REVIEW ARTICLE

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The Extent to Which Behavioural and Social Sciences Theories and Models are Used in Sport Injury Prevention Research

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Contents

Abstract . . . 841
1. Introduction . . . 842
2. Methods . . . 843
   2.1 Search and Selection Strategies . . . 843
   2.2 Classification and Review of Selected Studies . . . 844
3. Results . . . 845
   3.1 Prevention Measures in Sport Injury Prevention Research . . . 845
   3.2 Summary Characteristics of the Reviewed Studies . . . 845
   3.3 Theories and Models Used in Sport Injury Prevention Research . . . 845
4. Discussion . . . 846
   4.1 Limitations . . . 852
   4.2 Implications for Future Research . . . 853
5. Conclusion . . . 854

Abstract

Behavioural and social science theories and models (BSSTM) can enhance efforts to increase health and safety behaviours, such as the uptake and maintenance of injury prevention measures. However, the extent to which they have been used in sports injury research to date is currently unknown. A systematic review of 24 electronic databases was undertaken to identify the extent to which BSSTM have been incorporated into published sports injury prevention research studies and to identify which theories were adopted and how they were used. After assessment against specific inclusion and exclusion criteria, the full text of 100 potentially relevant papers was reviewed in detail. These papers were classified as follows: (i) explicit – the use of BSSTM was a stated key aspect in the design or conduct of the study; or (ii) atheoretical – there was no clear evidence for the use of BSSTM. The studies that explicitly mentioned BSSTM were assessed for how BSSTM were specifically used. Amongst the 100 identified papers, only eleven (11% of the total) explicitly mentioned BSSTM. Of these, BSSTM were most commonly used to guide programme design/implementation (n = 8) and/or to measure a theory/construct (n = 7). In conclusion, very few studies relating to sport safety behaviours have explicitly used any BSSTM. It is likely that future sports injury prevention efforts will only be enhanced, and achieve successful outcomes,

if increased attention is given to fully understanding the behavioural determinants of safety actions. Appropriate use of BSSTM is critical to provide the theoretical basis to guide these efforts.

1. Introduction

There has been, and continues to be, widespread concern about sport and recreational (hereafter referred to as sport) injury worldwide.[1-8] Prevention of sport injuries is a complex process because of the multi-factorial nature of their causes and risk factors.[9,10] Accordingly, a multidimensional approach is required to address the problem and this must be implemented within the context of the prevailing sports culture and player behaviours.[11-13] Although a range of injury prevention measures have been evaluated within sport,[14,15] a lack of rigorous, directed behavioural and social sciences research into sport injury prevention, either in isolation or in combination with other approaches, has been suggested as contributing to difficulties in achieving uptake and dissemination of effective preventive measures.[12,16,17] While there has been increasing attention directed at establishing the efficacy of many and varied sport injury measures or interventions to prevent injury, much less attention has been given to the development of, and research into, effective methods for broader uptake, dissemination and diffusion of interventions in this context.[12,13,18]

A recent systematic review[17] has emphasized the lack of behavioural and social science theories and models (BSSTM) being applied to unintentional injury prevention in general. These authors noted the paradox that while integration of BSSTM in other health research areas has grown significantly over recent years, it does not yet appear to have been adopted widely by injury prevention researchers.[17] Several other publications in the general injury prevention area have also emphasized the need to integrate BSSTM with the development of injury interventions.[19-22] More recently, in the context of sport, Finch[12] highlighted research into this area as a key knowledge requisite in her Translating Research into Injury Prevention Practice (TRIPP) framework.

The importance of BSSTM is that they can provide tools for moving beyond intuition about what might work, or efficacious evidence from controlled trials, to the design and evaluation of interventions requiring adoption and maintenance of safety behaviours in the real world. They do this by providing a theoretical and conceptual basis for understanding safety behaviours and their determinants,[19,23-25] thereby presenting a systematic way of better understanding the events or situations that can explain or predict injury events, as well as the relationships between them.[23] Models draw on a number of theories to help understand a particular problem in a certain setting or context,[23] as, for example, was recently applied to understand protective eyewear behaviours in squash players.[24]

Using BSSTM as a foundation for the development of interventions and planning for their delivery is consistent with the rationale for broader-based evidence-based interventions in public health and behavioural medicine.[19,23,25] Use of behavioural theory, in particular, provides a framework for studying problems, identifying target groups and behaviours for intervention, developing appropriate interventions, measuring change in relevant behaviours and for evaluating intervention success.[19] In turn, this can lead to greater insights for programme planners and implementers to translate stronger programmes with higher uptake. Considerations from BSSTM framed within an ecological framework contribute to this by explaining the dynamics of safety behaviours, including processes for changing them and both the positive and negative influencing factors associated with both social and physical environments.[24] It has been argued that intervention programme planning, implementation, and evaluation processes based on BSSTM are more likely to succeed than those developed without the benefit of a theoretical perspective.[19,26]

