ENHANCING THE IMPLEMENTATION OF INJURY PREVENTION EXERCISE PROGRAMS IN PROFESSIONAL SOCCER

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ABBREVIATIONS

ACL	Anterior cruciate ligament
AT	Artificial turf
BMI	Body mass index
DOMS	Delayed onset muscle soreness
CG	Control group
CI	Confidence interval
FIFA	Fédération Internationale de Football Association
F-MARC	FIFA Medical Assessment and Research Centre
HR	Hazard ratio
IG	Intervention group
IPEP	Injury prevention exercise program
LL	Lower limb
MCL	Medial collateral ligament
MDIC	Model Dimension Items Checklist
NG	Natural grass
OR	Odds ratio
PEP	Prevent Injury and Enhance Performance
RCT	Randomised controlled trial
RE-AIM	Reach Effectiveness Adoption Implementation Maintenance
RR	Rate ratio
SD	Standard deviation
TRIPP	Translating Research into Injury Prevention Practice
UEFA	Union des Associations Européennes de Football
UEFA-ECIS	UEFA Elite Club Injury Study

SUMMARY

Recently, injury prevention exercise programs (IPEPs) for soccer have received considerable attention and their efficacy has been demonstrated in large-scale trials. However, the ultimate impact of IPEPs will depend not only on their efficacy under controlled conditions, but also on the extent to which they are successfully implemented under real-world conditions. Despite increasing recognition of the challenges involved in successfully implementing IPEPs, there is a paucity of research addressing these challenges.

The first aim of this thesis was to systematically review published IPEP trial reports, from an implementation perspective, in both soccer and other team ball sports. To achieve this, an established health-promotion framework, called the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework, was employed. The subsequent phases of the thesis aimed to identify IPEP implementation barriers and facilitators in the specific context of professional soccer. Two cross-sectional surveys explored the perceptions of IPEP users in professional teams and a prospective observational study assessed IPEP use, over one playing season, in a professional youth soccer academy.

Evaluation of the published literature against the RE-AIM framework revealed major gaps in the reporting of specific IPEP implementation aspects, particularly relating to program adoption and maintenance. In professional soccer teams, multiple IPEP implementation barriers and facilitators were identified. These factors related either to the content and nature of the IPEPs themselves (e.g. variation, progression and soccer-specificity), or the delivery and support of programs (e.g. communication and team work) at different levels of the professional soccer ecology.

In summary, there are major gaps in the reporting of implementation aspects in team ball sport trials. To enhance the implementation of IPEPs in professional soccer settings, the content and delivery of programs require significant tailoring to the specific implementation context.

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Candidate's contributions

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1	It will take more than an existing exercise program to prevent injury.	Published in the *British Journal of Sports Medicine*[1]	Principal author responsible for the concept and the writing up of the manuscript.
2	The three must-do's of intervention reporting: enhancing sports injury prevention research.	Published in the *British Journal of Sports Medicine*[2]	Principal author responsible for the concept and the writing up of the manuscript.
2	A systematic review of core implementation components in team ball sport injury prevention trials.	Published in *Injury Prevention*[3]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.
2	The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework.	Published in *Sports Medicine*[4]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.

Candidate's contributions (continued)

3	Injury prevention exercise programs for professional soccer: understanding the perceptions of the end-users.	Published in the *Clinical Journal of Sports Medicine*[5]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.
3	Injury prevention exercise programs in professional youth soccer: understanding the perceptions of program deliverers.	Published in *BMJ Open Sport & Exercise Medicine*[6]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.
4	The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+.	Published in the *Journal of Science and Medicine in Sport*[7]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.
4	The use and modification of injury prevention exercises by professional youth soccer teams.	Published in the *Scandinavian Journal of Medicine & Science in Sports* [8]	Principal author responsible for the concept, data extraction and synthesis, interpretation of the results and the writing up of the manuscript.

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DEDICATION

For my family, on both sides of the world.

1.0 INTRODUCTION

Soccer (Association Football) is the world's most popular sport, with over 260 million participants.[9] Playing soccer is associated with multiple health benefits,[10] but injuries are both common and costly.[11] In Switzerland, soccer injuries resulted in costs of approximately $US 130 million and the loss of over 500,000 working days in 2002.[11] In professional soccer, with approximately 65,000 registered players,[12] the risk of injury and the associated costs are particularly high.[13] It has been suggested that the risk of injury among these players is 1000 times greater than that of other occupations traditionally viewed as high-risk, such as manufacturing and construction.[14] The estimated financial loss due to injuries in professional English soccer leagues in the 1999/2000 season was over £74 million.[15] More recently, the financial loss incurred by a top-level professional club, due to one player being injured, was reported to average €500,000 per month.[13]

In addition to the financial costs, injuries are also associated with negative effects on soccer players' long-term health. A high prevalence of osteoarthritis, particularly in the knee joints, along with a lower quality of life, has been found in former professional players.[16-18] In a survey of 500 former players, 47% reported retiring due to injury and 32% had been diagnosed with osteoarthritis.[19] Team performance is also negatively impacted by injuries, as demonstrated in recent studies of professional European[20] and Qatari teams.[21] In view of the high risk and multiple negative impacts of soccer injuries, the development of successful injury prevention strategies is imperative.

1.1 BACKGROUND

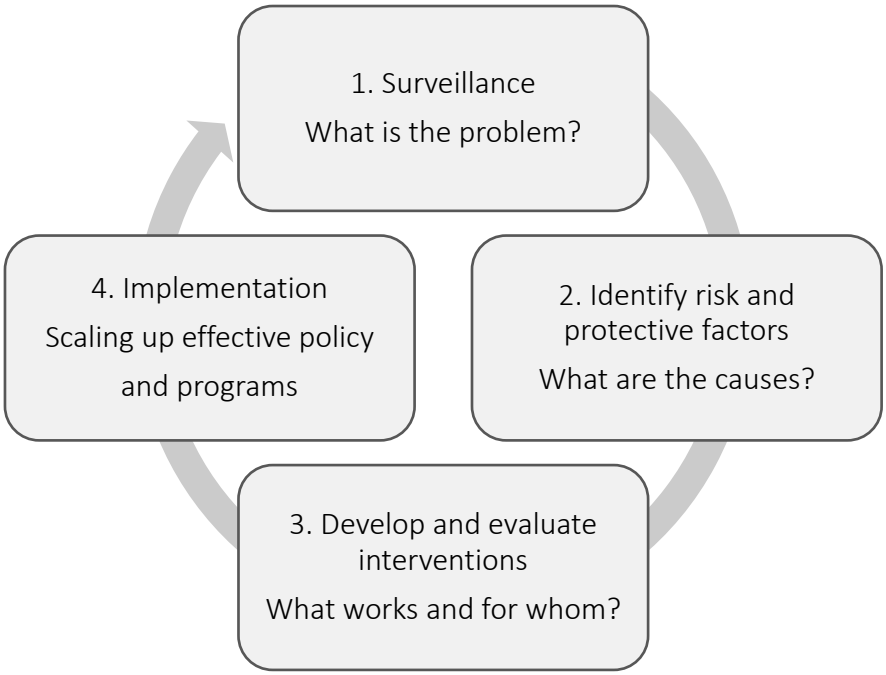
1.1.1 Definition of professional soccer

The Fédération Internationale de Football Association (FIFA) categorises soccer players as either amateur or professional. Professional players have written contracts with a club and are paid more for their football activity than the expenses they incur. All other players are considered amateurs.[22] The study participants in this thesis research consisted of professional players, along with staff members (coaches, fitness coaches and physiotherapists) working full-time with professional soccer teams. Hence the term "professional soccer" is used throughout this thesis.

1.1.2 Injury prevention frameworks: the steps to success

The public health approach to prevention provides a systematic, four-step framework for identifying the cause of injuries and preventing their occurrence.[23 24] The first step focuses on establishing the extent and nature of the injury problem; step two aims to identify the cause and risk factors in order to inform preventive strategies; the third step involves testing a preventive measure; and step four focuses on large-scale dissemination and implementation of programs and policies. Step one is then repeated to evaluate the impact of the preventive measure. (Figure 1.1)

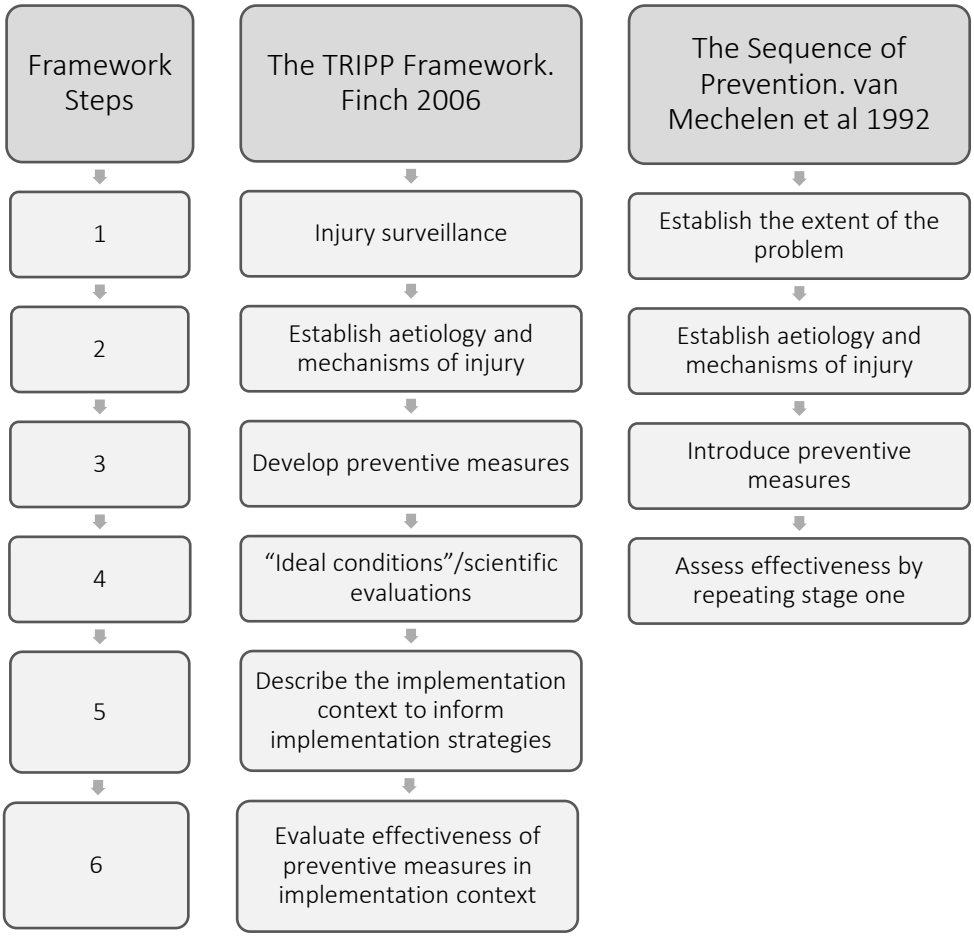
Figure 1.1 The public health approach to prevention, adapted from the World Health Organization[24]



In 1992, van Mechelen and co-workers[25] described an adaptation of the public health approach for the context of sport, called the "Sequence of Prevention". This has since become one of the mostly widely cited publications in sports medicine. In 2006, Finch[26] highlighted limitations of the four-step approach and presented an extension of the van Mechelen model, called the Translating Research into Injury Prevention Practice (TRIPP)[26] framework. This six-step approach emphasises that in addition to establishing the efficacy of sports injury prevention interventions under "ideal conditions", research must also address the effectiveness of these interventions in "real-world" settings (Figure 1.2). Steps 5 and 6 of the TRIPP framework focus on

translating efficacious injury prevention interventions into real-world injury prevention practice. Step 5 involves describing the context in which an injury prevention intervention is to be delivered. This step is important to identify factors in the targeted sport setting which are likely to impact on the ultimate success of an injury prevention program. Such factors might include the number, education and injury prevention beliefs of staff members, the injury prevention measures (if any) currently in use and the availability of equipment. Step 6 of the TRIPP framework involves evaluating the effectiveness of an injury prevention measure under real-world conditions. As stressed by Finch,[26] no injury prevention measure will reach its full potential unless it is adopted, correctly implemented and maintained by the targeted end-users.

Figure 1.2 Translating Research into Injury Prevention Practice (TRIPP) framework steps,[26] compared to the four-step framework from van Mechelen et al.[25]



To date, the vast majority of sports injury prevention research has focussed on the first two steps of the TRIPP framework. In 2010, Klügl and co-workers[27] reviewed the published sports injury prevention literature, identifying 11 859 articles. The authors categorised the original research reports (comprising less than half of the total retrieved articles) according to the steps of the TRIPP framework, finding that 33% focussed on the incidence or aetiology of injuries (TRIPP steps 1 and 2). Published reports on preventive interventions and efficacy trials (TRIPP steps 3 and 4) were far less common (10%) and only 1% of the publications investigated implementation and real-world effectiveness (TRIPP steps 5 and 6).[27] The authors concluded that a wide gap exists between current research knowledge of efficacious injury prevention programs and the ability to successfully implement them under real-world conditions. They also suggested that addressing this gap represents one of the greatest opportunities to enhance sports-injury prevention.[27]

1.1.2 What do we currently know about preventing soccer injuries?

This section will explore research knowledge on the prevention of soccer injuries, categorised by the steps of the TRIPP framework. The discussion is focussed on professional male soccer players at both senior and youth academy level. However, certain research from other soccer settings, holding relevance to this current PhD thesis, is also included.

1.1.2.1 What is the extent and nature of the problem? (TRIPP step 1)

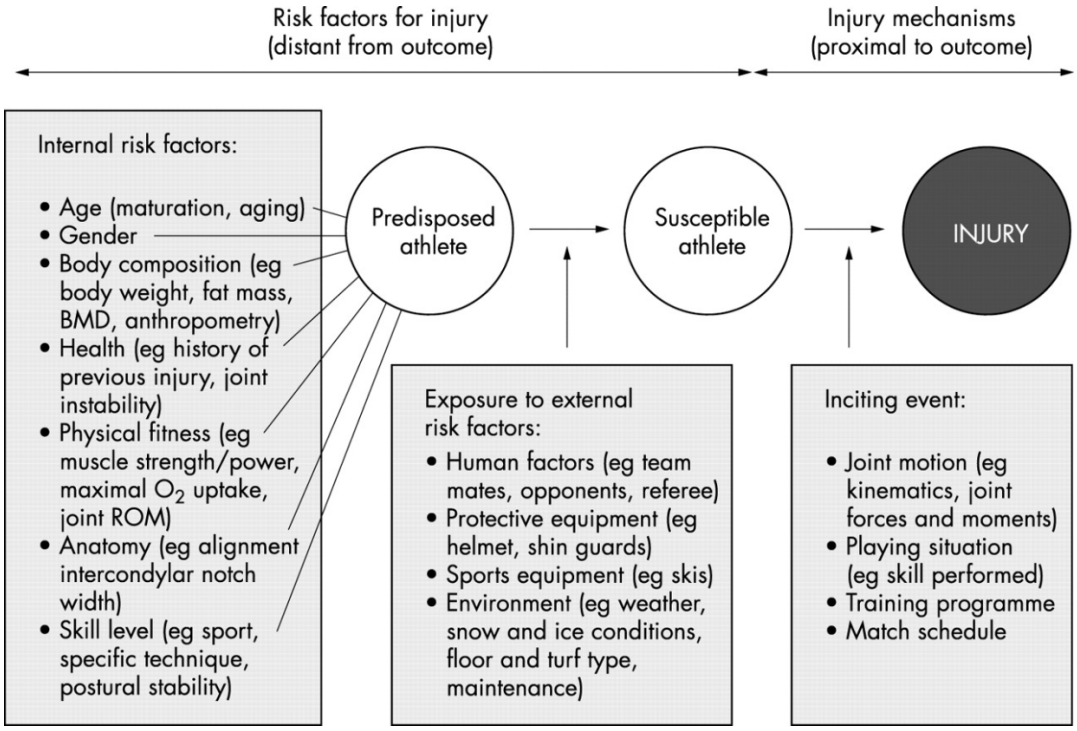
Large-scale injury surveillance studies have been conducted in elite male soccer teams from Norway,[28] Sweden[29] and England.[30] Additionally, the Union des Associations Européennes de Football (UEFA) elite club injury study (ECIS) has recorded injuries in European teams since 2001.[31] In these studies, the most commonly injured body regions were the thigh (22-23% of all injuries), knee (14-18%), hip/groin (11-19%) and ankle (9-18%). The most common injury types were muscle injuries (19-41%), followed by ligament injuries (15-20%) and contusions (15-20%). In an analysis of UEFA-ECIS data, the incidence of injury per 1000 hours was 27.5 in matches and 4.1 in training, with a player suffering an average of two injuries per season.[31]

Injury surveillance in professional youth academy players has been conducted over multiple seasons in both France[32] and England.[33] Le Gall and co-workers[32] analysed injuries in Under-14, Under-15 and Under-16 age groups, over a period of 10 seasons. Price and co-authors[33] conducted a two-year analysis of injuries in 38 professional youth academies with players aged 9 to 19. In these studies, the most commonly injured body parts in academy players were the thigh (19-25% of all injuries), followed by the ankle (18-19%) and knee (15-18%). The most common injury types were muscle injuries (15-31%), contusions (8-31%) and ligament sprains (17-10%).[32 33] Hence, the reported location and type of injuries were similar to the above findings for professional adult players. In the French academy study,[32] the incidence of injuries was 11.2 and 3.9 injuries per 1000 hours for matches and training respectively, but exposure time was not recorded in the English study.[33] The lower incidence of match injuries in professional academy players, compared to their senior counterparts, aligns with data from European championships showing an increase in match injury incidence with age.[34]

1.1.2.2 What are the risk factors for soccer injuries? (TRIPP step 2)

Risk factors refer to any variables associated with the occurrence of an injury, and are traditionally separated into internal and external risk factors, based on the multi-factorial causation model described by Meeuwisse.[35] Internal risk factors refer to player-related variables, such as gender, age, strength and flexibility. External risk factors relate to environmental factors, external to the athlete, such as weather, playing surface and equipment. Meeuwisse[35] proposed that the presence and interaction between multiple internal and external risk factors increases an athlete's susceptibility to injury. However, risk factors alone are insufficient to result in an injury; the final link in the chain of causation which triggers an injury is the inciting event (e.g. the playing situation). In 2005, Bahr and Krosshaug[36] proposed an extension of Meeuwisse's model (Figure 1.3), including a more detailed description of the inciting event. The most recent and comprehensive descriptions of risk factors in professional male soccer have arisen from sub-analyses of the UEFA-ECIS,[37-43] which are summarised in Tables 1.1 and 1.2.

Figure 1.3 A multi-factorial model for sports injury causation[36]



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1.1.2.3 Internal risk factors in professional soccer

Previous injury has been established as an important internal risk factor for injury in several studies, including studies based on UEFA-ECIS data (Table 1.1). Arnason and co-workers[44] showed previous injury to be a risk factor for hamstring, groin, knee and ankle injuries in players from the two highest Icelandic divisions. In Swedish first league teams, previous hamstring injury, groin injury and knee joint trauma were established as risk factors for suffering identical injuries in the following season,[29] but no such association was found for ankle sprain. Previous anterior cruciate ligament (ACL) injury was also established as a risk factor for a subsequent knee injury of any type in Swedish first league teams.[45] In a study of 508 players from the top three Norwegian male divisions, Engebretsen and co-workers found previous injury to be a risk factor for groin,[46] hamstring[47] and ankle injuries.[48] Contrastingly, in one study of Greek third-division teams, players with no previous hamstring injury were at higher risk of suffering a subsequent hamstring injury.[49] This discrepancy could be explained by differences in the study's methodology or the specific study cohort (e.g. level of competition and rehabilitative practices).

Several studies have evaluated age as a potential internal risk factor, but results have been conflicting. A higher risk of hamstring injury was found in older players from English,[50] Swedish[29] and Icelandic[44] leagues, but increased age was not a risk factor for hamstring injury in an UEFA-ECIS sub-analysis (Table 1.1).[37] Studies in first division American teams[51] and first division Swedish teams[29] found no association between age and overall injury rates. There was also no significant association between age and overall injury rates in elite youth male players from a professional French academy (Under-14, Under-15 and Under-16).[32] However, in terms of specific injury types, the Under-14 players experienced significantly more training injuries and growth-related injuries.[32] Among players in English youth academies, those aged between 17–19 years experienced more injuries than those aged 9–16 years.[33] In European championship competitions, match injuries increased with age.[34] In UEFA-ECIS sub-analyses, older age was associated with a higher risk of calf injury and Achilles tendon injury,[41] whereas younger age was associated with fifth metatarsal fractures[40] and stress fractures[39] (Table 1.1). The conflicting results regarding the association between age and injury rates may be the result of different study designs (e.g. cut-offs for age, inclusion of individual exposure data, injury surveillance methods) and differences in the study cohorts (e.g. level of competition).

Table 1.1 Internal risk factors in professional soccer: key findings from the UEFA-ECIS† analyses

Authors	Injury types	Potential risk factors	Main findings
Ekstrand and Torstveit[39]	Stress fractures	o Age o Anthropometrics	o Higher risk in younger players o No association for height, body weight or BMI
Ekstrand and van Dijk[40]	Fifth metatarsal fractures	o Age o Anthropometrics	o Higher risk in younger player o No association for height, body weight or BMI
Ekstrand et al.[52]	Muscle injury	o Age	o Higher risk of calf strain in older players
Ekstrand et al.[53]	Upper-extremity injury	o Playing position	o Higher risk in goalkeepers
Gajhede-Knudsen et al.[41]	Achilles tendinopathy	o Age o Anthropometrics	o Older players at higher risk o No association for height, body weight or BMI
Hägglund et al.[54]	Patella tendinopathy	o Anthropometrics o Age o Kicking leg	o Increased body mass borderline significant o No association o No association
Hägglund et al.[37]	Lower-limb muscle injury	o Previous injury o Age o Kicking leg o Playing positon o Anthropometrics	o Higher risk of suffering an identical injury in the following season* o Higher risk of suffering an injury in a different muscle group* o Higher risk of calf (but not other muscle) injuries in older players o Higher risk of quadriceps and adductors injuries in kicking leg o Lower risk in goalkeepers o No association for body weight/stature
Kristenson et al.[55]	All injury	o Newcomers o Age o Playing position	o Lower rate of overall injury, but higher rate of fractures for newcomers o Increased overall injury rate with age o Lower injury rate in goalkeepers
Larsson et al.[56]	Fractures	o Age o Playing positon	o Higher risk of stress fractures in younger players o No association
Lundblad et al.[42]	MCL injury	o Playing position	o Lower rate in goal keepers
Nilsson et al.[57]	Head and neck injury	o Playing position	o Defenders at higher risk of head/neck injuries
Nordström et al.[58]	Concussion	o Previous injury	o Higher risk of a subsequent injury following concussion

†UEFA-ECIS: Union des Associations Européennes de Football elite club injury study. *For all muscle groups, a previous injury was a risk factor for suffering an identical injury in the following season (e.g. a previous hamstring increased the risk of a future hamstring injury). Additionally, in the case of calf and quadriceps injury, previous injury in a different muscle group was a risk factor (e.g. a previous hamstring injury increased the risk of calf injury).[37]

Anthropometric parameters including player height, weight and body mass index (BMI) have also been investigated as potential internal risk factors. In third-division Greek teams, Fousekis and co-workers[49 59] found a higher risk of quadriceps injury in shorter and heavier players[49] and a higher risk of ankle sprain in players with an increased BMI and body weight.[59] In UEFA ECIS sub-analyses, player height and weight were not associated with muscle injury,[37] stress fractures,[39] Achilles tendinopathy[41] or fifth metatarsal fractures[40] (Table 1.1). In relation to ACL injuries, certain aspects of knee-geometry, such as a narrowed intercondylar notch width and altered notch angle have been associated with a higher risk of ACL injury,[60 61] although these findings are not specific to male soccer players.

A further potential internal risk factor for soccer injuries is playing position. A lower injury rate in goalkeepers, compared to other playing positions, has been reported in studies from France[62], Denmark[63] and Japan,[64] along with UEFA ECIS sub-analyses of muscle injuries,[37] and MCL injuries.[42] However, in the case of upper limb injuries, goalkeepers have been shown to have a higher risk.[31] Other studies investigating player position as a risk factor have reported conflicting results. While some studies found a higher risk in midfielders,[65 66] forwards[67] and (in the case of head and neck injuries) defenders,[57] others have found no association between playing position and injury.[51 68]

Relatively few studies have investigated physical parameters (e.g. strength and flexibility) as potential internal risk factors in professional soccer players. Arnason and co-workers[44] examined jump height, flexibility, leg extension power and peak oxygen uptake in Icelandic players, with only decreased hip abduction flexibility being identified as a risk factor for groin injury.[44] Dauty et al.[69] evaluated 28 players from the first French league, finding no association between isokinetic strength parameters and the incidence of new hamstring injuries. A study of 462 Brazilian, Belgian and French players[70] reported a higher risk of hamstring injury in players with unresolved strength imbalances (based on isokinetic testing) compared to players whose imbalances were corrected. In a small study of English premier league players[50] increased power (measured with a non-counter movement jump test) and decreased hip flexion flexibility increased the risk of hamstring injury.

Fousekis and co-workers evaluated intrinsic risk factors for non-contact hamstring, quadriceps[49] and ankle injuries[59] in 100 players from the Greek third-division. The rate of hamstring injury was higher in players with asymmetrical isokinetic eccentric strength values and functional leg-length asymmetries. The rate of quadriceps injury was higher in players with eccentric quadriceps strength asymmetries and quadriceps flexibility asymmetries.[49] The rate of ankle sprains was higher in players with isokinetic ankle flexion strength asymmetries.[59] More recently, a study in professional soccer players in Australia[71] found that short fascicles in the Biceps Femoris and eccentric knee flexor weakness increased the risk of hamstring injury. The discrepancies in study results relating to physical parameters and injury risk could be partly explained by the different test methods employed in studies (e.g. the different contraction types, speeds and outcome measures used in isokinetic hamstring tests).

Other potential internal risk factors, having received little research attention to date, include psychological factors,[72 73] genetic variations,[74] fatigue[75 76] and preferred kicking leg.[37] Overall, multiple internal risk factors for injury in professional soccer have been identified, but the results from different studies are contradictory, possibly due to differences in study design and cohorts.

1.1.2.4 External risk factors in professional soccer

External (environmental) risk factors for soccer injury have also received considerable research attention in recent years, but for many variables the results have been conflicting. The findings from studies drawing on the UEFA ECIS are summarised in Table 1.2. A higher rate of injury in the pre-season has been found in a number of studies,[39 40 41 54] while others found no difference in injury rates across the season.[28 68] Both a UEFA ECIS sub-analysis[37] and a study of professional players in England found an increased rate of quadriceps injury in the pre-season,[15] but the injury incidence for other muscle groups was either evenly distributed between the pre- and competitive seasons,[15] or higher in the competitive season.[37]

Studies have consistently demonstrated higher injury rates in matches than training[29 31 32] and trends towards an increased injury rate towards the ends of the match halves have been reported for medial collateral ligament (MCL) injuries,[42] ankle injuries[43], overall injuries[31] and contact-related match injuries.[64] Research into the influence of climate region on injury rates has shown conflicting results, with professional teams from

Table 1.2 External risk factors in professional soccer: recent findings from studies drawing on UEFA ECIS† data

Authors	Injury types	Potential risk factors	Main findings
Bengtsson et al.[77]	All injury	o Match variables	o Short recovery period a risk factor for total injuries and muscle injuries o High match load a risk factor for muscle injuries (during matches in the same period) and ligament injuries (during training in the subsequent period)
Bengtsson et al.[78]	All injury	o Match variables o Competition	o Increased injury rates in matches resulting in a loss or draw o Lower injury rates in away matches compared to home matches o Rate of severe injuries increases with importance of the match
Ekstrand and Torstveit[39]	Stress fractures	o In-season variation	o Higher risk in pre-season for the UEFA ECIS cohort
Ekstrand and van Dijk[40]	Fifth metatarsal fractures	o In-season variation	o Higher rate in pre-season
Ekstrand et al.[79]	All injury	o Playing surface	o No difference in the incidence or severity of overall injuries between surfaces o Risk of ankle sprain higher on artificial turf
Ekstrand et al.[52]	Muscle injury	o Match variables	o Higher injury rate in match play and towards end of playing halves
Ekstrand et al.[31]	All injury	o Match variables o In-season variation	o Higher injury rate in match play and towards end of playing halves o More traumatic injuries in competitive season, more overuse injuries in pre-season o Increased risk of hamstring strain in competitive season
Ekstrand et al.[53]	Upper extremity injury	o Match variables	o Higher injury rate in match play
Gajhede-Knudsen et al.[41]	Achilles tendinopathy	o In-season variation o Recovery period	o Higher injury rate in the pre-season o Higher risk of re-injury after shorter recovery periods
Hägglund et al.[37]	Lower limb muscle injury	o Match variables o Competition o In-season variation o Climate region	o Lower risk of hamstring/adductor injuries in away matches o Increase in calf, and decrease in quadriceps injuries in UEFA ECIS matches o Incidence of quadriceps injury higher in pre-season o Higher incidence of adductor, hamstring, calf injuries in the competitive season o No association

Table 1.2 (continued)

Hägglund et al.[54]	Patella tendinopathy	o	Exposure time	o	Higher risk with high total exposure time
		o	In-season variation	o	Increased incidence in pre-season for teams in northern part of Europe
		o	Playing surface	o	No association
Hägglund et al.[80]	Re-injury	o	In-season variation	o	Proportion of recurrent injuries highest in second half of season
		o	Playing level	o	Proportion of recurrent injuries inversely related to playing level
Lundblad et al.[42]	MCL injury	o	Match variables	o	Higher injury rate in matches than training and towards end of playing halves
		o	In-season variation	o	No association
Nilsson et al.[57]	Head and neck injury	o	Match variables	o	Higher injury rate in match play
				o	Higher injury rate in away matches compared to matches played at home
Ueblacker et al.[81]	Muscle injury	o	Match variables	o	Higher injury rate during match play
				o	Tendency for more injuries towards end of playing halves
Waldén et al.[82]	ACL injury	o	Match variables	o	Higher injury rate during match play
Waldén et al.[83]	All injury	o	Climate region	o	Higher risk of match injury and major injuries in teams from Denmark and England compared to teams from Spain, France and Italy
Waldén et al.[84]	All injury	o	Climate region	o	Teams from northern parts of Europe had higher incidence of overall, training and severe injuries in, but lower incidence of ACL injury
Waldén et al.[43]	Ankle injury	o	In-season variation	o	No difference in incidence pre-season vs. season
		o	Match variables	o	Higher incidence in matches, but no change across playing halves

[†]UEFA-ECIS: Union des Associations Européennes de Football elite club injury study.

northern parts of Europe having a higher overall injury rate, but a lower rate of ACL injury,[84] while no effect was found for LL muscle injuries[37] (Table 1.2). Large-scale studies[77 85] have found higher injury rates in periods of increased match congestion, while the results of studies in smaller cohorts have been conflicting.[68 86-88] These discrepancies could be partly explained by differences in study design (e.g. sample size and player inclusion criteria) and the differences in the cohorts under investigation (e.g. playing style and squad size). Most recently, a study of 19 professional players in Australia, found significant changes in players' individual training and match load in the weeks directly preceding a non-contact injury, relative to season averages.[89]

The risk of injury playing on natural grass (NG) soccer pitches, compared to artificial turf (AT) pitches, has been the focus of several investigations. Early Scandinavian studies found a higher risk of injury on first and second generation artificial pitches.[90 91] However, more recent studies in professional soccer settings have found no significant differences in injury incidence between NG pitches and modern, third generation AT pitches.[79 92 93] In relation to injury pattern, a higher rate of ankle injuries[79 92] and lower rate of muscle injury[92] has been reported in men playing matches on AT pitches.

Kristenson and co-workers[94 95] recently evaluated potential risks factors associated with playing surfaces among 32 Scandinavian professional male teams. Higher injury rates were found in professional clubs with AT installed at their home venue.[94] However, no association was found between injury risk and surface shifts (between NG and AT) or playing matches on an unaccustomed surface.[95] In spite of the lack of evidence for an increased injury rate on AT, 94% of surveyed professional major league soccer players believed the risk of injury was greater on AT.[96]

Other potential external risk factors which have received less research attention to date are weather and pitch conditions. A reduced injury rate was reported for rainy conditions in Japanese matches,[64] and poor pitch conditions were reported as an external risk factor in Czech players.[97] Overall, the research findings relating to the external risk factors for injury in professional soccer are conflicting, with the exception of a consistently higher injury rate in matches compared to training. The inconsistent findings could be explained by differences in study design (e.g. injury definitions, injury surveillance methods, inclusion of individual exposure data), study cohorts (e.g. competition level, playing style) or other unknown injury risk factors.

The final link in the causation of injury is the inciting event.[35 36] Foul play has been associated with injuries in several studies.[42 97 98] In an analysis of UEFA ECIS data, 40% of the match-related ankle sprains involved foul play,[43] and MCL injuries were more frequently caused by foul play than non-foul play.[42] Waldén and co-workers recently evaluated the mechanism of ACL injuries in professional male players.[99] Although direct contact with the injured leg or knee was one of the observed injury mechanisms, the majority of injuries (85%) resulted from non-contact or indirect contact situations, with three main injury mechanisms being identified: pressing (applying defensive pressure to the player with the ball), re-gaining balance after kicking and landing after a header.[99] The vast majority of hamstring injuries also occur in non-contact situations. In a study of professional players in England,[15] 91% of hamstring injuries were non-contact injuries and 57% were sustained during running. Similarly, in sub-analyses of UEFA ECIS data, 92-96% of LL muscle injuries occurred in non-contact situations,[52] and 60% of indirect injuries (caused without the influence of direct external trauma) were sustained during sprinting or high-speed running.[81]

1.1.2.5 Developing preventive measures (TRIPP step 3)

The third step in the TRIPP model focuses on developing preventive solutions, based on the modifiable risk-factors identified in step 2.[26] This can involve conducting laboratory-based investigations prior to the testing of "on-field" preventive interventions.[26 27] However, in contrast to the step-wise progression outlined in the TRIPP framework, much of the research on IPEPs for soccer has progressed to the "on-field" testing of preventive measures (step 4) in the absence of direct prior laboratory evaluation of their ability to modify established risk factors. Many prevention programs have been developed primarily through expert consensus,[100 101] with research into the relevant preventive mechanisms only being undertaken when efficacy studies (step 4) had already been conducted[102-104] For example, Daneshjoo and co-workers[102 103 105] recently demonstrated improvements in strength, static balance and dynamic balance parameters in professional male youth players using established injury prevention programs. Similarly, Dello Locono et al.[106] demonstrated improvements in both intra- and inter-limb strength asymmetries of young national-level male soccer players, following a 6-week strength, core stability and balance program.

