Sport injury prevention exercise programmes work but have many challenges

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Participating in physical activity and sport is beneficial for health and wellbeing. However, there is an inherent risk of injury. Injury prevention exercise programmes have been proven to reduce the risk of injury in a range of sports, though adherence to them is poor. Preventive interventions that involve research evidence with practitioner expertise and end-users' experience are deemed important to improve their adoption and sustainability. Increasing our understanding about the complexity of developing preventive programmes and implementing them is important to enhance their impact in real sporting settings.

LEARNING OUTCOMES
TO SUPPORT PHYSIO FIRST QAP

1 Understand the common frameworks and models applied to develop sport injury prevention.
2 Be aware of the complexities and challenges at each step of the injury prevention process.
3 Develop an appreciation of the clinician's role in sport injury prevention.

Introduction

Physiotherapists are well placed to support people to lead healthy lifestyles and to be physically active. Participating in sport offers an opportunity to reduce sedentary time which confers numerous health benefits. However, there is an inherent risk of sustaining an injury. Indeed, the benefits of playing sport by far outweigh the risk of sport-related injury (Gosselin *et al* 2020). Nevertheless, more needs to be done by clinicians and researchers to reduce that risk. Sport injury prevention strategies may target sport policy / rule changes, exercise and training interventions, protective equipment and wearable technology (Vriend *et al* 2017). Injury prevention exercise programmes (IPEPs) have been proven efficacious and are applied in a range of different sports settings (Emery *et al* 2015). Understanding the efficacy and challenges of implementing IPEPs in sport is important to reduce the long-term health consequences and the economic burden on treatment (Gosselin *et al* 2020). The aim of this article is to review the frameworks that are applied in sport injury prevention and outline their associated challenges. The current evidence of efficacious IPEPs will then be considered and research about implementing and adopting IPEPs will be discussed.

Injury prevention frameworks and models

There are several sport injury prevention frameworks that exist, most notably the *Sequence of Prevention* (van Mechelen *et al* 1992) and *Translating Research Into Prevention Practice* (TRIPP) (Finch 2006). The TRIPP model overlaps the four steps of the *Sequence of Injury Prevention* and builds on it by necessitating that research advancements are made to understand the behavioural factors which contribute to the adoption of preventative interventions. It highlights that clinicians and researchers must realise the implementation context for the multifactorial complex nature of sport injury prevention to lead to real-world injury reduction. The existing evidence that has emerged from using these frameworks indicates a high level of concern about the impact of sport injuries, and a need to address the challenges of translating these concerns into intervention studies to prevent injuries in sport settings. It is worth noting that research in this field is lacking on female athletes and community youth players.

Step 1: injury and illness surveillance

Sport injury and illness surveillance is fundamental to determine the size of the problem in the first step of the prevention model and is where a vast amount of the sport injury research has been conducted. Data collection and reporting methods have advanced over the past decades, with an increasing focus on overuse injuries and illness (Bahr *et al* 2020). This, however, has largely benefited those in higher playing levels.

The lack of resources at lower playing levels, and particularly among community youth, impedes injury surveillance (Gabbe *et al* 2003), and is further hindered by considerable variation in surveillance methodology (Brooks & Fuller 2006; Clarsen & Bahr 2014), rendering data incomparable between studies using different methodologies.

Of note is the variation in the methods of reporting injuries (number, proportion and incidence), methods of data collection (medical personnel reported, self-reported and coach reported), injury definition (time loss, missed match, diagnostic assessment and surgery) and training and match injuries combined. The use of text messaging or short message service (SMS) (Ekegren *et al* 2014) are viable injury reporting methods that offer the potential to address some of the identified challenges in under-resourced settings, as they are relatively inexpensive and can capture injury data using a customisable system.

