


Comparison of two implementation strategies for anterior cruciate ligament injury prevention in amateur girls' youth soccer: a prospective cohort study

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To cite: Suits W, Darmofal M, Roe O, *et al.* Comparison of two implementation strategies for anterior cruciate ligament injury prevention in amateur girls' youth soccer: a prospective cohort study. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e002031. doi:10.1136/bmjsem-2024-002031

► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/bmjsem-2024-002031>).

Accepted 4 September 2024

ABSTRACT

Objectives To compare two implementation strategies, an educational handout and a knowledge-to-action (KTA) intervention, for promoting anterior cruciate ligament (ACL) injury prevention programme (ACL-IPP) implementation in amateur youth girls' soccer. The primary outcomes assessed include frequency of ACL-IPP implementation and ACL injury risk.

Methods This was a prospective cohort study, which followed 671 amateur female soccer players (15.72 ± 1.78 years) whose coaches received either a KTA intervention ($n=400$) or an educational handout ($n=271$) regarding implementing an ACL-IPP. Over a single season, we tracked the number of ACL injuries weekly and implementation rates at the end of the season through surveying participating coaches. A χ^2 test was used to compare the ACL-IPP implementation rate between the handout and KTA intervention. Cox-hazard proportional regressions were used to examine the effect of implementation rate and educational interventions on ACL injuries.

Results The KTA intervention yielded higher ACL-IPP implementation as compared with the educational handout ($\chi^2(1, n=671)=25.87, p<0.001$). Implementation of any ACL-IPP at least two times per week was associated with a lower risk of ACL injuries ($HR=0.15, 95\% CI=0.03, 0.73; p=0.019$) compared with implementing once per week or fewer. The KTA intervention was not associated with a significantly lower risk of ACL injuries ($HR=0.39, 95\% CI=0.09, 1.61; p=0.191$) compared with the educational handout.

Conclusion Stakeholder engagement in the process of planning and execution of IPPs, such as with a KTA intervention, appears beneficial for the purposes of increasing implementation rates. Since implementation was significantly associated with lower rates of ACL injuries, this process may lead to improved results in injury prevention in amateur youth soccer.

INTRODUCTION

The prevalence and burden of anterior cruciate ligament (ACL) injuries in adolescent athletes is high. This is particularly true among female soccer players, who are 1.88 to 3.67 times more likely to suffer an ACL injury compared with male athletes.^{1–3} Research

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Anterior cruciate ligament (ACL) injury prevention programmes (IPPs) are efficacious for female athletes. However, the real-world effectiveness may be limited by low implementation levels in amateur youth soccer.

WHAT THIS STUDY ADDS

⇒ Active stakeholder engagement through a knowledge-to-action intervention improved implementation rates of IPPs in amateur youth soccer compared with passive delivery of information. As implementation was associated with reduced ACL injury rates, this suggests this process may provide an avenue to improve the real-world effectiveness of ACL IPPs.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Engagement with community and organisational leaders in amateur sports may be beneficial to facilitate injury risk reduction programme implementation. Large-scale randomised hybrid effectiveness trials, as well as assessment of cost-effectiveness, will be useful to determine the scalability and utility of stakeholder engagement for injury risk reduction implementation in amateur youth soccer.

establishing the efficacy of ACL injury prevention programmes (ACL-IPPs) over several decades suggests the risk for sustaining an ACL injury can be reduced by as much as 67% in this population if programmes are fully adhered to.⁴ Despite strong research supporting the use of ACL-IPP in youth female players to reduce risk for ACL injury, the annual incidence of ACL injuries in youth females has increased by 2.5% every year over a recent 10-year period.^{5 6} One potential explanation for the discrepancy between the rising ACL injury rates and the growing evidence for ACL-IPP efficaciousness is low implementation rates of IPPs in amateur youth sport^{7 8}



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Low implementation rates of ACL-IPP negatively affect the true effectiveness of such programmes.^{9 10} Providing workshops for coaches on ACL-IPP implementation improves coaches' attitudes towards such programmes, but does not increase the implementation rates.¹¹ Access to outreach programmes, such as athletic trainers, is associated with improved ACL-IPP usage; however, this has not been prospectively studied.¹² Barriers precluding appropriate implementation of ACL-IPP in at-risk populations extend well beyond lack of knowledge, and these barriers appear to vary across sports and levels of competition.^{12–15} The variability in barriers to implementation of ACL-IPP suggests that an individualised approach could foster improved implementation. This has not been studied in amateur youth soccer.

