Dissemination and Implementation Strategies of Lower Extremity Preventive Training Programs in Youth: A Clinical Review

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Context: Neuromuscular preventive training programs effectively reduce injury and improve performance in youth athletes. However, program effectiveness is directly linked to program compliance, fidelity, and dosage. Preventive training programs are not widely adopted by youth sport coaches. One way to promote widespread dissemination and compliance is to identify implementation strategies that influence program adoption and maintenance. It is unknown how previously published programs have followed the elements of an implementation framework. The objective of this review was to evaluate how elements of the 7 steps of implementation, developed by Padua et al, have been performed in the evidence of lower extremity preventive training programs.

Evidence Acquisition: A systematic review of the literature from 1996 through September 2016 was conducted using electronic databases. Investigations that documented implementation of a sport team-based neuromuscular preventive training program in youth athletes and measured lower extremity injury rates were included.

Study Design: Clinical review.

Level of Evidence: Level 4.

Results: A total of 12 studies met the inclusion criteria and were reviewed. Information regarding the completion of any of the 7 steps within the implementation framework developed by Padua et al was extracted. None of the 12 articles documented completion of all 7 steps. While each study addressed some of the 7 steps, no study addressed maintenance or an exit strategy for youth athletes. Program implementation appears limited in obtaining administrative support, utilizing an interdisciplinary implementation team, and monitoring or promoting fidelity of the intervention.

Conclusion: Despite strong evidence supporting the effectiveness of preventive training programs in youth athletes, there is a gap between short-term improvements and long-term implementation strategies. Future interventions should include all 7 steps of the implementation framework to promote transparent dissemination of preventive training programs.

Keywords: preventive training programs; youth; adolescent; injury prevention

Neuromuscular preventive training programs demonstrate strong success in reducing the majority of lower extremity noncontact injuries, such as anterior cruciate ligament (ACL) and ankle sprain.[16,22,23,35,43] However, some reports document programs that have had limited success in reducing lower extremity injury rates.[11,21,33] Program effectiveness is directly related to athlete and coach compliance with the prescribed programs.[13,37,40] Despite a majority of the evidence supporting the use of preventive training programs to reduce lower extremity musculoskeletal injuries, program use is

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not widespread and appears to be adopted by less than 20% of all high school coaches in the United States.[17,27]

Evidence for the use of preventive training programs to reduce injury rates has traditionally been presented after a season- or year-long intervention with no follow-up. Outcomes observed in Norway over the past 15 years demonstrate the need for a maintenance and exit strategy to be included in the initial dissemination and implementation of a program. Myklebust et al[25] presented promising reductions in ACL injuries through the use of preventive training programs in Norwegian handball. However, ACL injury rates returned to baseline levels as program adoption declined after the study was complete.[25] A national information and education initiative regarding preventive training programs began in Norway shortly after the increase in injury rates was observed, which resulted in a successful decrease in injury rates for at least 6 years. The Norwegian experience and the apparent lack of widespread adoption by US high school coaches suggest that further work is needed to promote dissemination and implementation of preventive training programs in a manner that will be sustained over time.

There is a plethora of intervention implementation frameworks that have been utilized by the field of health behavior change and implementation science. One framework promoted for use by the sports medicine community is the RE-AIM (Reach, Efficacy, Adoption, Implementation, Maintenance Sports Setting Matrix [RE-AIM SSM]) framework, which accounts for the reach of the intervention through its maintenance over time.[10] O'Brien et al[29] performed a systematic review to evaluate if and how aspects of this framework have been addressed in preventive training program dissemination and implementation. Their conclusions highlighted significant gaps in adoption and maintenance regarding preventive training programs. Padua et al[32] modified the RE-AIM framework to include 7 steps with practical strategies to guide preventive training program implementation to close this gap in adoption and maintenance. It is not known if or how previous work in the field of lower extremity injury prevention has utilized the proposed steps to promote long-term adoption of the effective interventions. This knowledge is critical to guide future preventive training program dissemination and implementation.