When considering the lack of personnel and resources available in community youth rugby, the SMS injury tracking method has shown to be valid, reliable and feasible for participants and injury surveillance researchers (Alfven 2010; Axen *et al* 2012). Due to the variation in the injury registration methods, there are discrepancies in the data. Standardisation of injury surveillance methods and use of systems that are reliable, valid and represent the target audience may allow for a degree of homogeneity in comparing injury data (Ekegren *et al* 2016, 2014). Clinicians should consider the methods used when determining and comparing which are the most significant injuries that occur in a particular sport.

Step 2: aetiology and mechanisms of injury

Following on from epidemiological enquiry, modifiable injury risk factors are identified which can be used to inform the development of appropriate preventive interventions. Injury risk screening of intrinsic factors is used to support clinical judgement, and while there are a number of benefits of pre-participation screening, such as detecting existing health conditions, baseline testing and review of medication and supplements (Ljungqvist *et al* 2009), it is unlikely that musculoskeletal screening will be able to predict athletes at high risk of sustaining a future injury (Bahr 2016; Whittaker *et al* 2017). This signifies a shift in our understanding about the benefits of screening. It was previously recommended that research be conducted on screening to identify those athletes at risk, and prompt intervention to change outcomes (Ljungqvist *et al* 2009).

A meaningful debate has been deliberated regarding the effectiveness and efficiency of screening tests which outlines some of the complexities involved with its role in injury prevention (Bahr 2016; Hewett 2016; Verhagen *et al* 2018; Whittaker *et al* 2017). It is argued that there is value in continuing to offer screening assessments to determine which combination of tests are most useful in which context, and to incorporate repeated measures and monitoring of variables over time (Verhagen *et al* 2018). In addition, outcomes from a single testing session carried out in pre-season screening can change throughout the season, therefore associating pre-season data to injury prevention may be misleading (Baroni & Costa 2021).

A fundamental issue that needs to be pointed out is the importance of the context in which worthwhile screening can feasibly take place. In the community youth sport context where the coach is usually a parent of a child in the team and is also likely to be the first aider, having done a basic level qualification, it is practically impossible to meet these recommendations for screening (Donaldson & Finch 2012). Since there is minimal cost and discomfort to the athlete, the benefits of IPEPs should be targeted to sports teams and not based on those at-risk athletes as identified by screening tests.

Clinicians reading this might notice that these frameworks are research models, and it is less clear how they explain how injuries work. Sport injuries are complex and require a dynamic model to help understand the causes and mechanisms. In Meeuwisse's dynamic, multifactorial model of sport injury, an athlete is predisposed to injury by intrinsic risk factors, such as age, strength, and previous injury. They are then exposed to external risk factors, e.g. field conditions and equipment, in the sporting environment which makes them susceptible to injury (Meeuwisse *et al* 2007).

An inciting event can lead to an injury, or no injury can occur during the sporting exposure and adaptation may happen. If injured, the athlete can recover and return to their previous status, with potential adaptations that changes their risk factors to future potential injury. There could also, of course, be maladaption or incomplete recovery from injury.

It is clear from these complex interactions that sport injuries cannot be predicted. The complex systems model for sport injuries features in this multifactorial complexity, as well as bringing in the nature of team sports and training load (Bittencourt *et al* 2016; Gabbett 2020, 2016). It recognises that many factors may influence each other, for example restricted ankle dorsiflexion may overload the knee and thereby change the athlete's risk profile that leads to injury or adaptation. This approach moves away from identifying the isolated risk patterns that support clinicians to better understand the complexities of how risk factors interact.

In a recent Delphi study of 305 international experienced sport physical therapists from 32 countries, baseline / pre-season screening results were agreed

> "CONSIDER THE METHODS OF DATA COLLECTION USED WHEN DETERMINING AND COMPARING THE MOST SIGNIFICANT INJURIES THAT OCCUR IN A PARTICULAR SPORT"

to be important when planning IPEPs (Mendonça *et al* 2022). In addition to this, the athlete's injury history, psychological and mental factors, age, recovery strategies, the highest injury rates of the sport, financial support, number of participating athletes, and type of sport should also be included in the planning of IPEPs.