Knowledge translation (KT) frameworks are active and dynamic intervention strategies that attempt to reduce maladaptive gaps between what is supported by research and what is performed in practice. This is accomplished by collaborating with local stakeholders to tailor evidence-based recommendations to unique barriers and facilitators.^{16 17} KT frameworks come in various forms. However, they share a common goal: implementing evidence-based strategies to improve health outcomes.¹⁷ One commonly used KT framework is the knowledge-to-action (KTA) framework, which is an iterative process of identifying barriers and facilitators, discussing and tailoring interventions with local stakeholders, troubleshooting implementation strategies and encouraging sustained use.¹⁶ Utilisation of KT frameworks have yielded successful outcomes in medicine and preventative care areas, such as reducing falls in high-risk populations¹⁸ and increasing ACL-IPP adherence in elite Australian rules football.¹⁹ The success of KT interventions to improve evidence-based implementation and health outcomes has prompted calls for usage of such collaborative mechanisms to address injury risk in youth soccer.^{20 21}

Youth female soccer players are at a high risk for ACL injury, which may be partly related to the low levels of implementation of evidence-based ACL-IPPs. Utilisation

of a KT framework may facilitate improved implementation of ACL-IPPs and ultimately reduce the incidence and burden of ACL injuries. This study aims to address the gap between ACL-IPP efficacy and real-world effectiveness by analysing two ACL-IPP implementation strategies, an educational handout and a KTA intervention, in the context of amateur youth female soccer coaches. The studied outcomes were successful ACL-IPP implementation and risk for ACL injury.

METHODS

Study design

This was a prospective cohort study of amateur female adolescent soccer organisations in the state of Michigan in the USA. An invitation to participate in the study and receive information regarding soccer warm-up drills for injury prevention and performance enhancement was electronically distributed to 37 youth soccer organisations in southern Michigan. Seven organisations responded and were offered a choice of whether to receive an educational handout or to participate in a KTA intervention. Teams from three organisations opted for a KTA intervention to facilitate implementation of ACL-IPPs. Teams from an additional four organisations opted to receive an educational handout (see table 1). All coaches provided written informed consent prior to participating in this project. The Strengthening the Reporting of Observational Studies in Epidemiology cohort checklist was used when writing this study.²²

Implementation strategies

The KTA intervention was guided by the KTA framework.¹⁶ Prior to the beginning of the competitive season, a brief survey was distributed to all participating coaches to identify perceived barriers and facilitators regarding ACL-IPP implementation. Following this survey, separate meetings were held virtually for each organisation through Zoom (Zoom, San Jose, California, USA). At least two research team members with backgrounds in injury prevention and strength and conditioning attended all focus groups. These focus groups were 1 hour in duration and included

Table 1 Demographic information of participants

	Knowledge-to-action intervention (3 organisations)	Handout (4 organisations)
Teams (n)	26	16
Players (n)	400	271
Age (years)	15.76 (±1.71)	15.67 (±1.89)
Coaches (n)	18	11
Coaching experience (years)	12.28 (±9.80)	12.67 (±9.48)
Location (based on US Census data) ³¹	Urban	Urban
Socioeconomic conditions (median, range of national percentiles from ADI)	53 (48–89)	44 (20–76)
ADI: 0–100 with higher numbers indicating more disadvantaged. ^{32 33} ADI, Area Deprivation Index.		