As these approaches work for general public health and other safety initiatives, it would seem

likely that they would also make a significant contribution to the prevention of sports injuries.[24,27] Although a number of recent systematic reviews of sport injury prevention measures shown to be efficacious have been reported,[14,15,28-32] none have described the role of BSSTM in the reviewed interventions, even though almost all interventions trialled to date have required some form of behaviour change on the part of a player, athlete or coach. In contrast, there is a major knowledge gap in relation to the effectiveness, or real-world uptake, of sports injury prevention interventions. This article reviews and summarizes the extent to which use of BSSTM has been reported across a range of sports injury prevention studies, as a precursor to better understanding intervention effectiveness. In doing so, it identifies which BSSTM have been most commonly used to date and categorizes the theoretical contexts in which they have been applied.

2. Methods

2.1 Search and Selection Strategies

A comprehensive electronic database search strategy was developed to identify relevant published literature associated with BSSTM and sport injury prevention from the following 24 somewhat overlapping electronic databases: 'Academic Search Premium', 'AUSPORT', 'AUSPORTMed', 'Health Science Consumer', 'Health Source: Nursing', 'SportsDiscus® with full text', 'SpringerLink', 'Web of Science', 'Web of Knowledge', 'JSTOR', 'PsychArticles', 'PsycINFO', 'Psychology + Behaviour', 'Psychoanalytic Electronic Publishing (PEP)', 'CINAHL Plus with text', 'Meditext', 'Wiley Interscience', 'APA-FT', 'PubMed', 'BMJ Journals Online', 'Electronic Journals (EBSCO)', 'Science Direct', 'Informaworld' and 'MEDLINE'. The search covered all items in each database (including 'in press' items) from the earliest records available until July 2009.

An initial broad search filter was completed using three keywords: 'sport', 'injury' and 'prevention'. Initial searches combined this injury filter with keywords reflecting BSSTM including the names of common BSSTM (e.g. Health Belief Model) identified from the broader injury prevention, health behaviour and health promotion literature.[19,23,25,33,34] The search was further refined and expanded to capture other potential studies through the use of specific keywords (in isolation or in combination) chosen as relating to the following: (i) BSSTM constructs – 'attitude', 'perceptions', 'social norms', 'perceived behavioural control', 'perceived severity/susceptibility', 'barriers', 'knowledge', 'self-efficacy', 'behavioural capability', 'reinforcement', 'environment', 'empowerment', 'motivation', 'antecedents', 'behaviour', 'adoption', 'maintenance', 'implementation', 'intrapersonal/interpersonal', 'organizational/community'; (ii) common sports injury prevention measures – 'protective equipment', 'mouthguards', 'headgear', 'eyewear', 'faceguards', 'warm-up', 'education', 'training', 'exercises (including biomechanical and neuromuscular)'; (iii) specific sports activities – 'football', 'hockey', 'soccer', 'rugby', 'squash', 'netball', 'basketball', 'tennis', 'volleyball', 'handball', 'baseball', 'softball', 'athletics', 'badminton', excluding cycling/bicycling; and (iv) terms – 'survey/questionnaires', because these are commonly used tools in BSSTM studies. The Cochrane Database of Systematic Reviews (www.cochrane.org) was also checked to ensure that no similar review was in existence there.

Figure 1 summarizes the systematic process underpinning the review search strategy and the numbers of relevant papers identified and retained at each stage. In the initial stage, all potential articles were identified upon a preliminary review of titles, abstracts and keywords screened according to the defined broad search criteria. All duplicate articles were removed. Any study not exactly matching the stated exclusion criteria was kept for further full text review. Hand searching of the reference lists, individual journals, and identified review papers was undertaken to identify any further relevant studies not retrieved via the initial database searches. An author and citation search was also conducted to identify further studies undertaken by authors of the retained studies. The final studies identified for more detailed review were assessed against a checklist of specified inclusion/exclusion criteria (see Appendix 1 of the Supplemental Digital

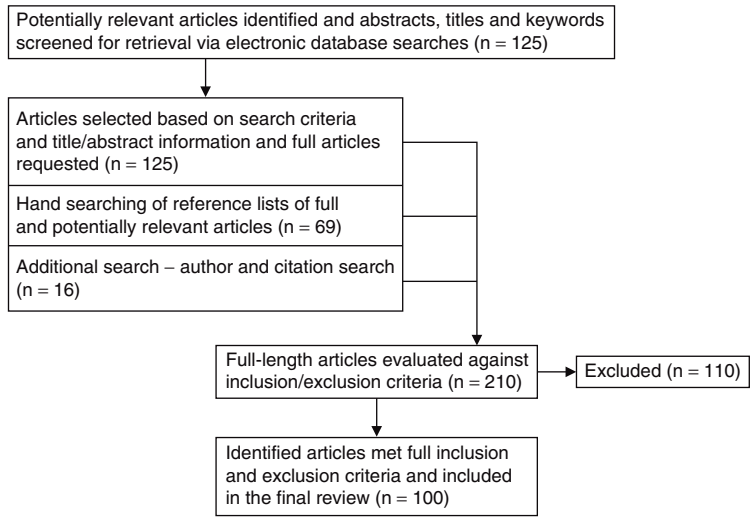

Fig. 1. Summary of the systematic literature search strategy and the numbers of studies selected or excluded at each stage.

