EDITOR'S CHOICE

No longer lost in translation: the art and science of sports injury prevention implementation research

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ABSTRACT

It is now understood that sports injury interventions will not have significant public health impact if they are not widely accepted and adopted by target sports participants. Although there has been increasing recognition of the need for intervention studies conducted within the real-world context of sports delivery, very few studies have been conducted in this important area. A major reason for this is that there are significant challenges in conducting implementation research; the more traditional sports medicine approaches may not be fully appropriate and new ways of thinking about how to design, conduct and report such research is needed. Moreover, real-world implementation of sports injury interventions and evaluation of their effectiveness needs to start to take into account the broad ecological context in which they are introduced, as well as considering the best way to translate this knowledge to reach the audiences who most need to benefit from such research. This overview paper provides perspectives and guidance on the design, conduct and evaluation of sports injury intervention implementation studies, including better understanding of the complexity of the ecological settings for intervention delivery. Some conceptual approaches that could be adopted in future implementation studies are discussed; particular emphasis is given to Intervention Mapping as a tool to assist intervention development, Diffusion of Innovations Theory to guide the planning of intervention strategies and the RE-AIM (reach, effectiveness, adoption, implementation and maintenance) framework for programme evaluation and programme design. Finally, a broad agenda for this emerging important field of sports medicine research is outlined.

INTRODUCTION

Implementation research is a broad term covering the specific development/refinement of population-targeted interventions (following demonstrated efficacy), the design of programme components to support the delivery of interventions and the design/conduct of evaluations of intervention effectiveness, uptake, adoption and sustainability.[1–3] While increasingly recognised as being an essential evidence for interventions with a more general health promotion focus, surprisingly little attention has been given to this in sports medicine and sports injury prevention. Accordingly, there has been a call for need for sports injury effectiveness research that is conducted within the real-world context of sports delivery.[1 3] A major reason for this gap is likely to be the fact that there are significant challenges in conducting implementation research. More traditional sports medicine approaches, especially those based purely on clinical or epidemiological approaches, are unlikely to be fully appropriate, and new ways of thinking about how to design, conduct and report such research is needed. This will require a paradigm shift for many sports injury researchers and the development of new partnerships between researchers, policy makers and injury prevention practitioners, as well as the sports participants who should benefit most from this research. Importantly, research into the real-world implementation of injury interventions and evaluation of their effectiveness needs to take into account the broad ecological context in which they are delivered.[3]

Sports injury prevention research has been well published in peer-review medical and scientific journals.[4] It is very tempting to therefore assume that the findings and conclusions from this research findings have been disseminated. However, if this really is the case, why then do sports injuries still occur? Assuming that the strong potential preventive effects of the interventions is not in doubt, this question has at least three answers:

1. A dissemination failure has occurred in which the results have not even reached the target audience of coaches and players.[5]
2. There has been a translation/adoption failure in that the relevant information reaches the intended audience but not is able to understood or acted on by them.
3. There is a research relevance failure because the research findings and their reporting is not directly relevant to real-world sports safety practice (eg, fewer than 1% of the 11 859 sports injury prevention publications published since 1938 has included effectiveness aspects).[4]

The aim of this overview paper is to provide perspectives on the design, conduct and evaluation of sports injury intervention studies, including research to better understand the implementation context for intervention delivery. It begins with an overview of why research into intervention delivery and evaluation of its full outcomes is necessary. The ecological context for injury prevention is summarised and the implications of this for the planning of intervention delivery and subsequent evaluation are described. Some conceptual considerations relevant to implementation research are introduced, with particular emphasis given to Intervention Mapping (IM) as a tool to assist in the intervention development process,[6] Diffusion of Innovations Theory (DIT) to guide efforts in the planning of intervention strategies,[7] and the RE-AIM (reach, effectiveness, adoption, implementation and maintenance) framework.[8]

OVERVIEW OF CURRENT STATUS

While there is a relatively large literature relating to the rationale, design and development of injury interventions and their evaluation in efficacy studies, there have been correspondingly few published studies of sports injury prevention effectiveness. There have been even fewer reports of key implementation factors and how these can impact on the results of these studies. This is a major knowledge gap because, for most sports injury interventions:

1. No information exists about the reasons for the presence or absence of prevention benefits.
2. It is only known that something did/did not work in one particular study and a specified homogeneous study group.
3. There is no guidance on how to transfer the findings to another setting or similar intervention where some modification may be required.