One preventive exercise which did receive research attention consistent with TRIPP step 3, prior to efficacy trials, is the hamstring lower (or "Nordic Hamstring") exercise. Working on the assumption that a hamstring

strength deficit is a modifiable injury risk factor, Brockett et al.[107] evaluated the effect of hamstring lowers on mechanical muscle properties. The authors found a significant change in the optimal angle for torque generation, to a longer muscle length, post-intervention. Following this, Mjølsnes and co-workers[108] demonstrated that hamstring lowers can significantly increase maximal eccentric hamstring strength in soccer players. These results provided a scientific basis for subsequent studies that directly evaluated the effect of hamstring lowers on hamstring injury rates.[109-111]

The use of exercises and technique training to modify ACL injury risk factors has been evaluated in biomechanical, laboratory-based settings,[112] although the majority of studies have focussed on young female athletes,[113-115] or sports other than soccer.[116] One study found training of the side-step cutting technique in a group of non-elite male athletes (including one soccer player) to be effective in reducing the peak valgus loading of the knee.[117] Further research of these factors in professional male soccer populations is needed.

1.1.2.6 Injury prevention strategies for soccer (TRIPP step 4)

A number of different strategies to prevent soccer injuries have been evaluated, including education, taping and orthoses.[118-120] However, injury prevention exercise programs (IPEP) have received by far the most research attention to date.[121] As IPEPs are the focus of this current PhD thesis, and research on IPEPs in professional male soccer remains rare, this section will also review research from other soccer settings. In 1983, Ekstrand and colleagues[122] published the first randomised controlled trial (RCT) of an injury prevention strategy in soccer, reporting a staggering 75% reduction in injury risk among the players in the intervention group. This Swedish study employed a multi-modal prevention strategy including education, taping and controlled rehabilitation, along with a structured warm-up and cool-down in division IV male players (180 players in total). In 1985, a further Swedish RCT, targeting ankle injuries, was reported by Tropp and co-workers.[119] The study allocated 439 players to either a control group, a balance training group, or an ankle orthosis group. A significantly reduced risk of ankle sprains was demonstrated in both intervention groups.[119]

Following these two early reports, the volume of published IPEP trials in soccer grew substantially between 1995 and 2015, with a further 36 trials emerging (Appendix I). Caraffa and co-workers[123] employed a progressive balance program in a prospective non-randomised trial of 600 Italian players, published in 1996.

The risk of ACL injury was significantly reduced in the intervention group. In 2007, Mohammadi[124] reported an 87% reduction in the rate of ankle sprains in an RCT evaluating balance training (as one of three different interventions) in first division Iranian players. Balance training also had a positive effect on the rate of ankle sprains in both a prospective cohort study of 125 players[125] and a cluster RCT of 765 players (soccer and basketball)[126] conducted in America.

The prevention of hamstring injuries has been the specific focus of several studies. In 2003, Askling and colleagues[110] reported a RCT involving 30 elite Swedish male players. The intervention group performed eccentric hamstring strengthening on a "Yo Yo" flywheel over 10 weeks. The authors reported 70% fewer players from the intervention group suffering a hamstring injury in the following season, compared to controls.[110] In 2008, a study in Norwegian and Icelandic elite players by Arnason and co-workers[109] also reported a significant reduction in hamstring injuries following eccentric training, in this case using hamstring lowers with progressive difficulty. The preventive effect of hamstring lowers was also demonstrated in a recent Danish RCT of 942 male soccer players from the first to fifth divisions.[111] A 10-week, progressive program in the mid-season break, followed by a maintenance program across the season, reduced the rate of overall (71%), new (59%) and recurrent hamstring injuries (86%).

In addition to the above studies focussing on one particular exercise type (e.g. balance training) or one particular injury type (e.g. hamstring injury), a number of large cluster RCTs have evaluated the efficacy of multi-faceted IPEPs (e.g. strength, balance and plyometric exercises) on multiple injury outcome measures (e.g. lower limb, knee and overuse injuries). Examples of such multi-faceted IPEPs include a Swedish program called Knäkontroll,[127] an American program called Prevent Injury and Enhance Performance (PEP)[128] and two programs endorsed by the Fédération Internationale de Football Association (FIFA): the FIFA 11+[101 129-131] and its predecessor, the FIFA 11.[132-134]

The FIFA 11 is a 15 minute IPEP developed by FIFA's Medical Assessment and Research Centre (F-MARC) in 2003.[132] The program consists of 10 different exercises focussing on strength, balance, core stability, jumping and agility.[132] In 2008, Steffen et al.[132] reported no effect of the FIFA 11 on overall injuries in a cluster RCT involving over 2000 Norwegian female soccer players. The authors hypothesised that the lack of effect was

due to low compliance levels (i.e. the program not being performed as prescribed). Similarly, a Dutch cluster RCT[133] with over 400 amateur male players found no effect of the FIFA 11 on overall injuries. However, significantly fewer knee injuries were reported among players with high compliance.[133] A further FIFA 11 trial found no effect in a cohort study of Italian amateur male players.[134]

In 2006, FIFA, in collaboration with two leading research centres, developed a new injury prevention program for soccer, called the FIFA 11+.[101] The program was designed as a comprehensive warm-up program, targeting players aged 14 years and older. Taking approximately 20 minutes to complete, the FIFA 11+ consists of three parts and a total of 15 exercises:[129]

Part 1 (6 exercises): slow running drills combined with stretching and partner exercises.

Part 2 (6 exercises): core stability, lower limb (LL) strength, balance, and jumping/landing exercises, each with three progressive difficulty levels.

Part 3 (3 exercises): moderate/high speed running drills including planting and cutting.

The FIFA 11+ is backed by a comprehensive website, providing background information, user manuals, posters and videos in multiple languages.[129] In a large-scale, cluster RCT of the FIFA 11+ in Norwegian female youth players, Soligard et al.[101] reported a statistically significant reduction in overall injuries (32%) and overuse injuries (53%), while the 29% reduction in the primary outcome, LL injuries, did not reach significance. In a subsequent study, Soligard and co-workers[135] evaluated compliance to the FIFA 11+ and coaches' injury prevention perceptions. The risk of injury among players with high compliance to the FIFA 11+ was 35% lower than the risk of injuries in players with intermediate compliance. The probability of having low compliance was significantly increased if the coach viewed the FIFA 11+ as too time consuming (87% higher) or was not football-specific (81% higher).[135]

Subsequent RCTs have demonstrated the preventive effect of the FIFA 11+ in other soccer populations.[130 131] In a study of 416 amateur Nigerian male players, Owoeye et al[130] demonstrated a 41% reduction in the rate of overall injuries and a 48% reduction in the rate of LL injuries. Silvers-Granelli and colleagues investigated the effect of the FIFA 11+ in a study of 396 collegiate male soccer teams. The intervention group had a 46% reduced injury rate compared to controls.[131] In agreement with the aforementioned findings[135] the authors

found high compliance to the FIFA 11+ to be associated with lower injury rates.[131] Steffen et al.[136] also reported an association between high compliance and lower injury rates in a cluster RCT evaluating different FIFA 11+ delivery methods in Canadian female youth players. The risk of suffering an injury was significant lower in the high compliance group compared to the medium compliance group, for both overall injuries (72%) and LL injuries (68%).[136] High compliance levels were also associated with improvements in dynamic balance. However, different delivery methods only minimally impacted on performance tests and had no effect on injury risk.[136]

Hammes and co-workers evaluated the preventive effect of the FIFA 11+ in a cluster RCT of 20 veteran soccer teams.[137] They found no significant difference in the overall injury rate between the intervention and control groups. However, the rate of severe injuries were significantly higher in the control group. The authors attributed the lack of effect of the FIFA 11+ to the teams' low training frequency. They also observed a decline in player motivation across the season and suggested that the FIFA 11+ requires more variation and individualisation for the specific setting of male veteran soccer.[137] A recent cluster RCT described a modified FIFA 11+ program tailored to younger children,[138] with the authors reporting a positive effect of the program on balance and agility.

Knäkontroll was developed by SISU Idrottsböcker in Sweden and has been promoted by the Swedish Football Association.[127 139] The program consists of six exercises focussing on knee control and core stability and takes approximately 15 minutes to complete. Each exercise has four steps of progressive difficulty, along with the option of partner exercises.[127] In a cluster RCT, reported by Waldén and co-authors,[127] Knäkontroll was evaluated in over 4500 Swedish female players aged 12–17 years. The program reduced the rate of ACL injury by 64%. A secondary analysis of this RCT, reported by Hägglund et al,[140] investigated the association between injury rates and compliance levels. Players with high compliance (upper tertile) had an 88% reduction in the ACL injury rate, a 90% reduced rate of severe knee injuries and 72% reduction in the rate of acute knee injuries, compared to players with low compliance (lower tertile).[140] A significant deterioration in compliance, at both team and player level, were observed over the season, most notably in the low-compliance tertile.

A multi-faceted IPEP, including strength, balance, agility and stretching exercises, was evaluated in youth indoor soccer players by Emery and co-workers.[141] The IPEP was delivered as a warm-up program with the addition of home-based balance training. The authors reported a 38% reduction in the rate of overall injuries and a 43% reduction in the rate of acute-onset injuries. Self-reported compliance to the home-based balance training was poor (<15%).[141] A further multi-faceted IPEP, called Prevent Injury and Enhance Performance (PEP), consists of strengthening, stretching, plyometric and agility exercises, and has been investigated in two studies.[100 128] Mandelbaum and co-workers conducted a prospective cohort study in 2003, involving over 5000 female youth players.[100] Non-contact ACL studies were reduced by 88% in the first season and 74% in the second season of the study. Following this, a cluster RCT evaluated the preventive effect of the PEP program in over 1400 amateur female players.[128] The intervention group sustained significantly fewer ACL injuries in training compared to the control group (0 vs. 6). A non-significant reduction in match injuries (7 vs. 12) was also recorded for the intervention group.[128] Labella and colleagues[142] trialled an IPEP consisting of strength, plyometric, balance and agility exercises in high school basketball and soccer coaches, reporting a 52% reduction in the rate of gradual onset injuries and a 67% reduction in the rate of acute injuries. In this trial, only 95 of the 258 (37%) targeted coaches agreed to participate.[142]

As the volume of published trials on IPEPs for soccer and other team ball sports has grown, a number of systematic reviews evaluating the efficacy of IPEPs have emerged. Rössler and co-authors[143] conducted a systematic review and meta-analysis on the effect of IPEPs in youth sport. Nine of the 21 studies included in the quantitative analysis focused exclusively on soccer, whilst a further four multi-sport studies included soccer. The authors concluded that IPEPs can reduce injuries in organised youth sports by 46%, with programs which included plyometric exercises showing a greater preventive effect.[143] The effect of IPEPs in youth sport was also the focus of a systematic review and meta-analysis conducted by Emery and co-workers.[121] Among the 25 studies analysed, 11 focused solely on soccer, with a further four multi-sport studies including soccer. In the pooled results, IPEPs demonstrated a 36% reduction in the risk of LL injury. The authors concluded that IPEPs can effectively reduce injuries in various team ball sports, but stressed that low levels of adoption and maintenance of these programs are an ongoing concern.[121]

In a systematic review and meta-analysis with heterogeneous populations (military recruits, recreational and professional athletes), and interventions (e.g. FIFA 11+, Knäekontroll and PEP), Lauersen et al.[144] concluded that IPEPs can significantly reduce both acute injuries (35%) and overuse injuries (48%). Ten of the 25 analysed studies included soccer players. Analysis of individual exercise components suggested no preventive effect from stretching, but beneficial effects from strength, balance and multi-faceted interventions.[144] Earlier systematic reviews including (but not limited to) soccer by Hübscher et al.[145] and Herman et al.[146] also found support for the efficacy of IPEPs in pooled analyses. In contrast, another systematic review focussing solely on soccer, including six trials, found conflicting evidence for the efficacy of IPEPs.[147]

Other recent systematic reviews have restricted their focus to the preventive effect of F-MARC programs.[148-150] Most recently, Al Attar and co-workers[150] analysed five FIFA 11+ studies and four FIFA 11 studies in a systematic review and meta-analysis. The pooled results demonstrated significant reductions in overall injuries (35%) and LL injuries (39%) among teams using the FIFA 11+. However, in the case of the FIFA 11, a 33% injury reduction did not reach statistical significance.

Taken together, the above research findings provide considerable support for the efficacy of IPEPs for soccer. However, a number of studies highlight the importance of achieving adequate IPEP adoption and compliance to enhance the ultimate impact of these programs.

1.1.2.7 Understanding the Implementation context (TRIPP step 5)

TRIPP step 5 focuses on understanding the setting in which an injury prevention strategy is to be delivered. This involves identifying and analysing aspects of the targeted setting which could facilitate or hinder the successful delivery of an IPEP. The previous section included a number of studies from amateur soccer settings which highlighted the importance of achieving adequate IPEP compliance.[135 136 140] However, there is currently a lack of published information on the barriers and facilitators to IPEP implementation in professional male soccer, and no published information in professional male youth soccer. The challenge in convincing professional teams to use evidence-based injury prevention exercises was recently demonstrated by Bahr et al.[151] The authors found very low levels of adoption of a hamstring lowers program among top professional teams, despite the program's proven efficacy and 88% of the teams being familiar with it. The authors

concluded that adoption of the program was too low to expect any impact on the rate of hamstring injury. Another recent survey, including 44 professional teams, found hamstring lowers to be ranked fifth among the preferred preventive exercises, as rated by staff members.[152] In 2016, McCall and co-workers[153] reported a survey of head medical officers from 34 teams in the UEFA ECIS. The level of coach compliance to injury prevention measures, as reported by the medical officers, was generally high. However, the level of player compliance was highly variable across teams, with only 4 teams reporting full compliance from all player and 17 teams reporting either 'low' or 'no adherence' in up to 50% of their players. Ninety-four percent of the teams rated player compliance as either "essential" or "very important" to preventing injuries in professional soccer teams. The authors concluded that the lack of high player compliance may be limiting the effectiveness of injury prevention programs in professional soccer teams.[153]

In other soccer settings, Frank and co-workers[154] demonstrated that the attitudes of coaches from elite junior female teams can be positively influenced by an injury prevention workshop, but high levels of coach intention to implement IPEPs did not ensure actual adoption of programs. Norcross et al.[155] highlighted the challenges which IPEPs can face in a high school soccer and basketball setting. Despite 52% of coaches being aware of IPEPs, just 21% reported using one, and a mere 9% performed the program as originally intended. Similarly, Joy et al.[156] reported only 20% of coaches from youth female teams using an IPEP. A three-year follow-up to a Knäkontroll trial, by Lindblom and colleagues,[139] evaluated maintenance of the program in the context of Swedish youth female soccer. This is one of very few IPEP trials in soccer with a follow-up period beyond one season.[157] The authors found high levels of knowledge and adoption of the Knäkontroll program, both among coaches involved in the original trial and other active coaches in female youth teams. However, compliance with the original program was low; only 23% of the still active trial coaches used Knäkontroll without modification, while the corresponding level among other active coaches was 26%.[139]

1.1.2.8 Evaluating injury prevention under real-world conditions (TRIPP step 6)

The final stage of the TRIPP framework involves evaluating the effectiveness of an efficacious IPEP under less-controlled, real-world conditions.[26] No studies have addressed this step in professional soccer settings and only one has been conducted in any level of soccer participation. Junge et al.[11] evaluated the nation-wide

implementation of coach education in the FIFA 11 in non-elite soccer settings. Samples of coaches were interviewed in 2004 and again in 2008, with 30% of the coaches from the first sample also included in the second. In 2008, 80% of coaches were aware of the FIFA 11 and 57% reported performing the program, in part or full. The teams of coaches using the program in 2008 had a 12% lower incidence of injuries in matches and a 25% lower incidence of injuries in training, compared to other teams.[11]

1.1.3 Summary

The majority of research on injury prevention in male professional soccer has focussed on establishing the extent and nature of the problem (TRIPP step 1) and the risk factors for injury (TRIPP step 2). Recent results from sub-analyses of the UEFA ECIS have contributed substantially to the body of research knowledge relating to these initial steps of the TRIPP model. However, there remains a paucity of published research relating to the subsequent TRIPP steps. A number of studies have evaluated the efficacy of IPEPs in soccer (TRIPP step 4), but prior laboratory research evaluating their ability to modify risk factors (TRIPP step 3) is scarce. Major knowledge gaps are also evident relating to the implementation aspects of IPEPs (TRIPP steps 5 and 6). Even highly efficacious programs (as evidenced by RCTs) can fail to reduce real-world injuries due to a lack of adoption, program fidelity or maintenance by the targeted users.[26 158] The original research reports and systematic reviews summarised above, provide considerable support for the efficacy of IPEPs in non-professional soccer settings, while also highlighting the challenges in achieving adequate IPEP compliance and the superior preventive effects in players with high program compliance.[135 136 140] Implementation challenges at the organisational levels of the soccer system are also evident; Bizzini and Dvorak[159] recently reported just 10% of national governing bodies having endorsed the FIFA 11+, despite the considerable research and dissemination efforts by FIFA since 2006. Emery and co-authors[115] concluded their recent systematic review on IPEPs by stressing the need for a shift in research focus:

> *"Lack of uptake and ongoing maintenance of such programmes is an ongoing concern. A focus on implementation is critical to influence knowledge, behaviour change and sustainability of evidence informed injury prevention practice."* [121 (page 865)]

In order to enhance the real-world impact of IPEPs in professional soccer, a focus on improved implementation is now needed.

1.2 RESEARCH AIM AND QUESTIONS

1.2.1 Research Aim

The overall aim of this research was to identify facilitators and barriers to implementing injury prevention exercise programs (IPEPs) in professional male soccer settings. Due to the lack of published literature specific to professional soccer settings, the initial focus was broadened to include IPEPs in all team ball sport settings.

1.2.2 Research Questions

In order to achieve this overall aim, the following specific questions were addressed:

1. Can the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework be applied to the context of reviewing published team ball sport IPEP trial reports?
2. What is the current state of published knowledge on the implementation of IPEPs in team ball sports?
3. What are the facilitators and barriers to implementing IPEPs in professional senior male soccer?
4. What are the facilitators and barriers to implementing IPEPs in professional youth male soccer?

1.3 RESEARCH CONTEXT

The primary research setting was a European professional male soccer club, which wished to remain anonymous. In addition to the club's highest-level team, competing nationally and in UEFA championships, four teams from the club's development academy were included in the project. The academy is designed to develop the next generation of young, talented players for the first team. Such academies are common across Europe.[33] Three studies from this thesis (Papers six, seven and eight) focus on teams in the club's academy. The club is also affiliated with three other professional male soccer clubs in different countries. The first-team players and staff members from all four clubs participated in one study in this thesis (Paper five).

1.4 THESIS OVERVIEW

This PhD research is presented as a thesis by publication, with five chapters and eight original publications (Table 1.3). To set the scene, the current chapter concludes with a published peer-reviewed editorial, providing an overview of the current "state-of-play" in team ball sport injury prevention research. Chapter Two focuses on reviewing the published literature on team ball sport injury prevention (IPEP) trials. In order to evaluate the literature from an implementation perspective, an established framework from the field of health promotion was employed: the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework. The chapter begins with a published editorial describing the initial challenges faced in applying RE-AIM to this context, along with the key information which needed to be extracted from trial reports to overcome these challenges. A screening worksheet was developed to assist reviewers in extracting this key information, and then applied to reviewing the published literature on team ball sport IPEPs in a systematic review. This preliminary research then led to a second systematic review with full application of the RE-AIM framework.

Having identified gaps in the existing literature, the research then focused on addressing these gaps within the specific implementation context of professional male soccer. To identify potential implementation facilitators and barriers, two cross-sectional surveys were performed (Chapter Three). These studies explored the perceptions of professional soccer players and team staff members towards injury prevention in general and, more specifically, injury prevention exercise programs.

Chapter Four includes two papers from a prospective observational study of IPEP implementation in a professional soccer academy. These papers assessed the use and modification of injury prevention exercise programs in four teams, across one season. An extensive list of IPEP implementation facilitators and barriers, experienced by staff members, was identified.

Finally, Chapter Five summarises the results of the entire body of research in relation to the project's aim and questions. The strengths and weaknesses of the overall body of research in this thesis are discussed along with recommendations for future research.

Table 1.3 Thesis structure

Chapter	Content	Aims
1	Introduction	
	Background Paper 1: It will take more than an existing exercise program to prevent injury. British Journal of Sports Medicine 2015[1]	1. To review relevant background literature. 2. To define research aims and questions. 3. To describe the research context. 4. To outline the thesis structure.
2	Systematic reviews	
	Paper 2: The three must-do's of intervention reporting: enhancing sports injury prevention research. British Journal of Sports Medicine 2014[2] Paper 3: A systematic review of core implementation components in team ball sport injury prevention trials. Injury Prevention 2014[3] Paper 4: The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework. Sports Medicine 2014[4]	1. To describe the challenges in applying the RE-AIM framework to reviewing team ball sport trial reports. 2. To identify which key information is necessary to apply RE-AIM to reviewing literature in this context. 3. To evaluate the extent to which this key information in reported in published team ball sport IPEP trial reports. 4. To assess the reporting of team ball sport IPEP trials against the full RE-AIM framework. 5. To identify current knowledge gaps.
3	Cross-sectional surveys	
	Paper 5: Injury prevention exercise programs for professional soccer: understanding the perceptions of the end-users. Clinical Journal of Sports Medicine 2016[5] Paper 6: Injury prevention exercise programs in professional youth soccer: understanding the perceptions of program deliverers. BMJ Open Sport & Exercise Medicine 2016[6]	1. To evaluate the perceptions of players and staff members, in professional adult male soccer teams, regarding Injury prevention, IPEPs and the FIFA 11+. 2. To evaluate the perceptions of staff members, in professional youth male soccer teams, regarding Injury prevention, IPEPs and the FIFA 11+.

Table 1.3 Thesis structure (continued)

4	Prospective observational study	
	Paper 7: The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+. Paper 8: The use and modification of individual FIFA 11+ exercises by professional youth soccer teams.	1. To describe the use and modification of IPEPs, over one season, in professional youth soccer teams. 2. To compare the delivery and content of IPEPs chosen by professional youth soccer teams to the industry-standard IPEP, the FIFA 11+. 3. To evaluate the facilitators and barriers to implementing IPEPs in professional youth soccer teams.
5	Conclusion	
		1. To discuss strengths and limitations of the thesis research. 2. To summarise the key research findings. 3. To discuss recommendations for future research.

1.5 PAPER ONE

O'Brien J, Donaldson A, Finch CF. It will take more than an existing exercise programme to prevent injury. Br J Sports Med 2015;50:264-5.[1]

1.5.1 Overview

The first paper in this PhD thesis provides an overview of the current "state-of-play" in team ball sport injury prevention research. Recent publications relating to the Swedish Knäkontroll program[127 139] are employed to demonstrate the challenges involved in translating an efficacious IPEP into widespread, real-world practice. Following this, the key aspects of successful implementation are summarised. As this paper is aimed at both sports medicine researchers and practitioners, the use of complicated language and models from implementation science was purposely avoided.

The following paper, 'It will take more than an existing exercise program to prevent injury" was accepted for publication by the British Journal of Sport Medicine on June 17 2015 and was originally published "Online First" on July 9, 2015. The paper was subsequently published in 2016, Volume 50(5), page 264–265 and can be accessed via the following link: doi:10.1136/bjsports-2015-094841. Reproduced with permission of BMJ Publishing Group Ltd.

1.5.2 Manuscript

Declaration for Paper 1

O'Brien J, Donaldson A, Finch CF. It will take more than an existing exercise programme to prevent injury. Br J Sports Med 2015;50:264-5.

Declaration by candidate

For Paper 1, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept and writing up of the manuscript.	85%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept and the writing up of the manuscript
Dr. Alex Donaldson	Contributed to the concept and the writing up of the manuscript

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal Supervisor's Signature		Date 18.05.2016

It will take more than an existing exercise programme to prevent injury

James O'Brien, Alex Donaldson, Caroline F Finch

In 1983, Ekstrand *et al*[1] published the first randomised controlled trial (RCT) of an injury prevention programme for team ball sport. Three decades on from this landmark study, it is worth reflecting on the progress made and the current 'state-of-play' in the field of team ball sport injury prevention research. The volume of published research has grown considerably with a recent systematic review of team ball sport injury prevention exercise programmes (IPEPs) identifying over 50 published trials.[2] The scale, quality and outcomes of recent RCTs are also encouraging with a Swedish trial including over 4500 female soccer players and demonstrating a 64% reduction in the rate of anterior cruciate ligament (ACL) injuries.[3]

In 2013, a subsequent subanalysis of the original Swedish RCT, published in this journal, highlighted the importance of adequate IPEP compliance in preventing injuries. The ACL injury rate was 88% lower in highly compliant players, compared to those with low compliance.[4] A 3-year follow-up,[5] also published in this journal, investigated if coaches from the original trial and others in the same target population were still using the IPEP, and found that many had modified it (74–77%) or had not implemented it regularly across the season (52–60%). Others did not know about the programme, or had chosen not to adopt it.[5]

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HOW BIG IS THE PROBLEM?

Considering that only compliant players had a reduced injury rate in the original RCT, the results of the above implementation study are of concern and demonstrate that it takes more than the existence of an IPEP to prevent injury. Even highly efficacious IPEPs risk losing much of their effect under real-world conditions, unless they are successfully adopted, implemented and maintained. A major challenge currently facing injury prevention in team ball sports is translating the positive outcomes of RCTs into injury reductions under real world, less controlled conditions. Unfortunately, little guidance is available in the sports medicine literature to help researchers and clinicians tackle this challenge. Our recent systematic review evaluating 52 published IPEP trials using the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework[2] identified major gaps in the reporting of key implementation aspects, particularly those relating to Adoption and Maintenance. The proportion of trials reporting the RE-AIM's eight items of adoption averaged just 4%. The corresponding figure across the nine measures of maintenance was less than 1%.[2]

WHAT CAN BE DONE?

While numerous IPEPs with demonstrated efficacy exist, making a significant real-world impact on sport injuries now requires specific focus on enhancing implementation. Adopting frameworks from the field of health promotion and implementation science can provide guidance on how to do this.[6 7]

REACH THE TARGET AUDIENCE

To maximise preventive impact, IPEP implementation needs to target multiple levels of the team ball sport system, including players (the health beneficiaries), coaches and other staff (the IPEP deliverers) and administrators (the policymakers).[6 8] Reaching the target audience can be enhanced by embedding IPEPs in coach education, using social media and endorsement of IPEPs by sporting organisations and high-profile figures. All target groups need to understand the relevant benefits (eg, injury reduction, physiological benefits and improved team performance) and potential negative side effects (eg, muscle soreness).

ENHANCE ADOPTION

Having knowledge of an IPEP, and good intentions to use it, do not ensure adoption. Key considerations are *how* an IPEP will be delivered and by *whom*. Consulting all levels of the system when developing IPEPs and their related implementation plans can identify potential barriers to programme adoption (eg, lack of knowledge, time or programme acceptance).[2 7] These barriers can be tackled with appropriate programme development or modification, information, training, funding, incentives and policies.

SUPPORT IMPLEMENTATION

Coaches and sports medicine staff often modify IPEPs, most likely to improve the fit with their specific practical context, without knowing how this impacts programme effectiveness. They also frequently fail to implement IPEPs regularly and consistently.[5] Programme fidelity can be enhanced through adequate resourcing (manuals, apps, online resources, etc), training, feedback and mentoring.[7]

PROMOTE MAINTENANCE

Finally, players, coaches and administrators need support to maintain IPEP implementation over multiple seasons. A key here is establishing systems, policies and procedures at the team, club, league and association level.[6] In addition, ongoing support in the form of evaluation, funding and mentoring are needed.

CONCLUDING REMARKS

Three decades on from Ekstrand *et al*'s[1] landmark study, significant progress has been made in the field of team ball sport injury prevention. The existence of efficacious IPEPs demonstrates what *could* be done. Unfortunately, the question of how best to do it remains unanswered.[2] By focusing research efforts on understanding IPEP implementation, along with better reporting of key implementation components to inform others of how to improve their prevention programme delivery, future decades of sports injury prevention research will ensure IPEPs are not only efficacious, but also highly effective under real-world conditions.

Twitter Follow James O'Brien at @_jamesobrien and Caroline Finch at @CarolineFinch

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1.5.3 Summary

This first paper set the scene for the PhD thesis by outlining the current state of research in the field and highlighting the need for future research focussed on the implementation aspects of IPEPs. The following sections of the research thesis address this research need, both through a novel evaluation of the existing literature from an implementation perspective, and original research on IPEP implementation in professional soccer settings.

2.0 SYSTEMATIC REVIEWS

2.1 OVERVIEW OF CHAPTER TWO

An important first step in this research was evaluating the existing knowledge base relevant to the topic. In view of the paucity of published information on IPEPs in the specific context of professional soccer, it was decided to broaden the initial focus to include all team ball sports. It was anticipated that reported information on IPEP implementation in other sports (e.g. Australian Football, Handball and Volleyball) would also hold relevance to the aims of this current research. A number of published systematic reviews have evaluated team ball sport IPEPs from an efficacy perspective,[121 144 145 150] but no systematic review, prior to this current research, had evaluated IPEPs from an implementation perspective. As highlighted by the first paper in this thesis, these implementation aspects strongly influence the ultimate real-world impact of IPEPs. In order to evaluate the literature through an implementation lens, an established Health Promotion framework was employed, called the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework.[160]

This chapter includes three papers published in peer-reviewed journals. The first paper is an editorial describing key aspects of applying the RE-AIM framework to the context of sport injury prevention. This is followed by two systematic reviews evaluating the reporting of implementation aspects in published team ball sport injury prevention trials.

2.2 PAPER TWO

O'Brien J, Donaldson A, Barbery G, Finch CF. The three must-do's of intervention reporting: enhancing sports injury prevention research. *Br J Sports Med*. 2014 48: 1267.[2]

2.2.1 Overview

As the RE-AIM framework has not previously been applied to the specific context of reviewing sports injury prevention literature, a pilot trial was performed. A version of the RE-AIM framework specifically developed for reviewing purposes, called the RE-AIM Model Dimension Items Checklist (MDIC),[161] was employed. Four reviewers independently applied the RE-AIM MDIC to assessing the reporting of five team ball sport IPEP trials, before meeting to discuss the findings. The reviewers experienced considerable difficulties in applying the RE-AIM MDIC to this context and in reaching consensus among reviewers. The reasons for these difficulties and the associated implications for the future reporting of sports injury prevention research are the focus of this paper.

The following paper, “The three must-do’s of intervention reporting: enhancing sports injury prevention research” was accepted for publication by the British Journal of Sport Medicine on August 5, 2013 and was originally published “Online First” on September 3, 2013. The paper was subsequently published in 2014, Volume 48, page 1267-1269 and can be accessed via the following link: doi:10.1136/bjsports-2013-092913. Reproduced with permission of BMJ Publishing Group Ltd.

2.2.2 Manuscript

Declaration for Paper 2

O'Brien J, Donaldson A, Barbery G, Finch CF. The three must-do's of intervention reporting: enhancing sports injury prevention research. *Br J Sports Med*. 2014 48: 1267.

Declaration by candidate

For Paper 2, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept and writing up of the manuscript.	85%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept and the writing up of the manuscript
Dr Alex Donaldson	Contributed to the concept and the writing up of the manuscript
Gaery Barbery	Contributed to the writing up of the manuscript

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal Supervisor's Signature		Date 18.05.2016

The three must-do's of intervention reporting: enhancing sports injury prevention research

James O'Brien, Alex Donaldson, Gaery Barbery, Caroline F Finch

Injuries in team ball sports (eg, soccer, handball, volleyball and basketball) are common, accounting for 44% of all non-fatal sports injuries in the 27 EU Nations.[1] Combined with high participation rates, this gives team ball sports the potential to pose significant health burdens, and highlights the importance of preventing injuries in this context.

As neuromuscular injury prevention programmes for team ball sports gain increasing attention,[2–7] the need to establish the effectiveness of these interventions in real-world sports settings has been emphasised.[8–13] Conceptual models and frameworks from the broader field of health promotion can potentially facilitate the translation of efficacious interventions into practice, and examples of applying implementation science to sports injury prevention have been reported.[9 14 15]

The RE-AIM framework[16 17] was developed to enhance the translation of research into practice, and has been applied in such diverse fields as falls prevention,[18] weight loss[19] and mental health.[20] Recently, an extension of the framework specific to the community sport context, the RE-AIM Sports Setting Matrix, has also been developed (table 1).[14] The RE-AIM framework can be applied across all research phases, from planning and implementation, to reporting and reviewing.[17] However, there have been very few assessments of how RE-AIM has actually been used in any context. Recently, the RE-AIM Model Dimension Items Checklist (MDIC) was developed to assist the reviewing of project grant applications.[21] This checklist comprises 31 items covering the five RE-AIM dimensions of Reach (4 items), Effectiveness (5 items), Adoption (8 items), Implementation (5 items) and Maintenance (9 items).[16 21]

While reviewing the literature on injury prevention studies in team ball sports, we attempted to use the RE-AIM MDIC[21] as a tool to appraise the quality of implementation reporting in these studies. We independently applied the RE-AIM MDCI to five purposively selected reports of neuromuscular programme trials of varying design, before meeting to discuss the findings.

While we found the RE-AIM MDIC to be relatively clear, considerable problems arose when attempting to extract information corresponding to individual RE-AIM MDIC items from the study reports. This was due to large discrepancies between the reporting requirements of the RE-AIM MDIC, and the design or reporting style of the selected studies. To reach a consensus on the reporting of RE-AIM MDIC items, assessors required critical information to address three interrelated questions.

