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SYSTEMATIC REVIEW

How Effective are F-MARC Injury Prevention Programs for Soccer Players? A Systematic Review and Meta-Analysis

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Abstract

Background The FIFA Medical and Research Centre (F-MARC) has designed a comprehensive warm-up program targeting muscular strength, body kinaesthetic awareness, and neuromuscular control during static and dynamic movements to decrease injury risk for soccer players. Prior studies have investigated the effectiveness of the F-MARC programs, but have not consistently reported a statistically significant reduction in injury and reduction in time loss due to injury from utilizing the program.

Objective The purpose of this study was to conduct a systematic review and meta-analysis of randomized controlled trials and interventional studies that evaluated the efficacy of the F-MARC injury prevention programs in soccer.

Methods Two independent researchers searched the relevant article databases. The keyword domains used during the search were 'F-MARC', 'FIFA 11+', 'the 11+', 'injury prevention programs', 'soccer', and variations of these keywords. The initial search resulted in 4299 articles which were filtered to nine articles that met the inclusion criteria. Main inclusion criteria were randomized controlled trials or interventional studies, use of F-MARC injury prevention programs, and the primary outcome measuring overall and lower extremity injuries. Extracted data were entered and analyzed using Comprehensive Meta-Analysis software, version 2 (CMA.V2).

Results The pooled results based on total injuries per 1000 h of exposure showed that F-MARC injury prevention programs had a statistically significant reduction in the overall injury risk ratio of 0.771 (95 % CI 0.647–0.918, $p = 0.003$) and the lower extremity injury risk ratio of 0.762 (95 % CI 0.621–0.935, $p = 0.009$). Moreover, FIFA '11+' had a statistically significant reduction in the overall injury risk ratio to 0.654 (95 % CI 0.537–0.798, $p < 0.001$) and the lower extremity injury risk ratio of 0.612 (95 % CI 0.475–0.788, $p < 0.001$). However, FIFA '11' did not reach significance for the lower extremity and overall injury reduction. It can be suggested that teams involved in the FIFA '11+' warm-up program will reduce injury rates by between 20 and 50 % in the long term compared with the teams that do not engage in F-MARC programs.

Conclusions This systematic review and meta-analysis indicated that use of F-MARC injury prevention programs, particularly the '11+' program, decreases the risk of injuries among soccer players. These data also support the case for the development and introduction of sport-specific programs.

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Key Points

There is good evidence that soccer teams using Fédération Internationale de Football Association Medical and Research Centre (F-MARC) injury prevention programs can reduce injury by between 20 and 50 % in the long term compared with teams that do not engage in F-MARC programs.

The '11+' in particular was shown to be highly effective in reducing overall and lower extremity injury.

1 Introduction

Increased participation in sports leads to a rise in sports-related injuries which could be detrimental to an athlete's health and career [1]. Sports injury prevention programs (IPPs) have become a prime area of interest in sports medicine in recent years [2]. IPPs for athletes have been developed in sports such as soccer [3]. The effect of IPPs on injuries among soccer players has been investigated in several studies with conflicting results. Some studies found that IPPs can be effective [3–8] while others found no significant effect [9–12].

In 2003, the Fédération Internationale de Football Association (FIFA) Medical and Research Centre (F-MARC) developed the FIFA '11' prevention program. The '11' program included 10 exercises and takes around 15 min to apply before each training session. These exercises included the bench, sideways bench, Nordic hamstring, cross-country skiing, chest passing in single-leg stance, forward bend in single-leg stance, figures-of-eight single-leg stance, jumps over a line, zigzag shuffle, and bounding (i.e., jogging with jumping).

No effect of the '11' was found among Norwegian female youth players in a cluster-randomized controlled trial with low compliance conducted by Steffen et al. [11]. Similarly, there were no significant differences in the overall injury incidence or injury severity between the intervention and control group of Dutch male amateur soccer players [13]. However, knee injuries were reduced amongst those players who complied well with the program. Consequently, it is unclear whether the non-significant reduction in injuries in these studies was related to the effectiveness of the prevention program or the lack of compliance among the participants.