Content 1, http://links.adisonline.com/sportsmedicine/SMZ/A5).

To be retained for final review, an article had to focus on a sport injury prevention measure and mention some aspect of safety behaviours (e.g. mouthguard use) as well as some behavioural determinant/s in relation to the measure (e.g. attitudes). Specific inclusion and exclusion criteria were developed and agreed to by the authors. Full text articles were obtained and their content assessed to determine whether they met the stated inclusion/exclusion criteria (as listed in table I).

2.2 Classification and Review of Selected Studies

The lead author (AMcG) summarized the key characteristics of the selected studies and classified the use of BSSTM in the studies where applicable. For studies reporting use of BSSTM, details were recorded for the particular BSSTM reported and how they were used.

In the first stage, the use of BSSTM in the selected studies was categorized as belonging to only one of the following categories:

- Explicit: whereby, BSSTM were a clearly stated key aspect in the design or conduct of the study. Studies assigned to this category were required to state that BSSTM were used and to specifically mention the name of the theories or models.
- Atheorectical: where there was no clear evidence for the use of BSSTM in the design or conduct of the study (including unrelated to, lacking a theoretical basis or somewhat implied though not plainly expressed). For example, a number of studies only implied or presented information potentially relating to one or more BSSTM constructs such as risk perceptions, safety attitudes, self-efficacy or perceived behavioural control, with no direct relevance to BSSTM. In these studies, it was not evident whether the particular 'construct' used by the authors had been chosen by chance or because of its theoretical basis.

Based on the information provided in the papers, each author independently classified all studies according to the BSSTM use. Any discrepancies in the classifications were resolved through consensus discussion.

In the second stage, studies classified as having explicit BSSTM use were summarized and assessed against the Trifiletti et al.[17] categorization of BSSTM use. This categorization allowed studies to be classified in more than one category. Application of the Trifiletti et al.[17] categorization required use of BSSTM in these studies to be rated as follows:

Table I. Inclusion and exclusion criteria for selecting papers to be included in the systematic review

Inclusion criteria	Exclusion criteria
Full-text (complete) peer-reviewed, English language, earliest records to July 2009	Studies relating to chronic, recurrent or illness-related conditions
Original research studies	Studies not published in the peer-review literature, reports, reviews, theses and conference proceedings: not reported as full peer-reviewed paper
Studies relating to all ages and both sexes	
Sports activities (team/individual) in formal, competitive and social/recreational settings	Intervention/prevention measure studies not considering prevalence of use and determinants of safety behaviour
Related to the prevention of acute or traumatic injuries	Bicycle-related studies, including bicycle helmet use studies[a]
Unintentional injury	Reviews or commentaries on injury prevention interventions, even if peer reviewed
Target populations – e.g. sports participants (athletes, players), coaches, officials, parents (or significant others)	Studies relating to violence-related behaviours or intentional injuries
Studies specifically related to specified safety behaviours or behavioural interventions to prevent acute sport injury – e.g. protective equipment, warm-up	
Mention of behavioural and social sciences themes, aspects or approach	

a Bicycle-related studies were excluded from this review because it is not clear to what extent the bicycling activity described would be related to sport and active recreation, rather than to transportation. Even though this means that many studies of bicycle helmets have been excluded from this review, it is appropriate because most of those helmet-wearing interventions were implemented and assessed in the context of road safety initiatives rather than sports safety.

(a) Theory was used to guide programme design and/or implementation and/or to select programme measures.
(b) Measurement of a theory or construct or model was undertaken (e.g. data was provided that described predisposing or enabling factors of player safety practices).
(c) A theoretical construct or an extension of a theory (i.e. whether changes or variation in outcomes as predicted by models) was tested (e.g. whether the theory of reasoned action was helpful in understanding variations in beliefs, attitudes, subjective norms and safety practices).
(d) Other: the use of BSSTM did not conform to the aforementioned categorization or when the study authors did not adequately explain the role of theory or models.

The categories (a) to (c) represent Trifiletti et al's.[17] increasing levels of theory application, from (a) low to (c) high, whilst the 'other' category (d) did not correspond to a 'level' of theory application.

3. Results

3.1 Prevention Measures in Sport Injury Prevention Research

Table II shows the total number of potential studies identified, total exclusions and inclusions, and the number of studies according to prevention measure categories.

3.2 Summary Characteristics of the Reviewed Studies

Table III summarizes the characteristics of the 100 studies that met the inclusion criteria. Most studies (n = 74) related to personal protective equipment (PPE) as the major injury prevention measure. The sporting activities varied from team ball sports, to team bat and ball sports, racquet sports, target and precision sports, individual water sports, individual athletic activities, equestrian activities and wheeled non-motorized sports. Most studies focused on the athletes/players themselves (n = 61 studies) but other common groups were coaches (n = 11), officials (n = 4) and dentists (n = 4). Sixteen studies related to multiple types of participants.