1. WHO IS THE INTERVENTION TARGET?

In the context of team ball sports, the end beneficiaries of any injury prevention

Table 1 The RE-AIM Sports Setting Matrix[14]

	Level of assessment/intervention setting or target					
RE-AIM Dimension	National Sporting Organisation	State/Provincial Sporting Organisation	Regional Association or League	Club	Team	Participant
Reach						
Effectiveness						
Adoption						
Implementation						
Maintenance						

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efforts will be the players. However, players are not always directly targeted by researchers. An example is when researchers educate and train coaches to deliver a neuromuscular programme to their players. In such cases, there is a need to distinguish between the targeted health beneficiaries (the players), and the target of the researchers' intervention (the coaches). In studies employing a cluster-randomised trial design, differentiation between clusters (teams) and individuals within those clusters (players) is also necessary. The RE-AIM MDIC refers to 'participants', but when applying this to published studies, confusion can occur as to whether the participants are the players, teams, coaches or a combination of these.

2. WHAT IS THE INTERVENTION?

In the above example of educating and training coaches to deliver a neuromuscular programme to players, there are two levels of interaction taking place: one between researchers and coaches, and the other between coaches and their respective players. This can lead to confusion if the reporting of studies does not clarify whether the intervention is the coach education delivered by the researchers, the neuromuscular injury prevention programme delivered by the coaches, or both. The two levels of interaction might best be distinguished by the terms 'researcher intervention' and 'injury prevention intervention'. Clearly, different outcome measures should be applied to these different intervention types; adoption and implementation by coaches in the case of the researcher intervention, and changes in injury incidence in the case of the injury prevention intervention. Confusion arises if authors do not clearly specify which type of intervention their reporting refers to.

3. WHO DELIVERED THE INTERVENTION AND WERE THEY UNDER RESEARCHER CONTROL?

The coaches who deliver an injury-prevention intervention to their players are 'delivery agents' in RE-AIM terms, and the RE-AIM MDIC dedicates an entire category to these individuals. However, the applicability of this category will differ across studies. In some, the delivery agents are coaches, sport scientists or physiotherapists already affiliated with teams,[4 22 23] but in others the delivery agents are employed, trained and controlled by the researchers.[24–26] In the latter case, these individuals are essentially part of the research team, and RE-AIM MDIC items addressing their choices and behaviour are less applicable or relevant. Confusion arises when authors do not report the presence or role of delivery agents, and the extent to which these individuals were under researcher control.

WHY IS THIS IMPORTANT?

When it is not possible to clearly answer these three questions from the information provided in a study report, using the RE-AIM MDIC is particularly challenging. When we used the RE-AIM MDIC to assess the reporting of five selected studies, the most common difficulty we encountered was extracting and distinguishing specific information about the health beneficiaries (eg, players), delivery agents (eg, coaches) and settings (eg, clubs). This information was often entangled within the general term 'team'. For example, when authors reported the percentage of invited teams who adopted an intervention, it was often unclear if it was the players, coaches, medical staff, club administrators or a combination of these making the decision. Similarly, when authors reported the percentage of invited players who agreed to participate in an intervention, it was often unclear if individual players chose to participate, or if the decision was made by a coach or administrator on their behalf. This detailed information is important to accurately identify the precise barriers to injury prevention implementation in team ball sports, and hence inform future research efforts.

WHAT IS THE DIFFERENCE BETWEEN A TEAM AND A CLUB?

Frequently, distinguishing between the terms 'setting' and the 'individual' as used by RE-AIM, is also hampered by authors using the terms 'clubs' and 'teams' synonymously. We feel the distinction between a 'team', as a cluster of individual players, and a 'club' as the setting for one or more teams, is extremely important. Coaches are usually aligned to a particular team, but a club may encompass a number of teams and coaches. The decision to adopt, or not adopt an injury prevention intervention may involve different individuals at the team-level (eg, team coach, senior players), as opposed to the club-level (eg, club president, club manager).[14] For the progression of sports injury implementation science, gleaning information on the specific behaviour of individuals and their role within the sports delivery sector is paramount.

SPECIFIC RECOMMENDATIONS FOR REPORTING

Although none of the studies we reviewed specifically used RE-AIM in their design or reporting, a number of criticisms and limitations we identified apply more generally to all intervention implementation studies, whether or not they are based on RE-AIM principles. In our experience, most of the published sports injury prevention implementation studies to date suffer from this. Moreover, reporting of study elements such as generalisability of results, eligibility criteria and attrition rates overlap with components of the CONSORT statement[27] and its extension to cluster randomised trials.[28]

While frameworks such as RE-AIM can potentially help navigate the complexities of the implementation process and the reporting of implementation studies, clarification of how the RE-AIM components directly relate to various study designs is necessary. Reporting information on core implementation components,[29] including the target group, the nature of the intervention, and the delivery agents, should be a minimum requirement of all intervention implementation studies, as these factors all impact on the intervention's generalisability and reproducibility.

Contributors JO designed the study and led its conduct. He selected the papers for review and had the major role in paper writing. This work was led by JO as part of his PhD studies, supervised by CFF. All other authors independently reviewed the selected papers, participated in the consensus discussions and contributed to the writing of the paper.

Competing interests Authors JO and GB were supported by University of Ballarat Postgraduate Scholarships. CFF was supported by an NHMRC Principal Research Fellowship (ID:565900).

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2.2.3 Summary

This paper discussed the challenges involved in applying the RE-AIM framework[160] to reviewing published team ball sport IPEP trial reports, along with the key information required to overcome these challenges. This was an important initial step towards employing the RE-AIM framework to systematically review the published literature. The findings also hold broader relevance for the reporting of all sport injury prevention intervention trials.

2.3 PAPER THREE

O'Brien J, Finch CF. A systematic review of core implementation components in team ball sport injury prevention trials. *Inj Prev*. 2014: 20: 357-362.

2.3.1 Overview

Having identified the key information which needed to be extracted from IPEP trial reports in order to apply the RE-AIM framework, a systematic review was conducted to assess the extent to which this information is reported in team ball sport injury prevention trial reports. The term "core implementation components" was adopted from the field of Implementation Science to describe this key information.[162] In order to develop consensus among reviewers, a worksheet was developed to assist the identification of core implementation components in published trial reports. It was anticipated that a two-stage process, in which reviewers first reached consensus on the reporting of these basic components, would facilitate the subsequent full application of the RE-AIM MDIC.[161]

The following paper, "A systematic review of core implementation components in team ball sport injury prevention trials" was accepted for publication by Injury Prevention on March 3, 2014 and was originally published "Online First" on April 4, 2014. The paper was subsequently published in 2014, Volume 20, page 357-362 and can be accessed via the following link: doi:10.1136/injuryprev-2013-041087. Reproduced with permission of BMJ Publishing Group Ltd.

2.3.2 Manuscript

Declaration for Paper 3

O'Brien J, Finch CF. A systematic review of core implementation components in team ball sport injury prevention trials. *Inj Prev*. 2014: 20: 357-362.

Declaration by candidate

For Paper 3, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	90%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, the coding of studies, interpretation of results and the writing up of the manuscript.

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principle Supervisor's Signature		Date 18.05.2016

A systematic review of core implementation components in team ball sport injury prevention trials

James O'Brien, Caroline F Finch

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/injuryprev-2013-041087).

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ABSTRACT

Background Recently, the use of specific exercise programmes to prevent musculoskeletal injuries in team ball sports has gained considerable attention, and the results of large-scale, randomised controlled trials have supported their efficacy. To enhance the translation of these interventions into widespread use, research trials must be reported in a way that allows the players, staff and policymakers associated with sports teams to implement these interventions effectively. In particular, information is needed on core implementation components, which represent the essential and indispensable aspects of successful implementation.

Objectives To assess the extent to which team ball sport injury prevention trial reports have reported the core implementation components of the intervention, the intervention target and the use of any delivery agents (ie, staff or other personnel delivering the intervention). To summarise which specific types of intervention, intervention target and delivery agents are reported. To develop consensus between reviewers on the reporting of these components.

Methods Six electronic databases were systematically searched for English-language, peer-reviewed papers on injury prevention exercise programme (IPEP) trials in team ball sports. The reporting of all eligible trials was assessed by two independent reviewers. The reporting of the three core implementation components were coded as 'yes', 'no' or 'unclear'. For cases coded as 'yes', the specific types of interventions, intervention targets and delivery agents were extracted and summarised.

Results The search strategy identified 52 eligible trials. The intervention and the intervention target were reported in all 52 trials. The reporting of 25 trials (48%) specified the use of delivery agents, the reporting of three trials (6%) specified not using delivery agents, and in the reporting of the remaining 24 trials (46%) the use of delivery agents was unclear. The reported intervention type was an IPEP alone in 43 trials (83%), education/instruction in how to deliver an IPEP in three trials (6%) and multiple types of interventions (including an IPEP) in six trials (12%). Players were the most commonly reported intervention target (88%, n=46), followed by multiple targets (8%, n=4) and coaches (4%, n=2). Of the 25 trials for which delivery agents were reported, 13 (52%) reported a single type of delivery agent and 12 (48%) multiple types. The types of delivery agents reported included coaches, physiotherapists, athletic trainers and team captains.

Conclusions The current reporting of core implementation components in team ball sport IPEP trials is inadequate. In many trial reports, it is unclear whether researchers delivered the IPEP directly to players themselves or engaged delivery agents (eg, coaches, physiotherapists, athletic trainers) to deliver the programme. When researchers do interact with delivery agents, the education/instruction of delivery agents should be acknowledged as an intervention component and the delivery agents as an intervention target. Detailed reporting of implementation components in team ball sport IPEP trials will facilitate the successful replication of these interventions by intended users in practice and by researchers in other studies.

INTRODUCTION

Injuries in team ball sports (eg, soccer, basketball and volleyball) are common. In the European Union, team ball sports injuries account for 44% of all hospitalised sports injuries,[1] and in the USA, the three sports resulting in the highest number of hospitalisations in young athletes are football, basketball and soccer.[2] The high treatment costs and loss of sports participation associated with these injuries highlight the importance of injury prevention in this context.[3 4]

Recently, there has been considerable interest in strategies to prevent team ball sport injuries, and in particular the use of injury prevention exercise programmes (IPEPs) specifically designed to reduce musculoskeletal injuries.[5–9] Examples of IPEPs are the 'FIFA 11+',[6] the 'PEP' programme,[10 11] 'Knaekontroll'[9] and 'PAFIX'.[12] These programmes generally consist of a combination of balance, plyometric, stability and sport-specific exercises targeting established lower limb injury risk factors.[13 14] The results of recent published trials support the efficacy of team ball sport IPEPs.[6 7 9 15] The FIFA 11+ reduced overall injuries by 32%, overuse injuries by 53% and severe injuries by 45% in female soccer players.[6] The 'Knaekontroll' programme resulted in a 64% reduction in the rate of anterior cruciate ligament injury in female soccer players.[9] A 68% reduction in the number of injured players was reported following implementation of the FIFA 11+ in male basketball players,[15] and implementation of an IPEP in female handball players resulted in a 49% reduction in the risk of acute ankle and knee injuries.[16]

While establishing efficacy is an important step in building the evidence base for team ball sport IPEPs, it has been emphasised that efficacy alone is not enough.[17–22] As articulated by Sogolow *et al*[22]:

> For many years, injury prevention researchers have assumed that an intervention deemed efficacious in an experimental setting will easily (or often automatically) be translated to the field of practice. Unfortunately, this is not the case. (page 494)

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Without high-quality implementation, no evidence-based intervention will fully achieve its intended effects in real life.[17–27] In addition to information on *what* can be done to prevent injuries (eg, details of an efficacious IPEP's design), the players, staff and policymakers of sports teams need high-quality information on *how* it can be done in practice (eg, the staff, training and resources required to implement an IPEP with success). While there is a paucity of knowledge on which factors influence the successful implementation of sports injury interventions,[19 28] in other research fields the most essential and indispensable aspects of programme implementation have been described.[23–25] These aspects have been termed 'core implementation components' (also known as 'implementation drivers' or 'core elements') and include the selection, training and evaluation of the staff who deliver an intervention.[22–24 29] Identifying and attending to core implementation components is seen as a key process in successfully translating interventions from research into practice.[22 23 28] In the context of team ball sport, injury prevention core implementation components relate to the sports team staff (eg, coaches, physiotherapists, athletic trainers) who deliver the programme to players.

Unfortunately, the reporting of many sports injury prevention trials contains very little or no information on precisely who delivered the intervention and exactly how it was delivered.[17 19 20 30] We recently reported the difficulties experienced when attempting to identify information on core implementation components from the reporting of five team ball sport IPEP trials.[30] A detailed evaluation of implementation components, as outlined in the RE-AIM framework,[31] was hindered by a lack of clear reporting of information relating to three basic components:

1. What is the intervention?
2. Who is the intervention target?
3. Who delivered the intervention and were they under researcher control?

A prerequisite to fully evaluating the reporting of core implementation components in team ball sport IPEP trials, and applying conceptual models such as the RE-AIM framework, is identifying and reaching consensus on these three basic components. Therefore, we conducted a systematic review of published trials on team ball sport IPEPs to assess the reporting of information related to these components. The specific aims were to

1. determine the extent to which IPEP trials reports have clearly reported the intervention, the intervention target and delivery agents;
2. summarise the types of intervention, intervention target and delivery agents reported in published trials;
3. to develop consensus between reviewers on the reporting of these components, as a precursor to applying the full RE-AIM framework to the reviewing of team ball sport IPEP trials.

The term delivery agents (also known as intervention agents) originates from the RE-AIM framework[31 32] and refers to the staff who deliver an intervention to the intended beneficiaries. As shown in figure 1, one approach to delivering an IPEP is for researchers to directly deliver the IPEP to players themselves; in other words, it is the researchers who have direct engagement with the players (figure 1A). A more common approach, however, is for the researchers to directly engage with others (the delivery agents) who they would then like to deliver the IPEP to players (figure 1B). For example, researchers might educate coaches or other team staff about how to deliver an IPEP and then require the coaches to deliver this to their players.

METHODS

Search strategy

The following electronic databases were systematically searched from their inception to 20 December 2012 by one of the authors (JO'B): PubMed, Medline, CINAHL, Embase, Scopus and the Cochrane Controlled Trials Register. Search terms were combined into the following search strings, representing key themes: ("Team sport" OR "Team sports" OR Soccer OR Football OR Rugby OR Gridiron OR Basketball OR Netball OR Hockey OR Handball OR Volleyball") AND (Program* OR Exercise* OR Training) AND (Injur*) AND (Prevent*). Additional articles were sought by scanning the reference lists of retrieved articles and by contacting experts.

Eligibility criteria

All identified records were pooled and duplicates removed. The titles and abstracts of all records were screened for eligibility by one of the authors (JO'B). Papers were included if they were English-language, peer-reviewed, reported an IPEP in team ball sport players and included an outcome related to changes in injury incidence. In the context of this review, an IPEP was defined as a structured exercise programme specifically aimed at preventing musculoskeletal injuries. Review papers, abstracts and case studies were excluded. A full list of eligibility criteria is shown in the online supplementary appendix 1. Full-text versions of all remaining trial reports were obtained, and eligibility screening was repeated.

Quality appraisal

The reports of all eligible trials were assessed by two independent reviewers using a purposely designed data extraction sheet. One data extraction sheet was used for each unique trial; in cases where multiple papers reported results from the same trial they were considered together. The content of the data extraction sheet was based on our three previously identified components relating to essential information when reporting sports injury prevention interventions.[17] The reporting of the intervention, the intervention target and delivery agents was coded as 'yes', 'no' or 'unclear'. In cases coded as 'yes', reviewers also extracted information to answer the following questions in the data extraction sheet: "What is the intervention?", "Who is the target?" and "Who are the delivery agents?"

The intervention was defined as the change in conditions trialled by the researchers. The intervention target was defined as the trial participants on whom the intervention was imposed. Delivery agents were defined as non-researchers who directly delivered the IPEP to players (eg, coaches). Two methods were used to calculate agreement between the two reviewers. The first method aimed to assess agreement on whether or not the intervention, the intervention target and delivery agents were reported, and only considered the coding of questions as 'yes', 'no' or 'unclear'. For this method, the percentage agreement for each of the three questions was calculated as (the number of trials with matching codes/the total number of trials)×100. The second method aimed to assess the level of agreement on extraction of information about the reported type of intervention, intervention target and delivery agents, and considered both the coding and answers to the data extraction questions. For this method, the percentage agreement for each question was calculated as (the number of trials with matching codes and answers/the total number of trials)×100. Percentage agreement was considered the most appropriate measure of reliability as only two

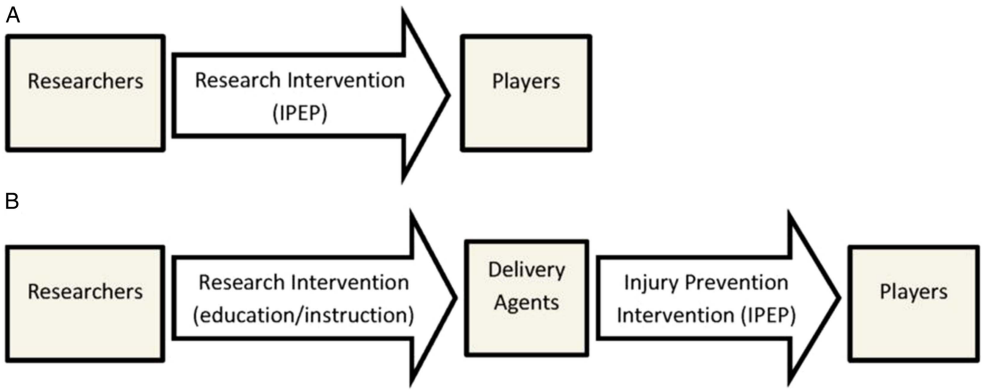

Figure 1 Illustration of two different methods of delivering an injury prevention exercise programme (IPEP). (A) The research team delivers an IPEP directly to players. The research intervention is the IPEP, and the intervention target is the players. (B) The research team educates and instructs delivery agents (eg, coaches) in how to deliver an IPEP to players. The research intervention is the education/instruction, and the target of the research intervention is the coaches. The injury prevention intervention is the IPEP, and the target of the injury prevention intervention is the players.

reviewers were involved, and the high prevalence of 'yes' codes was considered problematic for κ coefficients.

The two reviewers met to compare their results and reach agreement on the coding and answers of all eligible trials, through a process of discussion and mutual consensus. Trials were only coded as 'yes' or 'no' if the relevant information was explicitly reported. For example, trials were coded as 'yes' for the question relating to delivery agents if the use of multiple, non-researcher agents (eg, team staff) to deliver the programme to players was explicitly reported. Similarly, trials were coded 'no' if it was clearly reported that delivery agents were not involved (eg, trials in which researchers delivered an IPEP directly to players). All other trials were coded as 'unclear'. After consensus, the percentage of trials coded as 'yes', 'no' and 'unclear' for each question was calculated. From the consensus answers, the percentage of trials reporting each different type of intervention, intervention target and delivery agent was calculated.

RESULTS

The systematic search identified a total of 60 eligible papers, covering 52 unique intervention trials (figure 2). As multiple papers covering the same trial were considered together, the following results are presented in terms of the 52 trials.

The independent-review level of agreement when only considering the codes 'yes'/'no'/'unclear' was 100% for reporting of the intervention, 98% for reporting of the intervention target and 58% for the reporting of delivery agents. The level of agreement when also considering the reviewers' extraction of information in relation to "What is the intervention?", "Who is the target?" and "Who are the delivery agents?" was 79% for the intervention, 77% for the intervention target and 58% for delivery agents.

The consensus codes and extracted information agreed upon by the two reviewers are summarised below, and readers are referred to the online supplementary appendices 2 and 3 for a full listing of consensus codes and the reported interventions, intervention targets and delivery agents.

The reporting of the intervention and intervention target were coded as 'yes' for all 52 trials. For the reporting of delivery agents, 25 (48%) trials were coded as 'yes', 3 (6%) as 'no' and 24 (46%) as 'unclear'.

The types of reported research intervention and the proportion of trials for which each type was reported are summarised in figure 3. An IPEP was reported in all trials (as per eligibility criteria), and for 43 (83%) of the trials the IPEP was reported as the sole intervention. For three trials (6%), the education and instruction of coaches[3 33] or coaches and team captains[6] in how to deliver an IPEP was reported as the research intervention. For six trials (12%), multiple interventions (including an IPEP) were reported. The other types of interventions in these trials included the education and instruction of coaches, team staff, players or parents,[34–36] ankle orthoses[37 38] and a seven-part prophylactic programme.[39]

The types of intervention target and the proportion of trials for which each type was reported are shown in figure 4. Players were the reported target of the interventions in 46 (88%) of the included trials. In the reporting of two (4%) trials, coaches were the intervention target, while in four (8%) trials multiple targets, including coaches, team staff, parents and players, were reported.

Of the 25 trials with clear reporting of delivery agents, the types of delivery agents and proportion of trials for which each type was reported are shown in figure 5. A combination of delivery agent types (including coaches, physiotherapists, team captains and athletic trainers) was reported for 12 (48%) of the included trials. In the reporting of 10 (40%) trials, the delivery agents were all coaches, and in three (12%) trials, they were all physiotherapists.

Despite the presence of delivery agents being reported in 25 trials, only four (16%) of these identified the delivery agents as an intervention target, and the education and instruction of these delivery agents as an intervention.

DISCUSSION

This is the first systematic review to evaluate the extent to which interventions, intervention targets and delivery agents are reported in team ball sport IPEP trials. Accurate identification of these three components is a prerequisite to more extensive evaluation of implementation components.[30] In many of the trial reports included in this review, it was unclear whether researchers delivered the IPEP directly to players or engaged delivery agents (eg, coaches, physiotherapists, athletic trainers) to deliver the programme. Clear reporting of precisely how IPEPs were delivered in their intervention trials is necessary to facilitate the replication of these programmes by intended users in practice and by researchers in other studies.

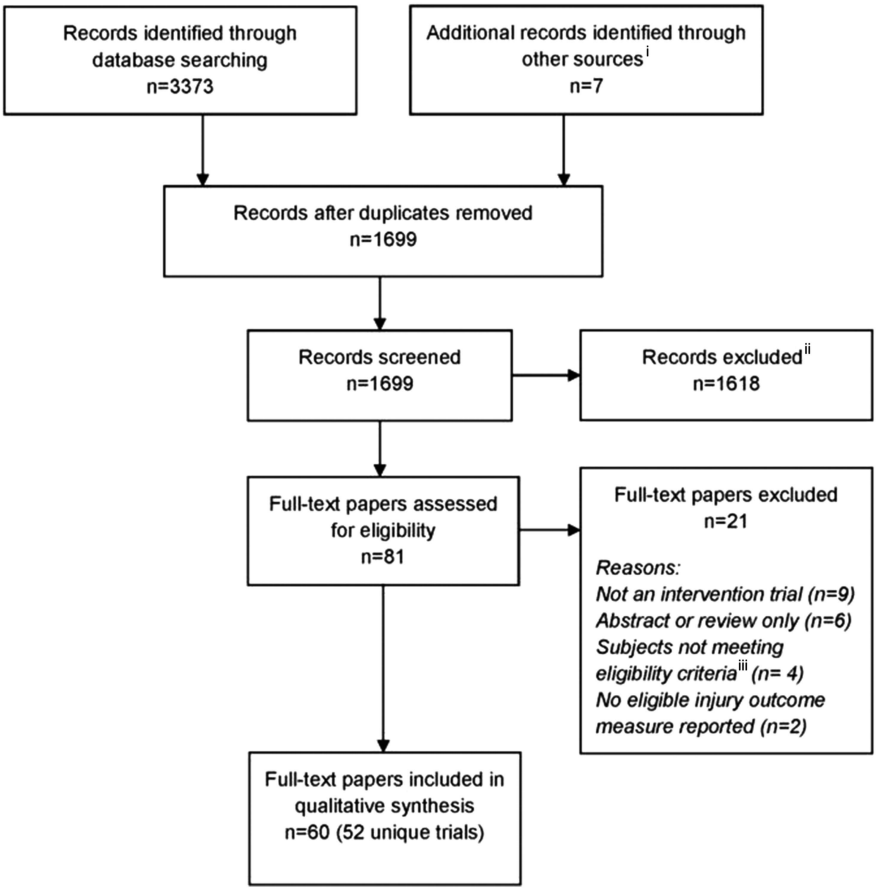

Figure 2 Search strategy used to identify team-based injury prevention exercise programme (IPEP) trials. [i]Seven additional records were identified in the reference lists of retrieved articles. [ii]The most common reasons for excluding records were (1) they were not intervention trials; (2) they did not investigate musculoskeletal injuries and (3) they did not include an injury outcome. [iii]Four studies were excluded due to the subjects having existing injuries or not being team ball sports players.

The need to bridge the gap between research and practice and focus more research efforts on the successful implementation and dissemination of evidence-based interventions has been emphasised in many areas of health promotion.[17–29 40–42] A key process in enhancing implementation is identifying core implementation components as the indispensable aspects of an implementation programme.[23] The authors of intervention trials can potentially contribute valuable information regarding core implementation components, but often these aspects are not sufficiently reported.[17 30 42–45] This review demonstrates the current poor level of reporting implementation components in team ball sport IPEP trials.

Although all the trials in this review were coded as 'yes' for reporting an intervention and intervention target, in many cases it was difficult to ascertain whether the intervention was the IPEP, education/instruction in the IPEP, or both. Similar difficulty was encountered in labelling the intervention target as the players, the delivery agents, or both. From a reporting perspective, it is worrying that the use of delivery agents was unclear in 46% of the included trials. The rare examples where detailed

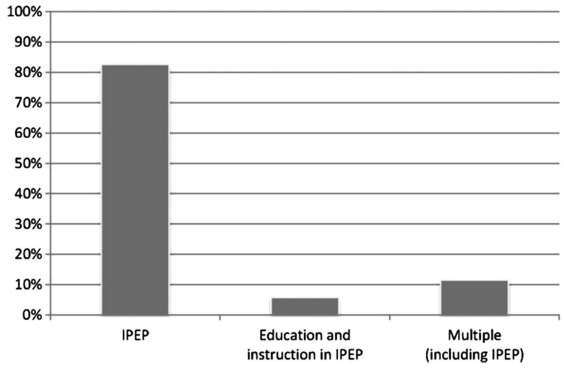

Figure 3 Percentage of team ball sport injury prevention exercise programme trials (n=52) reporting each type of intervention.

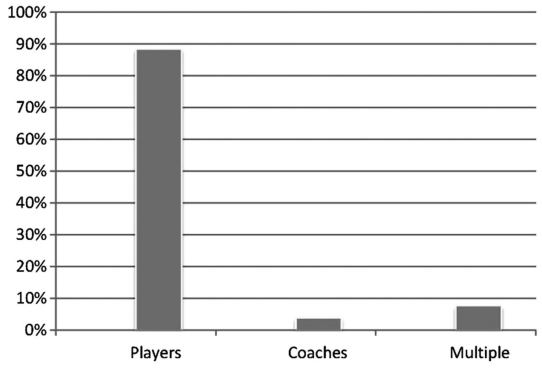

Figure 4 Percentage of team ball sport injury prevention exercise programme trials (n=52) reporting each type of intervention target.

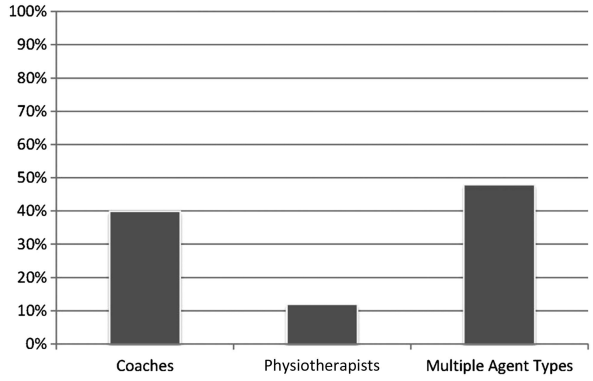

Figure 5 Percentage of team ball sport trials (n=25) reporting each type of delivery agent.

information on delivery agents was provided illustrate the potential value of this information for future implementation efforts. For example, Soligard *et al*[7] reported an 87% higher probability of an IPEP having low compliance if the coach believed the programme was too time consuming. Similarly, if the coach believed the programme lacked football-specific activities, the probability of low compliance with the IPEP was 81% higher. Another study on the effects of an IPEP in high school team ball sports reported over 60% of eligible coaches not enrolling, primarily due to lack of time or interest in collecting data on injuries and athletic exposure.[33]

Many team ball sport injury prevention trials use team coaches, physiotherapists or other delivery agents to deliver IPEPs to players. Most IPEPs are intended to be integrated in the team training warm-up, and the successful adoption, implementation and maintenance of the IPEP will largely be determined by the coaches or other team staff members who deliver the warm-up. While the players are the intended health beneficiaries of IPEPs, a prerequisite to players fully benefiting from the programme is the successful engagement of delivery agents. Educating delivery agents about the IPEP, instructing them in how to deliver it, providing support and evaluating their delivery are all key components for achieving the desired outcome.

This systematic review represents an important initial step towards a better understanding of core implementation components in team ball sport IPEPs. In addition to illustrating deficits in the current reporting of IPEP trials, we believe the process of reaching consensus between reviewers on the intervention, intervention target and delivery agents will allow us to overcome our previous difficulties in applying the RE-AIM framework to this specific context.[30] While no such review has been conducted in the field of sports injury prevention, application of the RE-AIM framework as a reviewing tool in other fields of health promotion has identified important knowledge gaps and potential directions for future research.[46–48]

The key challenge in reaching consensus between the reviewers was ascertaining (from the available reporting) who actually delivered the IPEP to the players: the members of the research team or non-researcher delivery agents such as team coaches or physiotherapists. In many trial reports, details of the IPEP design (eg, individual exercises and dose) were reported in detail, but information on how the IPEP was delivered, and by whom, was either scarce or completely absent. In some cases, it was reported that physiotherapists or athletic trainers delivered the IPEP, but it was not clearly reported whether these individuals were sporting team or research team members. In other cases, while it was reported that coaches were educated about the IPEP, whether the coaches actually delivered the programme was not stated. The lack of clear reporting made it difficult to judge which delivery method (as depicted in figure 1) had been employed by the researchers, and accordingly whether the research intervention should be labelled as an IPEP, education/instruction in a IPEP, or both, and the intervention target as players, delivery agents, or both.

Limitations

The data extraction tool used in this systematic review has not been previously validated or subjected to reliability testing. The authors are aware that other studies meeting the eligibility criteria may have been published since completion of the search strategy. The use of more than two independent reviewers may have strengthened the methodology of this review. As the use of κ coefficients was judged inappropriate, the results for reviewer agreement may have been influenced by chance agreement. This review focussed on the use of IPEPs designed to reduce musculoskeletal injuries: the inclusion of injury prevention strategies designed to reduce other types of injuries (eg, spinal cord injury, concussion) may have yielded different results. Despite the importance of the reporting issues covered in this review, the ultimate effectiveness of any injury prevention intervention will only be as strong as the difference in injury incidence and severity before and after its intervention.[49]

CONCLUSION

The current reporting of core implementation components in team ball sport IPEP trials is inadequate. In many trial reports, it is unclear whether researchers delivered the IPEP directly to players or engaged delivery agents (eg, coaches, physiotherapists, athletic trainers) to deliver the programme. When researchers do interact with delivery agents, the education/instruction of delivery agents should be acknowledged as an intervention and the delivery agents as an intervention target. Detailed reporting of implementation components in team ball sport IPEP trials will allow intended users to successfully replicate these programmes in practice.

What is already known on the subject

- Recent research supports the efficacy of injury prevention exercise programmes (IPEPs) in team ball sports.
- To enhance the reproducibility of IPEPs in practice, information is needed on how they were implemented in their evaluation trials.
- Core implementation components represent the most crucial and indispensable aspects of an implementation programme.

What this study adds

- The current level of reporting of delivery agents in team ball sport injury prevention exercise programme trials is inadequate.
- For almost half (46%) of the 52 included trials, it was unclear whether or not delivery agents were used.
- In many cases, the key interaction between researchers and delivery agents was not reflected in the reporting of the intervention and intervention target.

Acknowledgements This work was led by JO'B as part of his PhD studies, supervised by CFF. The Australian Centre for Research into Injury in Sport and its Prevention (ACRISP) is one of the International Research Centres for Prevention of Injury and Protection of Athlete Health supported by the International Olympic Committee (IOC).

Contributors JO'B designed the study, led its conduct, performed the systematic search and had a major role in writing the paper. CFF independently reviewed the eligible full-text papers, participated in the consensus discussions and contributed to the writing of the paper.

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Provenance and peer review Not commissioned; externally peer reviewed.

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2.3.3 Summary

This systematic review identified significant gaps in the reporting of team ball sport IPEP trials, particularly relating to delivery agents (the staff who deliver IPEPs to players). For almost half of the 52 included trials, it was unclear whether or not delivery agents were used. This information is important to guide the successful replication of IPEPs in other settings and in other research trials. Consensus between reviewers on the reporting of core intervention components was reached, which opened the way for application of the full RE-AIM MDIC[161] to reviewing team ball sport IPEP trials.

2.4 PAPER FOUR

O'Brien J, Finch CF. The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework. *Sports Med*. 2014: 44: 1305-1318.

2.4.1 Overview

In the previous paper, the reporting of key information relating to the intervention, intervention target, delivery agents, primary outcome and settings were extracted from published IPEP trial reports. Furthermore, consensus was reached between reviewers on the reporting of this information. Through performing these steps, the initial challenges in applying the RE-AIM to reviewing literature in this context were overcome. This next paper reports a systematic review which evaluated the reporting of team ball sport IPEP trials, against the full 32-item RE-AIM MDIC. The aim was to provide a comprehensive overview of the current knowledge base regarding implementation aspects of team ball sport IPEPs.

It is worth noting here, that the definition of "implementation", as a specific RE-AIM dimension, differs from the broader definition of implementation in the field of Implementation Science. In the broad sense, implementation relates to any methods aimed at integrating research findings into practice and/or policy.[163] However, the RE-AIM dimension of implementation is defined as the degree to which an intervention is delivered as intended, and the time and cost of the intervention.[160]

The following paper, "The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework" was accepted for publication by Sports Medicine on May 17, 2014 and was originally published "Online First" on Jul 2, 2014. The paper was subsequently published in 2014, Volume 44 (9) page 1305-1318 and can be accessed via the following link: doi:10.1007/s40279-014-0208-4.

2.4.2 Manuscript

Declaration for Paper 4

O'Brien J, Finch CF. The implementation of musculoskeletal injury-prevention exercise programmes in team ball sports: a systematic review employing the RE-AIM framework. *Sports Med*. 2014: 44: 1305-1318.

Declaration by candidate

For Paper 4, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	85%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, the coding and summary of extracted data, interpretation of results and the writing up of the manuscript.

The hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal Supervisor's Signature		Date 18.05.2016

2.4.3 Summary

This was the first systematic review to evaluate team ball sport IPEP trial reports from an implementation perspective. It also the first application of the RE-AIM framework to reviewing published literature in the field of sports injury prevention. The review identified major gaps in the reporting of specific IPEP implementation aspects, particularly relating to the RE-AIM dimensions of adoption and maintenance. This is a concern, because these aspects play a key role in enhancing the ultimate real-world impact of interventions. Although a number of trial reports included in this systematic review highlighted the challenges involved in enhancing IPEP implementation, there was a paucity of published information regarding which factors influence successful implementation. Overall, the body of reported knowledge offers little to inform efforts to enhance the implementation of IPEPs in real-world settings.

3.0 CROSS-SECTIONAL SURVEYS

3.1 OVERVIEW OF CHAPTER THREE

Having identified significant gaps in the reporting of implementation aspects in IPEP trial reports, the next section of this thesis research aimed to address these knowledge gaps, by assessing IPEP implementation in the specific context of professional soccer. Recent implementation research emphasises the importance of understanding the context in which an intervention will be delivered, in order to enhance implementation.[164-166] This includes developing an understanding of the injury prevention perceptions of key individuals in the setting (e.g. players, coaches and other team staff). These perceptions are likely to influence the injury prevention behaviour of these individuals, such as the adoption or non-adoption of an IPEP. Accordingly, a survey was developed to assess the perceptions of key stakeholders in professional soccer settings. Chapter Three presents two published, peer-reviewed papers reporting the results of this survey, in two different professional soccer settings.

3.2 PAPER FIVE

O'Brien J, Finch CF. Injury prevention exercise programs for professional soccer: understanding the perceptions of the end-users. *Clin J Sport Med*. 2016. 10.1097/jsm.0000000000000291.

3.2.1 Overview

Paper five reports the results of a survey conducted in four professional senior male soccer teams, which were selected based on established connections to the author. The survey was designed to assess the perceptions of players and staff members towards injury prevention in general and, more specifically, the use of IPEPs. The survey questions covered a full range of implementation factors, as outlined in the RE-AIM framework. The specific formulation of questions was guided by constructs of the Health Belief Model (as employed in a previous survey in an Australian Football setting),[167] along with specific implementation barriers identified in previous IPEP trial reports. As there is no industry-standard IPEP for professional soccer to use as a comparator for assessing respondents' perceptions, the survey employed the most widely-promoted IPEP for amateur soccer, the FIFA 11+. It was anticipated that using the FIFA 11+ as a comparator would help to identify important aspects of IPEP content and delivery in professional soccer settings, and facilitate the design of future context-specific programs.

The following paper, "Injury prevention exercise programs for professional soccer: understanding the perceptions of the end-users", was accepted for publication by the Clinical Journal of Sports Medicine on October 22, 2015 and was published "Online First" on January 19, 2016. The paper can be accessed via the following link: doi: 10.1097/JSM.0000000000000291. Reproduced with permission of Wolters Kluwer Health Lippincott Williams & Wilkins©.

3.2.2 Manuscript

Declaration for Paper 5

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Declaration by candidate

For Paper 5, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	90%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, interpretation of results and the writing up of the manuscript.

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal Supervisor's Signature		Date 18.05.2016

Injury Prevention Exercise Programs for Professional Soccer: Understanding the Perceptions of the End-Users

James O'Brien, MASc and Caroline F. Finch, PhD

Objective: To evaluate the perceptions of professional soccer players and staff members toward injury prevention exercise programs (IPEPs).

Design: Self-report survey.

Setting: Four professional soccer teams in 4 different countries.

Participants: 126 players, coaches, physiotherapists, and fitness coaches were invited to participate, with 72 respondents.

Main Outcome Measures: Web-based survey detailing perceptions of lower limb (LL) injury susceptibility and seriousness, the value of IPEPs in general, and more specifically the International Federation of Association Football (FIFA) 11+.

Results: The vast majority of the respondents believed that professional soccer players are at high risk of LL injuries (93%) and that players should perform evidence-based injury prevention exercises (98%). They also agreed that LL injuries can shorten a player's career (85%), cause physical problems later in life (82%), and negatively impact on team performance (77%). However, perceptions varied across teams regarding which types of injury prevention exercises are effective, who holds responsibility for injury prevention, and when IPEPs should be performed. Specific knowledge of the FIFA 11+ was very low and 47% of respondents believed the program would need modification for use in their team.

Conclusions: Players and staff members in professional soccer teams strongly support the use of evidence-based IPEPs. However, perceptions vary considerably between teams regarding which exercises can prevent injuries, who holds the responsibility for injury prevention, and when preventive exercises should be performed. Enhancing the ultimate impact of IPEPs in professional soccer requires a detailed understanding of each team's specific implementation context.

Key Words: sports injury prevention, soccer, implementation, attitudinal survey, FIFA 11+

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INTRODUCTION

Soccer is the world's most popular sport with over 260 million participants worldwide,[1] and 65 000 registered professional players.[2] Lower limb (LL) injuries are common in soccer[3] and are associated with significant participation loss, treatment costs, decreased team performance, and long-term negative side-effects.[3–9] In view of these negative impacts, the development of effective strategies to prevent soccer-related LL injuries is imperative.

Recently, injury prevention exercise programs (IPEPs) for soccer have gained considerable attention.[10–12] Examples of soccer IPEPs include the "International Federation of Association Football (FIFA) 11+,"[10,13,14] the "PEP" program[15,16] and "Knaekontroll."[11] Large-scale trials in amateur settings have demonstrated that these programs can significantly prevent injuries,[10,11,13] especially in teams with high compliance levels.[10,12,17] Unfortunately, published IPEP trials involving professional soccer teams remain rare.[18] To enhance injury prevention efforts in professional soccer, further research is needed on both the efficacy and the real-world effectiveness of IPEPs in this context. It has been emphasized that the success of an IPEP in a tightly controlled efficacy study, such as a randomized controlled trial (RCT), by no means guarantees its success under real-world, noncontrolled conditions.[19] Before the injury reductions demonstrated in efficacy, RCTs can be replicated under everyday conditions, there is a need to understand the factors influencing the successful implementation of IPEPs, including why soccer teams do, or do not, adopt and comply with these programs.[20,21]

The current knowledge gap regarding IPEP adoption has been clearly demonstrated in a recent systematic review.[22] The reporting of 52 team ball sport IPEP trials was evaluated against the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework, a tool designed to enhance the real-world impact of health-related interventions.[23] The proportion of IPEP trials reporting the RE-AIM's 8 measures of adoption averaged a mere 4% across all adoption measures. In one included trial,[24] only

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Ethical considerations statement: All participants completed informed consent forms, and the study was approved by the Federation University Australia Human Research Ethics Committee.

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95 of 258 (37%) coaches agreed to participate in the IPEP trial, highlighting the challenge of achieving adequate adoption. The review also summarised the rarely reported reasons why teams do not adopt IPEPs, including perceptions of the programs as being too time consuming, ineffective in reducing injuries, lacking sports specificity, and lacking variation.[22]

Although players are the intended health beneficiaries of IPEPs, the decision of a team to adopt a program will often be the responsibility of team staff members such as coaches, fitness staff, and physiotherapists. Many published reports of IPEP trials fail to report the role of these staff members in the implementation of programs,[25] but the importance of understanding their perceptions has been demonstrated in studies in amateur soccer. Joy et al[26] reported that coaches of amateur female soccer teams with more experience (>7 years) and supporting staff members were more likely to be using an IPEP. Coaches themselves perceived lack of coach knowledge, lack of coach ability to give feedback on exercises, time restrictions, and gaining support from parents and athletes as barriers to implementing an IPEP.[26] Gaps in the injury prevention knowledge of amateur soccer coaches, players, and parents have also been identified in other studies.[27–29] However, there remains a paucity of information on perceptions toward injury prevention programs in professional soccer settings.[30,31] The specific implementation context of IPEPs in professional soccer teams will differ to their amateur counterparts in regard to game and training schedules, staff support, and the availability of equipment. Many IPEPs described in amateur soccer trials are led by a coach or team captain, and do not require any additional equipment.[13,32] In contrast, professional soccer teams generally have academically educated staff to run and monitor injury prevention programs[30,33] and there are fewer limitations regarding the use of equipment.[18,34]

Generating a better understanding of end-users' perceptions of injury prevention programs represents an important step in increasing adoption levels, and hence the ultimate impact of these programs.[35,36] This information can also inform the development of new, efficacious IPEPs, specifically for professional soccer. Evidenced-based IPEPs from amateur soccer, such as the FIFA 11+ can serve as valuable blueprints for developing programs for professional soccer. Accordingly, the aim of this study was to determine the perceptions of professional soccer players, coaches, and other staff members toward IPEPs in general, and more specifically the FIFA 11+.

MATERIALS AND METHODS

Study Participants

The players, coaches, fitness coaches, and physiotherapists (n = 126 in total) of 4 senior professional soccer teams (first or second playing divisions) were invited to participate. The teams were located in 4 different countries and were chosen on the basis of established contact to the research team, and administrative ties between the teams. Approval for the study and email addresses of potential participants were obtained from club managers, who also encouraged their players and staff members to participate. All participants completed informed consent forms, and the study was approved by a university ethics committee.

Web-Based Survey

Consenting participants completed a web-based survey (administered through Survey Monkey) detailing their perceptions of LL injury susceptibility and seriousness, the value of IPEPs in general, and more specifically, an IPEP endorsed by the FIFA,[37] called the FIFA 11+. The development of the survey was guided by Health Belief Model constructs,[38] the RE-AIM framework,[23] previously reported surveys,[39] and previously proposed barriers to the adoption of team ball sport IPEPs.[12,22,24,39,40] Face validity was evaluated by pilot testing the survey on 2 professional soccer players and 2 physiotherapists. Face validity was strengthened by the authors' differing backgrounds in professional team sport, epidemiology, implementation research, and injury prevention research. The survey contained both open and closed questions (32 in total), including 5-point Likert scales, multiple choice questions (yes, no, unsure), and questions with free-text answers. Specifically, the free-text questions asked respondents to detail the facilitators and barriers to maintaining IPEPs. The survey was offered in multiple languages, and took approximately 25 minutes to complete. The section of the survey specifically relating to the FIFA 11+ was preceded by a link to the official FIFA 11+ website,[37] which contained extensive information on the program.

Data Analysis

Data were downloaded from Survey Monkey and underwent extensive data cleaning and editing before analysis. In view of the response rate and distribution of the data (little variability at the extremes), all 5-point Likert scales were collapsed into 3-point scales: "strongly-agree"/"agree," "neither agree nor disagree," and "disagree/strongly-disagree." Cross-tabulation tables (frequencies and percentages) were produced from categorical data using IBM statistics SPSS 20. For each survey question, data were initially analyzed with all the responses combined. Cross-tabulation tables were then produced to compare answers across the 4 different teams and also to compare the answers of all players to the answers of all staff members. In view of the sample size, testing of statistical significance between the groups was not performed. In cases where questions were not answered by all respondents, the nonresponders were excluded from the sample size (n) for analysis of that question. All non-English free-text responses were translated into English by professional translators. The free-text responses were analyzed by 2 reviewers using a content analysis approach to generate an initial list of themes. All survey responses were then independently categorized into the initial themes by the 2 reviewers. Categorization discrepancies were discussed and the themes were revised. This process was repeated until both agreed on the final list of themes and the allocation of all responses to a theme.

RESULTS

Respondents

The total response rate across all participants was 57% (72/126). Of the 64 respondents providing their role at the soccer club, there were 49 players, 4 coaches, 5 physiotherapists, and 6 fitness coaches. The response rate for players alone was 49% (49/100), and for staff alone 54% (15/26), whereas eight respondents could not be classified. The median age of respondents was 24.5 years (range of 18-61). Across all respondents, 11 different countries of birth were reported.

Perceptions of Injury Susceptibility and Injury Seriousness

Table 1 shows that the vast majority of respondents agreed with statements regarding professional soccer players' high susceptibility to LL injuries and the serious negative impacts of these injuries. A higher proportion of staff (100%), than players (67%), believed that LL injuries have a negative impact on team performance.

Perceptions of Injury Prevention Exercise Programs

There were high levels of agreement regarding the preventability of certain LL injuries, the importance of using evidence-based exercises, and the importance of exercise variation and progression (Table 1). The vast majority of respondents agreed that common types of injury prevention exercises (eg, balance exercises and eccentric strengthening) can prevent injuries, but far fewer participants supported the use of a cool-down jog/run. A breakdown of results across teams, showed considerable variation in the proportion agreeing that injury prevention exercises should be incorporated into club policy (100%, 100%, 67%, 88%) and that LL injuries can be prevented with eccentric strengthening exercises (92%, 100%, 69%, 81%) and cutting exercises (85%, 67%, 62%, 100%).

In response to the multiple-choice question, "When should exercises to prevent lower limb injuries be performed?" (as part of training, separate from team training, both), 68% indicated "both." However, a breakdown across teams showed considerable variation for the proportions

TABLE 1. Respondents' Perceptions of LL injury Susceptibility, Injury Seriousness and Injury Prevention Exercise Programs

Theme	Statement	Health Belief Model Construct	RE-AIM* Framework Dimension(s)	n	Agree % (95% CI)	Neither Agree nor Disagree % (95% CI)	Disagree % (95% CI)
Injury susceptibility and seriousness	Soccer players are at high risk of suffering a LL injury	Perceived susceptibility	A, M	68	93 (90–97)	3 (0–6)	4 (1–7)
	LL injuries can shorten a professional soccer player's career	Perceived seriousness	A, M	67	85 (80–91)	6 (2–10)	9 (4–14)
	LL soccer injuries can cause physical problems later in life	Perceived seriousness	A, M	66	82 (76–88)	12 (7–17)	6 (2–10)
	LL injuries have a negative impact on team performance	Perceived seriousness	A, M	68	77 (70–84)	13 (8–18)	10 (5–15)
	LL injuries have a negative impact on a soccer player's quality of life	Perceived seriousness	A, M	67	72 (65–80)	13 (7–19)	15 (9–21)
IPEP	It is possible to prevent some LL soccer injuries	Perceived benefit	A, E	67	90 (85–95)	8 (4–12)	3 (0–6)
	Exercises which have been scientifically proven to prevent LLI should be performed by soccer players	Perceived benefit	A, M	59	98 (96–100)	2 (0–5)	0 (0)
	Exercises to prevent injuries should be varied and progressed over time	Cues to action	A, I, M	53	93 (88–98)	8 (2–14)	0 (0)
	Exercises which have been scientifically proven to prevent LL injuries should be incorporated into the club's training guidelines	Cues to action	M	52	89 (82–96)	12 (5–19)	0 (0)
	Balance exercises can prevent LL injuries	Perceived benefit	E, A, I	51	94 (89–99)	6 (1–11)	0 (0)
	Controlled jumping/landing can prevent LL injuries	Perceived benefit	E, A, I	54	87 (80–94)	9 (3–15)	4 (0–8)
	Eccentric muscle strengthening can prevent LL injuries	Perceived benefit	E, A, I	54	85 (77–92)	6 (1–11)	9 (3–15)
	A warm-up jog/run can prevent LL injuries	Perceived benefit	E, A, I	54	82 (74–90)	7 (2–12)	11 (5–17)
	Cutting exercises can prevent LL injuries	Perceived benefit	E, A, I	54	80 (72–88)	19 (11–27)	2 (0–5)
	Cool-down jog/run can prevent LL injuries	Perceived benefit	E, A, I	53	47 (37–57)	25 (16–34)	28 (19–37)

*RE-AIM framework: E, effectiveness; A, adoption; I, implementation; M, maintenance.

indicating "As part of training" (6%, 50%, 0% 6%), "separate from training" (0%, 17%, 15%, 39%), and "both" (94%, 33%, 85%, 56%). In response to the question, "How much time is appropriate for a warm-up session at the start of team training?" the most frequent answers across all participants were 15 minutes (28%), 20 minutes (23%), and 10 minutes (16%).

Perceptions of Injury Prevention Responsibility

Figure 1 shows that from 8 different soccer club roles listed by the researchers, respondents were most likely to nominate the player (93%), fitness coach (93%), and the physiotherapist (86%) as holding responsibility for injury prevention. There seemed to be considerable variation across the 4 teams for the proportion of respondents nominating the player (100%, 75%, 100%, 93%), head coach (62%, 50%, 39%, 94%), doctor (85%, 25%, 54%, 44%), and sports director (31%, 17%, 0%, 56%). The median number of different roles nominated by individual respondents was 5 (range 1-8). All staff members and 90% of players indicated their own role as holding responsibility for injury prevention.

Respondents were most likely to indicate that the player (52%), fitness coach (22%), and head coach (19%) hold the ultimate responsibility for injury prevention. In 2 teams, the most frequent response (92% and 54%) was the player. In 1 team, the fitness coach was the most frequent response (64%), whereas in another it was the head coach (47%).The proportion of players and staff members indicating their own role as holding the ultimate responsibility was 61% and 17%, respectively.

Perceptions and Current Practices in Relation to the FIFA 11+

The respondents' awareness, use, and perceptions of the FIFA 11+ are shown in Table 2. Only 27% of all respondents had previously heard of the FIFA 11+ (93% of staff members and 9% of players), whereas 3% of respondents were unsure. Only 2% of all respondents reported their team using the FIFA 11+ (no staff members and 2% of players), whereas 10% reported using a modified version (43% of staff and no players). Of those not currently using the FIFA 11+ (n = 55), 10% reported having previously been in a team which used the FIFA 11+. Forty-seven percent of all respondents believed the FIFA 11+ needed improvement for use in their team, and 68% believed their club should develop its own version of the FIFA 11+.

Just under half (45%) of respondents believed the FIFA 11+ had the potential to reduce injuries in their team, and 53% agreed that the program is soccer-specific (Table 2). However, it was perceived as being too long by 22% of respondents and only 30% agreed that the program contained adequate variation and progression. Thirty percent of all respondents believed their team could maintain the FIFA 11+ over multiple seasons, with higher agreement among staff members (44%) than players (23%).

Barriers and Facilitators to IPEP Maintenance

In free-text answers, respondents identified multiple barriers and facilitators to IPEP maintenance (Table 3). The thematic analysis identified 2 main themes. One theme was the nature/content of the IPEP itself. The second theme was IPEP delivery and support. The second theme had 5 distinct sub-themes relating to different ecological levels of the professional soccer setting: the player, team staff, the club, governing bodies, and the physical environment (Table 3).

DISCUSSION

This study provides a rare insight into the perceptions of IPEPs in professional soccer teams. To our knowledge,

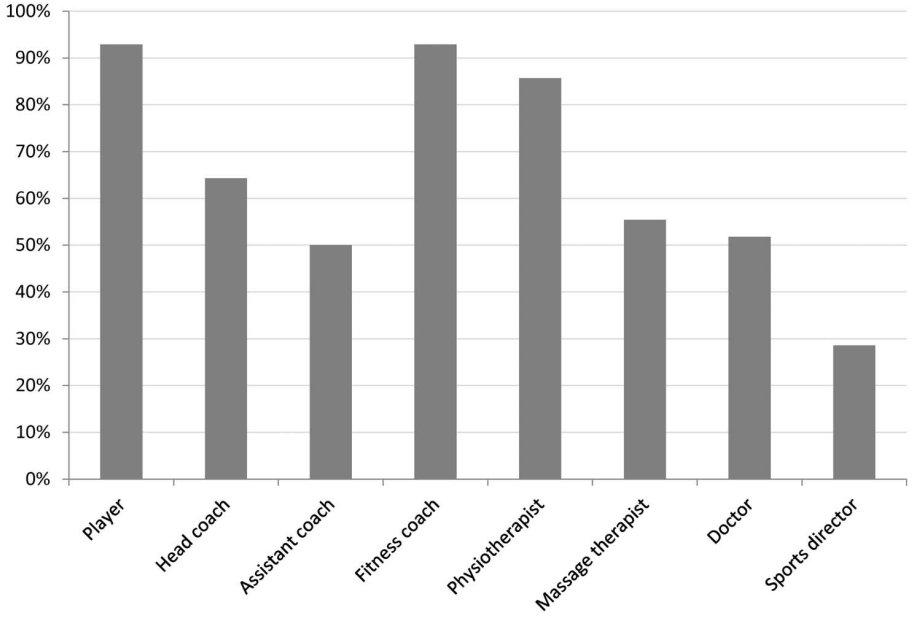

FIGURE 1. The proportion of respondents (n = 56) indicating each different role as holding responsibility for preventing injuries in professional soccer.

TABLE 2. Respondents' Awareness, Use and Perceptions of the FIFA 11+ Program

Question or Statement	Health Belief Model Construct	RE-AIM* Framework dimension(s)	n	Yes % (95% CI)	No % (95% CI)	Unsure % (95% CI)	Agree % (95% CI)	Neither Agree nor Disagree % (95% CI)	Disagree % (95% CI)
Had you heard of the FIFA 11+ before taking part in this questionnaire?	Cues to action	R	64	27 (19–35)	70 (62–78)	3 (0–6)			
Does your team currently use the FIFA 11+?	Perceived benefit	R, A, M	61	11† (5–17)	41 (32–50)	48 (39–57)			
Have you ever been in a team which used the FIFA 11+?	Perceived benefit	R, A	55	11 (5–17)	51 (41–61)	38 (28–48)			
Does the FIFA 11+ need to be improved for use in your team?	Perceived benefit	A, I, M	58	47 (38–56)	3 (0–6)	50 (41–59)			
Should your club develop its own version of the FIFA 11+?	Cues to action	A, I, M	60	68 (59–77)	2 (0–5)	30 (22–38)			
The FIFA can prevent LL injuries in your team	Perceived benefit	E, A	60				45 (36–54)	43 (34–52)	12 (6–18)
The FIFA 11+ is soccer specific	Perceived benefit	A, I, M	61				53 (44–62)	34 (25–43)	13 (7–19)
The FIFA 11+ is too long	Perceived barrier	A, I, M	60				22 (14–30)	58 (49–67)	20 (13–27)
The FIFA 11+ contains adequate variation and progression for our team	Perceived benefit	A, I, M	61				30 (22–38)	46 (37–55)	25 (17–33)
The FIFA 11+ could be maintained over multiple seasons by our team	Cues to action	A, I, M	61				30 (22–38)	43 (34–52)	28 (20–36)

*The RE-AIM framework: R, reach; E, effectiveness; A, adoption; I, implementation; M, maintenance.
†Sum of "yes" (1.6%) and "yes, but modified" (9.8%).

there has only been 1 previous study in this context[30] but that study did not include players. The vast majority of respondents in our study agreed that professional soccer players are at high risk of sustaining LL injuries, and that these injuries have a negative impact on players' long-term health, quality of life, and team performance. There were also high levels of agreement across respondents that LL injuries can be prevented, and that soccer players should perform evidence-based injury prevention exercises. Opinions were far more diverse regarding which types of exercise can prevent injuries, who holds the responsibility for injury prevention, and when injury prevention exercises should be performed. Awareness and use of the FIFA 11+ was very low. After being linked to information on the FIFA 11+, almost half of the respondents indicated that the program needed improvement for use in their team.

To enhance the real-world impact of efficacious soccer IPEPs, it is essential to understand the barriers these programs can face when translated and up-scaled into everyday real-world settings. The perceptions of soccer IPEPs from intended users, including health-beneficiaries (players) and program deliverers (coaches and staff) will influence the adoption of these programs. This has been demonstrated by studies in amateur soccer teams, and also in other team ball sports.[26–29,39,41,42] The results of our survey suggest that players and staff members in professional soccer teams recognise the high risk and negative impacts of LL injuries. This appears in line with the current scientific evidence on soccer injuries.[3,4] However, only 67% of the players, compared with 100% of staff, believed that injuries have a negative impact on team performance. A recently published study over 11 seasons, in 24 European professional soccer teams, clearly demonstrated the negative impact of injuries on team performance.[4]

High proportions of respondents agreed that balance exercises, controlled jumping/landing, eccentric muscle strengthening, warm-up run/jog, and cutting exercises can prevent LL injuries. The preventive effect of IPEPs incorporating these components has been demonstrated in amateur soccer teams,[11,13] but studies specific to professional teams are rare. Most survey respondents believed that preventive exercises should be performed both during team training and separate from team training. This shows that implementing IPEPs in professional teams requires consideration of multiple delivery formats, rather than only through the warm-up programs described in many IPEP trials. McCall et al[30] recently reported 73% of professional teams using both global and individualized injury prevention programs, and ranking eccentric exercises and balance exercises as the top 2 most effective injury prevention exercises.

TABLE 3. Barriers and Facilitators to IPEP Maintenance in Professional Soccer Teams categorized by Themes and Sub-themes

Main Theme	Subtheme	Survey Framework	Examples
IPEP content/nature	—	Facilitators	Adequate documentation
			Continuity in methodology
			Fun and soccer specific exercises
			Implementation at the start of the season
			Individualisation and goal setting
			Integration into team training
			Performing program in various locations
			Progression and variation of exercises
			Proven effectiveness through tests
			Short and not too strenuous
			Specificity for lower-limb injuries
		Barriers	Boring, monotonous exercises
			Lack of adequate supervision
			Lack of data collection
			Lack of equipment
			Lack of individualisation and athlete specificity
			Lack of proven effectiveness
			Irregular sessions
			Monotony of training location
			Performing separately from team training
			Too long
IPEP delivery and support at different ecological levels	Player	Facilitators	Acceptance of program
			Ambition
			Motivation
		Barriers	Fatigue
			Lack of diligence
			Lack of interest
	Team staff	Facilitators	Acceptance of program by head coach
			Attitude and motivation
			Communication and agreement between staff members
			Continuity in methodology
			Knowledge and experience of the head coach
			Number, structure, and continuity of staff
			Planning and organization
			Team work
		Barriers	Disagreement about the prevention strategy
			Low staff numbers and changes to staff
			Lack of acceptance and interest from coaches
			Lack of explanation
			Lack of long-term planning
			Lack of knowledge, communication, and team work
			Lack of time
	Club	Facilitators	Acceptance of program by sports director
			Club culture of prevention
			Incorporation into club policy
			Experience of sports director
			Maintenance of club policy
			Support from all levels of the club
			Team success
		Barriers	Lack of club policy
			Lack of team success
			Pressure to win
			High number of injuries

TABLE 3. (*Continued*) Barriers and Facilitators to IPEP Maintenance in Professional Soccer Teams categorized by Themes and Subthemes

Main Theme	Subtheme	Survey Framework	Examples
	Governing bodies	Facilitators	Light game schedule
		Barriers	Heavy game schedule
	Physical environment	Facilitators	Favorable weather
		Barriers	Adverse weather

Individual respondents indicated a median of 5 different individual roles within their clubs as being responsible for injury prevention. This demonstrates the complexity of the implementation context for injury prevention in professional soccer teams. In contrast to amateur teams, many professional teams employ multiple coaches and large interdisciplinary health teams.[30,33] Accordingly, several different individuals can play a role in both the adoption and delivery of injury prevention programs. The specific communicative and organizational challenges posed by interdisciplinary health teams in professional team sports have been highlighted in published studies,[43,44] and these challenges were evident in the free-text answers of respondents in this study. Perceptions of injury prevention responsibility varied across the 4 teams, both in relation to the proportion of respondents indicating individual roles, and the perceptions of who holds the ultimate responsibility for injury prevention. This suggests that successful implementation of injury prevention programs requires an appreciation of the specific implementation context of each professional soccer team.

Awareness of the FIFA 11+, the most highly promoted IPEP for soccer, was very low, with the vast majority of respondents having not heard of it. Although the program has been disseminated worldwide, including in the 4 countries where our survey was administered,[45] there are a number of possible explanations for this low level of awareness. First, the FIFA 11+ was developed for amateur and recreational teams, whereas the respondents in this study were from professional teams. It is possible that the respondents were not aware of the FIFA 11+ because they had not been in an amateur soccer team since the development of the program in 2006. The low level of awareness could also be explained by the high proportion of players, in relation to staff, participating in our survey. It is perceivable that many professional players do not play a major role in the adoption of IPEPs, with this responsibility lying more with the staff. This explanation is supported by the higher level of FIFA 11+ awareness among staff in this survey, compared with players. A further potential explanation is that despite the FIFA 11+ having been disseminated to FIFA's national member associations in different countries, the program has not yet been successfully absorbed through the multiple layers of soccer's organizational fabric (eg, regional governing bodies, leagues, clubs, teams, and players). A recent study in Nigerian first division youth male soccer also reported very low levels of FIFA 11+ awareness, with just 21% of players having heard of it,[29] suggesting that this lack of awareness exists in multiple contexts.

The proportion of respondents currently using the FIFA 11+ was very low. However, 43% of staff members reported using a modified version of the program. This highlights the importance of tailoring IPEPs to the specific needs of professional soccer. The FIFA 11+, as an evidence-based program endorsed by the sport's international governing body, could serve as a valuable blueprint for developing programs for professional teams.

Respondents identified a wide range of barriers and facilitators to IPEP maintenance, relating to 2 major themes and 5 sub-themes. The 2 major themes were the nature/content of the IPEP itself and the support and delivery of IPEPs at different ecological levels of the professional soccer setting. This knowledge will inform efforts to enhance the maintenance of existing IPEPs and to develop new programs, better tailored to the professional soccer implementation context.

It is important to acknowledge several limitations of this study. As the sample size was small, and the response rate only moderate, caution must be exercised in generalizing the results of this study to other settings. However, other surveys in professional soccer settings have reported very similar response rates,[30,46] and gaining access to professional soccer teams is challenging. The survey used in this study was not subjected to reliability and validity testing, beyond face validity. The answers to Likert scale questions in the survey may have been influenced by central tendency bias, acquiescence bias, or social desirability bias.[47] Collapsing Likert-scales reduced the level of analytical detail. The results may have been influenced by nonresponse bias, as a number of respondents did not answer every question. Potential confounding variables (eg, age, coaching experience, injury history) were not addressed in this study and may have influenced respondents' perceptions. This study focussed on IPEPs, but other factors such as training load, match load, and playing surface are also important considerations for injury prevention in this setting.

CONCLUSION

To enhance the impact of IPEPs in professional soccer teams, it is essential to understand how players, coaches, and staff members perceive these programs. Across all teams in this study, there were high levels of agreement regarding LL injury susceptibility and the seriousness of soccer injuries. However, perceptions were far more diverse across teams regarding which exercises can prevent injuries, who holds the responsibility for injury prevention, and when preventive exercises should be performed. Understanding the specific implementation context of IPEPs in professional soccer teams will enhance the impact of these programs.

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J.O. led this work as part of his PhD studies. He designed the study, led its conduct, and had the major role in article writing. C.F.F. contributed to the design of the study and the writing of the article. The authors would also like to thank Anna Wong Shee for her contribution to an earlier version of this article and as a coder of the qualitative data.

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3.2.3 Summary

This cross-sectional survey identified multiple barriers and facilitators to IPEP implementation in professional soccer teams, hence addressing question three of the thesis (page 23). There was a high level of awareness among survey respondents regarding players' susceptibility to injury and the negative consequences of injuries. There was also strong support for the use of evidence-based injury prevention exercises. However, perceptions varied across teams regarding which exercises are effective and when they should be performed. The survey respondents also identified a range of barriers and facilitators to maintaining IPEPs.

This is one of very few studies to assess the injury prevention perceptions of players and staff members in professional soccer teams. Prior to the commencement of this research, only one study on professional English players,[168] published in 1998, had addressed this topic. However, the results of four other surveys assessing injury prevention perceptions of staff members in professional soccer have been published since 2014.[151-153 169] Taken together, my PhD research and these studies provide a much needed insight into the IPEP implementation context of professional soccer.

3.3 PAPER SIX

O'Brien J, Finch CF. Injury prevention exercise programmes in professional youth soccer: understanding the perceptions of programme deliverers. *BMJ Open Sport Exerc Med*. 2016: 2: doi:10.1136/bmjsem-2015-000075.

3.3.1 Overview

The next paper in this thesis reports a cross-sectional survey in a specific professional soccer setting: four male youth teams in a professional soccer academy. Many professional soccer clubs have youth academies, which aim to develop the next generation of young players for future engagement in senior teams.[33] The survey aimed to assess the injury prevention perceptions of staff members (soccer coaches, fitness coaches and physiotherapists) in the academy, which was important for two reasons. Firstly, to offer insight into an IPEP implementation context which had not previously been reported, and secondly, as a precursor to conducting a prospective observational study on IPEP implementation (Papers 7 and 8) in the same target group.

The following paper, "Injury prevention exercise programmes in professional youth soccer: understanding the perceptions of programme deliverers", was accepted for publication by the BMJ Open Sport & Exercise Medicine on October 28, 2015 and was originally published "Online First" on January 4, 2016. The paper was subsequently published in 2016, Volume 2 (1) e000075 and can be accessed via the following link: doi:10.1136/bmjsem-2015-000043. Reproduced with permission of BMJ Publishing Group Ltd.

3.3.2 Manuscript

Declaration for Paper 6

O'Brien J, Finch CF. Injury prevention exercise programmes in professional youth soccer: understanding the pceptions of programme deliverers. *BMJ Open Sport Exerc Med*. 2016: 2: doi:10.1136/bmjsem-2015-000075.

Declaration by candidate
For Paper 6, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	90%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, interpretation of results and the writing up of the manuscript.

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal supervisor's Signature		Date 18.05.2016

BMJ Open Sport & Exercise Medicine

Injury prevention exercise programmes in professional youth soccer: understanding the perceptions of programme deliverers

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ABSTRACT

Background: There are well-known challenges to implementing injury prevention strategies in amateur soccer, but information from other soccer settings is scarce. This cross-sectional survey analysed the injury prevention perceptions of soccer coaches, fitness coaches and physiotherapists from 4 male teams in a professional youth soccer academy.

Methods: The respondents (n=18) completed a web-based survey relating to lower limb (LL) soccer injuries, the value and practicality of injury prevention exercise programmes (IPEPs) in general and, more specifically, the IPEP endorsed by FIFA, the FIFA 11+.

Results: There were very high levels of agreement regarding players' susceptibility to LL injury and the seriousness of these injuries. Respondents agreed unanimously that players should perform evidence-based injury prevention exercises. Despite 61% of respondents having previously heard of the FIFA 11+, just 6% reported current use of the full programme, with a further 22% reporting modified use. 22% believed the FIFA 11+ contained adequate variation and progression for their team and 78% felt it needed improvement. Respondents identified multiple barriers and facilitators to maintaining IPEPs, relating either to the programme content (eg, exercise variation), or the delivery and support of the programme (eg, coach acceptance).