In 2006, the '11' program was developed further and improved to form FIFA '11+' [14]. The '11+' was an attempt to rebuild and regroup the '11' program with an international group of researchers that predicted their choice of exercise inclusion based on the rate and type of injuries associated with the sport. The '11' was disbanded because of its lack of efficacy. The '11+' combines key exercises from the '11' but with higher intensity by adding an advanced manoeuvre with an extra variety of running exercises and progression in the number of repetitions of some exercises to improve the preventive effect. Better marketing of the program for coaches and players was used to improve compliance.

The '11+' comprises 15 exercises divided into three parts and should be implemented as a standard warm-up at the start of each training session, at least twice a week. This program takes approximately 20 min to complete and includes the following three main components: (1) initial running and active stretching session; (2) a core and leg strength exercise session; and (3) a high-speed planting and cutting exercise session.

These exercises focus mainly on strengthening the core and leg muscles to improve static, dynamic and reactive neuromuscular control, coordination, balance and agility.

Soligard et al. [3] evaluated the '11+' and found a significantly lower risk of overall injuries in the intervention group among young female Norwegian players in one season; however, the primary outcome of a reduction in lower extremity injuries did not reach significance. Steffen et al. [15] found that high adherence to the '11+' led to significant improvements in functional balance and decreased the injury risk among young female Canadian players by 57 % (injury rate ratio [IRR] 0.43; 95 % CI 0.19–1.00). However, after modifying for covariates, this between-group difference was not statistically significant (IRR 0.44; 95 % CI 0.18–1.06). Furthermore, in a cluster-randomized controlled trial conducted by Owoeye et al. [16] to evaluate the efficacy of the '11+', the overall rate of injury of the intervention group reduced by 41 % and all lower extremity injuries by 48 % among African players. The rate of injury reduction based on body location, etiology, mechanism, and severity, however, did not reach the significance level. The Hammes et al. [17] study showed that the'11+' program did not reduce the incidence of injuries among veteran German soccer players (IRR 0.91; 95 % CI 0.64–1.48, $p = 0.89$). Only severe injuries reached statistical significance with a higher incidence in the control group (IRR 0.46; 95 % CI 0.21–0.97, $p = 0.04$).

Many studies have evaluated the effectiveness of the '11' and the '11+' in Africa, Canada, Europe and the US [3, 11, 13, 15–20]. However, given the lack of agreement among studies and the results of some studies not reaching statistical significance, a meta-analysis of pooled results across studies will yield a more powerful statistical result. The aim of this meta-analysis was to investigate the effectiveness of the F-MARC injury prevention programs for reducing injuries in soccer.

2 Methods

2.1 Search Strategy

The search was based upon the guidelines of the Cochrane Handbook [21]. Two researchers independently searched for eligible studies using the databases: the Cochrane Central Register of Controlled Trials via OvidSP, AMED: Allied and Complementary Medicine via OvidSP (1985–present), EMBASE, PubMed, MEDLINE, SPORTDiscus, Web of Science, CINAHL and AusSportMed.

A standardized method was used to perform electronic searches based on the word strings that covered relevant study designs and purposes. Briefly, the following search criteria were used: (F-MARC) OR (FIFA) OR (FIFA 11) OR (FIFA 11+) OR ("The 11+") OR ("warm-up program") OR (Warm-Up Exercise) OR ("Injury prevention program") OR (neuromuscular training) OR (Soccer/football warm up program) OR ("Injury prevention") AND (Athletes) OR ("soccer player") OR ("Football player") AND (sport injuries) OR (Athletic Injuries).

2.2 Included Studies Criteria

2.2.1 Types of Studies

Randomized control trials, cluster-randomized control trials, or prospective cohort studies in which a specified F-MARC IPP was prescribed to modify injury risk, were included in the review.

2.2.2 Types of Participants

Only studies with soccer players were included. Studies of cohorts containing athletes from multiple different sports were excluded. Studies were not excluded because of any of the following factors: sex, skill level of athletes, or age group.