Table III also indicates the categorization of each study according to its use or non-use of BSSTM. Overall, of the 100 studies that met the inclusion criteria, only eleven (11%) studies mentioned *explicit* use of BSSTM.

3.3 Theories and Models Used in Sport Injury Prevention Research

Table IV summarizes the specific BSSTM used in the eleven studies stating explicit use. Of the

studies that explicitly mentioned BSSTM, seven were related to the use of PPE.[16,24,38,39,41,58,107] Only the Theory of Reasoned Action/Theory of Planned Behaviour[39,107,109,122] and Diffusion of Innovation[58,129] were used in more than one study. When explicit studies were rated according to the Trifiletti et al.[17] categorization of BSSTM use, it was apparent that the majority (n = 8) had used BSSTM to guide programme design and/or implementation, or to measure a specific theory or a theoretical construct (n = 7); only four studies formally tested a theory and three studies did not meet any of the aforementioned criteria and was specified as 'other'.

4. Discussion

It is critical that sports safety interventions have a strong evidence-base for their efficacy and effectiveness before they are delivered to players, coaches and sporting bodies. It is equally important that they are both effective from a public health perspective and can be readily adopted and maintained in the 'real world'. Although it is now accepted that behavioural approaches are useful for understanding, explaining and changing behaviour related to injury problems[19,21] and are an important consideration in intervention effectiveness,[13] this review highlights the lack of BSSTM applications to published sport injury prevention research. This is a concern because most solutions to preventing the sport injury problem rely on some form of behaviour change or modification on the part of players, athletes, coaches, officials, administrators or peak sports bodies.[12,16,18,24] Whilst this review found quite a large number of studies relating to sport injury prevention measures with some behavioural basis, only 11% applied any formal theoretical considerations to their study, suggesting that most authors in this area are either not aware of the importance of BSSTM, or do not appreciate the value of theoretical underpinnings and their application to practice, or may simply lack the knowledge, expertise or requisite skills/training to utilize them.

When BSSTM were used in the published sports injury studies, this tended to be in relation to individual-level (intrapersonal/interpersonal) theories. These included the Health Belief Model,[38,131] Theory of Reasoned Action/Theory of Planned Behaviour,[39,107,109,122,132] Attitude-Social Influence Self Efficacy (ASE) model (an elaboration of the Theory of Planned Behaviour),[41,133] and Social Cognitive Theory.[16,134] This is quite appropriate and not surprising given the focus on ensuring the safety of individuals involved either in team sports or as individual participants of activities such as skating. However, recent commentary has stressed that it is more than just individual (i.e. player) factors that affect uptake and adoption of safety measures, and hence sustained behaviour change.[13] Such factors relate to the capacity of the full sports delivery system to deliver and implement preventive measures for the benefits of sports participants.[13]

Table II. Overall summary of identified sport injury prevention measure studies at different stages in the review process

Prevention measure	No. of potential studies	Total studies excluded	Total studies included	Atheoretical studies	BSSTM explicit studies (%[a])
Equipment	7	5	2	1	1 (50.0)
Multi-focused	6	0	6	4	2 (33.3)
General IP	5	0	5	4	1 (20.0)
Education	8	2	6	5	1 (16.7)
Protective equipment	109	36	74	68	6 (8.2)
Specialized exercise	74	67	7	7	0 (0.0)
Total	**210**	**110**	**100**	**89**	**11 (11.0)**

a % denotes BSSTM out of total studies included per prevention measure.

BSSTM = behavioural and social science theories and models; **IP** = injury prevention.

Table III. Characteristics of the 100 studies included in this review and classification of their use of behavioural and social science theories and models (BSSTM)