Overuse injuries in sport do not have a specific, identifiable, inciting event responsible for the injury and therefore do not fit the typical injury reporting definitions. Athletes may continue to train, or modify their training by refraining from the most aggravating activity in the early stages of the injury and, at a later stage, will seek medical consultation for the injury (Bahr 2009; Clarsen *et al* 2014). They may even make attempts to avoid time loss from their sport by postponing rest and recovery to the off season outside of the injury surveillance coverage.

In an attempt to derive greater information regarding overuse injuries, the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire (Clarsen *et al* 2014) was developed to address these challenges. The four parts of the questionnaire evaluate the consequence of overuse injury and include data on sports participation, training volume, sports performance and pain. Regularly administering the questionnaire (weekly) allows clinicians the ability to monitor the impact of overuse injury over time.

Steps 3 and 4: developing and testing IPEPs

Informed by the findings from steps one and two, preventive interventions can then be developed in step three and subsequently evaluated in step four.

Interventions such as IPEPs as part of a warm-up routine have shown to be efficacious in preventing less severe, although more frequent, musculoskeletal injuries (Emery *et al* 2015; Leppänen *et al* 2014; Thorborg *et al* 2017).

There are a number of preventive exercise programmes that have shown efficacy in reducing the risk of lower limb injury in sport. These include the Prevent Injury and Enhance Performance Programme (PEP) (Gilchrist *et al* 2008; Mandelbaum *et al* 2005), the FIFA Medical Assessment and Research Centre (F-MARC) 11+ (Grooms *et al* 2013; Soligard *et al* 2010), HarmoKnee (Kiani *et al* 2010), the Knee Injury Prevention Programme (LaBella *et al* 2011), the Anterior Knee Pain Preventive Training Programme (Coppack *et al* 2011), and the Activate Injury Prevention Exercise Programme (Attwood *et al* 2018; Hislop *et al* 2017).

There are fewer efficacious upper limb IPEPs used in sport, namely the OSTRC Shoulder Injury Prevention Programme (Andersson *et al* 2017) and the FIFA 11+ Shoulder (Al Attar *et al* 2021), which have been developed and evaluated in handball and soccer players respectively. A recent meta-analysis on sport injury prevention provides a concise review of the topic for specific sports and injury types (Stephenson *et al* 2021) with shoulder IPEPs reviewed by Wright *et al* (2021).

Steps 5 and 6: description and evaluation of IPEPs

The common features that emerge in the majority of these preventive programmes include sport-specific running-based exercises, targeted resistance training, perturbation and plyometric exercises. It is apparent from the Lauersen *et al* (2014) meta-analysis, that multicomponent preventive programmes that compose of strength and proprioception with exercise progressions, lead to reduced overall injury risk. These components are therefore considered important across IPEPs in sport.

It is less clear how the mechanisms of these multicomponent IPEPs work, and this warrants further research to better understand their acute-chronic effects (Barden *et al* 2021). Specific exercises within these IPEPs have been shown to be effective in preventing injury, such as those incurred in the hamstring, head, and neck. Meta-analysis data of 15 studies showed that IPEPs that included Nordic, eccentric hamstring exercises reduced hamstring injuries by up to 51% (Dyk *et al* 2019). In another recent review of six studies, it was deemed clinically worthwhile to include neck strengthening exercises, as greater neck strength was associated with a lower risk of sport-related concussion. These findings offer a good evidence-based justification for their respective inclusion in primary prevention of hamstring and head and neck injuries in sport (Elliott *et al* 2021).

Implementation of IPEPs

Returning to steps 5 and 6 of the TRIPP model, we can see that it advances its predecessors by moving beyond efficacy of preventative interventions and towards understanding the enablers and barriers in the implementation context. Issues of poor compliance and adherence to preventive programmes have been shown to affect the effectiveness of injury prevention exercise programmes in a range of sports (Steffen *et al* 2013; van Reijen *et al* 2016). A number of the issues that have been reported to reduce adherence to IPEPs include the lack of coach / player buy-in, prolonged duration of the routines and some exercises inducing fatigue (O'Brien & Finch 2017). The barriers to implementing evidence-based IPEPs further includes the financial cost of the programme, the lack of confidence from coaches in their ability to implement

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it, and the complexity of the exercises (Minnig *et al* 2022). In contrast, implementation is better facilitated if coaches are aware of the efficacy of the IPEP, if there is shared motivation from the coach and athlete to complete the IPEP, and if the IPEP is easy to integrate into practice schedules.