Recent examples of these limitations are evident from published exercise intervention studies. Studies describing the benefits of an exercise-training programme to prevent injuries in community soccer have shown only limited success, because few of the targeted participants adopted the programmes and there are perceptions that they were not relevant to the real-world sport setting in which they were implemented.[9–11] Similarly, challenges arose when translating Tai Chi exercise for falls-prevention because there was suboptimal uptake that compromised intervention effectiveness.[12] An important point to take from these studies, however, is that it is exactly because they did report these implementation factors (eg, programme uptake, pragmatic changes to interventions for delivery purposes, etc), that reasons for the lack of success were identified.

WHY DOES IMPLEMENTATION SOMETIMES FAIL?

There are many reasons why implemented programmes and their evaluations can fail and these can be summarised broadly as[13 14]:

1. Programme theory failure: because the intervention is either (A) too complex for its implementation setting or (B) not properly designed to achieve the desired behaviour change.
2. Implementation failure in which the intervention does not adequately address (A) the implementers' own behaviours in relation to intervention delivery or (B) the context in which it is to be delivered.
3. Methodology failure in which (A) internal and/or external validity are compromised, (B) the evaluation plan and tools are not up to the task required of them to demonstrate the outcomes of the intervention or (C) no concurrent process evaluation has been undertaken to explain unexpected observations or to confirm expectations.

In terms of published sports injury prevention studies, most have:

1. Not considered implementation aspects at all.
2. When they had done so, they have only included implementation issues as a minor component of an effectiveness study.
3. Evaluated very few aspects of intervention implementation, with little consideration of the many complexities involved in conducting implementation research in real-world settings.
4. Only reported injury outcomes without examining the required intermediary behaviour change too, such as exercise adoption or protective equipment use, necessary to firmly link those reductions to the implemented preventive measures. Others have only reported these proxy or intermediary outcomes and assumed that they will lead to the desired injury outcome, in the absence of any real evidence to support this.[15]

PERHAPS EVEN MORE IMPORTANTLY, THE VAST MAJORITY OF PUBLISHED STUDIES HAVE NOT:

1. Even considered whether or not the intervention target groups actually adopted, or complied with, the intervention.
2. Recognised that individual safety behaviour change is also significantly influenced by other factors such as the form of the intervention delivery, the person delivering it and the broader ecological system in which the intervention has taken place.
3. Included theoretical considerations in their design, implementation and evaluation and realised that prevention research efforts will only develop if they begin to incorporate them.[16]
4. Recognised that many different types of implementation and intervention delivery approaches can, and should, be considered to support prevention efforts, either in isolation or jointly (eg, educational/behaviour change strategies, environmental modifications, policy/regulation changes, social marketing, stakeholder engagement).[17–19]
5. Recognised that there are major differences between efficacy and effectiveness studies including in how subjects are recruited, the level of control required for assessing preventive effects, processes for the monitoring of intervention outcomes and intervention delivery.[1 2 20–22]
6. Realised that the ecological context in which sport is delivered and injuries occur has a major influence of intervention uptake and outcomes.

ECOLOGICAL CONTEXTS FOR PREVENTION

Relevant high-quality implementation research requires full understanding of the ecological systems or contexts in which sports injury interventions need to be delivered, adopted and evaluated. In particular, prevention strategies aimed at individual-focused injury reductions must consider the broader context in which intervention delivery needs to occur. This is because individuals are heavily influenced by the groups they belong to and broader social and cultural norms related to the injury risk behaviour being targeted.[3 23–26] Individual-targeted approaches cannot alter environmental (physical, social or cultural) factors that influence the initiation and maintenance of safety behaviour.