Conclusions: The coaches, fitness coaches and physiotherapists of professional youth teams support the use of IPEPs, but enhancing their impact requires tailoring of programme content, along with adequate delivery and support at multiple levels. The findings suggest that the FIFA 11+ needs modification for use in professional youth soccer teams.

What are the new findings

- Coaches, fitness coaches and physiotherapists of professional youth soccer teams support the use of injury prevention exercise programmes (IPEPs).
- The majority of respondents were aware of the FIFA 11+, but less than a third used the programme and mostly in a modified form.
- Multiple challenges to implementing IPEPs in professional youth teams were identified.

INTRODUCTION

Soccer is the world's most popular sport with over 260 million participants worldwide.[1] Lower limb (LL) injuries are common in soccer and the negative impacts of these injuries have been well documented.[2–7] Recently, injury prevention strategies for soccer have gained increased research attention, particularly the use of injury prevention exercise programmes (IPEPs). The efficacy of IPEPs in amateur soccer teams has been established in large-scale randomised controlled trials (RCTs).[8–10] The *Knaekontroll* programme reduced the overall rate of anterior cruciate ligament (ACL) injuries by 64% in a RCT including over 4500 amateur female soccer players.[8] The FIFA 11+, an IPEP endorsed by the FIFA, significantly reduced injuries in large-scale RCTs of amateur female[9] and male players[10] as well as collegiate male players.[11]

Alongside growing support for IPEP efficacy, evidence of significant challenges to implementing these programmes has emerged.[12] These challenges span aspects of programme reach, adoption, compliance and maintenance, aligning closely with the implementation challenges identified in other team ball sports[13–19] and other health-related fields.[20–23] To date, the most commonly reported implementation challenges relate to programme compliance (also termed adherence or fidelity). This refers to the extent to which an IPEP is performed as intended. High compliance to IPEPs has been associated with greater injury reductions.[11 24–26] For example, a subsequent analysis of the aforementioned *Knaekontroll* RCT[8] illustrated that players with high

compliance experienced an 88% lower rate of ACL injury, compared with players with low compliance, who did not differ from controls.[24] However, achieving adequate compliance can be challenging.[27–29]

Enhancing the adoption of IPEPs has also been identified as a major implementation challenge.[12 30] Despite extensive promotion of the FIFA 11+ by soccer's international governing body since 2009, just 10% of the member soccer associations have actually endorsed the programme.[12] Coaches have been identified as important adoption targets for IPEPs in amateur soccer,[12] whereas other staff members (eg, physiotherapists and fitness staff) represent key programme deliverers in professional and collegiate soccer settings.[31–33] In recent studies, just 20% of female soccer team coaches in Utah[34] and 21% of female high school soccer and basketball coaches in Oregon[35] reported using an IPEP. Among coaches of public high school soccer and basketball teams in Chicago, only 37% agreed to participate in an IPEP trial.[36] Injury prevention knowledge gaps among players, coaches and parents have been identified in both male[37] and female[38 39] amateur soccer communities and also in other team ball sports settings.[14 15 17] In one recent study of youth male soccer players, 79% had not heard of the FIFA 11+.[37]

Improving IPEP maintenance represents another key challenge in enhancing the impact of IPEPs, but information on programme maintenance is rare. In a systematic review on the reporting of team ball sport IPEP trials, maintenance was the least reported of all implementation aspects.[40] A recently published, 3-year follow-up[41] to the previously mentioned *Knaekontroll* RCT,[8] investigated the maintenance of the programme by amateur female soccer coaches. Use of the programme by still active coaches, in some form, was very high (82% for intervention group coaches and 68% for control group coaches). However, the majority performed the IPEP less frequently than recommended and around three-quarters had modified the content of the programme.[41]

Research on IPEP implementation in professional soccer settings remains scarce, but awareness of the impact of implementation on injury prevention success in professional teams is growing.[42 43] In a study of coaches from elite junior female teams,[44] high levels of coach intent to deliver an IPEP were observed following a coach workshop. Despite this, only 53% of coaches actually adopted an IPEP during the following season. A recent study in high-level professional male soccer investigated use of the evidence-based Nordic Hamstring (NH) exercise programme.[45] Although 88% of clubs were familiar with the NH programme, it was performed fully in only 11% and partly in just 6% of the total 150 club seasons included in the study.

The above research findings underpin a well-established principle of sports injury prevention: no intervention will achieve its full potential unless it is adopted, correctly implemented and maintained over time.[46] It has been emphasised that for sports injury prevention measures to succeed, an in-depth understanding of end-user (eg, coach and other programme deliverers) perceptions and the specific implementation context in which the programme takes place is required.[15 47 48]

Identification of the factors which influence IPEP implementation can provide valuable information for the design, delivery and support of these programmes, thereby enhancing their success. The tailoring of programmes to specific target groups is also important, with consideration of age,[49 50] knowledge and beliefs,[38 39] programme length[13] and climate.[13 26]

This study aimed to identify challenges to implementing IPEPs in the specific context of professional male youth soccer, particularly relating to the established reporting gaps of adoption and maintenance.[40] As there is currently no industry-standard IPEP for professional soccer, the most highly promoted IPEP for amateur soccer, the FIFA 11+, was used as a blueprint for analysing IPEPs in this study. The specific aims were to:

1. Analyse the perceptions of soccer coaches, fitness coaches and physiotherapists towards injury prevention in general, IPEPs and specifically the FIFA 11+.
2. To seek direct input from staff members regarding the challenges to maintaining IPEPs in their setting.

METHODS

Study design

This study was a cross-sectional, web-based survey hosted by Survey Monkey. All participants completed informed consent forms and the study was approved by the Federation University Australia Human Research Ethics Committee (Ballarat, Australia).

Participants

The targeted participants were all soccer coaches, fitness coaches and physiotherapists working with four elite junior male soccer teams during the 2014/2015 season. The four teams were all based in an elite European soccer academy and were selected based on existing connections with the research team. Three of the teams were competing in the highest national under-age league and one team was competing in the second highest national adult league.

Survey design

The content and development of the survey has been previously reported.[51] Briefly, the development was guided by the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework dimensions[52] and Health Belief Model constructs.[53] The first section of the survey covered perceptions of LL injury susceptibility and seriousness in soccer and the value of IPEPs in general. In the second section, respondents were prompted to visit the official website of the FIFA 11+ (http://f-marc.com/11plus/home/). Subsequent questions focused specifically on the

perceived value of the FIFA 11+ and its relevance to the respondents' context. Both open and closed questions were employed in the survey, including five-point Likert scales, multiple option questions (yes, no, unsure) and questions with free-text answers. The open questions focused on the barriers and facilitators to IPEP maintenance. The survey took approximately 25 min to complete. Face validity was evaluated by pilot testing the survey on two professional soccer players and two physiotherapists. Face and content validity were also strengthened by the authors' differing backgrounds in professional team sport, epidemiology, implementation research and injury prevention research, along with the previous successful administration of the same survey in another professional soccer setting.[51]

Data collection

Following approval from the soccer academy's management, all targeted staff members (soccer coaches, fitness coaches and physiotherapists) were invited to participate. The participants completed the survey during the soccer preseason or, in the case of staff changes, when they first joined their team.

Analysis

The data were exported from Survey Monkey and extensively cleaned and edited. Because of the relatively small sample size and lack of variability, Likert scale responses were converted into three-point scales ('strongly agree/agree', 'neither agree nor disagree' and 'disagree/strongly disagree'). The data were analysed with the responses from all four teams combined. Missing responses were excluded. For each survey question, the proportion (%) of respondents indicating each different answer was calculated in Microsoft Excel and 95% CIs for the sample proportions were calculated with an online calculator (http://www.select-statistics.co.uk). One author categorised the free-text barriers and facilitators to IPEP maintenance into two themes, identified through a previous thematic analysis of the same survey in an adult male professional soccer setting.[51] The first theme related to the content and nature of the IPEP itself. The second theme related to the delivery and support of IPEPs at different ecological levels, and responses were further allocated to five subthemes, reflecting different ecological levels in the professional soccer system (player, team staff, club, governing bodies and the external environment). Responses relating to multiple themes or subthemes were allocated to all relevant themes, and the proportions (%) of total responses allocated to each theme were calculated.

RESULTS

Participants

Eighteen (90%) of the 20 eligible staff members agreed to participate, with 2 (10%) not participating due to lack of time. The respondents included nine coaches, four fitness coaches and five physiotherapists. From a total of 576 answers across respondents, only 5 (<1%) were missing and hence excluded from the analysis of the particular survey item.

Perceptions of injury susceptibility and injury seriousness

Very high proportions (89–100%) of respondents agreed to statements regarding professional soccer players' high susceptibility to LL injuries and the negative impacts of these injuries (table 1).

Perceptions of IPEPs

Respondents unanimously agreed that certain LL injuries can be prevented, that evidence-based exercises should be performed by players and that common types of injury prevention exercises such as balance, eccentric strengthening, controlled jumping/landing and cutting can prevent LL injuries (table 1). All respondents believed that these exercises should be varied and progressed over time, and 94% believed evidence-based exercise should be incorporated into training guidelines.

The multiple-choice question, 'When should exercises to prevent lower limb injuries be performed?' (as part of training, separate from team training, both), was answered with 'both' by 89% of respondents. The most frequent answers to the question, 'How much time is appropriate for a warm-up session at the start of team training?' were 15 min (28%), 20 min (22%) and 25 min (22%), while four respondents indicated that the appropriate warm-up varied depending on factors such as the content of training and age of the players:

> It depends on the content of the team training, the length and intensity should be attuned to the training which follows.

> Very variable depending on age. 10–25 mins before the first maximal sprint/shooting action.

Perceptions of injury prevention responsibility

From eight different soccer club roles listed in the survey, respondents indicated a median of seven different roles as holding responsibility for injury prevention. The most common answers were the player (100%), fitness coach (100%), physiotherapist (100%) and head coach (94%). When asked which role holds the ultimate responsibility for injury prevention, the most common answers were the head coach (35%), the player (24%) and the fitness coach (24%).

Perceptions and current practices in relation to the FIFA 11+

Sixty-one per cent of respondents had previously heard of the FIFA 11+ (table 2), but less than a third of them reported using it in some form. When asked, 'Does your team currently use the FIFA 11+?' a total of 28% indicated either 'yes' (6%) or 'yes, but modified' (22%). All of the respondents using the programme indicated that

Table 1 Respondents' perceptions of lower limb (LL) injury susceptibility, injury seriousness and injury prevention exercise programmes, including the Health Belief Model (HBM) constructs[53] and Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework dimensions[52] which each question related to

Theme	Statement	HBM construct	RE-AIM* dimension(s)	n	Agree % (95% CI)†	Neither agree nor disagree % (95% CI)†	Disagree % (95% CI)†
Injury susceptibility and seriousness	Soccer players are at high risk of suffering a LL injury	Perceived susceptibility	A, M	18	94 (90 to 98)	6 (2 to 10)	0
	LL injuries can shorten a professional soccer player's career	Perceived seriousness	A, M	18	100	0	0
	LL soccer injuries can cause physical problems later in life	Perceived seriousness	A, M	18	100	0	0
	LL injuries have a negative impact on team performance	Perceived seriousness	A, M	18	89 (84 to 94)	11 (6 to 16)	0
	LL injuries have a negative impact on a soccer player's quality of life	Perceived seriousness	A, M	18	100	0	0
Injury prevention exercise programmes	It is possible to prevent some LL soccer injuries	Perceived benefit	A, E	18	100	0	0
	Exercises which have been scientifically proven to prevent LL injuries should be performed by soccer players	Perceived benefit	A, M	18	100	0	0
	Exercises to prevent injuries should be varied and progressed over time	Cues to action	A, I, M	18	100	0	0
	Exercises which have been scientifically proven to prevent LL injuries should be incorporated into the club's training guidelines	Cues to action	M	18	94 (90 to 98)	6 (2 to 10)	0
	Balance exercises can prevent LL injuries	Perceived benefit	E, A, I	18	100	0	0
	Controlled jumping/landing can prevent LL injuries	Perceived benefit	E, A, I	18	100	0	0
	Eccentric muscle strengthening can prevent LL injuries	Perceived benefit	E, A, I	18	100	0	0
	A warm-up jog/run can prevent LL injuries	Perceived benefit	E, A, I	18	100	0	0
	Cutting exercises can prevent LL injuries	Perceived benefit	E, A, I	18	100	0	0
	Cool-down jog/run can prevent LL injuries	Perceived benefit	E, A, I	18	61 (54 to 68)	17 (11 to 23)	22 (16 to 28)

*Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework: E=effectiveness, A=adoption, I=implementation, M=maintenance.
†In cases of 0% and 100% agreement, 95% CIs calculations returning (0–0) or (100–100) are left blank.

Table 2 Respondents' awareness, use and perceptions of the FIFA 11+ programme, including the HBM constructs[53] and RE-AIM framework dimensions[52] which each question related to

Question or statement	HBM construct	RE-AIM* dimension(s)	n	Yes % (95% CI)†	No % (95% CI)†	Unsure % (95% CI)†	Agree % (95% CI)†	Neither agree nor disagree % (95% CI)†	Disagree % (95% CI)†
Had you heard of the FIFA 11+ before taking part in this questionnaire?	Cues to action	R	18	61 (54 to 68)	39 (32 to 46)	0			
Does your team currently use the FIFA 11+?	Perceived benefit	R, A, M	18	28‡ (22 to 36)	61 (54 to 68)	11 (6 to 16)			
Have you ever been in a team which used the FIFA 11+?	Perceived benefit	R, A	13§	0§	69 (54 to 84)	31 (16 to 46)			
Does the FIFA 11+ need to be improved for use in your team?	Perceived benefit	A, I, M	17	78 (70 to 86)	6 (2 to 10)	17 (10 to 24)			
Should your club develop its own version of the FIFA 11+?	Cues to action	A, I, M	17	100	0	0			
The FIFA can prevent LL injuries in your team	Perceived benefit	E, A	18				83 (77 to 89)	17 (11 to 23)	0
The FIFA 11+ is soccer specific	Perceived benefit	A, I, M	18				50 (43 to 57)	44 (37 to 51)	6 (2 to 10)
The FIFA 11+ is too long	Perceived barrier	A, I, M	17				6 (2 to 10)	35 (26 to 44)	59 (50 to 68)
The FIFA 11+ contains adequate variation and progression for our team	Perceived benefit	A, I, M	17				22 (14 to 30)	28 (20 to 36)	50 (41 to 59)
The FIFA 11+ could be maintained over multiple seasons by our team	Cues to action	A, I, M	18				44 (37 to 51)	17 (11 to 23)	39 (32 to 46)

*The Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework: R=reach, E=effectiveness, A=adoption, I=implementation, M=maintenance.
†In cases of 0% agreement, 95% CIs calculations returning (0–0) are left blank.
‡Sum of 'yes' (6%) and 'yes, but modified' (22%).
§Skip-logic was employed for the five respondents already using the FIFA 11+.
HBM, Health Belief Model; LL, lower limb; RE-AIM, Reach Effectiveness Adoption Implementation Maintenance.

they liked it, with some providing reasons as free-text answers:

> It's simple and the basics are covered. Transparency and comprehensibility are present.

> I like it, but I find it too monotonous for regular use.

While 83% of respondents believed that the FIFA 11+ could prevent injuries in their team, only half agreed that it is soccer-specific and just 22% believed it contains adequate variation and progression (table 2). Only 44% agreed that the FIFA 11+ could be maintained by their team over multiple seasons. The vast majority of respondents (78%) indicated that the FIFA 11+ needed improvement for use in their team, and there was unanimous agreement that the club should develop its own version (table 2).

> In my opinion a standard program is the best option for clubs with minimal medical and sport science staff, to keep the injury rate as low as possible. If possible, players should also perform additional, individual exercises based on grounded, specific test procedures. This needs to be tailored to the specific playing level and age group in question.

Barriers and facilitators to IPEP maintenance

The barriers and facilitators to IPEP maintenance, categorised by theme and subtheme, are presented in table 3. The majority of respondents' answers were related to multiple themes and subthemes. Thirty-two per cent of all responses were included under the first theme, the nature and content of the IPEP itself. Almost all responses (97%) were included under the second theme, IPEP delivery and support. One subtheme, IPEP delivery and support at the team staff level, included 88% of all responses (table 3).

DISCUSSION

Key results

This study evaluated the perceptions of IPEP deliverers in the specific context of professional male youth soccer. Soccer coaches, fitness coaches and physiotherapists recognised the high risk and seriousness of soccer injuries and strongly supported the use of evidence-based exercises. Although the majority of respondents had heard of the FIFA 11+ and believed it could prevent injuries in their team, less than a third used it and mostly in a modified form. Overall, the results of this study suggest that established IPEPs need modification for use in professional youth male soccer settings. The findings also hold relevance for the implementation of IPEPs in other soccer settings and in other team ball sports.

Respondents' perceptions of IPEPs

The participants in this study strongly supported the use of injury prevention exercises in general, with all respondents indicating that soccer players should perform them. This is in accordance with other recent research results in professional soccer settings.[31 42] From 32 national teams participating in the FIFA 2014 World Cup, 91% reported using IPEPs.[42] The staff of 44 high-level professional male teams all reported prescribing IPEPs for their players and their top five rated injury prevention exercise types (eg, eccentric strengthening and balance) corresponded closely to the components of the FIFA 11+.[12 31] In the current study, 83% of respondents thought the FIFA 11+ could prevent injuries in their team. Taken together, these results suggest that IPEPs play an important role in professional soccer and although the FIFA 11+ was designed for amateur players, the types of exercises in the programme also hold relevance for professional soccer settings. Despite this, the respondents' reported use of the FIFA 11+ in its original form (6%) or a modified form (22%) was very low in this present study.

A potential explanation for these findings is that while the basic FIFA 11+ components, such as strengthening and balance, are relevant to professional teams, the specific exercises need to be adapted to the professional soccer context. Respondents in this study agreed unanimously that injury prevention exercises need to be varied and progressed over time, with only 22% of respondents believing the FIFA 11+ contained adequate progression and variation. Furthermore, the need for fun and challenging injury prevention exercises, with sufficient variety, was evident in free-text answers.

The delivery of injury prevention exercises may also need tailoring to the professional soccer context. The FIFA 11+ is delivered as a team warm-up programme, but the majority of participants in this study believed that injury prevention exercises should be delivered both during team training and separate from training. This suggests that the future design and delivery of IPEPs for professional soccer needs to consider various formats for delivering exercises, beyond the warm-up alone. Other studies in professional support these findings.[31 42] Optimising the individualisation of programmes was the most commonly reported injury prevention challenge in a survey of 2014 FIFA World Cup teams,[42] and 73% of premier league professional soccer teams reported prescribing both individual and group injury prevention sessions.[31]

Barriers and facilitators to IPEP maintenance

Far more clues to the specific implementation challenges in professional soccer emerged from the free-text answers regarding IPEP maintenance. The diversity and nature of the reported challenges highlight that efficacious IPEPs alone are not enough to prevent injuries. Almost all responses related to aspects of programme delivery and support (eg, coach acceptance, communication and team work). Hence, to ensure the ultimate success of these programmes, there is a need to focus on addressing implementation challenges at various levels of the soccer system.

Table 3 Barriers and facilitators to injury prevention exercise programme (IPEP) maintenance in professional soccer teams categorised by themes and subthemes, including the proportion (%) of total responses included under each theme

Main theme (percentage of responses)	Subtheme (percentage of responses)	Survey framework	Examples
IPEP content/nature (32%)	–	Facilitators	Fun and challenging exercises Positive effect on injury statistics Programme practicality Progression and variation of exercises
		Barriers	Boring, monotonous exercises Lack of effectiveness and objective measures
IPEP delivery and support at different ecological levels* (97%)	Player (47%)	Facilitators	Acceptance of the programme Awareness of the benefits Motivation
		Barriers	Lack of acceptance/knowledge Lack of motivation/diligence
	Team staff (88%)	Facilitators	Acceptance/support from the head coach and other staff Continuity in methodology Explanation from staff to players Staff numbers, knowledge and motivation Planning and organisation
		Barriers	Lack of acceptance/support from the head coach and other staff Lack of communication and team work Lack of explanation to players Lack of knowledge and motivation Lack of long-term planning Lack of professional implementation Lack of staff numbers and continuity
	Club (24%)	Facilitators	Club structure and support Incorporation into club policy
		Barriers	High number of injuries in the club Lack of structure and support Pressure to win
	Governing bodies (9%)	Facilitators*	–
		Barriers	Heavy game schedule

*The categories governing bodies/facilitators was included because it arose in a previous study using the same survey, but no respondents in the current study provided relevant responses. There were also no relevant responses for the previously identified subtheme 'external environment'.[51]

It is noteworthy that one subtheme, IPEP delivery and support at team staff level, included 88% of all responses. Examples in this subtheme included staff acceptance of IPEPs, staff number and continuity, communication and team work. The frequency of responses in this sub theme strongly suggests that factors at staff level represent a key challenge in the successful maintenance of IPEPs in professional youth soccer. The presence of large interdisciplinary teams in professional sports clubs and the potential for conflict among these teams has been previously reported.[32 54 55] The high number of roles sharing the responsibility for injury prevention in clubs, as indicated by the respondents in this study, adds to the challenge of ensuring adequate acceptance and support for IPEPs. Physicians working with 2014 FIFA World Cup teams identified 'compliance of and between staff' as one of the main challenges in preventing injuries.[42] Research reports from the Union of European Football Associations (UEFA) injury study, involving top-level professional European teams, have also identified internal communication and the stability of staffing as important elements for successful injury prevention.[43]

Limitations

This study had several limitations. The sample size, which was dictated by the targeted real-world setting, was small. Accordingly, care is warranted in extrapolating the study results to other populations. The small sample size also precluded analysis of participant subgroups (eg, coaches only), or potential modifying variables (eg, age, coaching experience) due to insufficient power. The survey used in this study was not subjected to validity testing beyond face and content validity, similar to other studies in this field,[31 41 42] though the same survey was successfully conducted in a group of professional adult

soccer teams.[51] The answers to Likert scale questions may have been influenced by factors such as acquiescence bias and social desirability bias.[56] Only one researcher allocated free-text responses to themes and subthemes, and the use of multiple independent reviewers may have strengthened this method.

Future research

Further studies are needed to investigate exactly how IPEPs are used in professional youth soccer settings and the specific implementation challenges they face. As reported injury prevention behaviour does not necessarily reflect actual behaviour,[57] direct observation of IPEP use through longitudinal observational studies, with multiple assessment times, is recommended. Such studies will provide insight into exactly how IPEPs are modified by end users and the specific reasons behind these modifications.

CONCLUSION

The coaches, fitness coaches and physiotherapists of professional youth male soccer teams strongly support the use of injury prevention exercise programmes. However, to enhance their impact, IPEPs must be tailored to the specific implementation context of professional youth soccer. This includes modifying IPEP content to provide adequate exercise challenge, variation and progression. Additionally, adequate delivery and support of IPEPs at various levels, particularly team staff level, are key considerations. The results of this study provide valuable information for enhancing the delivery of existing exercise programmes and also for the future development of improved IPEPs for professional youth soccer.

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Contributors JO led this work as part of his PhD studies. He designed the study, led its conduct, had the major role in paper writing and is responsible for the overall content as guarantor. CFF contributed to the design of the study and the writing of the paper.

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Competing interests JO is employed at the professional soccer academy involved in this study. Although all survey responses were anonymous, it is possible that the author's relationship to academy staff influenced the results.

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3.3.3 Summary

Paper six in this thesis assessed the specific IPEP implementation context of professional youth male soccer teams. The results showed high levels of awareness, among key stakeholders, regarding players' susceptibility to injury and the negative impact of these injuries. The survey respondents strongly supported the use of IPEPs, but also believed that IPEPs (when measured against the industry standard FIFA 11+) required more variation and progression. They also detailed a wide range of barriers and facilitators to maintaining IPEPs, relating either to the programs themselves, or IPEP delivery and support at different ecological levels of the professional soccer system.

4.0 PROSPECTIVE OBSERVATIONAL STUDY

4.1 OVERVIEW OF CHAPTER FOUR

The next chapter of this thesis includes two papers reporting the results of a prospective observational study. As staff members in professional youth soccer teams emphasise the need to tailor IPEPs to their specific context (established in Chapter Three), this study aimed to assess exactly how teams adapt IPEPs, along with the reasons for these adaptations. It was anticipated that weekly observations of IPEP use would provide a novel insight into how teams' tailor programs to fit their specific context, along with detailed information on specific IPEP implementation barriers and facilitators.

4.2 PAPER SEVEN

The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+.

4.2.1 Overview

The next paper reports the results of a prospective observational study of IPEP implementation in four professional youth soccer teams. The participants were the same staff members involved in the previously reported survey (Paper 6). Hence, it was already established that the majority of the participants supported the use of IPEPs, but believed that programs needed more variation and progression for their specific context (as measured against the industry-standard FIFA 11+). It was also known that under a third of these participants reported using the FIFA 11+, and mostly in a modified form. The FIFA 11+ was once again employed as a comparator, in absence of an equivalent injury prevention program, specifically designed for professional soccer.

The following paper, "The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+", was published online on the 1st June 2016 in the Journal of Science and Medicine in Sport.

4.2.2 Manuscript

Declaration for Paper 7

The delivery of injury prevention exercise programs in professional youth soccer: comparison to the FIFA 11+.

Declaration by candidate

For Paper 7, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	90%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, interpretation of results and the writing up of the manuscript.
Associate Professor Warren Young	Contributed to the interpretation of results and the writing up of the manuscript.

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal Supervisor's Signature		Date 18.05.2016

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Original research

The delivery of injury prevention exercise programmes in professional youth soccer: Comparison to the FIFA 11+

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ABSTRACT

Objectives: Injury prevention exercise programmes for amateur soccer have gained considerable attention, but little is known about their relevance and adaptability to professional soccer settings. The first aim of this study was to evaluate the delivery and content of injury prevention exercise programmes used by professional youth soccer teams, compared to the industry standard injury prevention exercise programme for soccer, the Fédération Internationale de Football Association's FIFA 11+. The second aim was to document specific challenges to implementing injury prevention exercise programmes in this context.
Design: Prospective observational study.
Methods: The participants were soccer coaches, fitness coaches and physiotherapists ($n = 18$) from four teams in a professional youth soccer academy. Each team's chosen injury prevention exercise programmes were observed weekly across an entire soccer season (160 sessions). The delivery and content of the programmes were documented on a standardised worksheet and compared to the FIFA 11+. Specific implementation challenges were recorded.
Results: Fitness coaches were the primary deliverers of injury prevention exercise programmes, with support from physiotherapists. Multiple delivery formats and locations were employed, along with the extensive use of equipment. Across all injury prevention exercise programme sessions, a median of one FIFA 11+ exercise was performed in its original form and a further four in a modified form. Implementation challenges included poor staff communication, competing training priorities and heavy game schedules.
Conclusions: Although the basic components of the FIFA 11+ hold relevance for professional youth male teams, the delivery and content of injury prevention exercise programmes require considerable tailoring for this context. Recognising this will inform the development of improved, context-specific injury prevention exercise programmes, along with corresponding strategies to enhance their implementation.

1. Introduction

Soccer is the world's most popular sport,[1] but injuries are both common and associated with considerable costs, participation loss, decreased team performance and long-term negative side effects.[2–4] In recent years, there has been increased research interest in the prevention of soccer injuries, particularly the use of injury prevention exercise programmes (IPEPs). The efficacy of established IPEPs, including the Fédération Internationale de Football Association's *FIFA 11+* and a Swedish IPEP called *Knäkontroll*, has been demonstrated in large-scale randomised controlled trials (RCTs).[5,6] However, it has also been emphasised that establishing an IPEP's efficacy is only one of several steps in successfully preventing real-world injuries.[7,8] Recent research has highlighted the challenges of reaching target IPEP audiences, enhancing adoption and ensuring adequate compliance over time.[9–11] For example, in a trial of the *Knäkontroll* programme in amateur female Swedish teams, players with high compliance experienced an 88% reduction in the rate of Anterior Cruciate Ligament (ACL) injuries, whereas the rate among players with low compliance did not differ significantly from the control group.[10] In a further example, Norwegian female players with high compliance to the *FIFA 11+* programme, demonstrated a 35% lower risk of injuries compared to players with intermediate compliance levels.[12]

To enhance the real-world impact of sports injury prevention interventions, researchers and evaluators have begun to embrace implementation frameworks from the broader field of health promotion, such as the Reach Effectiveness Adoption Implementation

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Maintenance (RE-AIM) framework.[13–15] This framework outlines a range of factors influencing the successful translation of evidence-based interventions into real-world practice.[15] A recent systematic review of team ball sport IPEP trials, employing RE-AIM, demonstrated the paucity of current knowledge on implementation factors, particularly relating to aspects of adoption and maintenance.[16] Other recent RE-AIM studies in soccer settings have highlighted the challenge of convincing soccer coaches to adopt IPEPs, perform them as intended and maintain them over time.[9,11,17] In a three-year follow up to the *Knäkontroll* RCT, approximately three-quarters of coaches had modified the original content of the programme, or had failed to perform it with the prescribed frequency.[9] In a study of Oregon high school soccer and basketball coaches, 52% were aware of IPEPs, but just 21% reported using one and only 9% reported performing the programme as originally designed.[17]

Recent sports injury prevention implementation research has emphasised that a key first step to enhancing an intervention's success is developing an understanding of the specific context in which it is to be delivered.[8,18] The design and delivery of IPEPs require tailoring to the specific target setting, with consideration of factors such as player age,[19,20] knowledge and beliefs,[21] competitive level[22] and climate.[18,23] Recent studies have evaluated the perceptions of players and staff members towards injury prevention programmes within the specific setting of professional male soccer[24] and professional youth male soccer.[25] The respondents in these teams expressed strong support for the use of IPEPs, and also identified multiple factors influencing the successful implementation of these programmes in their context. These factors related to both the content and nature of the IPEP itself (e.g. exercise variation/progression), and the delivery and support of IPEPs (e.g. staff communication and coach acceptance). In professional male teams, only 30% of respondents believed that the *FIFA 11+* contained adequate progression and variation for their context.[24] In professional youth male teams, the majority of respondents were aware of the *FIFA 11+*, but fewer than a third actually used it and mostly in a modified form.[25]

Taken together, the results of the above studies suggest that established IPEPs require considerable tailoring for use in professional soccer teams. However, there is currently a lack of published information on the content and delivery of IPEPs in these settings.[24] Hence, the aims of the current study were:

(1) To directly observe the delivery and content of IPEPs in a professional youth soccer academy at weekly intervals across an entire season.
(2) To document the specific IPEP implementation challenges experienced by staff.

2. Methods

The study design was a prospective weekly observation of four teams across one entire soccer season. The targeted participants were all soccer coaches, fitness coaches and physiotherapists from four professional youth male soccer teams during the 2014/2015 season. The four teams were all based in a professional European soccer academy and were selected based on existing connections to the researchers. Three teams (Under-15, Under-16 and Under-18 age groups) were competing in the premier national under-age league and one team (Under-23) was competing in the second highest national adult league. The teams typically trained 6–7 times per week.

All participants completed informed consent forms and the study was approved by the Federation University Australia Human Research Ethics Committee. Prior to the current study, all consenting participants completed a web-based survey, detailing their perceptions of soccer injuries, IPEPs in general and the *FIFA 11+*. Participants were prompted to follow a link in the survey to the official FIFA 11+ website, to familiarise themselves with the programme. The results of this survey have been previously reported.[25]

During the pre-season, the first author met with the staff of each team. In a semi-structured interview, each teams' strategy for implementing IPEPs in the coming season was discussed. In addition to the planned content of IPEPs, aspects of delivery (e.g. format, location and staffing) were discussed.

Each week, during the 49 week soccer season, the delivery of one IPEP session from each of the four teams was randomly selected for observation and documented on a standardised worksheet. A block randomisation method was used to ensure a balance in the number of observations at different time points across the training week. In cases where block randomisation was not possible (e.g. short-term cancellation of the selected session), one of the remaining sessions in the week was chosen at random using an online generator (*www.random.org*).

A standardised data collection sheet (Supplemental file 1), structured around the industry-standard IPEP for soccer, the FIFA 11+, was developed in Microsoft Excel™. At every observation, the team's use of each FIFA 11+[26] exercise was coded by the first author as either (1) performed as prescribed, (2) performed modified or (3) not performed. Exercises were considered modified when progressions or equipment, other than those outlined in the original FIFA 11+,[26] were observed. Additionally, the location where the IPEP was delivered (e.g. outdoor pitch, gym), the training format (e.g. warm-up, cool-down), the number and type of staff members delivering the IPEP (e.g. fitness coach, physiotherapist) and the use of equipment (e.g. weights, balance pads) were documented. For each session, staff also provided the current number of players in the squad, along with the number and reasons for any player absences. Throughout the season, both at staff meetings and following every IPEP observation, staff members were asked verbally to explain any facilitators and barriers to IPEP implementation. This information was solicited through casual questioning as opposed to formal, structured interviews.

The data from all IPEP observations was summarised and analysed using Microsoft Excel™, with all teams combined. The types of IPEP delivery format, types of IPEP delivery location and primary IPEP deliverer were summarised descriptively (total number, percentage of all observations, mean and range). The primary deliverer was defined as the staff member who took on the main role of instructing players during the IPEP. The minimum, 25% quartile, median, 75% quartile and maximum number of FIFA 11+ exercises performed, performed modified and not performed across all observations in the entire season were calculated. The facilitators and barriers to implementing IPEPs, identified by staff members, were categorised according to themes identified in earlier studies of professional soccer teams.[25,27]

3. Results

Eighteen (90%) of the 20 eligible staff members, including nine soccer coaches, four fitness coaches and five physiotherapists, agreed to participate. The remaining 2 (10%) cited lack of time as the reason for not participating.

During the initial team meetings, all four teams reported planning to use IPEPs in the coming season and had a defined strategy for the content and delivery of these programmes. None of the teams intended to use the FIFA 11+ in its original form, but their IPEPs were structured on basic exercise components overlapping closely with those of the FIFA 11+ (e.g. strength, balance, jumping/landing and core stability). Fitness coaches and physiotherapists decided

on the programme content, with consideration given to player age, published research, injury statistics and past experience. Fitness coaches were responsible for delivering the IPEPs, while physiotherapists assisted with the supervision and correction of exercises. Head coaches ultimately decided on the number and length of IPEPs in each training week, with consideration of the game and training schedule. All teams planned to use multiple delivery formats (e.g. warm-up, separate sessions) and multiple delivery locations (e.g. outdoor pitch, gym). Incorporating different preventive training cycles across the season (e.g. a cycle focussing on strength) was also considered important. Staff emphasised the need to tailor IPEP content to the chosen delivery format (e.g. including more running and dynamic stretching exercises in warm-ups).

