACL injuries than male athletes.
5	(True/False) Female and male athletes should have the same treatment for the same injuries.
6	(True/False) ACL injuries can be preventable.
7	Have you ever been educated on ACL injuries?
7a	If yes, by whom? (coach, athletic trainer, other:____) (If no, write N/A)
8	Are you familiar with the concept of an ACL preventive training program?
8a	If yes, where did you hear about this? (coach, athletic trainer, other:____)
9	Have you ever performed an ACL preventive training program?
9a	If yes, who oversaw this? (coach, athletic trainer, PT, parent, self, other:____)
10	Do you currently perform an ACL preventive training program?
11	Would you perform a daily exercise program if you knew it could prevent ACL injury?
12	What is your level of interest in learning more about ACL preventive training programs? ^b

Abbreviations: N/A, not applicable; PT, physical therapist.

^a Instrument is reproduced in its original format.

^b Answered on a 7-point Likert scale, with 1 indicating *no interest* and 7 indicating *very high interest*.

Electronic links to the survey were also posted on the social media platforms Facebook (Facebook, Inc, Menlo Park, CA) and Twitter (Twitter, Inc, San Francisco, CA) that requested current female collegiate athletes to participate. Respondents indicated their written informed consent by completing the survey, and the study was approved by the Johns Hopkins Medicine Institutional Review Board (IRB00096616).

Data Analyses

Responses were collected electronically and transferred to a secure Excel (Microsoft Corp, Redmond, WA) spreadsheet. We studied female athletes aged 18 to 23 years who were participating in any NCAA athletic program. Male participants and respondents who were outside the age group or were not involved in an NCAA athletic program at the time of the study were excluded from the analysis. Athletes who had any missing responses in the survey were also excluded.

For each question, we categorized responses according to respondent characteristics and reported descriptive statistics, including the mean, standard deviation, and frequency. Odds ratios with 95% confidence intervals (CIs) were calculated to assess the relationships between demographic factors and knowledge of or interest in performing a PTP. Statistical analyses were performed using MedCalc (MedCalc Software, Ostend, Belgium).

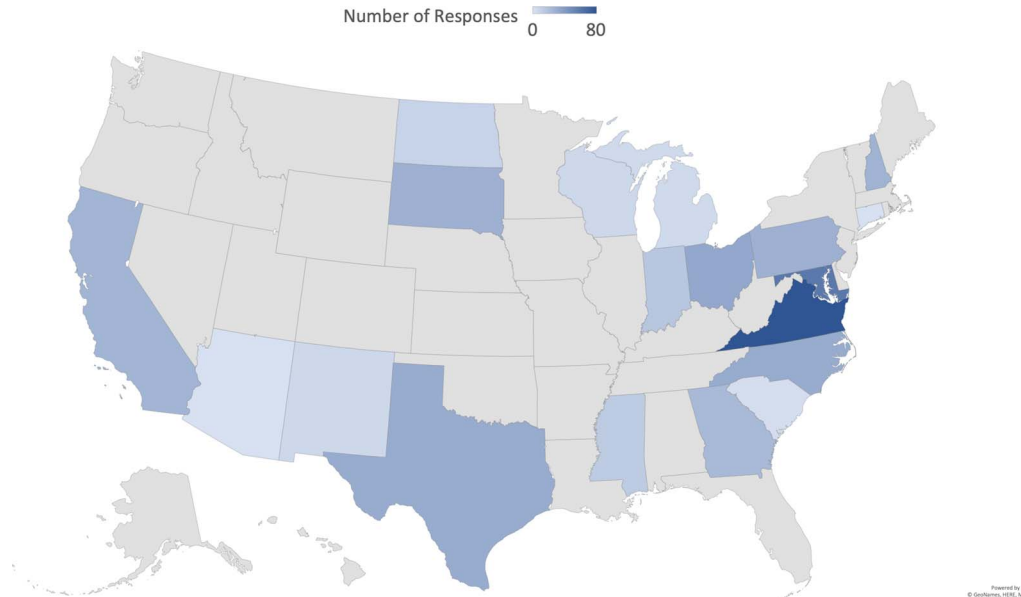


Figure. Map of the United States shows the college locations of the 440 current female National Collegiate Athletic Association athletes who responded to a survey regarding anterior cruciate ligament preventive training programs.