Safety behaviour[a]	Country of study	Categorizations of BSSTM use and sport; level of play[b]		Study focus	Reference
		atheoretical	explicit		
PPE, general	Australia	Australian football; adult/community		Players	35
PPE, general	USA	Rugby (female); various		Players	36
PPE, general	Ireland	Hurling; adults/inter-county		Players	37
PPE, general	USA		Various sports (12 sports); junior/high school (athletes)	Players, coaches	16
PPE, general	USA		In-line skating; adult/recreational	Participants	38
PPE, general	France		In-line skating; adult/non-specific	Participants	39
PPE, general	USA	In-line skating, skateboarding and snowboarding; junior/adolescent extreme sports		Participants	40
PPE, general	The Netherlands		In-line skating; junior/children recreational to high performance	Participants	41
PPE, general	India	Various sports; junior to adult/high school, college and university		Coaches	42
PPE, eyewear	Australia	Squash; adult/competitive and social/recreational		Players	43
PPE, eyewear	Australia	Squash; adult/competitive and social/recreational to state		Players	44
PPE, eyewear	Australia	Squash; adult/competitive and social/recreational		Players	45
PPE, eyewear	Australia	Squash; non-specific level		Players	46
PPE, eyewear	Australia	Squash; adult/competitive and social/recreational		Players	47
PPE, eyewear	Australia	Squash; non-specific level		Venue operator	48
PPE, eyewear	Australia		Squash; non-specific	Players, venue managers	24
PPE, eyewear	Australia	Squash; adult (pennant)		Players	49
PPE, facial protection	USA	Ice hockey (indoor); adult/recreational		Players	50
PPE, faceguard	USA	Baseball; junior/youth league		Players, coaches and parents	51
PPE, headgear	Australia	Rugby union; junior/interschool		Players	52
PPE, headgear	Australia	Australian football; adult/amateur/community		Players	53
PPE, headgear	USA	Rugby union; adult/university		Players	54
PPE, headgear	Australia	Surfing; non-specific level		Participants	55
PPE, headgear	USA	Organized equestrian; non-specific level		Participants	56
PPE, headgear	USA	Wrestling; collegiate/division 1		Wrestlers	57
PPE, headgear	USA		Skiing and snowboarding; adult/non-specific	Participants	58
PPE, headgear	USA	Skiing; adults/non-specific		Ski-shop owners	59
PPE, headgear	USA	Skiing and snowboarding; adults/non-specific level		Ski patrollers	60

Continued next page

Table III. Contd

Safety behaviour[a]	Country of study	Categorizations of BSSTM use and sport; level of play[b]		Study focus	Reference
		atheoretical	explicit		
PPE, headgear	Canada	Rugby union; junior to adults/high school to national level		Players, coaches	61
PPE, mouthguards	Australia	Rugby; adult/elite international		Players	62
PPE, mouthguards	Australia	Rugby; adult/elite international		Players	63
PPE, mouthguards	Australia	Rugby; adolescents/high school (private)		Players	64
PPE, mouthguards	Australia, Scotland, Ireland, Wales	Rugby; adult/elite international		Players	65
PPE, mouthguards	UK	Rugby; adult/elite international		Players	66
PPE, mouthguards	UK	Rugby; non-specific level		Players	67
PPE, mouthguards	UK	Rugby league; adult/elite super league		Players	68
PPE, mouthguards	UK	Rugby; adult/various levels		Players	69
PPE, mouthguards	USA	Rugby; adult/elite international		Players	70
PPE, mouthguards	USA	American football; adult/university (freshman)		Players	71
PPE, mouthguards	USA	Football; junior/high school varsity		Players	72
PPE, mouthguards	USA	Football; junior/high school varsity		Players	73
PPE, mouthguards	USA	Basketball; junior/high school varsity		Players	74
PPE, mouthguards	Australia	Basketball; junior to adult/social to elite		Players	75
PPE, mouthguards	China	Basketball; adult/professional and semi-professional		Players	76
PPE, mouthguards	USA	Ice hockey; adult/university NCAA men's division 1		Players	77
PPE, mouthguards	USA	Ice hockey; junior/high school		Players	78
PPE, mouthguards	UK	Field hockey; adult/elite premium division		Players	79
PPE, mouthguards	Turkey	Tae Kwon Do; junior/elite		Players	80
PPE, mouthguards	Japan	Various sports (4 sports); adolescents/high School		Players	81
PPE, mouthguards	Singapore	Various sports; junior/high school		Players	82
PPE, mouthguards	Nigeria	Various sports; junior to adult		Players	83
PPE, mouthguards	USA	Various sports; junior/high school		Coaches	84
PPE, mouthguards	Nigeria	Various sports; junior/high school		Coaches	85
PPE, mouthguards	Switzerland	Various sports; adult/national level		Players, officials	86
PPE, mouthguards	Brazil	Various sports; adult/semi-professional to professional		Players	87
PPE, mouthguards	USA	American football; adult/university NCAA division I-A		Coaches	88
PPE, mouthguards	USA	Ice hockey; adult/university NCAA division I, II, and III, and independent varsity ice hockey programme		Athletic trainers	89