Across the 49 week soccer season, 160 IPEP sessions were observed across the four academy teams (range per team 35–43). In 28 instances, a team did not perform any IPEP session during a calendar week (range per team 4–12) with the most common reasons being season breaks and training interruptions due to heavy game schedules or athletic performance tests. In a further eight instances (range per team 1–3), an observation could not be performed due to short-term changes to the training plan (e.g. the last session in a week, randomised for observation, being cancelled by team staff) or the observer being ill/on educational leave. Hence, from 168 potential weekly observations, 160 (95%) were completed.

The observed IPEP format, location, primary deliverer, duration, active staff members, player absences and number of training equipment types per session are summarised in Table 1.

A median of four players were absent, with the most common reasons being injury, illness, national team/first squad selection and participation in other parallel training sessions (e.g. goalkeeper training). Across all IPEP sessions, a total of 53 different types of training equipment (e.g. balance pads, dumbbells and resistance bands) was observed, with a median of 26 (range 21–30) across the four teams.

The number of the 15 FIFA 11+ exercises performed in their original form, performed in a modified form and not performed are summarised in Fig. 1. A median of one FIFA 11+ exercise was performed in its original form and a further four in a modified form. Examples of modifications included performing squats with added weight and performing single-leg balance exercises on balance pads, while kicking a soccer ball to a partner. Exercises from part two of the FIFA 11+[26] (strength, plyometrics and balance) were more frequently performed that exercises from parts one and two of the FIFA 11+ (running exercises). The proportion of total IPEP sessions in which the six exercises in part two were performed, either in original or modified form, ranged from 43 to 73% (median 65%) across the six exercises. The corresponding figures for the nine running exercises were; range 2–68% (median 21%). Full details regarding the use and modification of each individual FIFA 11+ exercise will be reported elsewhere.

The participants reported multiple barriers and facilitators to implementing IPEPs (Supplemental file 2) relating either to the content and nature of the programmes (e.g. variation, progression, adaptability), or their delivery and support (e.g. staffing, teamwork, communication). Aspects of IPEP delivery and support spanned multiple levels of the professional youth soccer system, including the player (e.g. personality and motivation), team staff (e.g. coach acceptance and staff communication), the club (e.g. sports director acceptance), governing bodies (e.g. game schedules) and the external environment (e.g. weather).

4. Discussion

This is the first study to directly observe the implementation of IPEPs in any form of soccer on a weekly basis. This provided a detailed insight into IPEP delivery, content and implementation challenges in a real-world, professional soccer setting. The vast majority of observed sessions were delivered by fitness coaches, using a range of different locations, training formats and training equipment. Taken as a median across the season, over a third of the FIFA 11+ exercises were included in the observed IPEP sessions, albeit mostly in a modified form. Team staff provided a comprehensive list of barriers and facilitators to implementing IPEPs, relating either to the programme itself, or the delivery and support of IPEPs at different levels of the professional soccer system. The findings of this study will inform the design and delivery of future IPEPs for professional youth soccer, other soccer settings and other team ball sports.

The ultimate impact of IPEPs in real-world settings will depend on the efficacy of the programmes and the extent to which they are successfully adopted, performed and maintained by the targeted audiences.[28] Whilst players are the intended health beneficiaries of IPEPs, the individuals delivering the programmes (e.g. team staff) also play a key role in achieving the desired injury prevention outcomes.[29] To date, much of the research on IPEPs has focussed on amateur soccer settings, with coaches being identified as key IPEP deliverers.[30] However, as highlighted by this study, fitness coaches are the primary IPEP deliverers in professional soccer settings. Compared to the technical and tactical focus of soccer coaches, fitness coaches are primarily focussed on the physical conditioning of players, and are likely to have different educational backgrounds, injury prevention perceptions and specific training goals. For example, the fitness coaches in this study referred to the published sports science and sports medicine literature to inform the design of their IPEPs and aligned the content/delivery of the programmes to athletic goals and training cycles.

The IPEP delivery formats and delivery locations observed in this study also differ considerably to the recommendations in the industry-standard programme for amateur soccer, the FIFA 11+. Whereas the FIFA 11+ is promoted as an on-pitch, warm-up programme requiring minimal equipment,[26] the teams in this study employed IPEPs in several formats (e.g. warm-up, separate sessions, split sessions), different settings (e.g. outdoor pitch, indoor pitch, gym) and with extensive use of equipment. The challenges and opportunities arising from these contextual differences in professional soccer settings need careful consideration when planning the design and delivery of future programmes.

The fact that modified FIFA 11+ exercises were frequently incorporated into the IPEPs observed in this study suggests that the certain components of the FIFA 11+ hold relevance for professional youth teams. However, staff emphasised the need for adequate variation and progression of IPEP exercises in professional soccer settings, including fun/challenging/competitive exercises, the use of equipment and different training cycles. The staff also emphasised the importance of IPEP adaptability, with the length and content of programmes requiring tailoring to the specific training format (e.g. warm-up vs. cool-down), athletic training goals and the different ability levels of individual players.

The number and diversity of barriers and facilitators provided by staff highlights both the complexity of the IPEP implementation context and the importance of targeting multiple levels of the professional soccer system when implementing programmes. This aligns closely with established implementation frameworks such as the RE-AIM Sports Setting Matrix.[13] At the player level, the success of an IPEP will be facilitated by adequate education, motivation and more supervision (e.g. more staff or smaller groups). The significant proportion of player absences observed in this study holds implications for IPEP implementation strategies. Programmes that players can perform separately from the team training may compensate for missed team sessions. Staff also require strategies for

Table 1
The delivery of injury prevention exercise programmes (n = 160 sessions) in four professional youth soccer teams.

Category	Type	Number (%) across 160 sessions	Median (range) across 4 teams
Format of IPEP delivery	Warm-up	66 (41)	20 (0–26)
	Cool-down	11 (7)	2 (0–8)
	Separate[a]	69 (43)	14 (9–32)
	Split[b]	9 (6)	1 (0–8)
	Combination	5 (3)	1 (0–3)
Location of IPEP delivery	Outdoor pitch	42 (26)	12 (0–17)
	Indoor pitch	59 (37)	13 (6–27)
	Gym[c]	6 (4)	2 (0–3)
	Sports hall[d]	30 (19)	6 (1–17)
	Motor skills park[e]	5 (3)	1 (1–2)
	Combination	18 (11)	4 (0–10)
Primary IPEP deliverer[f]	Fitness coach	147 (92)	37 (34–39)
	Physiotherapist	12 (8)	3 (1–5)
	Soccer coach	1 (1)	0 (0–1)
Duration of the IPEP session (minutes)	Warm-up		35 (12–70)
	Cool-down		25 (10–46)
	Separate[a]		46 (15–75)
	Split[b]		19 (14–25)
	Other		66 (19–90)
	All sessions		39 (10–90)
Number of active staff	Fitness coach		1 (0–2)
	Physiotherapist		1 (0–2)
	Soccer coach		0 (0–2)
	All staff		2 (1–5)
Number of players absent			4 (0–17)
Proportion of squad absent			16% (0–71)
Number of training equipment types			3 (0–12)

[a] A session performed separately from soccer training (>15mins prior/post).
[b] A session performed with the squad split into groups, rotating through injury prevention and soccer technical/tactical stations.
[c] A room with weight-training equipment.
[d] A large hall used for various sports (e.g. soccer and basketball) and equipped with gymnastic apparatus.
[e] An outdoor training course with multiple stations focusing on strength, balance, agility and climbing skills.
[f] The staff member who took on the main role of instructing players during the IPEP.

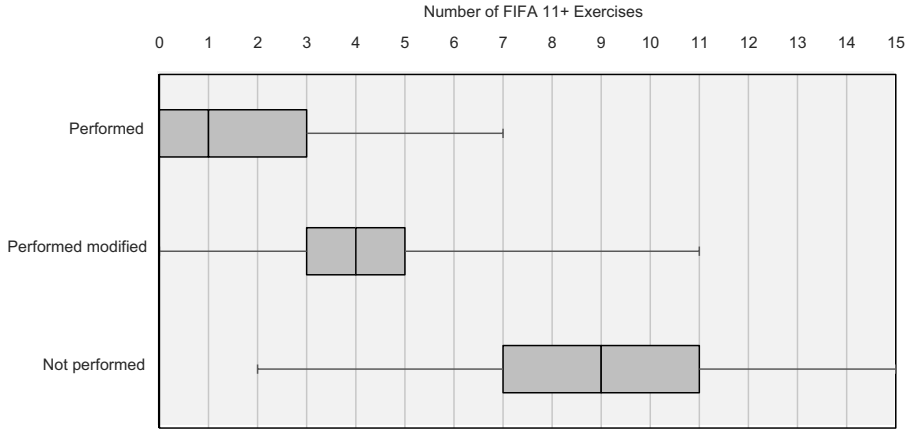

Fig. 1. The number of FIFA 11+ exercises performed by four professional youth soccer teams in 160 injury prevention sessions. *Note*: This box and whisker plot indicates the minimum, 25% quartile, median, 75% quartile and maximum number of FIFA 11+ exercises.

re-integrating players following absences due to injury/illness or involvement with other teams.

The reported implementation facilitators at the team staff level included communication, coach acceptance, staff stability and team work. The detailed list of factors identified in the study builds considerably on previous findings from professional soccer settings[25,27] and illustrates the key role of team staff in IPEP implementation. At the club level, IPEP acceptance, planning and stability were identified as important factors. Friendly games and tournaments, planned by club officials, can disrupt teams' regular training schedules, hence limiting the available time for injury prevention. Game scheduling was also the primary facilitator/barrier identified at the level of governing bodies (e.g. leagues and national governing bodies). As in previous IPEP studies,[18,23] weather conditions were reported as a factor influencing IPEP implementation, with favourable weather facilitating variation in the training location and performing exercises on the ground. Although the teams in this study had access to indoor facilities, changes to the delivery location (especially short-term) demanded a degree of IPEP adaptability, along with sufficient planning/organisation of shared facilities and equipment.

Modifications of FIFA 11+ exercises were frequently observed in this study. For example, squats were performed with additional weight and unstable surfaces were used to increase the difficulty of

balance exercises. Full details regarding the use and modification of individual exercises will be reported elsewhere. Future research should evaluate the efficacy of IPEPs that have been specifically tailored to professional soccer settings, along with their effectiveness under real-world conditions.

It is important to note certain limitations of this study, including the moderate sample size, which was dictated by the real-world soccer setting under investigation. Hence, care is warranted in extrapolating the results to other populations and settings. The observation worksheet was not formally tested for validity or reliability (beyond face validity), but was structured on an established, industry-standard IPEP. The coding of FIFA 11+ exercises as performed, performed modified or not performed was judged by a single observer and proved challenging at times. In particular, it was difficult to decide if certain observed exercises should be considered (considerable) modifications of FIFA 11+ exercises, or separate exercises, not related to the FIFA 11+. In such cases, the observer erred on the side of including the exercises in the category of "performed modified"; this may have resulted in an over-estimation of modified FIFA 11+ use. While all staff members provided feedback at team meetings, fitness coaches and physiotherapists were more likely to give feedback directly following IPEP sessions, due to their role as the primary IPEP deliverers.

5. Conclusion

The delivery and content of injury prevention exercise programmes used by professional youth soccer teams differ significantly to the recommendations in the industry-standard programme for amateur football, the FIFA 11+. Fitness coaches are the key IPEP deliverers and employ a range of different delivery formats, locations and training equipment. The successful implementation of IPEPs is influenced by a wide range of facilitators and barriers, relating either to the content and nature of the programmes (e.g. variation, progression, adaptability), or their delivery and support across different ecological levels in the professional youth soccer system (e.g. staffing, teamwork, communication). Addressing these factors in the design and delivery of future IPEPs will enhance the ultimate real-world impact of IPEPs in this context.

Practical implications

- Fitness coaches play a key role in the delivery of injury prevention exercise programmes (IPEPs) in professional youth soccer.
- The delivery and content of IPEPs for professional soccer need to be tailored to fit different training formats, training locations, player ability levels and athletic goals.
- A wide range of factors, across multiple levels of professional sport, influence the successful delivery of IPEPs.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jsams.2016.05.007.

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4.2.3 Summary

This study was the first to assess the specific IPEP implementation context of professional youth male soccer. The delivery of IPEPs in this context differed significantly to the recommendations for the industry-standard program for amateur football, the FIFA 11+. Fitness coaches were the primary deliverers of IPEPs and used a range of different delivery formats, locations and training equipment. A wide range of facilitators and barriers to implementing IPEPs were identified, relating either to the content and nature of the programs (e.g. variation, progression, individualisation), or their delivery and support across different levels of the professional youth soccer system (e.g. staffing, teamwork, communication). Addressing these factors in the design and delivery of future IPEPs will enhance the ultimate real-world impact of IPEPs in this context.

4.3 PAPER EIGHT

The use and modification of injury prevention exercises by professional youth soccer teams

4.3.1 Overview

The previous paper assessed IPEP implementation in the specific context of professional youth soccer, providing detailed insight into program delivery, along with an outline of program content. However, the analysis did not address the use and modification of individual exercises, or the reasons for these modifications, which are the focus of this next paper. It was anticipated that this analysis would provide further insight into how the content of IPEPs is tailored to this specific implementation context.

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4.3.2 Manuscript

Declaration for Paper 8

The use and modification of injury prevention exercises by professional youth soccer teams.

Declaration by candidate

For Paper 8, the nature and extent of my contribution to the work was as follows:

Nature of contribution	Extent of contribution (%)
Principal author responsible for the concept, data extraction and synthesis, interpretation of results and writing up of the manuscript.	90%

The following co-authors contributed to the work.

Name	Nature of contribution
Professor Caroline Finch	Contributed to the concept, interpretation of results and the writing up of the manuscript.
Associate Professor Warren Young	Contributed to the interpretation of results and the writing up of the manuscript.

I hereby declare that the above declaration correctly reflects the nature and extent of the candidate's contributions to this work.

Candidate's Signature		Date 18.05.2016
Principal supervisor's Signature		Date 18.05.2016

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The use and modification of injury prevention exercises by professional youth soccer teams

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The efficacy of injury prevention exercise programs (IPEPs) for amateur youth soccer has been established, but little is known about their adaptability to other soccer populations. This study aimed to assess the use of individual injury prevention exercises by professional youth soccer teams, against the industry-standard, FIFA 11+ program. Four teams' chosen IPEPs were observed across one season and documented on a standardized form. The use of each FIFA 11+ exercise was coded as "performed", "performed modified" or "not performed". The proportion of the 160 observed sessions containing each individual exercise was calculated. Staff provided reasons for their use and modification of FIFA 11+ exercises. On average, individual FIFA 11+ exercises were conducted in original form in 12% of the sessions (range 0–33%), and in modified form in 28% of sessions (range 2–62%). The five most frequently observed exercises, in either original or modified form, were "bench" (72%), "squats" (69%), "running straight" (68%), "single-leg stance" (66%), and "sideways bench" (64%). Staff modified exercises to add variation, progression, and individualization, and to align with specific training formats and goals. Professional youth soccer teams often use injury prevention exercises similar to those in the FIFA 11+, but tailor them considerably to fit their implementation context.

In view of soccer's world-wide popularity and high injury rates, the development of evidence-based strategies to prevent soccer injuries is of paramount importance (Bizzini et al., 2013). In 2006, the Fédération Internationale de Football Association (FIFA) teamed with two sports injury prevention research centres to develop the FIFA 11+, a basic injury prevention exercise program aimed at amateur soccer players (Bizzini & Dvorak, 2015). The results of large-scale randomized controlled trials (RCTs) have since supported the efficacy of the FIFA 11+ in teams of amateur female (Soligard et al., 2008), amateur male (Owoeye et al., 2014), and collegiate male soccer players (Silvers-Granelli et al., 2015). Other injury prevention exercise programs (IPEPs) for amateur soccer, including the Knäkontroll (Waldén et al., 2012) and Prevent Injury Enhance Performance (Mandelbaum et al., 2005), also have demonstrated efficacy. However, recent research highlights that, in addition to establishing efficacy, achieving adequate compliance to IPEPs plays a key role in their ultimate success (Soligard et al., 2010; Hägglund et al., 2013; Steffen et al., 2013).

As support for the FIFA 11+'s efficacy grows (Al Attar et al., 2016), researchers have also explored the program's adaptability to other soccer populations, including veteran (Hammes et al., 2015), children (Rössler et al., 2016), and professional youth teams (O'Brien & Finch, 2016a). In a cluster RCT of the FIFA 11+ in veteran players (minimum age of 32), Hammes et al. (2015) found no preventive effect of the FIFA 11+ on overall injuries. The authors attributed this lack of effect to the low frequency of performed sessions and suggested modifying the program (e.g., adding more ball-based and individual exercises) to better fit the specific implementation context. In recent cross-sectional surveys within professional soccer settings (O'Brien & Finch, 2016a, b), players and staff members also emphasized the need to adapt IPEPs to their specific context. The survey respondents emphasized the need for adequate exercise variation, progression, individualization, and soccer-specificity.

The importance of understanding the context in which an intervention is to be delivered has been highlighted in recent injury prevention implementation research (Padua et al., 2014; Twomey et al., 2015; Donaldson et al., 2016), as well as in established injury prevention models (Finch, 2006; Finch & Donaldson, 2010). Information on the delivery of IPEPs in professional soccer settings is scarce, but it is known that professional soccer teams strongly support the use of IPEPs and employ similar exercise components (e.g., strength, balance, core stability, and plyometrics) as in established amateur programs, such as the FIFA 11+ (McCall et al., 2014; O'Brien et al., 2016). It is also known that achieving adequate adoption and compliance to injury prevention programs can be challenging in these settings (Bahr et al., 2015).

Professional players, as defined by FIFA (Fédération Internationale de Football Association 2007) earn more than the expenses they occur for soccer activities and have written contracts with a club. In addition to their top-level teams, professional clubs also support youth teams, based in development academies (Price et al., 2004). To date, injury prevention in these professional youth players has received very little research attention (O'Brien & Finch, 2016b), despite knowledge that physiological loads, psychological loads, and injury rates are very high in these settings (Price et al., 2004; Brink et al., 2010). Reported injury incidences in this population range from 2.0 to 19.4 injuries per 1000 hours, with a recent systematic review finding a higher incidence of training injuries in professional youth players, compared to their adult counterparts (Pfirrmann et al., 2016). In comparison, the reported injury rate in amateur male soccer players ranges from 0.8 to 8.5 injuries per 1000 hours (Junge et al., 2002; Owoeye et al., 2014).

The injury prevention landscape in professional clubs differs to that of amateur soccer clubs in terms of training frequency and staffing. Professional teams typically train on an almost daily basis, compete both nationally and internationally, and are supported by large multi-disciplinary teams including soccer coaches, fitness coaches, and physiotherapists. It has been reported that professional teams adapt injury prevention programs to fit their specific context (O'Brien et al., 2016), which aligns with findings from amateur soccer (Lindblom et al., 2014; Frank et al., 2015) and Australian Football (Fortington et al., 2015; Twomey et al., 2015) settings. Unfortunately, there is a paucity of published information exploring exactly how, and why, teams modify individual exercises to fit their specific settings. For example, the fact that professional soccer teams strongly support the use of eccentric strengthening exercises (McCall et al., 2014), but rarely use the evidence-based (and FIFA 11+ advocated) hamstring lowers exercise (Bahr et al., 2015), raises the question of which alternate exercises they do perform and why. This information is necessary to guide the design and successful delivery of future IPEPs, specifically tailored to the professional soccer context. Accordingly the aims of this present study were:

1. To assess the injury prevention exercises used by professional youth soccer teams, against the industry standard program for amateur soccer, the FIFA 11+.
2. To report the reasons for use, and modification, of individual exercises by professional youth soccer teams

The findings are expected to inform the development of future IPEPs, specifically tailored to the context of professional youth soccer.

Materials and methods

This study was a secondary analysis of a prospective observational study. The selection of participants and data collection methods have been previously reported (O'Brien et al., 2016) and are summarized below. However, the original analysis did not address the use and modification of individual exercises, or the reasons for these modifications, which are the focus of this present paper. The study was approved by the Federation University Australia Human Research Ethics Committee and all participants completed informed consent forms.

Participants

The participants were the soccer coaches, fitness coaches, and physiotherapists from four youth male teams, in a European professional soccer academy. The academy was selected due to existing connections to the researchers. The consent rate was 90% (18 of 20 eligible staff members). All participants were familiar with the FIFA 11+ program from taking part in a previous survey focussing on injury prevention exercise programs and, more specifically, the FIFA 11+ (O'Brien & Finch, 2016a). Furthermore, the primary analysis identified fitness coaches as the primary deliverers of IPEPs in this context, with support from physiotherapists (O'Brien et al., 2016). The teams ranged from Under-15 to Under-23 age groups and typically trained 6–7 times/week in addition to playing a game. The majority of players attended school in addition to their soccer activities.

Data collection

On a weekly basis, across the entire 2014/2015 soccer season, one injury prevention exercise session from each of the four teams was observed by one author (J. O.) and documented on a standardized data collection sheet (O'Brien et al., 2016). To achieve a balance in the number of observations at different time points across the training week, a block randomization method was used, whereby one injury prevention session from the total number of scheduled sessions in the week (as provided by team staff) was selected for observation. When block randomization was compromised (e.g., short-term cancellation of the selected session), one of the remaining sessions in the week was chosen at random using an online generator (www.random.org). Ninety percent of the planned observations were completed (160 of 168) and eight observations were missed due to short-term cancellation by the team staff or the observer being absent (e.g., illness, educational leave).

Data collection sheet

During each observation, the team's use of each individual FIFA 11+ exercise (Fédération Internationale de Football Association 2016) was coded as either "performed", "performed modified", or "not performed". Exercises were considered modified when progressions or equipment, other than those outlined in the original FIFA 11+ (Fédération Internationale de Football Association 2016), were observed. This category was employed to evaluate the extent to which teams used exercises similar to the FIFA 11+. Directly following the IPEP observation, the staff delivering the session (fitness coaches and physiotherapists) were asked to explain the reasons for choosing individual exercises. In cases where FIFA 11+ exercises were observed in modified forms, staff provided reasons for the modifications. The staff members' verbal responses were noted on the data collection sheet. Information on the use and modification of exercises was also gathered at regular staff team meetings.

Analysis

The data from all four teams were combined for analysis. For each individual FIFA 11+ exercise, the proportions of the 160 observed IPEP sessions in which the exercise was "performed", "performed modified", and "not performed", were calculated using Microsoft Excel™. The reasons for including, excluding, and modifying each exercise, as provided by staff members, were entered into a table, structured on the components of the FIFA 11+. The number of staff members providing each reason was calculated.

Results

One hundred and sixty IPEP sessions were observed, which represented 36% of the total number of IPEP sessions performed by the teams across the season and 16% of the total training sessions (in any form) performed by the teams.

Use of individual FIFA 11+ exercises

The proportion of total IPEP sessions in which each FIFA 11+ exercise was coded as "performed", "performed modified", and "not performed" are summarized in Figure 1. The exercises are labeled as in the original FIFA 11+ (http://www.f-marc.com/downloads/posters_generic/english.pdf) and are ranked from left to right in descending order of the proportion performed in original form. The average proportion of sessions in which individual FIFA 11+ exercises were performed in original form was 12% (range across the different exercises 0–33%). The corresponding figure for exercises performed in modified form was 28% (range 2–62%), and for exercises not performed 61% (range 28–98%).

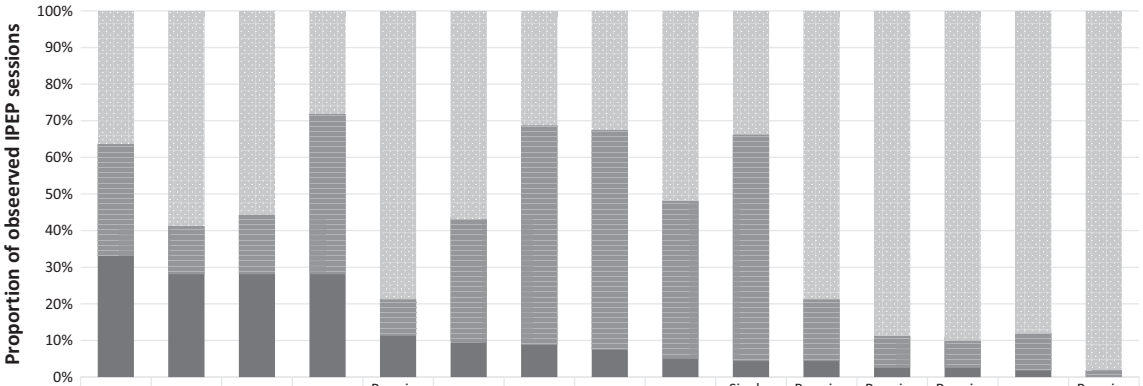
The five most frequently observed FIFA 11+ exercises in their original form, were the "sideways bench" (33%), followed by the "bench", "hip in", "hip out" (each 28%), and "running quick forward & back" (11%) (Fig. 1). The five most frequently observed exercises in modified form were the ""single-leg stance" (62%), "squats" (60%), "running straight" (60%), "bench" (44%), and "jumping" (43%) (Fig. 1). The five most frequently observed exercises, in either original or modified form, were the "bench" (72%), "squats" (69%), "running straight" (68%), "single-leg stance" (66%), and "sideways bench" (64%).

Staff input regarding reasons for the use and modification of individual exercises

The reasons for including, excluding or modifying individual FIFA 11+ exercises, including examples of modifications, are summarized in Table 1. Staff members could provide more than one reason in each category. The number of staff members (from the total of nine fitness coaches and physiotherapists) providing each reason is shown in brackets.

The most frequently provided reasons for modifying exercises were to add variation, progression, challenge, and individualization. Staff perceived these factors to be important for motivating players, avoiding boredom and tailoring the exercises to the different ability levels and situations of individual players. For example, exercises were often modified for players who had recently joined the team or had recently returned to the team following an absence due to injury, illness, or national team participation. Another frequently reported reason for modification was to align the preventive exercises with athletic training goals (e.g., strength and speed) and cognitive training goals (e.g. reaction time and peripheral awareness). For example, squats were performed with added weight to develop strength and players were challenged to react to visual or auditory cues during balance exercises, to add a cognitive challenge (Huijgen et al., 2015).

The first and last sections of the FIFA 11+, the "running exercises", were perceived by staff members as a valuable part of soccer training warm-ups. However, these exercises were considered to be less relevant when the IPEP delivery format was not a warm-up. Particular running exercises (e.g., circling partner, shoulder contact) were often omitted due to the overlap with drills in the (coach-led) technical and tactical sections of soccer training, which involved similar movements and challenges, but with added soccer specificity. In general, the exercises in the middle section of the FIFA 11+, "strength, plyometric and balance" were highly valued by the staff members, who cited their strong evidence-base and relevance to athletic goals. It was emphasized that the volume and intensity of strength and jumping exercises required careful coordination with the volume and intensity of the overall soccer training, along with consideration of



	Sideways bench	Running hip in	Running hip out	Bench	Running quick Fwd/Bwd	Ham-strings	Squats	Running straight	Jumping	Single-leg stance	Running across the pitch	Running circling partner	Running plant & cut	Running bounding	Running shoulder contact
% not performed	36%	59%	56%	28%	79%	57%	31%	33%	52%	34%	79%	89%	90%	88%	98%
% performed modified	31%	13%	16%	44%	10%	34%	60%	60%	43%	62%	17%	9%	8%	10%	2%
% peformed	33%	28%	28%	28%	11%	9%	9%	8%	5%	4%	4%	3%	3%	2%	0%

Fig. 1. The proportion of injury prevention exercise sessions ($n = 160$) in which individual FIFA 11+ exercises were performed, performed modified or not performed by four professional youth soccer teams [1].

its timing within the training week, in order to appropriately manage the total physiological load on players. This was particularly challenging in phases of the season with heavy game schedules, in which staff were cautious of player fatigue and overload.

Discussion

This is the first study to assess professional youth soccer teams' chosen injury prevention exercises against the industry-standard FIFA 11+ program. The FIFA 11+ exercises were observed more frequently in modified form (average 28% of sessions) than in their original form (average 12% of sessions). Staff modified exercises to add variation, progression, challenge, and individualization, as well as to tailor the exercises to specific athletic and cognitive training goals. This information is important for the ongoing development and delivery of future IPEPs, specifically tailored to this context.

The FIFA 11+ represents an efficacious injury prevention exercise program, backed by extensive supporting material and dissemination efforts (Bizzini & Dvorak, 2015). However, the program's ultimate real-world impact depends not only on its efficacy (established in RCTs), but also on the extent to which soccer teams adopt and maintain the exercises it contains. When teams modify FIFA 11+ exercises, there is need to understand why they do so, and to consider whether these modifications might impact (either positively or negatively) on the effectiveness of the program. Recent sports injury research emphasizes that enhancing the implementation of interventions necessitates a detailed understanding of both the individuals delivering the programs, and their specific delivery contexts (Finch & Donaldson, 2010; Saunders et al., 2010; Padua et al., 2014; Twomey et al., 2015; Donaldson et al., 2016). This present study represents an important contribution to describing how, and why, staff members in professional youth soccer teams modify individual IPEP exercises to fit their context. The study's main strengths are the high number of prospectively recorded direct observations, standardized documentation and use of the industry standard IPEP for amateur soccer, the FIFA 11+, as the gold standard comparator.

Five FIFA 11+ exercises ("bench", "squats", "running straight", "single-leg stance", and "sideways bench") were observed, either in original or modified form, in well over half of the IPEP sessions. This aligns with the results of other recent studies, suggesting that certain FIFA 11+ components hold relevance for professional soccer teams (McCall et al., 2014; O'Brien et al., 2016). Importantly, this present study also details the reasons why staff members included, excluded or modified exercises, hence providing novel insights into how IPEPs and their components are adapted to fit a particular implementation context.

Taken together, the above results suggest that IPEPs for professional youth soccer can be structured on the same basic components as the FIFA 11+ (e.g., strength, balance, core stability, and plyometrics), but require tailoring to the delivery context and a high degree of adaptability. Professional youth soccer teams have access to extensive training equipment and the support of multiple staff members. In

[1]Images and descriptions of the FIFA 11+ exercises are available at http://www.f-marc.com/downloads/posters_generic/english.pdf. The exercises are ranked from left to right in descending order of the % performed.

Table 1. Staff members' reasons for including, excluding, and modifying individual FIFA 11+ exercises in 160 injury prevention exercise program (IPEP) sessions. The number of staff (from a total of 9) providing each reason is shown in brackets*

Part	Exercise	Reason for inclusion	Reasons for exclusion	Example of observed modifications	Reasons for observed modifications
Running	Running Straight	Low-intensity start (5)	Lack of variation (8) IPEP separate from warm-up (5)	Jogging laps ± cognitive cues Adding sprint technique drills, arm movements and balls Format (e.g., small-sided game, players shoulder-to-shoulder)	Common practice (5) Acclimatize to surroundings (3) Cognitive and athletic goals (4) Variation and progression (8) Format wears out pitch (2)
	Hip Out	Low-intensity start (6) Common practice (8) Relevance to soccer (5) Format easy to supervise (2)	Lack of variation (7) IPEP separate from warm-up (5)	Inside heel-touch Format (e.g., small-sided game, players shoulder-to-shoulder)	Variation and progression (6) Cognitive and athletic goals (4) Format wears out pitch (2)
	Hip In	Low-intensity start (6) Common practice (8) Relevance to soccer (5) Format easy to supervise (2)	Lack of variation (7) IPEP separate from warm-up (5)	Outside heel-touch Format (e.g., small-sided game, players shoulder-to-shoulder)	Variation and progression (6) Cognitive and athletic goals (4) Format wears out pitch (2)
	Circling Partner	Train peripheral awareness (2) Format easy to supervise (2)	Lack of variation (4) IPEP separate from warm-up (3) Performed in soccer drills (6)	Circling cones Different formats (e.g., small-sided game, two-lane race)	Variation, progression and challenge (3) Cognitive goals (1) Format wears out pitch (2)
	Shoulder Contact	N/A†	Lack of variation (3) IPEP separate from warm-up (4) Performed in soccer drills (5)	Format (e.g., small-sided game)	Variation, progression and challenge (2) Cognitive goals (1) Format wears out pitch (2)
	Quick Fwd/Bwd	Relevance to athletic (speed/agility) goals (4) Format easy to supervise (2)	Lack of variation (6) IPEP separate from warm-up (5) Performed in soccer drills (5)	Format (small-sided game, speed ladder race)	Variation, progression and challenge (6) Cognitive and athletic goals (2) Format wears out pitch (2)

Table 1. (continued)

Part	Exercise	Reason for inclusion	Reasons for exclusion	Example of observed modifications	Reasons for observed modifications
Strength Plyometrics Balance	Bench	Common practice (6) Evidence base[‡] (6) Relevance to soccer tackling (5) Relevance to athletic core stability goals (6)	Lack of variation (4) Too static in warm-up (3) Pitch conditions-cold/wet (5)	Caterpillar walks and push ups Use of Swiss balls, medicine balls, slings and elastic bands Partner exercises Throwing, catching	Variation, progression, challenge and individualization (8) Cognitive and athletic goals (4)
	Sideways Bench	Common practice (6) Evidence base[‡] (6) Relevance to soccer tackling (5) Relevance to athletic core stability goals (6)	Lack of variation (4) Too static in warm-up (5) Pitch conditions-cold/wet (5)	Use of Swiss balls, medicine balls, slings and elastic bands Adductor side bench[§] Partner exercises Throwing, catching, kicking	Variation, progression, challenge and individualization (9) Cognitive and athletic goals (5) Soccer specificity (6)
	Hamstrings	Evidence base[‡] (8) Injury statistics – common injury in older age groups (4)	Lack of variation (6) Injury statistics – rare injury in younger age groups (3) Isokinetic data – deficits rare in younger age groups (3) Risk of neuromuscular fatigue, DOMS[¶] (5) Risk of injury (2) Managing high-intensity load (4)	Dead-lifts and hip-thrusts Use of Swiss balls, slide-boards and weight machines	Variation, progression, challenge and individualization (9) Athletic goals (7) Risk of neuromuscular fatigue, DOMS[¶] and injury (4)
	Single-Leg Stance	Evidence base[‡] (3) Relevance to soccer (7)	Lack of variation (7) Too static in warm-up (6) Not an athletic priority (2)	Use of unstable surfaces Different formats (e.g., parkour, motor skills park) Partner exercises with volleys, headers and cognitive cues	Variation, progression, challenge and individualization (8) Cognitive and athletic goals (9) Soccer specificity (7)
	Squats	Evidence base[‡] (7) Relevance to soccer and athletic goals/training cycle (6)	Lack of variation (4) Managing high-intensity load (5)	Use of weight-training equipment Lunge variations Decline squats	Variation, progression, challenge and individualization (9) Athletic goals (8) Decline unloads ankle joints (2)
	Jumping	Evidence base[‡] (5) Relevance to soccer and athletic goals/training cycle (7)	Lack of variation (7) Managing high-intensity load (6)	Use of boxes, unstable surfaces, hurdles and hoops Partner exercises with volleys, headers and cognitive cues	Variation, progression, challenge and individualization (9) Cognitive and athletic goals (6)

Table 1. (continued)

Part	Exercise	Reason for inclusion	Reasons for exclusion	Example of observed modifications	Reasons for observed modifications
Running	Across the Pitch	Relevance to soccer and athletic goals/training cycle (2) Format easy to supervise (2)	Lack of variation (6) Performed in soccer drills (4) IPEP separate from warm-up (5)	Combined with bounding, jumping, agility and cognitive exercises	Variation, progression, challenge and individualization (5) Cognitive and athletic goals (4)
	Bounding	Relevance to soccer and athletic goals/training cycle (3) Format easy to supervise (2)	Lack of variation (7) Performed in soccer drills (2) IPEP separate from warm-up (5)	Use of hurdles Diagonal bounding	Variation, progression, challenge and individualization (6) Athletic goals (4)
	Plant and Cut	Relevance to soccer and athletic goals/training cycle (2) Format easy to supervise (2)	Lack of variation (6) Performed in soccer drills (5) IPEP not delivered as warm-up (6)	Use of Bungee cords Format (e.g., small-sided game, partner challenge, in sand)	Variation, progression, challenge and individualization (4) Cognitive and athletic goals (1)

*Participants could provide more than one reason.