The purpose of this clinical review is to evaluate if and how elements of the 7 steps of implementation, proposed by Padua et al,[32] have been performed within the evidence surrounding preventive training programs that include a variety of exercise types (eg, balance, plyometric, resistance, agility, flexibility) for lower extremity injury. Because of the lack of widespread adoption observed in the United States, we hypothesized that previously published programs have not completed a majority of the elements in the 7-step process.

METHODS

Search Strategy

Five electronic databases (the Cochrane Central Register of Controlled Trials, MEDLINE, SPORTDiscus, CINAHL, and PubMed) were systematically searched for peer-reviewed publications between 1996 and September 2016 on the implementation of team-based neuromuscular preventive training programs in youth athletes. The following keywords were used in various combinations: *adolescent, youth, child, sport injury/ies, athletic injury/ies, prevention, preventive, program, intervention, warm-up, neuromuscular control, training, ACL, anterior cruciate ligament, knee, lower extremity, rate*, and *incidence*. Reference lists of articles were examined for additional relevant studies.

After deleting duplicates, article titles and abstracts were scanned for relevance. Articles were included if the article was written in English, documented implementation of a sport team-based neuromuscular preventive training program in either male or female youth athletes, the intervention contained at least 2 or more exercise categories (balance, strength, agility, plyometrics, flexibility, etc), and the study measured lower extremity musculoskeletal injury rates. Articles were excluded if the intervention included in-school or at-home components, the study population contained adult participants (age >18 years), intervention exclusively consisted of balance exercises, or the study did not report injury rates. Two investigators independently reviewed the articles selected through the electronic database search for inclusion and exclusion criteria.

Review of Implementation Framework

We created a checklist based on the 7-step model by Padua et al[32] (see Appendix 1, available in the online version of this article). For each of the 7 steps, a series of questions was asked and the investigators determined whether the study included this aspect of the implementation framework as part of their implementation strategy. Two investigators independently evaluated each of the selected articles regarding inclusion (Yes), exclusion (No), or lack of ability to determine (Unclear) whether each of the 7 steps identified by Padua et al[32] were applied during the implementation of a neuromuscular preventive training program (Table 1). A third investigator reviewed these data extractions for validity. A "majority rule" was implemented if disagreement existed on the inclusion of an element of a step of the Padua framework. After review of the 7-step implementation elements, the authors held a roundtable discussion to determine whether the overall study methodology described minimal inclusion of a step in the framework.

RESULTS

From an initial list of 868 articles, 12 studies met all the criteria. These 12 articles were reviewed, and information regarding their completion of any of the 7 steps of the Padua implementation framework was extracted (Table 1). None of the 12 articles completed all 7 steps of the implementation framework.

Step 1: Establish Administrative Support

Only 3 (25%) articles of the 12 included in this review reported attempts to establish administrative support, which is the first of

Table 1. Lower extremity preventative training program 7-step implementation assessment