a presentation delivered by researchers regarding exercise strategies to facilitate performance enhancement in youth soccer, ACL injuries and ACL-IPPs. Following this presentation, a focus group discussion was conducted to discuss barriers and facilitators that would preclude ACL-IPP implementation. Coaches were asked about their perceptions of the programmes, with a focus on how it might influence their goals for their teams. This was followed by a non-structured discussion about strategies to the programmes to address any concerns stated by coaches. The two ACL-IPPs that were presented in detail included the FIFA 11+ and a novel ACL-IPP, the neuromuscular explosive warm-up (NEW) programme. The FIFA 11+ was included because it is well established in the literature as being efficacious for reducing ACL injury risk in female soccer players.²³ The NEW programme was previously developed by the research team with consultations with local soccer coaches to be based on ACL-IPP clinical practice guidelines and tailored towards barriers and facilitators (see online supplemental material).²³ Two programmes were presented to facilitate autonomy and a locus of control for the coaches. The core components of content and structure of an efficacious ACL-IPP are present, and modifications were made to enhance the focus on performance and mesh with the structure of the warm-ups already performed by the soccer teams. Additionally, options are presented to allow coaches to choose what works for them. Following the presentations and discussion in the focus groups, coaches were offered and encouraged to set up individual meeting times and on-the-field training sessions for programme implementation of their choice of ACL-IPP, at a frequency and timing of their choosing. A minimum of two on-the-field training sessions was encouraged, and there was no maximum. Themes of barriers and facilitators were derived through discussions with the research team, which were followed with member checking with the coach. Coaches received electronic follow-up communication to encourage

sustained use and were offered virtual or in-person consultations for troubleshooting. During both on-the-field training and individual consultations towards the end of the pre season and beginning of the season, some slight modifications and refinements were made in terms of ACL-IPP contents, delivery and addressing knowledge gaps on an individual basis. Figure 1 depicts the timing of each component of the KTA intervention.

The educational handout intervention consisted of an electronically distributed copy of the FIFA 11+ IPP. Coaches in this group were informed of potential benefits in both injury risk and performance and were encouraged to follow-up with any questions or concerns.

Data collection

Data were collected through electronic surveys through Qualtrics (Qualtrics, Provo, Utah, USA) (see: online supplemental material). Initial background information, including the coaching certification and years of experience, was obtained. Outcomes assessed through electronic surveys included the number of new ACL injuries (assessed on a weekly basis) and the self-reported implementation rates of ACL-IPPs (assessed at the end of the season).

Patient and public involvement

Members of the public, specifically amateur youth soccer coaches, were involved throughout the project. The NEW warm-up programme used in this study was designed with collaboration with youth soccer coaches. Further, the KTA intervention was informed by the priorities and preferences of the youth soccer coaches, and both the KTA intervention and handout were offered as choices.

Statistical analysis

A χ^2 test was used to examine the implementation of ACL-IPP between the educational handout and KTA intervention. Implementation was defined as performing

KTA Cycle Component	Timing			Action Taken
	Pre-Season	In-Season	Post-Season	
Determine Know/Do Gap	●			Survey (100% completion)
Adapt to Local Context	▬	▬		Two separate focus groups for each organization (x3), individual discussions (6/18 coaches)
Assess Barriers/Facilitators	▬	▬		Survey (100% completion), focus groups (100% participation), one-on-one discussions (6/18)
Tailor and Implement Interventions		▬		Focus Groups, handouts provided, on-the-field training provided to 18/18 coaches (average: 2.4 sessions per coach)
Monitor Knowledge Use		▬		Monthly informal "check-ins" with all coaches through electronic communication
Evaluate Outcomes		▬		Weekly electronic surveys regarding injuries, end-of-season survey for implementation
Sustain Knowledge Use			▬	Encouragement, Additional resources and contact information provided

Figure 1 Knowledge-to-action (KTA) intervention components, timing and specific actions taken.