2.2.3 Types of Interventions and Comparison Groups

The only studies included were those that used the F-MARC injury prevention programs for soccer players. These F-MARC injury prevention programs included the FIFA 11+, the FIFA 11, and the FIFA 'F-MARC Bricks'.

2.2.4 Outcome Measures

The outcome measures were presence or absence of lower limb and overall injuries (i.e., the injury rate in the control group versus that in the intervention group).

2.3 Excluded Studies Criteria

Studies were excluded from the meta-analysis if they were (1) observational or cross-sectional studies; (2) case reports and case series, (3) studies that did not report player exposure hours; (4) studies with a primary aim of conducting performance or physical measurements; (5) studies that had multiple exposure groups and were primarily designed to assess the uptake and adherence of an intervention program; and (6) studies using protective equipment as part of the intervention.

2.4 Data Collection, Extraction and Analysis

2.4.1 Inclusion Procedure

The PRISMA Statement method was used for article screening [22]. Duplicates were eliminated from the two searches; articles were excluded if they did not fit the inclusion criteria. When disagreements were noted, a third reviewer facilitated group consensus agreement. Figure 1 summarizes the systematic steps involved in screening articles for inclusion. Once a preliminary list of studies was identified, reference lists of manuscripts and other related review articles were searched for additional potential studies. From 4299 initially identified studies, nine clearly met inclusion criteria and were included in the meta-analysis.

2.4.2 Data Extraction

Two reviewers independently extracted data from studies that met the inclusion criteria. The following outcome data elements were extracted from each study: type of injury (overall, lower extremity injuries), exposure hours, duration of follow-up, and compliance rate. If any of the data were missing or unclear, the study authors were contacted for clarification.

2.4.3 Administration

Endnote version X7 (Thomson Reuters, Philadelphia, PA, USA) was used to collate all studies identified and for screening studies for inclusion and exclusion. Primary outcome results from individual studies were extracted and collated in Excel (Microsoft Corp) prior to preparation and transfer into Comprehensive Meta-Analysis software, version 2 (CMA.V2) (Biostat, Inc., Englewood, NJ, USA).

2.4.4 Meta-Analysis and Subgroup Analysis

Extracted data were entered and analyzed using CMA.V2 for the meta-analysis and subgroup analysis.