Implementation Step	Hewett et al (1999)[15]	Heidt et al (2000)[14]	Junge et al (2002)[19]	Mandelbaum et al (2005)[24]	Olsen et al (2005)[30]	Pfeiffer et al (2006)[33]	Soligard et al (2008)[36]	Steffen et al (2008)[39]	Kiani et al (2010)[20]	Walden et al (2012)[46]	LaBella et al (2011)[22]	Steffen et al (2013)[38]	Yes		Unclear		No		Agreement[a]	
													Count	%	Count	%	Count	%	Count	%
1) Establish Administrative Support	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**NO**	**NO**	**NO**	**YES**	**NO**	**NO**								
Did the research team explain the negative outcomes of injury? (*lack of athlete availability, decreased athletic performance, long-term disability, high reinjury risk*)	No	No	Unclear	Unclear	No	No	No	No	Unclear	No	Unclear	No	0	0.0	4	33.3	8	66.7	11	91.7
Did the research team explain the positive outcomes of injury prevention programming? (*reduce injury risk, enhance athletic performance, increase athlete availability*)	No	No	Yes	Unclear	Yes	No	Yes	No	Unclear	No	Unclear	No	3	25.0	3	25.0	6	50.0	9	75.0
Did the research team formally receive permission from the organization to implement the preventative training program?	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	7	58.3	4	33.3	1	8.3	9	75.0
2) Develop an Interdisciplinary Team	**YES**	**NO**	**YES**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**								
Did the research team involve key stakeholders (*coaches, organizational administrators, parents, athletes, sports medicine staff*) in the design of the preventative training program?	Yes	No	Yes	No	Yes	No	No	No	No	Unclear	No	No	3	25.0	1	8.3	8	66.7	11	91.7
Did the research team involve key stakeholders (*coaches, organizational administrators, parents, athletes, sports medicine staff*) in the implementation plan of the preventative training program?	Yes	No	Yes	No	Yes	No	Yes	No	No	Unclear	No	No	4	33.3	1	8.3	7	58.3	10	83.3
3) Identify Barriers and Solutions	**NO**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**								
Were logistical (*organizational infrastructure, locations, resource availability, capacity*) barriers and solutions identified?	Unclear	Unclear	Yes	No	Unclear	Unclear	No	No	Unclear	No	Yes	No	2	16.7	5	41.7	5	41.7	11	91.7
Were time (*program and session duration*) barriers and solutions identified?	Unclear	No	Yes	Unclear	Yes	Yes	No	No	Unclear	No	No	No	3	25.0	3	25.0	6	50.0	11	91.7
Were the organization's personnel (*number of staff available, staff's background/professional education*) barriers and solutions identified?	Unclear	No	Yes	Unclear	Unclear	Unclear	No	No	Unclear	No	No	No	1	8.3	5	41.7	6	50.0	11	91.7
Were environmental (*training locations, surfaces, equipment availability*) barriers and solutions identified?	Unclear	No	Yes	Unclear	Unclear	Unclear	No	No	Unclear	No	No	No	1	8.3	5	41.7	6	50.0	12	100.0
4) Develop an Evidence-Based Preventive Training Program	**NO**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**NO**								
Is the program evidence based?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	12	100.0	0	0.0	0	0.0	12	100.0
Is the program solutions oriented? (*ie, improve biomechanics, enhance performance, provide warm-up, decrease muscle soreness)*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	12	100.0	0	0.0	0	0.0	12	100.0

(continued)

Table 1. (continued)