RESULTS

A total of 440 female collegiate athletes (age = 20 ± 1 years) representing 20 sports were included. Thirty-one institutions from 19 states were represented. Survey respondents reported competing at the Division I level (46%, $n = 201$) or the Division III (54%, $n = 239$) level. A map depicting the states and regions of the colleges represented by the respondents is presented in the Figure.

Of the respondents, 81% ($n = 356$) participated in sports considered to pose a risk for ACL injury, including basketball, cheerleading, field hockey, lacrosse, rugby, soccer, softball, tennis, trampoline, and volleyball.²⁵ In contrast, 19% ($n = 84$) participated in lower-risk sports, including cross-country, equestrian sports, fencing, golf, rifle, track and field, and water sports. Survey results are stratified by low-risk and high-risk sports in Table 2.

Among all respondents, 85% ($n = 373$) reported knowing that female athletes were at higher risk than male athletes for sustaining ACL injuries, and 89% ($n = 391$) reported knowing that ACL injuries can be preventable. However, only 33% ($n = 143$) stated they were familiar with the concept of an ACL PTP, and only 15% ($n = 64$) indicated they had performed an ACL PTP. In total, 89% ($n = 391$) stated that they would perform a daily exercise program if they knew it could prevent ACL injury. On the Likert scale, the level of interest in learning more about PTPs was 4.5 ± 1.5 (high-risk group = 4.7 ± 1.4 , low-risk group = 3.7 ± 1.7).

Of the 64 athletes who had performed an ACL PTP, 81% ($n = 52$) reported that it was overseen by an AT, a coach, or both. The provider types cited as having overseen respondents' ACL PTPs are listed in Table 3. Responses to the survey questions regarding the athletes' understanding of ACL injuries are presented in Table 4.

Athletes who participated in sports categorized as high risk for ACL injury were 10 times (95% CI = 4.0, 25.3) more likely to be familiar with the concept of an ACL PTP and 18 times (95% CI = 2.4, 130.6) more likely to have

performed an ACL PTP than those who participated in low-risk sports. Within the high-risk sports, Division I athletes were only slightly (odds ratio = 1.7; 95% CI = 1.1, 2.6) more likely to describe being familiar with the concept of an ACL PTP. However, Division I athletes were 3.4 times (95% CI = 1.9, 6.2) more likely to say they had performed an ACL PTP and 4.5 times (95% CI = 1.6, 12) more likely to indicate that they were currently performing an ACL PTP than Division III athletes.

Participants who had sustained an ACL injury were 3.5 times (95% CI = 2.0, 5.8) more likely to be familiar with the concept of an ACL PTP and 2.3 times (95% CI = 0.80, 6.6) more likely to display interest in performing a daily ACL PTP than those who had not sustained an ACL injury. Athletes who had not sustained an ACL injury but knew a teammate who had were 4.6 times (95% CI = 2.1, 9.8) more likely to be familiar with an ACL PTP than those who had no personal or known teammate history of ACL injury and were 3.4 times (95% CI = 1.8, 6.6) more likely to show interest in performing an ACL PTP than those who had no personal or known teammate history of ACL injury.

DISCUSSION

In our survey of 440 current female NCAA athletes, only 15% ($n = 64$) reported having ever performed an ACL PTP, even though 89% ($n = 391$) of respondents expressed an understanding that ACL injuries can be preventable and 89% ($n = 391$) indicated that they would perform a daily exercise program if they knew it would prevent ACL injury. Although multiple researchers^{15,19–22} have demonstrated the risk reduction associated with PTPs during the last 20 years, we found that implementation and awareness of such programs in current collegiate female athletes were low.