To overcome this, ecological models identify intrapersonal factors, sociocultural factors, policies, physical environments, as levels of influence on injury prevention behaviours. As such, they recognise that many factors combine to influence an individuals' protective or risk-reduction behaviour (and any decisions to not adopt them). The injury iceberg model is one conceptual representation of an ecological model for safety interventions, emphasising interpersonal, organisational, community and societal levels of influence.[26] Unfortunately, injury intervention studies have tended to ignore these influences and only focused on intrapersonal factors.[23]

The ecological context for sports injury intervention delivery and evaluation has been recently emphasised,[3] and considered in an outlining of levels of responsibility for child sport safety in sport.[27] Only one sports injury prevention study has directly applied the ecological model in an intervention evaluation.[16] This ecologically driven intervention implementation study involved the comprehensive development of a protective eyewear promotion programme for squash players that required behaviour change across multiple levels.[24]

CONCEPTUAL APPROACHES FOR INTERVENTION DEVELOPMENT, DELIVERY AND EVALUATION WITHIN AN ECOLOGICAL CONTEXT

While there has been an increasingly number of published papers describing so-called injury intervention implementation studies and the impact of interventions on both injury and process outcomes, there is surprisingly little information about how these interventions were first developed or how they were delivered. Yet it is this exactly information that has the greatest potential to further implementation knowledge because it gives valuable cues as to why some interventions do/do not work and what needs to be done to ensure programme sustainability. Moreover, interventions that are effective in one setting may not necessary work in others and some modification of them is likely to be needed for each new contextual setting.

The remainder of this paper presents a brief overview of three theoretical frameworks/approaches that show good promise for further sports injury research as they can be readily applied to ecological systems and contexts. These include the use of IM as a tool to assist in the intervention development process itself, DIT to guide efforts in the planning of intervention strategies and the RE-AIM framework most commonly (but not exclusively) used as an evaluation and evaluation planning tool.

The IM protocol

While interventions developed from a theoretical basis are likely to be more successful than others, it is also important that adequate consideration is given towards the practical strategies that will need to be adopted, or refined from the theoretical foundation, for successful implementation. IM considers intervention delivery to be necessary within an ecological framework in which behavioural and social science considerations are paramount and encourages intervention developers/implementers to draw on the best theoretical basis for their setting.[6] The IM protocol provides a systematic summary of the necessary steps needed to be undertaken to ensure combining of empirical evidence, relevant theoretical constructs, contextual knowledge, and context-specific experience to inform the development, implementation and evaluation of injury interventions. This systematic approach can assist with the planning and implementation of effective interventions, while assisting with understanding of why any intervention does/does not work. The interested reader is referred to the text by Bartholomew *et al* for specific details about IM.[6]

In the sport injury context, IM use has been reported for only one Dutch school-based physical activity injury prevention programme, which drew on the attitude, social influence and self-efficacy theoretical model and applied this to the engagement with teachers, parents and students.[28]

Designing appropriate interventions and accompanying intervention strategies and evaluation plans is a complex and time consuming process. When used fully and interactively, IM ensures that the views, needs and desired behavioural actions of each ecological level target group are considered at all stages of the planning and evaluation process.

Diffusion of Innovations Theory

Successful implementation research requires both a well-developed intervention, and detailed information about the context into which it is to be implemented and how this will affect adoption of the intervention. One of the most successful approaches for understanding the uptake and adoption of interventions is application of DIT, which is one of the most cited social theories in public health application.[7] Despite its wide application in other areas of health promotion and public health and its clear relevance to injury prevention initiatives,[29] it appears to have had only limited application to sports injury.[16] The strength of DIT is its focus on communication of new ideas (or innovations) within multilevel ecological structures that require some form of behavioural, social or other change across one or more levels for an innovation to be considered effective.