Table 2 Themes identified through coach interactions and actions taken in knowledge-to-action intervention

Themes: Preference for existing warm-up, desire for autonomy and flexibility	
Quotes	Action taken
“we’ve been doing our warm-up for awhile and it seems to work pretty good” [coach #2]	<ul style="list-style-type: none"> ▶ Components of existing warm-ups integrated into NEW. ▶ Allowance of limited interchangeability of comparable exercises. ▶ Design of exercises that fit structure of existing warm-up.
“I’m not sure how it can fit” [coach #4]	
“Will it still work if I change a few of the drills?” [coach #12]	
“I want something that can be integrated into our warm-up” [coach #2]	
“As long as it doesn’t take too much time, we don’t have a lot of time to work with” [coach #5]	
“how long is this going to take?” [coach #6]	
“Just seems like it’s going to take a long time” [coach #11]	
Theme: Athlete engagement, sport specificity	
Quotes	Action taken
“we tried [existing ACL-IPP] before, and it was great at first but the kids got bored [after a few weeks]” [coach #18]	<ul style="list-style-type: none"> ▶ Inclusion of gamified and competitive reactive drills. ▶ Emphasis on performance with messaging.
“[the athletes] don’t always have a long attention span” [coach #5]	
“how can we make sure they are working hard enough?” [coach #16]	
“the challenge is to keep them engaged” [coach #4]	
“Pushing the performance piece is going to help” [coach #1]	
Theme: Comfort and knowledge	
Quotes	Action taken
“I want to make sure I’m doing it right” [coach #7]	<ul style="list-style-type: none"> ▶ Straightforward instructions with limited decision-making required. ▶ In-person training sessions.
“I’m not sure I understand how it works out” [coach #3]	
NEW, neuromuscular explosive warm-up.	

the entire ACL-IPP at least two times per week, as this has been previously identified by clinical practice guidelines as an appropriate minimum.²³ Cox-hazard proportional regressions were used to examine the effect of ACL-IPP implementation rate and each educational intervention on ACL injuries.

RESULTS

Basic demographic information of the participants is presented in table 1. Themes identified in the KTA intervention through focus groups and one-on-one meetings with coaches are presented in table 2. The ACL-IPP was implemented at least two times per week for 302/400 athletes (75.5%) in the KTA intervention group and 154/271 athletes (56.8%) in the educational handout group. There was a statistically significant relationship between ACL-IPP implementation and implementation strategy. Individuals on teams receiving KTA intervention exhibited a higher level of ACL-IPP implementation as compared with educational handout ($X^2(1, n=671)=25.87, p<0.001$).

A total of eight ACL injuries occurred over the course of this study. Three ACL injuries occurred in the KTA intervention (7.50 injuries/1000 players/season) and five occurred in the educational handout (18.45 injuries/1000 players/season). The cox-hazard regression revealed that ACL-IPP implementation

was associated with risk of ACL injuries (HR=0.15, 95% CI=0.03, 0.73; $p=0.019$), suggesting individuals on teams with appropriate ACL-IPP implementation had an 85% lower risk of sustaining ACL injury (figure 2). However, the specific type of implementation intervention (KTA or educational handout) was

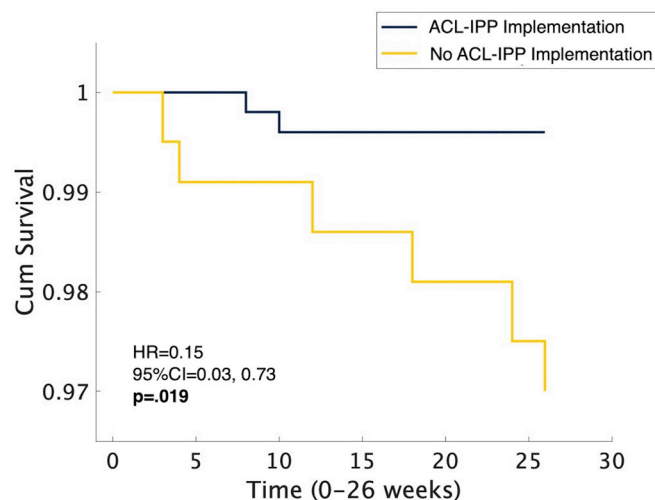


Figure 2 Cumulative survival curve for ACL injury according to the implementation of ACL-IPP implementation or no implementation. ACL, anterior cruciate ligament; IPP, injury prevention programme.