Implementation Step	Hewett et al (1999)[15]	Heidt et al (2000)[14]	Junge et al (2002)[19]	Mandelbaum et al (2005)[24]	Olsen et al (2005)[30]	Pfeiffer et al (2006)[33]	Soligard et al (2008)[36]	Steffen et al (2008)[39]	Kiani et al (2010)[20]	Walden et al (2012)[46]	LaBella et al (2011)[22]	Steffen et al (2013)[38]	Yes		Unclear		No		Agreement[a]	
													Count	%	Count	%	Count	%	Count	%
Is the program scalable? *(ie, do all components of the program need to be executed in order for it to be effective? Is program effectiveness maintained if intervention is adapted to meet the needs of the target population?)*	Unclear	Unclear	Yes	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Unclear	2	16.7	10	83.3	0	0.0	12	100.0
5) Train the Trainers and Users	**NO**	**NO**	**YES**	**YES**	**NO**	**YES**	**YES**	**YES**	**NO**	**YES**	**YES**	**YES**								
Was the effectiveness of the preventative training program explained to the trainers and users?	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	2	16.7	10	83.3	0	0.0	11	91.7
Was the injury prevention program aligned with organizational goals (*player safety, reduce organization injury rates, enhance athlete athletic performance*)?	Unclear	No	Yes	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	1	8.3	10	83.3	1	8.3	12	100.0
Were trainers' and users' knowledge, attitudes, and beliefs regarding injury prevention evaluated?	No	No	No	No	No	No	No	No	No	No	No	No	0	0.0	0	0.0	12	100.0	10	83.3
Were trainers' and users' self-efficacy assessed and addressed? (*ie, trainers and users believe they are able to effectively teach and deliver the preventative training program*)	No	No	No	No	No	No	No	No	No	No	No	No	0	0.0	0	0.0	12	100.0	12	100.0
Were trainers and users provided with regular feedback on their delivery and execution of the preventative training program?	Unclear	No	No	No	Unclear	No	No	Yes	No	No	Yes	Yes	3	25.0	2	16.7	7	58.3	8	66.7
6) Preventative Training Program Fidelity Control	**NO**	**NO**	**NO**	**YES**	**NO**	**NO**	**NO**	**NO**	**NO**	**YES**	**YES**	**YES**								
Was program implementation fidelity assessed?	No	Unclear	No	Yes	No	No	Unclear	No	No	Yes	Yes	Yes	4	33.3	2	16.7	6	50.0	10	83.3
Was continuous quality improvement feedback provided based on program fidelity assessment findings?	Unclear	No	No	No	No	No	Unclear	No	No	Yes	Unclear	No	1	8.3	3	25.0	8	66.7	8	66.7
7) Exit Strategy	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**								
Were objective criteria for achieving high-fidelity implementation established?	No	No	No	No	No	No	No	No	No	No	No	No	0	0.0	0	0.0	12	100.0	12	100.0
Was a goal-oriented exit strategy established? (*ie, organization has achieved ≥90% compliance with markers of program implementation fidelity for at least 2 months)*	No	No	No	No	No	No	No	No	No	No	No	No	0	0.0	0	0.0	12	100.0	12	100.0
Was implementation fidelity reassessed to ensure retention and maintenance after implementation support has been withdrawn for an extended period of time (ie, >6 months) following initial training?	No	No	No	No	No	No	No	No	No	No	No	No	0	0.0	0	0.0	12	100.0	12	100.0

[a]Percent agreement represents the original concordance between authors H.J.R. & B.S.F. In the case of disagreement a third author (L.J.D.) acted as an arbitrator as described above.

the 7-step implementation framework.[30,33,46] Olsen et al[30] and Walden et al[46] recruited participants by appealing to soccer/football clubs, which is the organizational structure for teams. Interested clubs then received further recruiting information to distribute to coaches for eventual enrollment in the study. The study by Pfeiffer et al[33] involved recruiting high schools, which infers support was garnered at the administrative level at the high school (ie, athletic director, principal) and then individual teams were enrolled. All other studies enrolled team participants at the team level, directly through the coach.

Step 2: Develop an Interdisciplinary Implementation Team

An interdisciplinary team for program dissemination and implementation can be critical for long-term feasibility and sustainability. Involving stakeholders from all levels in the implementation, including the program implementers, program supporters (eg, parents, administrators), participants, and decision makers, can be critical for avoiding logistical barriers to long-term implementation.[10,13,25,32] Because the articles included in this review were all designed as research studies first and foremost, a common theme involved the research staff's dictating to the coaches or implementers how the program should be delivered. This may be a significant limitation for long-term maintenance and use of the program, as the general "one-size-fits-all" implementation approach does not account for individual site needs. The F11+ is one program that was designed and continues to be promoted using an international team of stakeholders,[18] which may affect its long-term success in countries that have promoted its use.[25] None of the articles describe the participants or athletes having an active role in the implementation process. Failing to secure input from important stakeholders may inhibit program fidelity, or how the program is performed relative to how it is prescribed.