According to the theory,[7] the attributes of innovations that impact on their uptake are the extent to which they are (A) perceived to be better than existing programmes or practices; (B) consistent with the existing values, past experiences and needs of people targeted by it; (C) perceived to be easy (or difficult) to understand and use; (D) able to be tested or trialled by potential adopters; and (E) have clearly visible benefits to others. Interventions which are ranked more positively with regards to advantage, compatibility, trialability and observability and which are also perceived to be easier to use and understand will be taken up more readily than other interventions.

A review of theory use in sports injury prevention research,[16] found only two studies to have applied DIT: one study related to helmet use uptake in different skier and snowboarder groups.[30] The other developed a 'Heads Up: Concussion in high school sport' educations toolkit for coaches of school athletes in the US.[31]

The RE-AIM framework

The RE-AIM framework was first proposed by as a tool for evaluating the effectiveness of implemented programmes requiring behaviour change.[8 20] The framework has been most commonly applied as an evaluation tool but has broader application as a planning tool and as a method to review intervention studies (for more detail see http://www.re-aim.org/). It has recently been specifically advocated as a suitable model for the delivery and evaluation of sports injury interventions within an ecological sports delivery system.[2]

The RE-AIM framework has a strong underpinning of health promotion theory, including DIT, and stresses that desired behaviours will only be achieved if interventions are available to the target group, adopted by them, used as they were intended and then sustained over a period of time. It therefore incorporates important aspects relating to individuals' responses and readiness in relation to targeted interventions, as well as public health–orientated benefits. The RE-AIM framework has five key dimensions for assessing interventions that are useful for guiding thinking about the full complexities of the implementation context[8 20 32]: RE-AIM framework.

To date, six published sports prevention or exercise promotion related injury studies have reported use of the RE-AIM framework all within the past 2 years and used them in several ways:

1. As a model for describing and evaluating ecological contextual influences on sports injury interventions.[3] This paper explains how most sports injury interventions are multifaceted and complex and need to be targeted at multiple levels of the sports delivery system.
2. As a study protocol for the design and evaluation of a national programme (including both intervention and delivery plan development and testing) to prevent football-related lower limb injuries.[33]
3. To inform the development of an intervention delivery plan for a larger scale exercise programme to prevent lower limb injuries effectiveness study.[34]

4. As part of a process evaluation – the most common application. An American study evaluated the delivery of a Tai Chi group exercise programme to prevent falls in community dwelling older people through community health services.[35] A Dutch school-based study evaluated the translatability and flexibility elements of a school-based programme aimed at preventing physical activity related injuries.[36] An Australian study reported coaches' feedback on the implementation of a safe landings programme through targeted coach education sessions followed by coach delivery of the principles to their teams of junior netball players.[37]

THE FUTURE FOR SPORTS INJURY INTERVENTION IMPLEMENTATION RESEARCH

A major goal of all injury research is to prevent injuries. It is therefore important that the research does not stop with only producing effectiveness evidence. Because of the general lack of international implementation research in any aspect of injury prevention, there is very little direct information about how best to conduct intervention studies in relevant community settings. While some theoretical considerations have been developed specifically for some safety programmes (eg, safe communities),[38] and specific settings (eg, sports injury prevention delivery contexts,[3] most of the available examples come from broader health promotion or behavioural science applications. Direct application of this to sports injury intervention research will require new research partnerships and new ways of thinking about how to best conduct injury research, including incorporation of social science methods and concepts and the valuable input of policy makers, practitioners and end-user groups.

While this paper has focused on only three theoretically driven approaches, it is acknowledged that these are not the only ones that can be used for injury intervention research. Unfortunately, most implementation studies do not report any theoretical underpinnings to their research, even if they have used them.[16] Nonetheless, some of these atheoretical studies have included similar components to those suggested by theory. For example, an evaluation of sports-concussion education knowledge transfer, assessed this in terms of the optimal target audience, what message should be delivered, who should deliver the message, how the educational message/s should be delivered and the impact of the knowledge transfer on professional's knowledge, awareness and attitudes.[39] The discussion presented in this paper provides a starting point from which future implementation research could be better designed and reported.