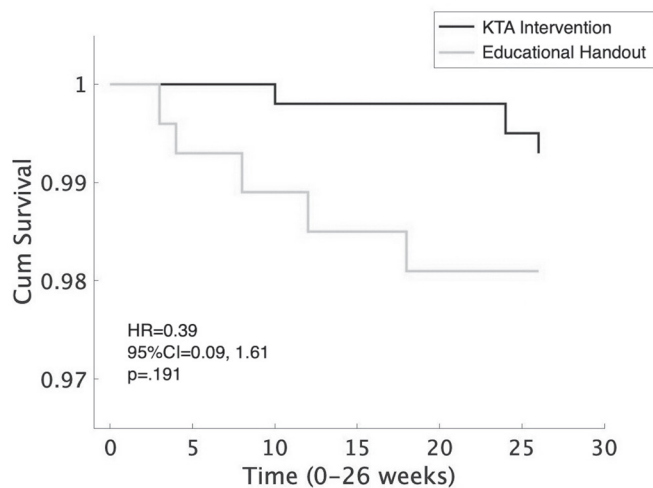


Figure 3 Cumulative survival curve for anterior cruciate ligament injury according to implementation intervention. KTA, knowledge-to-action intervention.

not associated with a lower or higher ACL injury risk (HR=0.39, 95% CI=0.09, 1.61; $p=0.191$) (figure 3). Each organisation independently reported that they chose to collectively follow a single programme for the sake of continuity. All coaches in the KTA intervention chose to follow the NEW programme.

DISCUSSION

Main findings

The main findings from this study were that (1) a KTA intervention strategy was associated with a significantly higher rate of implementation of ACL-IPPs as compared with an educational handout in amateur youth soccer and (2) compared with not implementing an ACL-IPP, implementation of an ACL-IPP of at least two times per week was strongly associated with a reduced risk of ACL injuries in amateur youth soccer, regardless of the programme performed. Additionally, there was no statistically significant difference between the educational handout and the KTA intervention in the risk of ACL injuries in this study. The findings of this study have powerful implications for future research and policy regarding injury prevention in amateur youth sports.

Mechanisms that drive implementation

IPP implementation is low in amateur youth sports. Prior research demonstrates that low implementation rates negatively affect the effectiveness of IPPs in sport.^{9 10} The results of this study are in agreement with the previous literature: consistent implementation of IPPs was associated with a significantly lower risk of ACL injury. A novel finding of this study was the difference in implementation rates between two different educational interventions. A KTA intervention was associated with a higher ACL-IPP implementation rate than an educational handout.

The specific mechanisms of the KTA intervention, if any, for improving implementation are unknown. Several qualities of the KTA intervention may have

catalysed the improved implementation rates compared with an educational handout. This includes the ongoing support provided,^{13 24} flexibility with the content and delivery^{19 25 26} and promotion of autonomy.¹⁹ None of these qualities were present in the educational handout intervention. Conversely, while lack of time, concerns for financial cost and lack of equipment have been previously cited as barriers to IPP implementation,^{13 27} there was no difference in the time or equipment necessary for programme implementation in either group in this study, and there was no financial cost either. This suggests that there may be a discrepancy between what is reported as a barrier and what is actually precluding the implementation of IPPs in sport. Practitioners attempting to facilitate implementation of an ACL-IPP in amateur youth sports should consider strategies beyond solely addressing what is reported as a barrier, as this may limit effectiveness. In addition to consideration of reported barriers, attempts at improving ACL-IPP implementation that has a consideration of effective strategies to facilitate behavioural change specific to the local context may yield improved results.