To our knowledge, no investigators have assessed the current awareness of ACL injury prevention among female athletes. Many authors^{6,26–32} have focused on the neuromuscular risk factors for ACL injury and the efficacy of

Table 2. Survey Responses of Current Female National Collegiate Athletic Association Athletes by High- and Low-Risk Sports and Total Responses (N = 440)

Sport	Survey Response, No. (%)									
	Total	Know What an ACL Injury Is	Have Sustained an ACL Injury	Know a Teammate Who Sustained an ACL Injury	Believe Female Athletes Are at Increased Risk for Sustaining ACL Injuries	Believe ACL Injuries Can Be Preventable	Familiar With the Concept of an ACL Injury-Preventive Training Program	Have Performed an ACL Injury-Preventive Training Program	Would Perform a Daily Exercise Program if it Could Prevent ACL Injury	
High risk	356 (81)	336 (94)	66 (19)	316 (89)	311 (87)	313 (88)	138 (39)	63 (18)	325 (91)	
Basketball	80 (18)	77 (96)	18 (23)	79 (99)	71 (89)	66 (83)	40 (50)	14 (18)	73 (91)	
Volleyball	80 (18)	79 (99)	13 (16)	75 (94)	69 (86)	70 (88)	28 (35)	13 (16)	71 (89)	
Softball	53 (12)	49 (92)	5 (9)	44 (83)	42 (79)	46 (87)	9 (17)	1 (2)	45 (85)	
Field hockey or lacrosse	48 (11)	43 (90)	9 (19)	45 (94)	45 (94)	44 (92)	20 (42)	9 (19)	46 (96)	
Soccer	44 (10)	43 (98)	14 (32)	44 (100)	43 (98)	40 (91)	27 (61)	22 (50)	42 (95)	
Squash or tennis	25 (6)	22 (88)	1 (4)	6 (24)	18 (72)	23 (92)	7 (28)	1 (4)	22 (88)	
Rugby	19 (4)	17 (89)	6 (32)	19 (100)	18 (95)	18 (95)	7 (37)	3 (16)	19 (100)	
Other ^a	7 (2)	6 (86)	0 (0)	4 (57)	5 (71)	6 (86)	0 (0)	0 (0)	7 (100)	
Low risk ^b	84 (19)	73 (87)	4 (5)	38 (45)	62 (74)	78 (93)	5 (6)	1 (1)	66 (79)	
All sports	440 (100)	409 (93)	70 (16)	354 (80)	373 (85)	391 (89)	143 (33)	64 (15)	391 (89)	

Abbreviation: ACL, anterior cruciate ligament.

^a Cheerleading (n = 5), dance (n = 1), and trampoline (n = 1).

^b Cross-country, equestrian sports, fencing, golf, rifle, track and field, and water sports.

Table 3. Distribution of Educators Providing Training to Survey Respondents Who Had Performed an Anterior Cruciate Ligament Preventive Training Program

Educator	No. (%)
Athletic trainer	25 (39)
Coach	17 (27)
Physical therapist	11 (17)
Coach and athletic trainer	7 (11)
Physical therapist and athletic trainer	3 (5)
Other	1 (2)
Total	64 (101) ^a

^a Total percentage does not equal 100 because percentages were rounded.

PTPs in mitigating them, as well as the barriers to implementing such programs. In a recent discussion of the role of a multidisciplinary approach to women's sports medicine programs, Tanaka et al³³ emphasized that addressing the problem of ACL injuries in female athletes extends beyond the single episode of perioperative care surrounding ACL reconstruction and that greater collaboration between physicians and ATs is needed to address the higher rate of ACL injuries in women.

Of the 15% of female collegiate athletes who had performed an ACL PTP, 81% reported that the PTP had been supervised by an AT, a coach, or both. This supports the concept that both ATs and coaches can serve as the first line of care for implementing PTPs. Frank et al²⁷ evaluated soccer coaches' attitudes toward PTP implementation based on surveys before and after a coaching workshop and then compared their attitudes with their implementation compliance during the next season. Although the PTP workshops increased coaches' interest in conducting PTPs and strengthened their intent to implement a PTP during the next season, only 53% of the teams had actually done so. Myklebust et al³⁴ described their experience with ACL PTPs in Norwegian female handball players and observed a lack of routine implementation despite promising findings in injury-reduction rates. The authors also noted initial low compliance based on the coaches' delivering the PTPs, which improved with the assistance of physical therapists, and they emphasized the importance of collaboration between practitioners and coaches to increase awareness and program compliance. Further studies are needed to fully characterize the factors that translate into increased compliance to improve rates of PTP implementation.