New evidence suggests that rescheduling part of the FIFA 11+ intervention to the end of the training session improves compliance and reduces the number of severe injuries, enhancing the effectiveness of the 11+ programme (Whalan *et al* 2019). Using this approach to scheduling may allow for coaches to complete their planned training sessions and add in the preventive exercises programme at the end. Who the IPEP is delivered by, i.e. the delivery agent, is considered to have an influence on the implementation of the intervention. There is agreement that the head coach and strength coach were those who most frequently deliver the IPEP as part of a warm-up routine, while the physical therapist frequently delivered individual prevention sessions (Mendonça *et al* 2022).

It is important to recognise that the delivery agents are integral to optimising the overall impact of injury prevention, and that the delivery agent may vary at different playing levels, for example, in youth sports the role of the parent is also recognised as important to support implementation of IPEPs. Involving the athlete's parents in the injury prevention process serves as a way for them to assume some of the responsibility for their child's sport injury prevention (Emery *et al* 2006).

There are also numerous contextual factors that need to be considered when implementing an IPEP in sport, and valuable advice from researchers, practitioners, policy makers, and others in the target community about what may work best. It needs to be feasible, affordable, and sustainable (Hanson *et al* 2014). Allowing for this variability in how the IPEP is implemented is recognised as being important to the end user and likely to influence adherence to the intervention. This comes with an acceptance that, when applying research into practice, there is less control over how the intervention will be used in a real-life setting, and that the efficacious effect of the intervention will be reduced (Verhagen & van Nassau 2019).

Conclusion

The injury prevention framework offers a useful structure to apply when considering preventive interventions in sport. The complexities of monitoring injuries at all playing levels needs focused efforts to address the outlined issues. Future opportunities to increase the adoption of injury prevention should explore a range of methods to promote the benefits of injury prevention that stresses its value to the same extent of importance that is given to competition results. There is value in educating sport clubs about injury prevention to increase a team's chances of success. Many questions still need to be answered about the development and implementation of IPEPs in sport. However, there is a large amount of good quality evidence to support their efficacy and they should be continued to implement in sport.

About the author

Vincent is a physiotherapist and works full-time as a senior lecturer at the University of the West of England (UWE) in Bristol where he also is the evaluation lead and co-theme lead of the Knowledge Mobilisation and Evaluation theme within the Centre for Health and Clinical Research. His research interests are in sport injury prevention and the use of physical activity and exercise in the prevention and management of non-communicable disease.

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References

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REVIEW SUPPORTING QAP

Having reviewed this article for how it might support Physio First members in obtaining and maintaining our Quality Assured Practitioner (QAP) status, my overall interpretation of the message is that it is important we understand our roles in injury prevention and act appropriately.

In his introduction, Vincent makes the point about how ideally placed physiotherapists are in being part of keeping people active, as well as advising on injury prevention strategies. Further in the article, in the section on developing and testing IPEPs, physios are also indicated as being important because we understand the value in, and the application of, physical preparation in the reduction of injuries.

As both a physio and an international gymnastics coach, I am in the unusual position of being involved in more than one of the roles this article highlights as being important. It implies that it is the job of the coach to ensure athletes are suitably prepared to compete in their chosen sport, and, in order to help with successful injury prevention and rehabilitation, it is up to us as physios to ensure we liaise appropriately with the coaching team.

In my own experience of both roles, I am aware that male artistic gymnastics has a comparatively low incidence of injury. This is down to a culture of ensuring that the athletes' level of physical preparation is significantly in advance of their skill level, and I hope it reinforces the importance that physical preparation plays in reducing the risk of injury.

Reviewer **Byron Clithero**