†This exercise was not observed in its original form.

‡Evidence base refers to participants' perception that an exercise's preventive effect was supported by trial reports in sports-medicine or sports-science journals.

§An exercise in the sideways-bench position with the upper leg supported, aimed at training the hip adductors (Ishoi et al., 2015).

¶Delayed Onset Muscle Soreness.

this context, IPEPs are delivered by educated fitness coaches and physiotherapists, with an awareness of the published literature relating to injury prevention in soccer. These individuals require IPEPs with more variation, progression, challenge, and individualization than standard programs such as the FIFA 11+. In view of their specific implementation context, the staff of professional youth teams would perhaps be better served by clear, evidence-based guidelines on the essential ingredients of IPEPs that provide sufficient flexibility regarding the delivery format, location and selection of individual exercises.

In the field of implementation science, the concept of a program's core intervention components is well-established. Fixsen et al. (2005) defined these as the aspects of a program which are essential and indispensable in achieving the desired outcome. When translating evidence-based interventions to different real-world settings and populations, the core implementation components need to be upheld, whereas other, less essential aspects of the program can be tailored to better fit the local context. Applying this concept to the FIFA 11+, it can be hypothesized that the program's core intervention components are the elements of strength, balance, core stability and plyometrics. It is noteworthy that other IPEPs, containing similar components to the FIFA 11+, but different individual exercises, have also demonstrated efficacy in large-scale RCTs (Mandelbaum et al., 2005; Emery & Meeuwisse, 2010; Waldén et al., 2012). This supports the notion that, as long as core components are maintained, a certain degree of exercise modification is possible without jeopardizing an IPEP's injury prevention effect. Two recent systematic reviews and meta-analyses both found strong evidence for the preventive effect of IPEPs, while also identifying specific program components which appeared particularly important in achieving success (Lauersen et al., 2014; Rössler et al., 2014). In a review of studies with heterogeneous populations and interventions, Lauersen et al. (2014) identified strength and balance components as being particularly important to the success of IPEPs. The second review, focussing more specifically on IPEPs in athletes under 19 years of age (Rössler et al., 2014), concluded that IPEPs can reduce injuries by around 46%, with those programs including jumping exercises appearing most effective.

In addition to establishing which core elements should be included in the content of IPEPs, there is a pressing need to define the essential aspects of successful IPEP delivery and support. These have been referred to, in the field of implementation science, as "core implementation components" (Fixsen et al., 2005), and typically relate to aspects of the staff who deliver interventions and organizational support. Unfortunately, many published reports on IPEPs in team ball sports fail to identify IPEP deliverers (O'Brien & Finch, 2014b) and other key implementation aspects (O'Brien & Finch, 2014a). The results of this present study highlight important aspects relating to the staff delivery of IPEPs in professional youth soccer. As fitness coaches are the primary deliverers in this context, the success of programs will be influenced by the injury prevention beliefs, training goals and planned training cycles of these individuals. The direct input of staff members in this study suggests that IPEPs which harmonize with athletic training goals and which contain a high level of variation, progression, and individualization, will be more likely to be implemented in professional youth soccer settings.

Study limitations

As this study was conducted in the specific real-world context of one professional soccer academy, care is warranted in extrapolating the results to other populations and settings. Although a high number of IPEP sessions were observed, over multiple time points, only one author performed the observations and the coding of FIFA 11+ exercises as "performed", "performed modified" or "not performed" proved challenging at times. Although IPEP sessions were randomly selected for observation, only one-third of the teams' total IPEP sessions were observed and it is possible that the behavior of the teams differed in the unobserved sessions. This study focussed on injury prevention exercises, but other injury prevention strategies, including managing match and training load, are also important considerations in professional football (McCall et al., 2014). As both the number of staff members present at each IPEP session, and the frequency in which individual exercises were performed, varied considerably, it is possible that the reasons for exercise use and modification were not equally represented across individual staff members or individual FIFA 11+ exercises. The data collection sheet did not undergo formal validity or reliability testing (beyond face validity), but was structured on industry-standard, FIFA 11+ program.

Future research

As IPEP deliverers frequently use modifications of established exercises, there is a need to establish which aspects of programs represent the essential core intervention components, as opposed to the non-essential aspects which can be modified without jeopardizing program fidelity. In view of the challenge of implementing IPEPs alongside heavy game schedules and other training priorities, there is need to define the minimum dosage of core IPEP components that is needed to achieve (and maintain) injury prevention effects. In implementation science, this is known as the adaptation vs fidelity challenge (Fortington et al., 2015).

Perspectives

This study adds to a growing body of recently published research (Lindblom et al., 2014; Fortington et al., 2015; Frank et al., 2015; Donaldson et al., 2016) highlighting the key role of successful implementation in preventing sports injuries. Employing the industry-standard FIFA 11+ program for amateur soccer as the comparator, the findings shed light on the use and modification of injury prevention exercises in professional youth soccer. The direct observations of IPEPs, in combination with input from staff members, demonstrates how and why end-users modify program to fit their specific context. This information will inform both researchers and practitioners aiming to enhance the real-world impact of IPEPs in professional soccer settings, while also holding relevance for IPEP implementation in other team ball sport settings.

Key words: Sport, injuries, training.

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Competing interests

W. Y. and C. F. F. have no conflicts of interest that are directly relevant to the content of this article. J. O. is employed at the professional soccer academy involved in this study. It is possible that the author's relationship with academy staff influenced the results.

Contributorship statement

J. O. led this work as part of his PhD studies. He designed the study, led its conduct, had the major role in paper writing and is responsible for the overall content. W. Y. and C. F. F. contributed to the design of the study, analysis of data, and the writing of the article.

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4.3.3 Summary

The final paper of this thesis assessed the use and modification of individual FIFA 11+ exercises by professional youth soccer teams, providing novel insight into how, and why, the content of IPEPs is tailored to this specific implementation context. The analysis showed that professional youth soccer teams often used individual FIFA 11+ exercises, but mostly in modified forms. The main reasons for modifying exercises were to add variation, progression and individualisation, and to align with specific training goals and formats. The findings of this study will inform the development of new IPEPs, specifically tailored to the professional youth soccer context. Future research should evaluate the efficacy of context-specific IPEPs and identify the core intervention components of these programs (the essential/indispensable aspects). This will inform professional soccer teams regarding which IPEP components are essential to achieving the desired outcomes, and which aspects can be modified without jeopardising fidelity. Future research should also focus on identifying the aspects of IPEP delivery and support, at different ecological levels, which are essential to a program's ultimate success.

5.0 CONCLUSION

5.1 INTRODUCTION

The final chapter of this thesis summarises the key findings, strengths and limitations of the entire body of research it contains. Based on the key findings, recommendations are made for further research in this field. Additionally, this chapter discusses how the research makes an original contribution to the previously published body of knowledge and how the findings relate to established sports injury prevention and health promotion frameworks.

The overarching aim of this thesis research was to identify barriers and facilitators to implementing IPEPs in professional male soccer. Firstly, the reporting of implementation aspects in published IPEP trials was evaluated against the RE-AIM framework.[160] Significant knowledge gaps were identified, particularly relating to the RE-AIM dimensions of adoption and maintenance. Secondly, cross-sectional studies of four professional senior male teams and four professional youth male teams were conducted, to assess key stakeholders' perceptions regarding injury prevention and IPEPs. The findings showed strong support for IPEPs, but multiple implementation challenges were also identified. Finally, the implementation of IPEPs in four professional youth teams was observed, on a weekly basis, across one playing season. This provided novel insight into the content and delivery of IPEPs in this specific implementation context, including extensive information on implementation barriers and facilitators.

5.2 KEY FINDINGS AND RECOMMENDATIONS

1. The Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) framework can be successfully applied to the context of reviewing published team ball sport IPEP trial reports

The RE-AIM framework[160] was successfully employed to systematically review published team ball sport IPEP trials (Paper 4). However, initial attempts to apply the RE-AIM to this context, and to reach consensus among reviewers, proved challenging (Paper 2). The key to successfully applying RE-AIM was a staged process, which first involved screening the trial reports to extract key information relating to the intervention, primary outcome, intervention target, delivery agents and settings. For example, it was necessary to determine if the intervention was the IPEP itself, coach education in delivering an IPEP, or both. Similarly, it was necessary to

determine if the intervention targeted players (as health beneficiaries), coaches (as IPEP deliverers) or both. The reporting of this basic information in published team ball sport IPEP trials was poor. In fact, almost half (46%) of the trials did not clearly report who delivered the IPEP (Paper 3).

> Recommendations: To enhance the replication of programs used in published team ball sport IPEP trials, both in other settings and in other studies, trial reports must provide clear information on basic implementation components. These include the intervention, primary outcome, intervention target, delivery agents and the settings. Clear reporting of these components will facilitate the application of implementation frameworks from the field of health promotion (e.g. RE-AIM[160]) and hence the translation of efficacious IPEPs into widespread, real-world practice. Employing the specific version of RE-AIM used in this research project, the RE-AIM MDIC,[161] as a tool for reviewing published sports injury prevention trials from an implementation perspective is recommended. However, a staged approach should be employed, with completion of a screening worksheet (Paper 4, Table 2) prior to application of the full RE-AIM MDIC. The screening worksheet can guide reviewers as to how the published information relates to the specific terminology used in RE-AIM.

2. There are major gaps in the published knowledge on implementation aspects of team ball sport IPEPs

This finding was established by evaluating the reporting of team ball sport IPEP trials against the RE-AIM MDIC.[161] Overall, reported information on specific implementation aspects was scarce. Knowledge gaps relating to the RE-AIM dimensions of adoption and maintenance were particularly evident (Figure 5.1). The lack of reporting of RE-AIM items in the literature is a concern, because these factors play a key role in enhancing the ultimate real-world impact of interventions. Even in cases where RE-AIM items were addressed, the depth and quality of the information was often limited (Paper 4). Accordingly, the body of reported knowledge does little to inform the efforts of researchers and practitioners aiming to translate and/or upscale IPEPs to other groups and settings.

There are a number of possible explanations for the poor reporting of RE-AIM MDIC items in published team ball sport injury prevention trials. Firstly, as implementation science is a young and emerging field, there may be a lack of awareness among authors, journal editors and reviewers regarding the importance of

implementation aspects. Secondly, the word limits imposed by journals may restrict the reporting of implementation aspects, particularly if these are not within the main objectives of the trial. It is also possible that authors intend to publish further details on implementation aspects in secondary analyses. Finally, the RE-AIM MDIC is not study-design specific; certain RE-AIM MDIC items are not applicable to all study designs.

> **Recommendations:** To enhance the real-world impact of team ball sport IPEPs, trials should be reported in a way which facilitates the translation of these programs into other settings. The RE-AIM framework[160] provides a comprehensive outline of the specific implementation aspects which require consideration. There is a need for future research focussing on the implementation aspects of IPEPs, particularly in relation to program adoption and maintenance. Enhancing IPEP adoption will require an understanding of the specific context in which programs are delivered and the individuals delivering IPEPs to players. Enhancing IPEP maintenance will require clear definitions of what maintenance means in the context of team ball sports and the development of pragmatic methods to record maintenance in real-world settings.

3. There are multiple barriers and facilitators to implementing IPEPs in professional senior male soccer

Barriers and facilitators to IPEP implementation in the specific context of professional senior male soccer were evaluated in a cross-sectional survey of four teams (Paper 5). In addition to factors relating to the nature and content of the IPEP itself, a wide range of factors relating to IPEP delivery and support across different ecological levels (e.g. player, team staff and club) were identified. There was a high level of awareness of players' susceptibility to injury and the negative impacts of these injuries. There was also strong support for the use of IPEPs across all teams, but perceptions varied regarding which types of preventive exercises are effective and when preventive exercises should be performed. The respondents consistently indicated multiple roles holding responsibility for injury prevention in professional soccer clubs, but perceptions of who holds the ultimate responsibility varied.

The vast majority of respondents believed that preventive exercises should be varied and progressed over time, and less than a third believed that the FIFA 11+ program contained adequate variation and progression. Similarly, less than a third thought the FIFA 11+ could be maintained over multiple seasons. The respondents

provided an extensive list of barriers and facilitators to maintaining IPEPs (Paper 5, Table 3), which were categorised into two main themes: the first theme was the nature and content of the IPEP itself (e.g. soccer-specificity and exercise variation and progression); the second theme was IPEP delivery and support (e.g. acceptance, communication, game schedules and weather conditions). This second theme had five distinct sub-themes, relating to the different ecological levels of the professional soccer setting: the player, team staff, the club, governing bodies, and the physical environment.

Recommendations: As the successful implementation of IPEPs is influenced by factors at multiple ecological levels (e.g. player, team staff and club), implementation strategies also require a multi-level approach. These strategies should include developing acceptance and support for IPEPs among players, staff members and club officials, along with fostering staff communication, team work and planning. Important considerations for the design of IPEPs are providing adequate variation and progression, soccer-specificity and adaptability to heavy game schedules and adverse weather conditions. As perceptions regarding IPEPs vary across teams, there is a need to understand the specific IPEP implementation context of each individual team. This can be facilitated by involving key stakeholders (e.g. players, coaches and club officials) in the development phase of IPEPs, as demonstrated in recent IPEP implementation studies from Australian Football[164] and Armed-Forces settings.[165]

Further studies on IPEP implementation in professional senior male soccer should include direct observation of IPEP use, as the actual behaviour of players and staff may differ to their reported behaviour. Studies in larger samples of professional teams, with adequate power to evaluate potential confounding variables (e.g. coaches' age, experience and injury history) are recommended, along with studies over multiple seasons to assess IPEP maintenance.

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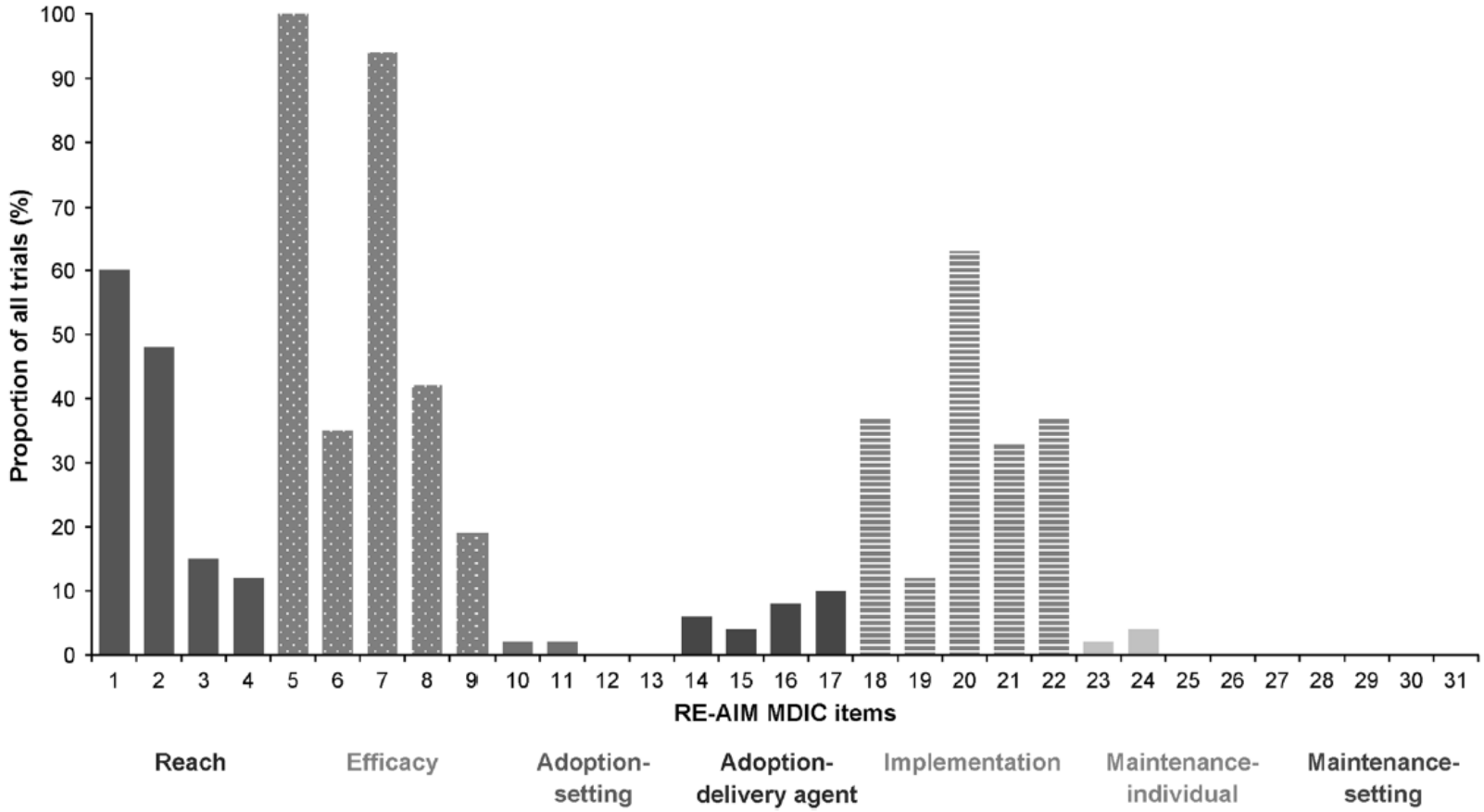
Figure 5.1 Reporting of individual RE-AIM MDIC items[51] in 52 team ball sport injury prevention exercise programme (IPEP) trials.



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4. There are multiple barriers and facilitators to implementing IPEPs in professional male youth soccer

The specific IPEP implementation context of professional youth teams was assessed in two studies in a professional soccer academy: a cross-sectional survey (Paper 6) and a prospective observation study of IPEP use over one season (Papers 7 and 8). Similar to their counterparts in professional senior teams, the respondents from professional youth teams strongly supported the use of IPEPs and were highly aware of the negative impacts of injuries. They nominated a median of seven different roles holding responsibility for injury prevention and, as for senior professional teams, perceptions varied regarding who holds the ultimate responsibility. The vast majority believed that the FIFA 11+ could reduce injuries in their team, but less than a quarter believed the program contained adequate variation and progression, and less than half believed their team could maintain the program over multiple seasons. The respondents identified a wide range of barriers and facilitators to IPEP maintenance (Paper 6, Table 3) relating either to the nature and content of IPEPs, or delivery and support of these programs.

In observed IPEP sessions, fitness coaches were the primary IPEP deliverers, supported by physiotherapists. The programs were delivered in multiple training formats (e.g. warm-up, cool-down and separate athletic sessions), multiple locations (e.g. outdoor pitch, indoor pitch and gym) and with the extensive use of equipment. The teams' chosen IPEPs were structured on exercise components similar to those in the FIFA 11+ (e.g. strength, balance and core stability). The use of FIFA 11+ exercises in their original form was low (median 1 per session), but teams frequently included exercises in a modified form (median 4 per session). The most common reasons for modifying exercises were to add variation, progression, challenge and individualisation. Further reasons were to align exercises with the chosen delivery format and specific training goals. The same factors were identified by staff members as important barriers and facilitators to implementing IPEPs in general (Paper 7, Supplemental File 2). Other factors included documentation, player testing and goal-setting.

> Recommendations: The content and delivery of IPEPs require tailoring to the specific implementation context of professional youth soccer. In terms of content, programs require adequate variation, progression and individualisation along with sufficient adaptability to different training formats and goals. To enhance implementation, IPEPs also require adequate delivery and support across multiple levels of the professional soccer ecology. In order to tailor programs to the delivery context of

professional sport, key stakeholders (e.g. players, coaches, fitness coaches and physiotherapists) should be involved in the design phase of IPEPs.[164 165] Further research should evaluate the efficacy of IPEPs tailored to professional soccer settings and identify the core intervention components of these programs. This will inform real-world IPEP deliverers as to which IPEP components are essential in achieving the desired outcomes, and which aspects can be modified without jeopardising fidelity. Similarly, further IPEP implementation research is needed to identify the aspects of IPEP delivery and support, at different ecological levels, which are essential to a program's ultimate success. As this current research thesis was conducted in a small sample of teams and focussed solely on the use of FIFA 11+ exercises, further research is needed to evaluate implementation facilitators and barriers in other professional soccer populations and in relation to other preventive exercises, not included in the FIFA 11+.

5.3 STRENGTHS AND LIMITATIONS OF THE RESEARCH

The research in this thesis had several strengths. Firstly, it took a systematic approach to evaluating team ball sport IPEPs from an implementation perspective, with application of an established health promotion framework, the RE-AIM framework.[160] Secondly, the research related to step 5 of the TRIPP Framework,[26] understanding the implementation context, which has previously been identified as a gap in the existing sports-injury prevention knowledge base.[17 18] Thirdly, the design of the survey employed in this research project was guided by the constructs of the Health Belief Model[170] and RE-AIM framework dimensions,[160] along with previously identified implementation barriers from team-ball sport IPEP trials.[4] A further strength was the high number of IPEP observations in the prospective study component (160). Finally, all IPEP observations were recorded on a standardised documentation sheet, structured on the industry-standard IPEP for soccer, the FIFA 11+.[129]

It is also important to acknowledge limitations of this research, which may have affected the findings. Firstly, the implementation aspects identified in the reporting of IPEP trials (Chapter 2) may not be directly applicable to IPEP implementation under real-world conditions, as the trials were performed under highly controlled, "ideal" conditions, with the aim of establishing IPEP efficacy. The sample of four professional soccer teams and four academy soccer teams including in this research thesis was small. Furthermore, it was a sample of

convenience, chosen on the basis of existing contact to the researchers. It is possible that the subjects' relationship to the candidate influenced the research findings. Accordingly, caution must be exercised in generalising the results of this study to other settings. Furthermore, although participation among the staff members in academy teams was high (90%), the participation from players and staff members in senior teams was much lower (57%). The survey was not subjected to formal reliability and validity testing, beyond face validity, and the results may have been influenced by non-response bias, central tendency bias, acquiescence bias or social desirability bias.[171] As the prospective observational study was limited to one soccer season, no information was recorded on the maintenance of IPEPs over multiple seasons. The IPEP observations and categorisation were conducted by one author only, and categorising FIFA 11+ exercises as performed, performed modified or not performed proved challenging at times. A disadvantage of this categorisation was that other injury prevention exercises, unrelated to the FIFA 11+, were not included in the analysis. Although staff members from the participating teams were regularly asked to provide feedback regarding IPEPs, questioning of individual staff members was limited to a maximum frequency of once every two weeks. Future studies could benefit from more frequent feedback from those staff members directly involved in delivering IPEPs (e.g. fitness coaches and physiotherapists). Finally, this study focused on IPEPs, but other factors such as training and match load are also important considerations for injury prevention in professional soccer settings.[13 38 77 80]

5.4 ORIGINAL CONTRIBUTIONS OF THE RESEARCH

- The systematic review of team ball sport IPEPs in this thesis (Paper 4) represents the first application of the RE-AIM framework to reviewing the published sports injury prevention literature. Importantly, the initial barriers to applying the RE-AIM to this specific context, along with the corresponding solutions, were identified. The results provide a novel overview of the reporting of team ball sport IPEP trials from an implementation perspective.

- This thesis was the first to assess the IPEP implementation context of professional youth male soccer, a setting which can be difficult to access for research purposes. It also included the first prospective study employing IPEP observation on a weekly basis in any soccer setting. The results provide first

insights into the IPEP implementation context of professional youth soccer and identified a wide range of implementation barriers and facilitators.

5.5 HOW DO THE FINDINGS RELATE TO OTHER STUDIES?

While no previous published research had assessed the IPEP implementation context of professional youth male soccer teams before this thesis was commenced, four recently published studies have contributed to the understanding of the IPEP implementation context of professional senior male teams.[151-153 169] In a survey of staff members from 44 premier league soccer teams, McCall et al.[152] assessed perceptions towards injury risk factors, player testing and injury prevention strategies. All the teams reported prescribing an injury prevention program for their players, with the vast majority using both global and individualised programs. Physiotherapists and fitness staff played key roles in delivering the programs, and there was strong support for preventive exercises focussing on strength, balance and core stability.[152] In general, these findings align with the results of this thesis research, which also found strong support for IPEPs, including the basic components of strength, balance and core stability, and identified fitness staff and physiotherapists as key IPEP deliverers. However, the professional teams involved in this thesis research also valued jumping and landing exercises as a basic component of IPEPs. There was unanimous support for the preventive effect of controlled jumping and landing exercises in professional youth teams and also from the vast majority of respondents from professional senior teams. This discrepancy may be explained by differences in survey design, as jumping and landing exercises were not offered as an example of preventive exercises in the survey used by McCall et al.[152]

In another recently published survey, the injury prevention perceptions and practices of physicians working with 2014 FIFA World Cup teams were reported.[169] The vast majority of respondents reported using IPEPs and tailoring the programs to individual players. The two main injury prevention challenges, reported in that survey, were optimising the individualisation of programs and achieving “compliance of and between staff”.[169] These factors also featured among the IPEP implementation barriers identified in this thesis research, both in professional senior teams and professional youth teams. In 2016, McCall and co-workers[153] reported a survey of the head medical officers from 34 teams in the UEFA ECIS. Once again, respondents identified strength, balance and core stability as important components of injury prevention exercise programs. The reported level of coach compliance to injury prevention measures was generally high, but the level of player compliance was

highly variable across teams; the authors concluded that insufficient player compliance may be limiting the effectiveness of IPEPs in professional soccer teams. The main reported barriers to achieving player compliance were players' concerns about experiencing muscle soreness or 'heavy legs', along with their concerns that the exercises may not be effective, or may even increase the risk of injury.[153] These reported barriers do not fully align with the findings from this thesis research, in which the vast majority of respondents from professional senior teams believed that injuries are preventable and that players should be performing evidence-based exercises. However, in professional youth teams, staff members reported the risk of neuromuscular fatigue, injury and Delayed Onset Muscle Soreness (DOMS) as reasons for excluding, or modifying, the hamstring lower exercise. The inconsistent findings could be explained by the different teams included in the studies; the specific IPEP implementation context of individual teams can vary, as demonstrated in Paper 5 of this thesis.

Finally, a study by Bahr et al.[151] evaluated the adoption of a hamstring lowers program among top professional male soccer teams. Despite the program's proven efficacy and the fact that 88% of the teams were familiar with it, adoption of the program was low, with full use in just 11% and partial use in 6% of club-seasons. The teams reported a wide range of alternate exercises for preventing hamstring injuries, which aligns with the findings of this thesis research; key stakeholders emphasised the need for adequate variation and progression in IPEPs. In observed sessions, professional youth teams performed several modifications of the hamstring lowers exercise, with lack of variation the most commonly cited reason for performing modifications. The results of the study by Bahr et al.[151] also underscore a key message of this thesis research, namely that the existence of an efficacious IPEP alone is not enough to prevent sports injury (Paper 1).[1]

5.6 HOW DO THE FINDINGS RELATE TO ESTABLISHED FRAMEWORKS?

5.6.1 The Translating Research into Injury Prevention Practice (TRIPP) Framework

It has been emphasised that major gaps exist in the current body of sports injury prevention knowledge, relating to implementation aspects (TRIPP steps 5 and 6).[26 27] The findings of this thesis research provide a novel and detailed insight into the IPEP implementation context (TRIPP step 5) of professional youth male soccer (Papers 6, 7 and 8). Furthermore, Paper 5 provides one of the very few insights into the implementation context of professional senior male soccer.

5.6.2 The Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) Framework

The RE-AIM framework[160] was employed in this research project to guide the evaluation of the reporting of implementation aspects in team-ball sport IPEP trials. The framework also guided the survey design in two cross-sectional studies. Although the RE-AIM framework has not previously been used to review literature in the field of sports injury prevention, it has been employed as a tool for planning and evaluating sports injury prevention interventions.[155 158 172 173] In 2008, Finch and Donaldson developed the RE-AIM Sports Setting Matrix (RE-AIM SSM), an adaptation of the original framework, for the specific context of community sport.[174] The RE-AIM SSM emphasises the importance of targeting injury prevention efforts at multiple levels of sport delivery systems (e.g. players, team staff, clubs and governing bodies). Since its development, the RE-AIM SSM has been employed to evaluate the coach-adoption of IPEPs in elite youth female teams[154] and the coach-maintenance of IPEPs in amateur female teams.[139]

The findings of this thesis research strongly support the multi-level implementation approach outlined in the RE-AIM SSM.[174] Firstly, a systematic review (Paper 3) identified multiple types of interventions (e.g. IPEPs and coach-education), intervention targets (e.g. players and coaches) and IPEP deliverers (e.g. coaches, physiotherapists and team-captains). Secondly, the implementation barriers and facilitators identified in professional soccer settings (Papers 5-8) spanned multiple ecological levels, including the player, team staff, clubs and governing bodies. Table 5.1 outlines the key findings of this thesis research, in relation to the five dimensions of the RE-AIM framework.

5.6.3 A seven-step approach to IPEP design and delivery

The findings of this thesis research highlight the need to tailor IPEPs to the specific implementation context of professional soccer. The number and diversity of barriers and facilitators to IPEP implementation identified in this project, raises the question of how best to approach the task of successfully implementing IPEPs in real-world settings. Guidance on how to do this is strikingly absent from the published literature on IPEPs for soccer, but approaches used in Australian Football[164 175] and in Armed-Forces settings[165] have recently been reported. Padua et al.[165] proposed a seven-step approach to designing and implementing IPEPs in real-world settings (Table 5.2). This model emphasises evaluation of the implementation context to identify potential barriers to IPEP implementation and then formulate corresponding solutions.

Table 5.1 Key findings of the research in relation to RE-AIM framework dimensions

RE-AIM Dimension	Key findings
Reach	o Within a team, a median of 4 players (range 0-17) missed IPEP sessions, with the main reasons being injury, illness, national team/first squad selection and participation in other parallel training sessions (e.g. goalkeeper training). o 27% of players and staff from senior teams were aware of the FIFA 11+. o 61% of staff members in academy teams were aware of the FIFA 11+. o 18 of 20 (90%) eligible academy staff members agreed to participate in a survey, with 2 citing lack of time as the reason for not participating. o 72 of 126 (57%) eligible players and staff members from senior teams agreed to participate in a survey. o In a systematic review of published team ball sport IPEP trials, the median proportion of players, teams and coaches agreeing to participate in trials was 83%, 82% and 60% respectively. Common reasons for not participating were lack of time and the requirement of data collection. However, it should be noted that the reasons for refusing to participate in a scientific trial may differ to the reasons for not using an IPEP under real-world conditions.
Effectiveness/Efficacy	o The proportion of survey respondents believing that warm-up, balance exercises, eccentric muscle strengthening, jumping/landing and cutting exercises can prevent LL injuries was 80-94% in senior teams and 100% in academy teams. o The proportion believing that a cool-down can prevent LL injuries was 47% in senior teams and 60% in academy teams. o Academy staff members cited the strong evidence-base supporting exercises in the FIFA 11+ "strength, plyometric and balance" section as a reason for including these exercises in IPEPs. o In a systematic review of published team ball sport IPEP trials, reported negative side-effects of IPEPs included Delayed Onset Muscle Soreness (DOMS) and injury resulting directly from the program. Broader IPEP outcome measures included physiological parameters and team success.
Adoption	o Fitness coaches were the primary deliverers of IPEPs in academy teams (92% of observed sessions), supported by physiotherapists. o Head coaches ultimately decided on the number and length of IPEPs in each training week in academy teams, with consideration of the game and training schedules. o Fitness coaches and physiotherapists decided on the IPEP content in academy teams, with consideration given to player age, published research, injury statistics and their past experiences. o The most important factors influencing the use and modification of IPEP exercises in academy teams were exercise variation, progression, challenge and individualisation, along with aligning the IPEP to the training format and training goals.

Table 5.1 (continued)

	o Survey respondents nominated a median of 7 different roles holding responsibility for injury prevention in academy teams and 5 different roles in senior teams. o 98% of participants from senior teams and 100% of participants from academy teams believed that soccer players should perform evidence-based IPEPs. o Only 22% of academy team participants and 30% of senior team participants believed the FIFA 11+ contains adequate variation and progression. o 50% of academy teams participants and 53% of senior team participants believed the FIFA 11+ is soccer specific. o In a systematic review of published team ball sport IPEP trials, barriers to IPEP adoption included the requirement of data collection, contentment with the current program and lack of program variation/progression.
Implementation	o The IPEPs implemented by academy teams were structured around the same basic components (e.g. strength, core stability, balance, jumping/landing) as established IPEPs for amateur soccer. o Academy staff frequently modified IPEPs to add progression, variation, challenge and individualisation. Programs were also modified to fit with specific delivery formats (e.g. warm-up, athletic sessions) and specific training goals (e.g. strength training and cognitive abilities).
Maintenance	o 44% of academy teams participants and 30% of senior team participants believed their team could maintain the FIFA 11+ over multiple seasons. o The barriers and facilitators to maintaining IPEPs in professional soccer settings relate either to the nature and content of the IPEP itself (e.g. soccer-specificity and exercise variation and progression) or the delivery and support of IPEPs (e.g. staffing, communication and team work).