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Table III. Contd

Safety behaviour[a]	Country of study	Categorizations of BSSTM use and sport; level of play[b]		Study focus	Reference
		atheoretical	explicit		
PPE, mouthguards	USA	Football; adult/university NCAA division I-A		Officials	88
PPE, mouthguards	USA	Football; adult/university NCAA division I-A		Officials	90
PPE, mouthguards	USA	Soccer; junior/competitive		Parents	91
PPE, mouthguards	USA	Various sports; junior/public school		Parents	92
PPE, mouthguards	USA	Soccer; junior/non-specific		Parents	93
PPE, mouthguards	USA	Various sports; non-specific		Dentists	94
PPE, mouthguards	USA	Various sports; non-specific level		Dentists	95
PPE, mouthguards	Singapore	Various sports; non-specific level		Dentists	96
PPE, mouthguards	Nigeria	Various contact sports; non-specific level		Dentists	97
PPE, mouthguards	Turkey	Various sports; junior/high school coaches and university athletes		Coaches, players	98
PPE, mouthguards	Turkey	Various sports; adult/university coaches and players		Coaches, players	99
PPE, mouthguards	Switzerland and Germany	Handball; adult/amateur, semi-professional		Coaches, players	100
PPE, mouthguards	Switzerland, Germany and France	Squash; junior, adult/juniors, amateur, semi-professional and professional		Coaches, players	101
PPE, mouthguards	USA	Football; junior/high school varsity		Coaches, trainers	102
PPE, mouthguards	UK	Rugby union; adult/elite players and community level parents of junior players		Players, parents	103
PPE, mouthguards	Australia	Australian football; junior to adult/amateur		Players, spectators (family and friends)	104
PPE, mouthguards	USA and Canada	Ice hockey; junior to senior/all levels		Players, trainers, dentists	105
Equipment, safety baseballs	USA	Baseball; junior/little league		President	106
Equipment-ski bindings	USA		Skiing; adult/non-specific	Skiers	107
General injury prevention	UK	English football (soccer); adults/professional non-specific level		Players	108
General injury prevention	Australia		Australian football; junior/elite	Players	109
General injury prevention	USA	Ice Hockey; junior/non-specific level		Players	110
General injury prevention	Australia	Little athletics; junior/non-specific level		Participants	111
General injury prevention	Australia	Rugby union; junior/community		Coaches	112

Continued next page

Table III. Contd

Safety behaviour[a]	Country of study	Categorizations of BSSTM use and sport; level of play[b]		Study focus	Reference
		atheoretical	explicit		
Specialized exercise, tackling 'spearing' and rule enforcement	USA	American football; junior/high school		Officials	113
Specialized exercise, tackling 'spearing'	USA	Football; junior/high school level		Players, coaches	114
Specialized exercise, warm-up	Australia	Golf; adult/non-specific level		Players	115
Specialized exercise, pre-exercise stretching	USA	Various sports; junior/high school level		Coaches	116
Specialized exercise, intervention	USA	Soccer; NCAA division 1 (female)		Coaches	117
Specialized exercise, non-intervention	Australia	Australian football; adult/elite		Coaches	118
Specialized exercise, non-intervention	UK	Cricket; adult/first-class county		Coaches	119
Multi, non-intervention (SEE)	Australia	Skiing/snowboarding; adults/various levels (beginners/intermediate/advanced)		Skiers	120
Multi, intervention	New Zealand		Rugby union; population wide	Multi-focused	27
Multi, intervention	USA	Skiing/snowboarding; junior, adult/ non-specific level		Multi-focused	121
Multi, non-intervention (SEE)	USA		Basketball; high school varsity, junior varsity, division III Massachusetts South Coast conference coaches	Players, coaches	122
Multi, non-intervention (SEE)	New Zealand	Soccer; junior		Players	123
Multi, non-intervention (SEE)	Australia	Skiing/snowboarding; adults/various levels (beginners/intermediate/advanced)		Skiers	124
Education intervention	The Netherlands	Running; adults/non-specific		Runners	125
Education intervention	The Netherlands	Skiing; various participants/levels (beginners to advanced)		Skiers	126
Education intervention	Australia	Soccer; adults/various club officials		Officials	127
Education intervention	New Zealand	Netball and soccer; various levels/ non-specific level		Coaches	128
Education intervention	USA		Various sports; adolescent/high school athletic coaches	Coaches	129
Education intervention	Australia	Basketball and rugby; junior/non-specific		Players, coaches parents	130

a General PPE refers to multiple types of PPE considered in the one study, e.g. helmets, wrist guards, knee and elbow pads.

b Non-specific denotes authors did not specify level of sport.

NCAA = National Collegiate Athletic Association; **PPE** = personal protective equipment; **SEE** = specialized exercise and education.

Table IV. Summary of behavioural and social science theory and models (BSSTM) explicitly stated as being used in sports injury research studies

BSSTM	Safety behaviour under investigation	Trifiletti et al. categorization[17] of BSSTM use	References
Health Belief model	Protective equipment	Tested theory	38
Theory of Reasoned Action/Theory of Planned Behaviour	General injury Prevention	Guided programme design and/or implementation; measured theory or construct	109
Theory of Reasoned Action/Theory of Planned Behaviour	Multi-intervention (SSE)	Measured theory or construct	122
Behavioural Intention model (otherwise known as Theory of Reasoned Action)	Equipment, ski bindings	Guided programme design and/or implementation; measured theory or construct; tested theory	107
Theory of Reasoned Action/Theory of Planned Behaviour (including threat perceptions)	Protective equipment	Guided programme design and/or implementation; measured theory or construct; tested theory	39
Social Cognitive Theory	Protective equipment	Guided programme design and/or implementation; measured theory or construct	16
Attitude-Social Influence Self-Efficacy model	Protective equipment	Guided programme design and/or implementation; tested theory	41
Refined Ecological model	Protective eyewear	Guided programme design and/or implementation; other	24
Diffusion of Innovation Theory	Protective headgear	Other	58
Diffusion of Innovation Theory	Coach education, general injury prevention	Guided programme design and/or implementation; measured theory or construct	129
PRECEDE-PROCEED model[a]	Multi-intervention	Guided programme design and/or implementation; measured theory or construct	27
Ottawa Charter[a]	Multi-intervention	Other	27

a PRECEDE-PROCEED model and Ottawa Charter applied in the same study;[27] (identified 12 BSSTM; n = 11 studies).
SEE = specialized exercise and education.