Step 3: Identify Barriers and Solutions

Time

Since the study by Hewett et al[15] was published in 1999, there has been a shift in preventive training program designs to be used as a team warm-up activity. The study by Heidt et al[14] was the only other to evaluate a program outside of a team warm-up. There are differences, however, in the total duration of program utilization, and Sugimoto et al[41] demonstrated that program dosage is directly related to its effectiveness. Three (25%) of the included studies utilized a phased implementation, with program dosage being reduced after an initial burst, which typically coincided with the preseason.[20,30,39] For example, in the study by Kiani et al,[20] coaches were instructed to implement the program twice per week during preseason and then once each week for the rest of the season.

Personnel

An important barrier to program implementation related to personnel is perceived self-efficacy. All but the study by Heidt et al[14] utilized the coach for program implementation.[15,19,20,22,24,30,33,36,38,39,46] Hewett et al[15] also included the high school athletic trainer in program implementation, while Heidt et al[14] utilized a preventive training program that was implemented by research staff provided to athletes at no additional cost. Several of the studies provided guidance to coaches (ie, implementers) using educational printed material,[15,20,22,24,30,33,37-39,46] and in some cases, a DVD.[15,22,24,33,37,38,46] Eight studies[19,20,22,30,35,36,38,46] included an in-person educational workshop for coaches. If this workshop included opportunities for coaches to practice implementation or perform the exercises themselves, their perceived self-efficacy may be improved. The education workshops and what was included in them are described inconsistently.

Environment

The studies by Heidt et al[14] and Hewett et al[15] are the only 2 in which the program was not performed as a team warm-up activity and, consequently, performed at a location other than the sport setting. Implementing the program on location of the sport setting likely overcomes the potential barrier of environment.

Organization

Because of the organizational structure of program implementation in all studies, the programs do not appear to have been modified to address any concerns at the organizational level.

Step 4: Develop an Evidence-Based Preventive Training Program

The F11+ preventive training program is the most commonly studied program among the selected articles.[36,38,39] Other studies utilized preventive training programs with similarities from previously published effective programs.[15,19,22,30,33,36,39,46]

Step 5: Train the Trainers and Users

Two studies (17%) simply supplied program implementers (ie, coaches) with educational materials via web-based platforms or mail.[15,39] Eight studies supplemented the educational materials with an in-person training workshop.[19,20,22,30,33,36,38,39] Kiani et al[20] offered an in-person workshop on request but did not describe how often this type of training was utilized. Training was irrelevant in the study by Heidt et al[14] since the research staff implemented the program.

Steffen et al[38] compared the effectiveness of 3 different training strategies for program implementation. The control group received access to web-based materials while the coaches in the intervention group attended an educational workshop. One intervention group also received supplemental implementation support from a trained health care professional weekly throughout the season. Interestingly, there was no difference between the 2 intervention groups, suggesting an educational workshop can be an effective method to train coaches to effectively implement a preventive training program.

Step 6: Fidelity Control

While compliance was measured in 6 studies,[20,22,24,30,38,39] the fidelity is poorly reported or monitored. Only 4 studies (33%) included fidelity outcomes.[22,24,38,46]

Step 7: Maintenance and Exit Strategy

None of the selected articles describe any type of maintenance or exit strategy.

DISCUSSION

The short-term effectiveness of some preventive training programs has been established.[35] While there is evidence of programming that is not consistently successful in significantly reducing injury rates, it is likely that the observed lack of effect on injury rate reduction is a function of limited dosage, which may be secondary to limited implementation and fidelity. However, there is failure in translating evidence from preventive training programs to long-term effectiveness and sustainability.[6,28] This review reveals a significant gap in previous preventive training program implementation to promote long-term adoption and maintenance that is imperative for the reduction of musculoskeletal injuries in youth athletes, which may be critical to reduce the burden of physical inactivity and osteoarthritis to society. These findings support and expand the work of O'Brien and Finch,[29] who evaluated preventive training programs by addressing the components of the RE-AIM implementation framework. We identify key gaps in preventive training implementation by considering a 7-step implementation model proposed by Padua et al.[32] This 7-step framework was developed to provide clinicians with a template to facilitate systematic implementation of a sport injury prevention program within an organization. At the time of this article's publication, it is not known whether the proposed 7-step implementation framework leads directly to increased adoption, fidelity, and maintenance. However, a template for sports preventive training program implementation guidelines is warranted, and the framework by Padua et al[32] can be deployed immediately to guide clinicians who are responsible for sports injury prevention in their organization. Specifically, program implementation appears limited in obtaining administrative support, utilizing an interdisciplinary implementation team, and monitoring or promoting fidelity of the intervention. In addition, a maintenance or exit strategy has yet to be included in a published study with youth athletes.