We found that 89% of surveyed female athletes would be willing to perform a PTP if it could prevent an ACL injury, and athletes with a history of or knowledge of a teammate

Table 4. Survey Responses of Female National Collegiate Athletic Association Athletes About Their Understanding of Anterior Cruciate Ligament Injuries (N = 440)

Topic	Yes, No. (%)
Know what an anterior cruciate ligament tear is	409 (93)
Believe female athletes are at increased risk for sustaining anterior cruciate ligament injuries	373 (85)
Believe female and male athletes should have the same treatment for the same injuries	152 (35)
Believe anterior cruciate ligament injuries can be preventable	391 (89)
Have been educated on anterior cruciate ligament injuries	197 (45)

with an ACL injury were more likely to express interest in performing a PTP. Our results are comparable with those of Martinez et al,³⁵ who surveyed 76 female high school athletes and reported that participants were willing to perform a PTP if data showed they would have fewer injury risk factors and would be less likely to sustain an ACL injury. Barriers to implementing PTPs have been cited as a lack of willingness or compliance on the part of athletes.¹⁷ However, willingness, or the desire to perform, should be distinguished from compliance with continuing PTP exercises over time. Martinez et al³⁵ noted that participants' stated willingness to perform did not appear to affect their compliance with PTPs over time.

In our study, athletes who had or knew a teammate who had sustained an ACL injury were more likely to be familiar with the concept of an ACL PTP. The highest rates of previous performance of a PTP were reported among athletes in high-risk sports, such as basketball (18%), lacrosse (19%), and soccer (50%), who had greater rates of awareness and experience regarding PTPs than athletes in low-risk sports. Previous efforts in PTP implementation have been focused on injury prevention in these high-risk sports. Whether the relationship between injury history and familiarity with PTPs results in or from efforts to increase awareness of PTPs among athletes playing these high-risk sports is unknown.

Our findings indicated overall low rates of exposure to PTPs among female collegiate athletes, with lower rates among Division III than Division I athletes. Routine assessment of PTP awareness among the targeted population is recommended to identify the optimal methods for widespread implementation. Padua et al³⁰ described a 7-step process for developing and implementing a PTP, including the importance of establishing administrative support and assembling an interdisciplinary implementation team. They found that identifying logistical barriers and solutions allowed for concrete goals during implementation. Evidence-based and context-appropriate programs help to improve compliance by meeting the needs of the organization. The authors also addressed the role of assessing the effectiveness of those who were implementing the PTP and an exit strategy to maintain compliance with the exercises and decrease the need for monitoring, which others have deemed to be lacking in implementation.³⁶ Although the efficacy of individual PTPs could be monitored through athlete compliance, greater organization of those who are teaching PTPs is needed to monitor the efficacy of outreach and implementation of such programs.

Our study had several limitations. The instrument was a self-report survey; therefore, we could not verify the accuracy of survey responses, particularly as they related to demographic data, such as age, sex, and the affiliation that qualified participants for inclusion in this study. Given that the survey was anonymous, we assumed participants were likely to answer the questions truthfully. Regarding data sampling, our study population represented a small proportion of the 200 000 female NCAA athletes. In addition, only 31 institutions from 19 states were represented, and therefore, regional differences in PTP implementation were possible. Furthermore, given that the survey was distributed to the student-athletes by their ATs, a selection bias favoring programs or athletes who had more interest in the topic of PTPs may have existed.

CONCLUSIONS

In our study of 440 female collegiate athletes, only 15% reported having ever performed an ACL PTP, and only 33% were familiar with the concept of ACL PTPs. These numbers persisted, although 89% of respondents expressed interest in performing daily PTPs. Despite evidence supporting the efficacy of ACL PTPs, our study suggested that awareness and performance of ACL PTPs were not widespread among collegiate female athletes. Further studies are needed to determine the most effective methods of implementing and monitoring compliance with ACL PTPs in this at-risk population.

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