Despite the increasing availability of evidence-based sports injury prevention measures, sports safety efforts to date have been hampered because limited research attention has focused on understanding the intervention implementation context and processes, including barriers and facilitators to sustainable programmes.[12,13,18] This knowledge gap requires not only the use of individual-level theories but also the application of organization- and community-level theories. Our review has confirmed that organizational- and community-level theories have rarely been used, with the exception of a refined Ecological model,[24] the Diffusion of Innovation Theory,[58,129] the PRECEDE-PROCEED planning model[27] and the Ottawa Charter.[27] Further application of BSSTM at multiple-levels of behavioural influence (i.e. aligning individual, organizational and community) in this area of research should strengthen the design of intervention strategies and ensure sustainability of implemented programmes. Their direct application could be used to develop different intervention strategies and methods when working with either individuals or communities[19,25] in different sports settings. For example, at the individual level, intervention strategies could include a variety of behavioural, educational, counselling, skills development and training methods.[25,135] At the organizational and community level, the use of

social marketing, mass media and media advocacy are important, as well as coalition building, social planning and community development.[25,135]

Another significant gap highlighted by this review is that many of the common theories from the behavioural literature were not identified in the reviewed sports injury studies; these include the Protection-Motivation Theory,[136] Stages of Change/Transtheoretical model,[135,137] Precaution Adoption Process model,[138] Applied Behavioural Analysis,[19] Social Networks and Social Support,[139] Self Efficacy,[140] Community Organisation and Mobilisation Theories (including Empowerment, Capacity, Participation and Relevance),[141] Communication Theories,[142] Organisational Development Theory (including Organisational Culture, Climate and Capacity),[143] the RE-AIM (Reach, Effectiveness-Adoption, Implementation and Maintenance) model[144] and Social Marketing.[145] Given the success of application of these BSSTM to other safety behaviours and health issues,[146,147] there could be considerable merit in also applying them to the sports injury context.[13] For instance, the Applied Behavioural Analysis[19,25] theory has been used in many injury settings (e.g. road safety,[148,149] child safety,[150] and occupational settings[151]) to change behaviour, but has yet to be applied to sports injury. Unlike the review conducted by Trifiletti et al.,[17] which found the PRECEDE-PROCEED planning model was most commonly used in unintentional injury prevention, our study has highlighted that this model has only been used in one sports injury prevention study to date.[27] The reasons for this are unclear, but could reflect the relative infancy of the application of BSTTM underpinnings to sports injury prevention.

All BSSTM can be applied at various stages of the research process. We applied the Trifiletti et al.[17] categorization to ascertain how theory had been used in the sports injury studies that adopted it. The most common application was used to guide programme design and/or implementation, and/or select programme measures of a study. This implies a low level of theory application according to Trifiletti et al.,[17] and demonstrates a significant absence of the systematic application of BSSTM to sports injury research. Most studies that did apply theory to programme design were also categorized as measuring a theory, construct or model, thereby strengthening their theory application moderately. There was little evidence of testing theories, to determine what might be most applicable to the sports injury context. Without this information, researchers who want to apply BSSTM appear to just select random constructs that they think may be relevant, without formal justification or rationale for their choice.

Often it seems that sport injury studies address constructs relevant to behaviour change in general, but there is little evidence of studies actually committing to the application of specific theory and systematically designing methods, such as questionnaires, accordingly. This is reflected in the large number of atheoretical studies. This could indeed lead to results that are neither replicable nor generalizable to other player groups or different interventions. Moreover, atheoretical studies are unlikely to build on existing behavioural knowledge and run the risk of omitting important psychosocial determinants and processes central to behaviour change. Although theory-based studies are more likely to provide a strong empirical foundation for evidence-based prevention approaches, this does not mean that nothing can be learnt from theoretical approaches. There is still a role for them in informing future theoretical studies, guiding implementation efforts and highlighting future research questions.