The literature on preventive training programs has not consistently included the value of buy-in from an administrative or organizational level. Myklebust et al[25] provided evidence that a nationally organized and implemented initiative can effectively promote program adoption and reduce injury rates. Similarly, national efforts have been made in New Zealand for soccer.[2] This type of national effort has not been present in the United States, however, and has not encompassed all youth sports. The implementation drivers theory, proposed by Blase et al,[3] discusses the need to include organizational structure and beliefs into intervention planning. While several studies first approached sports teams at the organizational (sport club) or administrative (high school) level,[19,22,30,33,36,39,46] this is not consistent. Furthermore, more work needs to be done to understand whether organizational perceptions can be driven by coach interest as well.

The majority of the evidence surrounding the effectiveness of preventive training programs has been gathered from research-led intervention planning. This method is not sustainable for a population-level and long-term impact. Padua et al[32] highlight the need for initial intervention planning to include input from an interdisciplinary team of stakeholders, which likely includes at least the club/athletic director, coaches, athletes, and parents in youth sport. This multistakeholder approach will help individual teams to identify logistical barriers that may not be present at every stakeholder level or with every team and create sustainable solutions. For many settings, coaches may request that the players lead their own implementation. Therefore, efforts to achieve player buy-in should be a priority.

To achieve widespread successful dissemination and implementation, an effective "train-the-trainer" strategy must be planned and in place. This strategy could occur at a national level through coach licensing and conferences or at a local level utilizing skilled allied health care professionals, such as athletic trainers and physical therapists. The majority of the studies in this clinical review provided educational materials to implementers (ie, coaches), which is a feasible long-term solution but may not be sufficient. Steffen et al[38] justified the inadequacy of simply providing stakeholders with knowledge-based information through a cluster-randomized trial. The control group in their study received only instructional materials, while the coaches in the intervention groups attended an in-person coach workshop, which was found to be effective with reducing injury rates through the implementation of a preventive training program. The details about what information needs to be translated and what method to utilize during a coaches workshop have yet to be determined. Frank et al[12] observed that a coaches workshop incorporating a presentation highlighting program effectiveness, trainer-led instruction, and access to on-field instructional materials effectively improved coach knowledge and intention to adopt a preventive training program; however, those improvements did not translate to actual program adoption. These findings suggest that traditional behavior change theory such as the theory of planned behavior[1] may not apply to real-world adoption of preventative training programs in the youth sport environment, and a more comprehensive systematic approach such as the 7 steps outlined by Padua et al[32] is necessary.[12]

The most common implementation strategy for preventive training programs in youth sport has involved incorporating the program as a warm-up strategy. A warm-up is a natural mode of delivery for youth sport teams that not only prevents injury but also sufficiently prepares the athlete for participation in physical activity through a gradual increase in body temperature and tissue lengthening. Dynamic warm-ups improve power

production,[48] sprint time,[8] vertical jump,[8,45] and neuromuscular control[34] immediately after they are performed. However, DiStefano et al[5] and Padua et al[31] demonstrate that the improvements in neuromuscular control observed after preventive training programs are transient and consequently require consistent program implementation to maximize long-term benefits. Therefore, performing a preventive training program as a warm-up prior to sport activity facilitates its use on a daily basis whenever sporting activity occurs, establishing a habit around this type of implementation. The majority of the selected articles in this review included a gradual decrease in program use, with a boost occurring during preseason. This type of delivery may impede long-term adoption and compliance because the program is not involved in the daily routine and instead is viewed as an option once a week, but additional research is necessary to confirm this effect. It is thus imperative that future efforts leverage effective synergistic implementation strategies that promote an organizational culture and boost habit-forming behaviors to ensure long-term compliance and fidelity.[47]