Flexibility of injury prevention contents

Common themes among efficacious ACL-IPPs include both elements of the content and delivery. The content of efficacious ACL-IPPs includes landing stabilising exercises, body weight strengthening, agility training and being comprised of multiple components.^{23 28 29} There appears to be a dose–response relationship with ACL-IPPs, and it is recommended that they be delivered throughout the preseason and season and done so multiple times per week.^{23 30} Several exercise programmes with these qualities appear to be efficacious, with no evidence that any are superior. One strategy to promote implementation may be to facilitate autonomy and control, and this could include providing flexibility of the specific contents of the programme.^{19 21 25 26}

In this study, the coaches in the KTA intervention group were invited to choose programmes and options within programmes, and this flexibility may have positively influenced the ACL-IPP implementation rate.^{19 25 26} The coaches in the KTA intervention group followed a programme of a different structure than the coaches in the handout group, yet there were no differences in injury rates between coaches who implemented one programme compared with the other, as long as it was actually implemented. The results of this study demonstrate that ACL injury risk were similar regardless of the programme performed as long as they were implemented at least two times per week. This finding supports the notion that the overarching themes of ACL-IPPs are important. However, coaches and practitioners may allow some degree of flexibility regarding specific details regarding the content and delivery of the ACL-IPP without reduced concerns for reducing the effectiveness, provided clinical practice guidelines are followed. This is relevant considering that the ACL-IPP implementation rate in the handout group

was significantly lower in this study compared with the KTA intervention group, as the latter allowed limited flexibility with the contents while the former did not.

Limitations

This study has notable limitations. This was not a randomised controlled trial, and there is a possibility of a selection bias due to the lack of randomisation. This is augmented by the low initial recruitment rate in this study. Further, reporting of ACL-IPP implementation was conducted at the end of the season, and it is possible that coaches had a recall bias. Other injuries common in soccer that could be targets of risk reduction measures in soccer, such as hamstring strains, were not assessed. It is not known if there are any added benefits of the prevention programmes or implementation strategies in this study beyond ACL injury risk reduction.

Research/policy implications

Future research will be beneficial for building on this study to better facilitate injury prevention implementation in sport. A randomised hybrid implementation–effectiveness trial will be useful to better elucidate the benefits of implementation strategies as well as long-term sustainability. Further, it is not known how flexible coaches and practitioners can be with the content and delivery of IPPs before adversely affecting the effectiveness. Further research will be useful to evaluate the effectiveness of exercise-based IPPs based on categories of exercises rather than specific exercises.

Policymakers may consider adapting education delivered to youth soccer coaches to ensure that practical information on injury prevention and performance enhancement warm-ups is included. Promotion of interdisciplinary collaboration with athletic trainers, physical therapists, strength and conditioning coaches, or other disciplines knowledgeable with exercise prescription may be useful as well, provided this is done in a cost-effective manner.

CONCLUSION

The results of this study demonstrate improved ACL-IPP implementation in a group of amateur youth soccer coaches through KTA intervention compared with delivering an educational handout. Further, there was a significantly lower risk of ACL injury in teams where the ACL-IPP was implemented, regardless of the implementation strategy or specific programme used. These results support the use of stakeholder engagement with limited flexibility for the facilitating implementation of ACL-IPPs in amateur youth soccer.

Contributors WS, MD and OR contributed to conceptualisation. WS and TCL contributed to methodology, formal analysis and data curation. All authors contributed to writing. WS contributed to funding acquisition and is the guarantor of this work.

Funding This project was partially funded through grants by the Arthur L. Tuuri, M.D. Children's Health Education Fund and the Arthur L. Tuuri Health Fund from the Community Foundation of Greater Flint (project #218436).

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the University of Michigan Institutional Review Board, approval number #HUM00214282. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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