4.1 Limitations

Although an extensive search strategy was adopted, it is possible that the ability to locate relevant papers for the review was limited by the use of specific keywords or series of keywords. Using search terms relating to common theories only resulted in two studies being found; these two studies were also identified using alternative search terms. This restriction to only common theories may have limited identification of other useful or newly emerging theories. However, we do not expect this to be a major omission because our search strategy did identify one study that used the ASE model[41] and another that applied a refined Ecological model,[24] which are uncom-

mon in the general literature. It is acknowledged that a recent review of behavioural research in the broader injury prevention context[17] identified a larger range of theory applications (e.g. Health Belief model, Theory of Reasoned Action/Theory of Planned Behaviour, Social Cognitive Theory, Diffusion of Innovations, PRECEDE-PROCEED and Social Marketing Theory) than we were able to find in the sports injury prevention literature. Moreover, although excluded from this review, there is recognized use of BSSTM in studies of bicycle helmets and bicycle safety (see references[152-154] for examples).

Our process of searching, which included hand searching reference lists and additional author searches, did identify further studies and point to the problem of how articles are indexed in databases. We excluded non-peer-reviewed (grey) literature, such as conference proceedings and dissertations, and this may have limited the identification of theory applications in sport injury prevention contexts, though we consider this unlikely. It is possible that some authors of peer-reviewed studies are not reporting full details of their use of BSSTM due to factors such as length restrictions applied by journals. If this were the case, then the number (and proportion) of papers we assigned to the atheoretical categories of BSSTM use may be overestimated. If the field is to progress and researchers are to benefit from the accumulated wisdom of others, it would be pertinent for authors to include these details in their papers and for journal editors to require it formally. Without this, it is likely that researchers will continue to make the same 'mistakes' resulting in critical components of interventions, their target behavioural variables and maximal implementation strategies not being identified.

The initial search for articles relied on abstract content only; it was, however, apparent that some studies seemed to have a behavioural approach (i.e. implementing an exercise programme) and did not clearly link to the stated exclusion criteria in the first instance. A full-text review of these 'unclear exclusion' studies was undertaken. None of the unclear exclusion studies mentioned theory applications; however, some did mention outcome measures (e.g. attitude, knowledge and behaviour) in the method/discussion section and, subsequently, were included in the review (see Braham et al.[35] for example).

4.2 Implications for Future Research

The lack of evidence supporting the widespread use of BSSTM in the design, implementation and evaluation of sports injury interventions results in difficulty providing clear direction or strategies to enhance uptake of sport injury prevention interventions. Unfortunately, the current status of the field also does not appear to assist in enhancing theory development in sport injury prevention research. Previous reviews of sports injury studies have also noted many problems with the quality of their research designs[15] and until these are addressed uniformly, this may have implications for sports injury prevention. Having said this, whether the application of BSSTM to sport injury prevention contexts will improve the uptake of sport injury interventions is largely unanswered, but the evidence from other areas of public health priority suggests it should play a key role. To date, very few studies have used BSSTM; when applied, their use has been varied, with no studies being undertaken in the same sporting setting to enable comparisons of theories or consistency of findings to be established.

Extending current work to the evaluation of the robustness of behavioural findings when theory is applied to particular sport injury prevention issues, and determination of what theories and models work best for specific sport injury prevention topics is needed. It is recommended that further research be conducted to compare or even integrate theories, so that the safety recommendations arising from future research studies take into account the complexity of sports behaviours and settings and the multitude of factors contributing to injury risk. It is unlikely that a single theory will be shown to explain the dynamics of safety behaviours in sporting contexts fully. Rather, it is likely that existing theories will need to be extended or refined to incorporate multi-level approaches. The extended ecological model of Eime et al.[24] is one step in this direction.

Finally, given the widespread use of BSSTM in other application areas (such as exercise promotion, occupational safety and road safety) valuable lessons could be synthesized and translated to the sport injury prevention area to reduce investment in unnecessary and costly duplication of efforts. Importantly, the sports injury prevention research field needs to embrace interdisciplinary collaborations and partnerships. This will enhance the applicability and relevance of research programmes to real-world safety applications and contexts (and vice versa). Significant injury reductions will only be achieved at a population level if research efforts contribute to collectively changing individual behaviours, environmental conditions and social structures to develop supportive safe sports contexts.[12,13]

5. Conclusions

This review has highlighted the general lack of use of BSSTM in studies relating to unintentional sport injury prevention research. Future research in this area, incorporating such approaches is needed in studies that are rigorously designed and analysed. It will also be important to interweave BSSTM approaches into the mainstream of sport injury prevention research, through increasing multidisciplinary/interdisciplinary research teams. There already exist a number of BSSTM applications that researchers could use in enhancing the uptake of sport injury prevention measures, and new behaviour change theories and models are constantly emerging.[135] The field needs researchers who are willing to put these theories to the test. Advances in BSSTM development, as well as increased attention to behaviour change research, will provide new opportunities for reducing injuries and enhancing the uptake of preventive measures. By combining the usual sports injury prevention methods with BSSTM, the field will obtain a better understanding of how and why sports participants (and the settings they play in) make safety-related decisions and what enhancements can be made to injury prevention strategies to ensure their sustained uptake. As Trifiletti et al.[17] posits "It will take creative researchers to find the nexus" (page 305).

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