Nearly 67% of selected studies measured compliance with the preventive training program, or that the program was being performed. However, only a few studies ever included measures of fidelity, or how well the program was performed. This is an important measure for future research on effectiveness to gather as well as to consider with future widespread dissemination. Several studies noted that coaches often chose to modify the program based on their perceptions. These perceptions may be guided by what teams are already doing. Sugimoto et al,[42] Lauersen et al,[23] and Taylor et al[44] all utilized meta-analyses to identify critical components of a preventive training program, but there does not appear to be 1 program that is solely responsible for protective effects. Therefore, allowing coach or team modifications may be beneficial for long-term adoption and compliance.

There are many theoretical models to support intervention mapping. Translating Research into Injury Prevention Practice (TRIPP)[9] and RE-AIM SSM[10] are strong examples that provide a systematic framework for the implementation of preventive training programs. However, the 7-step framework outlined by Padua et al[32] extends these existing models to include sufficient planning objectives prior to intervention, integration of primary stakeholders, and an exit strategy, which are currently missing from TRIPP and RE-AIM SSM. Implementation drivers effectively help identify stakeholders and promote implementation synergy across the organization but do not provide an effective "start to finish" plan. The 7-step methodology provides a roadmap for effective planning, implementation, maintenance, and continuous quality improvement (CQI cycle)[4] to allow for the implementation team to exit based on an objective and goal-oriented strategy.

Limitations

While implementation frameworks such as the RE-AIM SSM have existed in the literature for a number of years, the 7-step methodology was only recently published. The purpose of this review was to examine whether any of these steps were already being followed by interventions before this framework was released. This delay should be considered when interpreting the outcomes of this review. A major limitation of this review is that there is no evidence that the 7-step framework will effectively improve adoption, compliance, and program effectiveness. However, within the context of sport injury prevention, or even other areas of the health intervention literature, no comparative effectiveness studies have been carried out regarding the use of intervention frameworks. Thus, it is not possible to recommend a specific implementation framework over another. Despite this lack of empirical evidence, dissemination and implementation frameworks are still highly recommended to optimize long-term sustainability of interventions.[26] The 7-step framework is novel such that it provides clinicians and organization stakeholders with a template to implement programming within their organization whereas previously described injury prevention frameworks only afford assessments of implementation parameters.

The outcomes of this clinical review are limited to published studies that presented the effects of a team-based preventive training program using various combinations of exercises (eg, plyometric, balance, agility, flexibility, strengthening) on lower extremity injury rates in a youth athlete population. Therefore, these findings may not apply to all types of injury prevention implementation strategies and should not be generalized. For example, Emery et al[7] found successful results with home-based programs, but understanding how these types of programs should be disseminated is beyond the scope of this review. Factors affecting implementation of home-based programs may be different than those present in school or organized sport settings.

CONCLUSION

While the effectiveness of preventive training programs in youth athletes has been supported by a number of studies, there is a gap between the short-term improvements and long-term implementation strategies. This is concerning because the benefits of preventive training programs are transient, and programs must be implemented consistently over time and with high fidelity. While the outcomes of this clinical review demonstrate that published interventions address several steps of implementation frameworks, there are additional aspects that future interventions should consider including to potentially optimize long-term outcomes. More specifically, there is limited information in the literature on obtaining administrative support, utilizing an interdisciplinary implementation team, and monitoring or promoting fidelity of the intervention. Furthermore, a maintenance or exit strategy has yet to be included in a published study with youth athletes.

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