Table 5.2 A seven-step approach to designing and implementing IPEPs (Padua et al.)[165]

Step	Description
1	Establish administrative support
2	Develop an interdisciplinary implementation team
3	Identify logistical barriers and solutions
4	Develop an evidence-based and context-appropriate prevention training program
5	Train the trainers and users
6	Fidelity control
7	Exit strategy

The following section describes how each of these steps relates to implementing IPEPs in the specific context of professional soccer, with reference to the findings from this thesis research. It is hoped that presenting the project's findings in this manner will facilitate future efforts to design and implement IPEPs in professional soccer settings.

Step 1

The first step focuses on securing the support and buy-in of the organisation's leadership. In the context of professional soccer, this relates to securing support from club officials (e.g. the sports director) and the incorporation of IPEPs into club policy. As the overarching goal of soccer clubs is team success, demonstrating that injuries negatively impact on team success,[20] and that IPEPs can reduce injuries,[111] is likely to facilitate support from club officials.

Step 2

In the second step, an interdisciplinary team is formed to guide the design and delivery of an evidence-based and context-specific IPEP. As demonstrated in this thesis research, the responsibility for injury prevention is

shared across several roles in professional soccer teams. All key stakeholders need to be involved in the design phase of IPEPs and this thesis has highlighted the following key groups: players (as health-beneficiaries), fitness coaches and physiotherapists (as IPEP deliverers), soccer coaches (as partners or "time-keepers") and club officials (as policy makers).

Step 3

The third step focuses on identifying potential barriers to IPEP implementation and corresponding solutions. Padua et al.[165] categorised these barriers according to time, personnel, environment and organisation. This current thesis research provides extensive information across all these categories, specific to the context of professional soccer. Table 5.3 outlines the implementation barriers and other key findings in each category, along with potential solutions and implications for the future design and delivery of IPEPs in professional soccer.

Step 4

Step four involves designing an injury prevention program which is both evidence-based and tailored to the logistical restraints and important success metrics of the implementation context. There is a currently a paucity of evidenced-based injury prevention exercises for professional soccer, with the exception being the hamstring lower exercise.[111] However, the results of this thesis research suggest that the key components of IPEPs for professional soccer are exercises for strength, core stability, balance and jumping/landing. In order to overcome the multiple IPEP implementation barriers (Table 5.3), IPEPs need to be highly adaptable to different delivery formats, delivery locations and training goals. As multiple stakeholders share responsibility for injury prevention in professional teams, the key success metrics of IPEPs need to reflect the goals of these different parties. These include team success, injury statistics, athletic goals (e.g. strength, speed), and cognitive goals (e.g. reaction time, peripheral awareness), as indicated by the results of this thesis.

Step 5

This step focuses on educating and supporting those who deliver IPEPs to the health beneficiaries. This thesis research has identified fitness staff and physiotherapists as the key IPEP deliverers in professional soccer settings. These staff members strongly supported injury prevention and referred to the published sports-

medicine and sports-science literature to inform their decisions. Accordingly, they are not likely to require extensive background education regarding injury prevention. However, staff members highlighted the existence of multiple IPEP implementation barriers within inter-disciplinary teams (Table 5.3). Hence, support for these individuals should also focus on enhancing team work, communication, planning and organisation.

Step 6

Step six aims to evaluate IPEP fidelity. This can include monitoring the number of planned IPEP sessions which are completed, along with the quality of IPEP delivery and individual exercise execution. In this thesis research, the main reasons for professional youth teams not performing IPEPs were heavy game schedules, performance tests and short-term changes to the training plan. Hence, the delivery of IPEPs in professional soccer needs to be tailored to the game schedule and supported by adequate organisation and planning. As adequate supervision facilitates the quality and individualisation of IPEPs in professional soccer, providing sufficient staffing at IPEP sessions is also important.

Step 7

The final step is developing an exit strategy for removing, or reducing, IPEP implementation support. This should preferably be based on achieving pre-determined objective criteria, rather than time-based measures alone. Objective criteria can relate to IPEP fidelity (e.g. the number or quality of IPEP sessions) or other key success metrics, as identified in this thesis research (e.g. injury statistics and athletic goals). As staff members routinely collect data on players, this can be used for goal-setting and the objective assessment of IPEP success, preferably at an individual-player level. The results of this thesis research suggest that the structure of professional soccer playing seasons and training cycles will also influence when it is appropriate to introduce an IPEP, and how frequently IPEPs can be performed. The implementation of programs should begin in the pre-season or at the start of training cycles. During the main playing season, game schedules are likely to limit the frequency of IPEP sessions.

Table 5.3 IPEP implementation barriers: key findings of the research in relation to the categories identified by Padua et al.[165]

Category	Implementation barriers and other key findings identified in this research project	Solutions and implications for the future design and delivery of IPEPs for professional soccer
Time		
Length of individual IPEP sessions	o The head coach's perception that the IPEP is too long and strenuous for the warm-up was identified as a barrier. o The majority of staff in academy teams suggested 15-25 minutes as an appropriate warm-up length, but with tailoring to the specific training session necessary. o The majority of staff and players in adult teams suggested 15-20 minutes as an appropriate warm-up length. o The length of observed IPEPs in academy teams was a median 39 minutes (range 10-90). For the sessions performed as warm-ups, the median was 35 minutes (range 12-70).	o Tailor the length and intensity of IPEPs to the chosen delivery format. o Involve soccer coaches (along with other key stakeholders) in the designing of IPEPs. o The perceptions of staff members regarding the appropriate length of warm-up differs to their observed behaviour.
Timing of IPEP delivery within the overall soccer training	o Academy teams delivered IPEPs in different formats e.g. warm-up (41%), cool-down (7%) and separate sessions (43%). o 89% of academy staff believed IPEPs should be performed both in team training and separately. The corresponding figure for players and staff in adult professional teams was 68%.	o Design IPEPs for professional soccer which are adaptable to different delivery formats. o Design both global (team-based) and individual programs that are complementary and mutually supportive.

Table 5.3 (continued)

Personnel		
Players	o Multiple IPEP implementation barriers were identified at player level including: - Lack of acceptance, knowledge, motivation and diligence. - Lack of experience with the program. - Fatigue and lack of concentration. - Different ability levels.	o Educate players in the importance of injury prevention, with specific reference to their individual goals and motivators (e.g. avoid missing games, extend length of career, improved performance). o Enhance motivation through individual monitoring and goal setting, along with tailoring of IPEP exercises to individual players.
	o A median of four players (range 0-17) were absent from academy team IPEP sessions. o The main reasons for absences were injury, illness, national team/first squad selection and participation in other parallel training sessions.	o Design individual programs which can be performed separately from team training and reflect individual ability levels. o Provide adequate staffing to assist with individualisation and motivation. o Coordinate IPEPs between different teams (e.g. reserve and first team).
Team staff	o Multiple barriers were identified at the team-staff level, including: - Head coaches' perception that an IPEP lacks individualisation and soccer-specificity. - Lack of staff numbers and continuity. - Lack of knowledge, communication, and team work. - Lack of acceptance/support from staff members. - Disagreement about the prevention strategy. - Lack of long-term planning. - Lack of time. - Competing training priorities (soccer, athletic, prevention and psychology).	o Involve all key stakeholders in the design and planning phases of IPEPs. o Secure support from all team staff members from the onset. o When possible, harmonise IPEP content and delivery with other staff members' goals (e.g. soccer-specificity, athletic and cognitive goals). o Success metrics for IPEPs should reflect the goals of different stakeholders (e.g. player match availability, athletic parameters, and injury statistics). o The length and content of IPEPs need to be tailored to the overall soccer training plan.

Table 5.3 (continued)

	o The responsibility for injury prevention in professional teams was shared across several positions. Survey respondents from adult professional teams indicated a median of five roles as holding responsibility, while those in academy teams indicated a median of seven roles. o Fitness coaches were the primary deliverers of IPEPs (92% of observed IPEP sessions in academy teams) with support from physiotherapists. These staff members decided on the content of programs and referred to the published sports medicine and sports science literature. o Head coaches ultimately decided on the number and length of IPEPs in each training week.	o Develop strategies to enhance team communication, long-term planning and organisation regarding IPEP delivery (e.g. regular team meetings and ongoing evaluation of IPEPs).
Environment		
Location of IPEP delivery	o Adverse weather conditions were identified as an implementation barrier. o Academy teams employed a range of IPEP delivery locations, including outdoor pitch (26%), indoor pitch (37%), gym (4%) and sport hall (19%). o Non-availability of facilities and equipment (e.g. shared facilities) was identified as a barrier.	o Design exercise variations suitable for adverse weather conditions (e.g. alternatives to exercises on the ground in cold/wet conditions). o Design exercise variations which can performed (if necessary) with limited or no equipment.
Equipment		
	o Across one season, academy teams used a median of 26 (range 21-30) different types of training equipment in their IPEPs. o Lack of program variation, progression, challenge and individualisation were commonly reported barriers, and common reasons for modifying individual exercises.	o Include exercise variations with different types of equipment to increase variation, progression and individualisation.

Table 5.3 (continued)

Organisation		
Club goals and success metrics	o Lack of team success was identified as a barrier.	o Demonstrate the positive impact of IPEPs on success metrics relevant to club officials (i.e. reduced injury rates positively impacting on team performance).
Sport director	o Lack of acceptance from the sports director was identified as a barrier.	o Involve sports directors in the planning phase of IPEPs and secure their support/buy in from the onset.

5.7 CONCLUDING REMARKS

This PhD research project has met its aim of enhancing the implementation of injury prevention exercise programs (IPEPs) in professional soccer by identifying implementation barriers and facilitators. Its systematic reviews, employing the RE-AIM framework, highlighted major reporting gaps in published IPEP trials and led to direct recommendations for reporting guidelines to improve this. Two cross-sectional studies and a prospective observational study identified a wide-range of IPEP implementation barriers and facilitators in professional soccer settings. These factors related either to the content and nature of the IPEPs, or the delivery and support of these programs at different levels of the professional soccer ecology. These findings will inform the future design and delivery of IPEPs specifically tailored to the professional soccer context.

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APPENDIX I: Summary of IPEP trials in soccer

Reference Country Publication Year	Study design	Sport(s) Playing level	Injury type	Participants -Total -Groups	Gender and age (mean[SD])†	Description of intervention	Duration of intervention	Reported injury outcome
Arnason et al.[109] Iceland/ Norway 2008	Cohort	Soccer Elite	Hamstring	18-24 players per team 17-30 teams per season over 4 seasons	♂ Age not reported	Strength program (Nordic hamstrings). 3 times per week in pre-season. Once per week in regular season. Maximum 3 x 12/10/8 reps.	2 seasons	RR 0.35 (0.19-0.62)
Askling et al.[110] Sweden 2003	RCT	Soccer Elite	Hamstring	30 IG 15 CG 15	♂ IG 24 (2.6) CG 26 (3.6)	Warm-up (15-min jog/cycle). Strength program (flywheel). 16 sessions. 4 x 8 reps.	10 weeks	RR 0.30 (0.10-0.88)
Beijsterveldt van et al.[133] Netherlands 2012 **Beijsterveldt van et al. 2011*[176]	Cluster RCT	Soccer Sub-elite	All	456 IG 223 CC 233	♂ IG 24.4 (4.1) CG 25.1 (4.3)	FIFA 11 program. 2-3 times per week. 10-15 mins.	1 season (33 weeks)	Injuries/1000 hours (95% CI): IG 9.6 (8.4-1.10) CG 9.5 (8.5-1-11)
Caraffa et al.[123] Italy 1996	Controlled trial	Soccer Sub-elite	ACL	600 IG 300 CG 300	Age and gender not reported	Balance training with unstable surfaces Minimum 30 sessions Minimum 20-mins	3 seasons	Injuries/team/season IG 0.15 CG 1.15
Ekstrand et al.[122] Sweden 1983 **Ekstrand 1984*[118]	Cluster RCT	Soccer Sub-elite	All	180 IG 90 CG 90	♂ IG 24.3 (3.7) CG 24.7 (4.1)	Multifaceted: structured warm-up/cool-down, appropriate equipment, ankle tape, structured rehabilitation, exclusion of high risk players, education and supervision.	1 season (6 months)	Injuries/month: IG 0.65 CG: 2.6

Emery et al.[141] Canada 2010	Cluster RCT	Indoor soccer Sub-elite	All	744 IG 380 CG 364	IG 57.6% ♂ CG 31% ♂ U13–U18 age groups	Warm-up program (aerobic, stretching, strength, agility, balance) 15mins. Also home program (balance training with unstable surfaces) 15mins.	1 season (20 weeks)	RR 0.62 (0.39–0.99)
Engebretson et al.[177] Norway 2008	RCT	Soccer Elite and sub-elite	LL	508 IG 193 CGa 195 CGb 120	♂ Age not reported	Balance, eccentric strengthening, core, and plyometric.	1 season	RR 0.49 (0.33-0.71) (between low risk/high risk groups)
Fredberg et al.[178] Denmark 2008	Cluster RCT	Soccer Elite	Achilles/ Patellar tendon	242 IG 96 CG 146	♂ 25 (range 18-38)	Stretching and eccentric strengthening. 3 times per week 10 mins.	1 season (11 months)	Risk Difference (achilles + patellar tendons IG vs. CG): –1%; 95% CI -11% to 10%
Gatterer et al.[134] Italy 2012	Controlled trial	Soccer Sub-elite	All	60 IG 20 CGa 20 CGb 20	♂ IG 22.7 (5.5) CGa 22.9 (5.4) CGb 23.1 (5.1)	FIFA 11 program (core stability, balance with unstable surface, plyometric and strength). Twice per week 20 mins.	20 weeks	Injuries per 1000 hours: IG: 3.3 (0.7-5.9) CG: 4.3 (1.3-7.3)
Gilchrist et al.[128] USA 2008	Cluster RCT	Soccer Sub-elite	ACL (non-contact)	1435 IG 583 CG 852	♀ IG 19.9 CG 19.9	PEP warm-up program (stretching, strength, plyometric and soccer-specific agility) 20-mins.	1 season (3 months)	Injury incidence: 0.06 vs 0.19 per 1000 AE
Grooms et al.[179] USA 2013	Prospective cohort	Soccer Sub-elite	LL	41	♂ 20.1 (2)	FIFA 11+ warm-up (running, strength, core stability, plyometric and balance) 5–6 times per week 20 mins.	2 seasons	RR 0.28 (0.09–0.85)

Hägglund et al.[180] Sweden 2007	Cluster RCT	Soccer Sub-elite	All	437 IG 216 CG 221	♂ IG 24 (6) CG 24 (5)	Education and 10 step rehabilitation program.	1 season (10 months)	HR 0.34 (0.16-0.72)
Hammes et al.[137] Germany 2014	Cluster RCT	Soccer Sub-elite	All	265 IG 146 CG 119	♂ IG 45 (8) CG 43 (6)	FIFA 11+ warm-up (running, strength, core stability, plyometric and balance) Every training session 20-mins.	1 season (9 months)	RR: 0.91 (0.64–1.48)
Heidt et al.[181] USA 2000	RCT	Soccer Sub-elite	All	300 IG 42 CG 258	♀ 14–18 years	Frappier Acceleration Program (treadmill, plyometric, strength, flexibility). Treadmill twice, plyometric once per week.	7 weeks	14% of IG suffered an injury vs. 33.7% of CG
Hewett et al.[182] USA 1999	Prospective study	Soccer, basketball, volleyball Sub-elite	Knee	1263 IG 366 CG ♀ 463 CG ♂ 434	34% ♂ Age not reported	Pre-season training program (flexibility, plyometric, and strength training). 3 times per week 60- 90 min.	6 weeks	Injuries/1000 AE: IG: 0.12 CG ♀: 0.43 CG ♂: 0.09
Hölmich et al.[183] Denmark 2010	Cluster RCT	Soccer Sub-elite	Groin	907 IG 524 CG 453	♂	Warm-up program (Strengthening, stretching core stability, coordination) 13mins.	1 season (10 months)	HR 0.69 (0.40–1.19)
Horst et al[184] 2015 Holland	Cluster RCT	Soccer Sub-elite	Hamstring	IG 292 CG 287	♂ 24.5 (3.8)	Nordic Hamstring training protocol. 13 week progressive program: 1-2 times per week, 2-3 x 5-10 repetitions.	13 weeks	OR 0.28 (0.11-0.72)

Appendix 1 (continued)

Junge et al.[11] Switzerland 2011	Prospective study	Soccer coaches of sub-elite teams	All	5549 coaches trained, 1027/1015 interviewed in 2004/2008	Coaches: 2004: 99.3 ♂ 2008: 99% ♂	Coach education in the FIFA 11 (core stability, balance with unstable surface, plyometric and strength).	Nationwide implemen-tation 2004 -2008	Lower incidence of match (25.3%) and training (11.5%) injuries in teams using FIFA 11+
Junge et al.[185] Switzerland 2002	Controlled trial	Soccer Sub-elite	All	194 IG 101 CG 93	♂ 16.5 (1.2)	Warm-up and cool-down program (flexibility, strength, endurance, coordination, and fair play).	2 seasons with 1 season observation period	Injuries/1000 hours: IG: 6.7 CG: 8.5
Kiani et al.[157] Sweden 2010	Controlled trial	Soccer Sub-elite	Acute knee	1,506 IG 777 CG 729	♀ IG 14.7 (range 12.7– 18.6) CG 15.0 (range 13.0–17.6)	Warm-up program (strength, landing exercises) Pre-season, Twice per week Regular season, Once per week, 20- to 25-min.	1 season (8 months)	Injuries/1000 hours: IG 0.04 CG 0.20
Kraemer et al.[186] Germany 2009	Prospective cohort	Soccer Elite	Patellar/ Achilles tendon and hamstring	24	♀ 21 (4)	Soccer-specific balance program. Dose varied across seasons.	2.5 seasons	Injuries/1000 hours: Hamstring 22.4 vs. 8.2. Patellar 3.0 vs. 1.0. Achilles 1.5 vs 0.0
LaBella et al.[142] USA 2011	Cluster RCT	Soccer and basketball Sub-elite	LL	95 Coaches (1,492 players) IG 737 CG 755	♀ IG 16.2 (1.5) CG 16.2 (1.1)	Coach education in warm-up program (strength, plyometric, balance and agility). Every training and abbreviated before game, 20-mins	1 season	RR (Gradual onset): 0.48 (0.18-1.26) RR (Acute onset): 0.33 (0.17-0.61)

Malliou et al.[187] Greece 2004	Controlled trial	Soccer Sub-elite	LL	100 IG 50 CG 50	♂ IG 16.7 (0.5), CG 16.9 (0.7)	20-min football-specific balance training including Biodex Stability System, and unstable surfaces Twice/week.	12 months	IG: 60 LL injuries CG: 88 injuries.
Mandelbaum et al.[100] USA 2005	Prospective controlled cohort	Soccer Sub-elite	ACL (non-contact)	5,703 IG 1885 CG 3818	♀ 14–18	Prevent Injury and Enhance Performance (PEP) warm-up program (stretching, strength, plyometric and soccer-specific agility) 20-mins.	2 seasons	Season 1: RR 0.11 (0.03-0.48) Season 2: RR 0.26 (0.09-0.73)
McHugh et al.[125] USA 2007 **Tyler et al. 2006*[188]	Prospective cohort	Soccer	Ankle	125	Gender not reported 15-18 years	Balance training with unstable surfaces. 5 times per week for 4 weeks in preseason. Twice per week for 9 weeks during the season 5 mins.	1 season (13 weeks)	Injuries per 1000 exposures: Pre-intervention 2.2 (1.1-3.8) Post-intervention 0.5 (0.2-1.3)
McGuine and Keene[126] USA 2006	Cluster RCT	Soccer and basketball Sub-elite	Ankle	765 IG 373 CG 392	31.6% ♂ IG 16.4 (1.2) CG 16.6 (1.1)	Balance training program with unstable surfaces. Pre-season, 5 times per week. Regular season, 3 times per week 10 mins.	1 season	RR 0.56 (0.33–0.95)
Mohammadi [124] Iran 2007	RCT	Soccer Elite	Ankle	80 IGa: 20 IGb: 20 IGc: 20 CG: 20	♂ 24.6 (2.6)	IGa: Balance training IGb: Strength training IGc: Ankle orthosis	1 season	IGa vs. CG: RR 0.13 (0.00-0.93)

Owoeye et al.[130] Nigeria 2014	Cluster RCT	Soccer Sub-elite	All	416 IG: 212 CG: 204	♂ IG 17.8 (0.9) CG 17.4 (1.1)	FIFA 11+ program (running, strength, core stability, plyometric and balance) Every training session.	1 season (6 months)	RR 0.59 (0.40 – 0.86)
Owen et al.[189] Scotland 2013	Prospective Cohort	Soccer Elite	Muscle	Season 1: 26 Season 2: 23	♂ IG 28.6 (3.8) CG 27.4 (4.9)	Balance; functional strength; core stability; mobility	1 season	Fewer muscle injuries in the intervention season (25% vs. 52% of total)
Petersen et al.[111] Denmark 2011	Cluster RCT	Soccer Elite/ Sub-elite	Hamstring	942 IG 461 CG 481	♂ IG 23.0 (4.0) CG 23.5 (4.0)	Nordic Hamstring training protocol. 10 week progressive program: 1-3 times per week, 2-3 x 5-12 repetitions. Then once weekly during season, 3 x 12/10/8 repetitions	1 season (11 months)	RR: 0.3 (0.15-0.57)
Pfeiffer et al.[190] USA 2006	Cohort	Soccer, basketball, volleyball Sub-elite	ACL (non-contact)	1,439 IG 577 CG 862	♀ 14-18	Knee Ligament Injury Prevention (plyometric, agility) Twice per week. 20mins	2 seasons	Incidence per 1000 AE: IG: 0.167 CG: 0.078
Silvers-Granelli et al.[131] USA 2015	Cluster RCT	Soccer Sub-elite	All	IG 675 CG 850	♂ IG 20.4 (1.7) CG 20.7 (1.5)	FIFA 11+ program (running, strength, core stability, plyometric and balance) 3 times per week. 20mins	1 season	RR 0.54 (0.49-0.59)

Söderman et al.[191] Sweden 2000	Cluster RCT	Soccer Elite/sub-elite	LL	221 IG 121 CG 100	♀ IG 20.4 (4.6) CG 20.5 (5.4)	Balance training with unstable surfaces. 10-15mins. Daily for 30 days. Then 3 times per week.	1 season (7 months)	RR 1.24 (0.74–2.06)
Soligard et al.[101] Norway 2008 **Soligard et al. 2010* [135]	Cluster RCT	Soccer Sub-elite	LL	1,892 IG 1055 CG 837	♀ IG 15.4 (0.7) CG 15.4 (0.7)	FIFA 11+ program (running, strength, core stability, plyometrics and balance) Every training session.	1 season (8 months)	RR 0.71 (0.49–1.03)
Steffen et al.[101] Norway 2008	Cluster RCT	Soccer Sub-elite	All	2,020 IG 1073 CG 947	♀ IG 15.4 (0.8) CG 15.4 (0.8)	FIFA 11 program (core stability, balance with an unstable surface, plyometrics and strength). First 15 training sessions, then once per week, 20 mins.	1 season (8 months)	RR 1.00 (0.83–1.20)
Steffen et al.[136] Norway 2013 **McKay et al. 2014*	Cluster RCT	Soccer Sub-elite	All	226 CG: 80 IGa: 68 IGb: 78	♀ 13-18	FIFA 11+ program (running, strength, core stability, plyometrics and balance) Progressive difficulty. 2-3 times per week, 20mins.	4.5 months	RR 0.28 (0.10-0.79) High-adherence vs. medium-adherence group:
Tropp et al.[119] Sweden 1985	RCT	Soccer Sub-elite	Ankle	439 IGa 144 IGb 124 CG 171	♂	IGa: Ankle orthosis IGb: Balance training on unstable surface. 10 mins, 5 times per week for 10 weeks. Then 5 mins, 3 times per week.	1 season (6 months)	RR 0.28 (0.13-0.62) for balance training group (IGb vs. CG)

Waldén et al.[127] Sweden 2012 **Hägglund et al. 2009* [140] **Lindblom et al. 2014* [139]	Cluster RCT	Soccer Sub-elite	ACL Knee	4,564 IG 2479 CG 2085	♀ IG 14.0 (1.2) CG 14.1 (1.2)	Warm-up program (strength, knee alignment, core stability, jumping and landing). Twice per week, 15 mins.	1 season (7 months)	RR 0.36 (0.15–0.85) for ACL

CI=Confidence interval. RR=Risk ratio. Please note, direct comparison of RR's between studies is not advisable, due to the different calculations employed in different studies, including the presence/absence of adjustment for clustering. RCT= Randomised controlled trial. IG=Intervention group. CG=Control group. ♂=Male. ♀=Female. Reps=Exercise repetitions. LL=lower limb. ACL: Anterior Cruciate Ligament. OR=Odds Ratio. HR=Hazard ratio. AE=Athletic exposures. Elite is considered to be teams playing in the top 2 senior national divisions of the respective country. * Further publication related to the same trial. †Age is presented as mean (standard deviation) unless otherwise stated.

APPENDIX II: The RE-AIM checklist (Adapted from Virginia Polytechnic Institute and State University)[160 161]

REVIEWER						
AUTHOR						
REVIEW DATE						
This components refers to:	REACH *Reach refers to the number, proportion, and representativeness of participants targeted by the researchers*	YES	NO	YES Inappropriate use	N/A	Comments
	Did the study report the % of potential participants who were excluded OR the characteristics of participants who were excluded?					
	Was the % of individuals participating, based on a valid denominator reported (not volunteers indicating interest)?					
	Were the characteristics of the participants compared to non-participants or to the target population?					
	Did the study employ qualitative methods to help understand points in this category?					
	EFFECTIVENESS / EFFICACY *Effectiveness refers to changes in primary study outcomes, quality of life, and potential negative effects*	YES	NO	YES Inappropriate use	N/A	Comments
	Was a measure of the primary outcome with or w/o comparison to a public health goal reported?					
	Were broader outcomes or multiple criteria reported? (e.g. other outcomes, measure of QoL or potential negative outcomes)?					

	Was any within-group analysis conducted that allowed researchers to draw conclusions about how different sub-groups responded?					
	Did the study report the short-term attrition of targeted participants (%) AND differential attrition rates by participant characteristics or treatment condition.					
	Did the study employ qualitative methods/data to help understand points in this category?					
	ADOPTION – SETTING LEVEL *Adoption-setting level refers to the number, proportion, and representativeness of settings (e.g. sports club, school or other organisation) that agree to deliver an intervention.*	**YES**	**NO**	**YES Inappropriate use**	**N/A**	**Comments**
	Did the study report the % of potential settings that were excluded OR reasons for the exclusions.					
	Did the study report the % of settings accepting participation? The denominator should not be volunteers indicating interest.					
	Were the characteristics of those settings choosing to participate and those unwilling to participate described?					
	Did the study employ qualitative methods to help understand points in this category?					
	ADOPTION – DELIVERY AGENT LEVEL *Adoption-delivery agent level refers to the number, proportion, and representativeness of delivery agents (e.g. coach, physiotherapist) who agree to deliver an intervention.*	**YES**	**NO**	**YES Inappropriate use**	**N/A**	**Comments**
	Did the study report the % of potential delivery agents who were excluded OR reasons for the exclusions.					
	Did the study report the % of delivery agents accepting participation? The denominator should not be volunteers indicating interest.					

	Were the characteristics of those delivery agents choosing to participate and those unwilling to participate described? Credit is given to anything that is reported.					
	Did the study employ qualitative methods to help understand points in this category?					
	IMPLEMENTATION *The degree to which the intervention was delivered as intended and the cost of implementation*	**YES**	**NO**	**YES Inappropriate use**	**N/A**	**Comments**
	Was the % of perfect delivery or sessions completed reported (e.g. adherence or consistency)					
	Were adaptations made to the intervention during the study reported?					
	Did the study report the cost of the intervention (time or money)?					
	Did the study report the consistency of implementation across staff/time/settings/subgroups?					
	Did the study employ qualitative methods to help understand points in this category?					
	MAINTENANCE – INDIVIDUAL LEVEL *The extent to which an intervention and its effects are sustained by the targeted participants over time.*	**YES**	**NO**	**YES Inappropriate use**	**N/A**	**Comments**
	Was a measure of the primary outcome (with or w/o comparison to a public health goal) at ≥6 months after the final intervention by the study's researchers reported?					
	Were broader outcomes or multiple criteria reported at ≥6 months follow-up? (e.g. other outcomes, measure of QoL or potential negative outcomes)?					

	Was any within-group analysis conducted that allowed researchers to draw conclusions about how different sub-groups responded at ≥6 months follow-up?					
	Did the study report the long-term attrition (≥6 months) of targeted participants (%) AND differential attrition rates by participant characteristics or treatment condition.					
	Did the study employ qualitative methods to help understand points in this category?					
	MAINTENANCE-SETTING LEVEL *The extent to which an intervention and its effects are sustained by the relevant setting (e.g. sports club, school) over time.*	**YES**	**NO**	**YES Inappropriate use**	**N/A**	**Comments**
	Did the study report if the program is still on-going at ≥6 month post study funding					
	Did the study report if and how the program was adapted at ≥6 months (which elements retained AFTER program completed)?					
	Did the study report if, or how, the program was incorporated in the setting's policy/management model/philosophy?					
	Did the study employ qualitative methods/data to help understand points in this category?					

APPENDIX III: Survey

1. How old were you on your last birthday?

2. What is your current role at ***?

☐ Player

☐ Coach

☐ Trainer (exercise physiologist, athletic trainer, condition trainer)

☐ Physiotherapist

Please indicate your view on the following statements, by marking the most appropriate option. The term **lower limb injuries** is used in this survey to describe injuries in any body area between the hip and toes. Examples are hip, knee and ankle injuries, thigh and calf muscle injuries and groin injuries.

3. Soccer players are at high risk of suffering a lower limb injury

strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

4. Lower limb injuries have a negative impact on team performance

strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

5. Lower limb injuries can shorten a professional soccer player's career

strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

6. Lower limb injuries can cause physical problems later in life

strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

7. Lower limb injuries have a negative impact on a soccer player's quality of life

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

8. It is possible to prevent some lower limb soccer

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

9. Exercises which have been scientifically proven to prevent lower limb injuries should be performed by soccer players

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

---SKIP LOGIC---

10. When should exercises to prevent lower limb injuries be performed?

☐ as part of team training

☐ separate from team training

☐ both

11. Exercises to prevent injuries should be varied and progressed over time

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

12. Exercises which have been scientifically proven to prevent lower limb injuries should be incorporated into the club's training guidelines

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

13. The following types of exercise can prevent lower limb injuries

	strongly agree	agree	neither agree nor disagree	disagree	strongly disagree
warm-up jog/run	☐	☐	☐	☐	☐
cool-down jog/run	☐	☐	☐	☐	☐
eccentric muscle strengthening	☐	☐	☐	☐	☐
controlled jumping and landing	☐	☐	☐	☐	☐
controlled changes in direction (cutting)	☐	☐	☐	☐	☐
balance exercises	☐	☐	☐	☐	☐

14. Who is responsible for preventing injuries in a professional soccer club? (tick as many as appropriate)

- ☐ player
- ☐ head coach
- ☐ assistant coach
- ☐ condition trainer
- ☐ physiotherapist
- ☐ massage therapist
- ☐ doctor
- ☐ sports director
- ☐ other (please specify)

15. Who holds the ultimate responsibility for preventing injuries in a professional soccer club?

- ☐ player
- ☐ head coach
- ☐ assistant coach
- ☐ condition trainer
- ☐ physiotherapist
- ☐ massage therapist
- ☐ doctor
- ☐ sports director
- ☐ other (please specify)

16. What factors could make it easier for a team to maintain an injury prevention exercise program over time?

17. What factors could make it harder for a team to maintain an injury prevention exercise program over time?

18. How much time is appropriate for a warm-up session at the start of team training?

- ☐ under 5 minutes
- ☐ 5 minutes
- ☐ 10 minutes
- ☐ 15 minutes
- ☐ other (please specify)
- ☐ 20 minutes
- ☐ 25 minutes
- ☐ 30 minutes
- ☐ 35 minutes
- ☐ 40 minutes
- ☐ over 40 minutes

The next questions relate specifically to the FIFA 11+ warm-up programme. If you are not already familiar with the programme, you can find extensive information on the FIFA 11+, by following this link: click here Note: the information is available in multiple languages: you can select a language at the top, right-hand corner of the screen.

19. Had you heard of the FIFA 11+ programme before taking part in this questionnaire?

- ☐ yes
- ☐ no
- ☐ unsure

20. Does your team currently use the FIFA 11+ programme?

- ☐ yes
- ☐ yes, but modified
- ☐ no
- ☐ unsure

---SKIP LOGIC---

21. Do you like the FIFA 11+?

☐ yes*

☐ no*

☐ unsure

*please provide reasons for your answer

22. Have you ever been in a team which used the FIFA 11+ programme?

☐ yes

☐ no

☐ unsure

---SKIP LOGIC---

23. Did you like the FIFA 11+?

☐ yes*

☐ no*

☐ unsure

*please provide reasons for your answer

24. The FIFA 11+ can prevent lower limb injuries in your team

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

25. The FIFA 11+ is soccer-specific

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

26. The FIFA 11+ is too long

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

27. The FIFA 11+ contains adequate variation and progression for our team

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

28. The FIFA 11+ could be maintained over multiple seasons by our team

stongly agree	agree	neither agree nor disagree	disagree	strongly disagree
☐	☐	☐	☐	☐

29. Does the FIFA 11+ need to be improved for use in your team?

☐ yes

☐ no

☐ unsure

30. Should your club develop its own version of the FIFA 11+?

☐ yes

☐ no

☐ unsure

31. Do you have any further suggestions for injury prevention strategies?

☐ yes*

☐ no

*please specify

32. Please feel free to add any further information which you feel is important

Thank you for completing the survey. We appreciate your contribution to developing better injury prevention programs