While theoretical considerations have important implications for how intervention studies are designed and conducted there is also a need to improve the reporting standards of implementation studies to provide a more comprehensive analysis of the factors affecting intervention uptake and effectiveness.[1 40] Aligning more injury prevention research to existing health promotion frameworks and evaluating the public health impact of interventions, will also help to better understand contextual and policy influences of intervention uptake and sustainability.

To rise to this challenge, the sports injury research field will need to:

1. Think about intervention research more broadly. This will require equal attention to both the development of prevention measures/strategies/programmes and to the dissemination/distribution/delivery plans for implementing the interventions.
2. Consider the full range of factors directly related to the ecological context of sport delivery and intervention implementation that considers (A) actual behaviours of the target groups; (B) precursors to these behaviours and desired behaviour change such as knowledge, attitudes, perceptions and intentions; (C) factors that would make sports participants/groups/communities more or less likely to adopt preventive measures; and (D) what setting-specific or cultural factors will impact on how interventions can be delivered and sustained.
3. Identify markers of successful (or otherwise) implementation and prevention by better understanding how behaviours could be changed, with no adverse effects and how programmes and other prevention strategies can be sustained long-term.
4. Need to start assessing how interventions, implementation models and research evaluation approaches need to be developed and/or modified to suit different sports, different target participant groups and all aspects of the sports delivery setting.
5. Assess the extent to which existing health promotion and other behaviour change models are fully applicable across all sports injury prevention settings. The outcome of this may require modification of existing tools or development of new ones.
6. Develop or modify specific methodological approaches relevant to the design, analysis and reporting of sports injury intervention studies to ensure a high degree of validity, integrity and study quality.

CONCLUSIONS

To have long lasting public health effects, any intervention that is adopted needs to be sustained and the desired behaviour change and structural systems to support this maintained. With regards to sustained adoption of any prevention programme with ongoing desired injury prevention benefits, intervention studies should monitor the level to which the innovation is taken up by members of the target group, including their knowledge about it and how they use it; how the intervention is used in practice and ongoing implementation and continued use of the innovation in practice.[29]

Despite the availability of many efficacious injury interventions, it is clear that limited research attention has focused to date on understanding intervention implementation contexts and processes, including barriers and facilitators to sustainable programmes that need to be delivered and adopted within the complex ecological setting of real-world sports delivery. To address this challenge, future injury prevention research aimed at demonstrating real-world uptake of interventions will need to:

1. Draw on available evidence for the efficacy/effectiveness of interventions in terms of desired injury and injury risk reductions as well as intermediary behavioural measures (sometimes referred to as impact measures).
2. Engage relevant stakeholders and end-user groups in implementation and injury prevention research from the outset.
3. Continue to partner with these stakeholder groups in further intervention and intervention delivery developments, and even to modify research approaches to accommodate them.

4. Develop multifaceted and multiaction strategic approaches towards injury prevention in relevant real-world culturally relevant settings.
5. Develop and evaluate strategic implementation plans designed to address key barriers and facilitators towards intervention uptake across all ecological sports delivery levels.
6. Adopt a multidisciplinary approach that embraces both qualitative and quantitative research methodologies, both hard science and social science.

For those of us who work in sports injury prevention research, it may be disheartening to realise that there is still a fair way to go but hopefully also useful to have some broad guidance about what could be done. While good science about prevention is a necessary precursor to widespread safety and population-level injury prevention, this evidence alone is not sufficient. Researchers need to accept that it takes considerable time for evidence to be put into place but that there is also a major opportunity for them to become involved in documenting and evaluation this process from a research inquiry point of view. Collation of this new type of sports injury implementation evidence, when coupled with new research partnerships within the target sector, will ensure that injury prevention goals are successful. The next decade promises to be a time of research excitement, with implementation research confirming its status as both an art and a science. There has never been a better time to be a sports injury researcher!

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