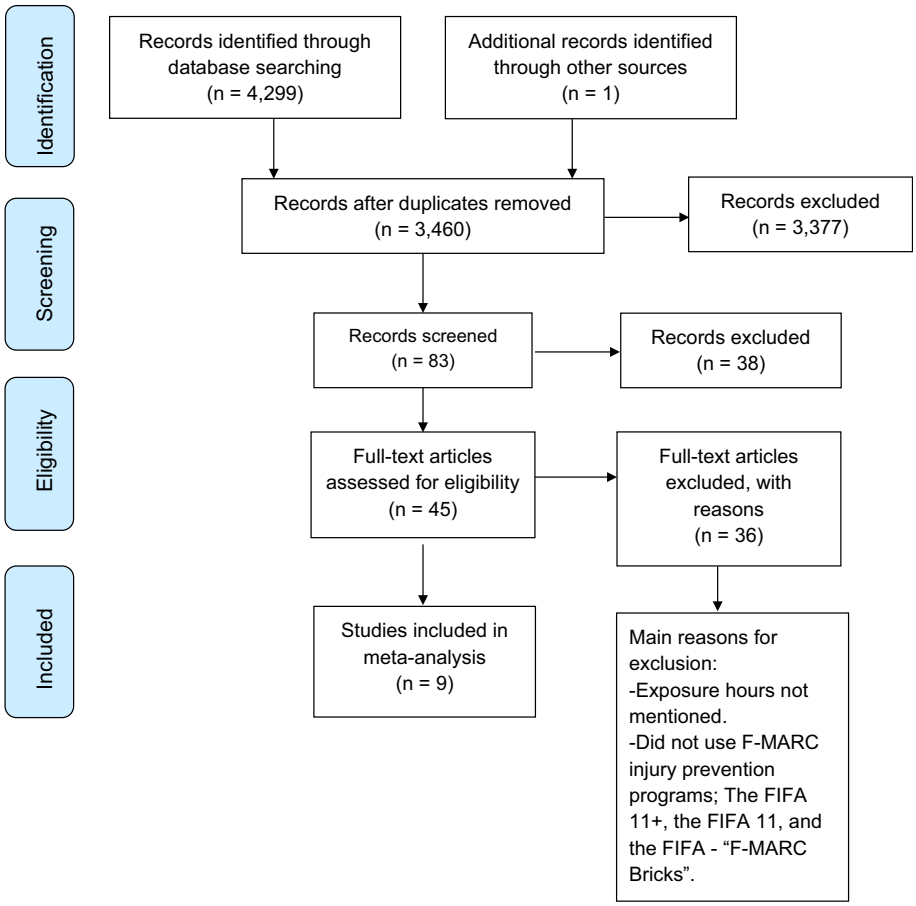

Fig. 1 Flowchart for review and triage of articles. *FIFA* Fédération Internationale de Football Association, *F-MARC* FIFA Medical and Research Centre

Subgroup analysis was performed for subsets of studies on the effect of types of interventions and sex.

2.5 Methodological Quality Assessment

The methodological quality of each study was assessed by two reviewers independently. The 12 quality criteria were evaluated according to the guidelines for systematic reviews in the Cochrane Back Review Group by Furlan et al. [23]. Each item was scored as (+ = 1 point, − or ? = 0 points). Any study that scored higher than 60 % of the overall score was considered high quality. The corresponding author of the study was contacted when the reviewers were unsure of whether a study met a particular quality criterion due to insufficient information in the article. Table 1 shows quality scores for all the studies. Five of the nine studies were considered high-quality studies.

2.6 Definitions of Injury, Injury Rates, Injury Rate Ratio and Injury Prevention Program

The following consensus statement on injury definitions and data collection procedures in studies of soccer injuries was used to define injury: "injury can be recorded if it causes the player to be not able to completely participate in the following match or training session" [24]. The injury rate refers to the number of incident injuries divided by the total time at risk and is usually multiplied by 1000. This can accommodate variations in the exposure time of individual athletes, and it is the preferred measure of incidence in sports research [25].

IRR is calculated by the formula: IRR = injury rate in intervention group/injury rate in control group.

An estimated IRR <1, along with confidence intervals (CIs) <1 consequently suggested a positive intervention effect; for example, an IRR of 0.60 is termed as 40 % reduction.

For the purpose of this review, IPP is defined as "the 11+, the 11 and the F-MARC Bricks". The IPP partially or completely precedes a match or practice session of the sport during the regular season on the playing field.

3 Results

3.1 Trial Flow

Following the initial search of the databases, title and abstract lists of all the 4299 articles were obtained, and

Table 1 Methodological quality scores of the included studies

Criterion	Junge et al. [18] (2002)	Soligard et al. [3] (2008)	Steffen et al. [11] (2008)	Gatterer et al. [19] (2012)	Van Beijsterveldt et al. [13] (2012)	Grooms et al. [20] (2013)	Steffen et al. [15] (2013)	Hammes et al. [17] (2014)	Owoeye et al. [16] (2014)
Adequate randomization	−	+	+	−	+	−	+	+	+
Allocation concealment	−	+	+	+	+	+	+	+	−
Blinding patients	−	−	−	−	−	−	+	−	−
Blinding caregiver	−	−	−	−	−	+	+	−	−
Blinding/outcome assessors	−	−	+	−	−	+	+	−	−
Incomplete outcome data addressed/drop-outs	+	+	+	+	+	+	+	+	+
Incomplete outcome data/ intention-to-treat (ITT) analysis	−	+	+	−	+	+	+	+	+
Free of suggestions of selective outcome reporting	+	+	+	+	+	+	+	−	+
Similarity baseline characteristics	+	+	+	+	+	+	+	+	+
Co-interventions avoided or similar	+	+	+	−	+	+	−	−	?
Compliance acceptable in all groups	−	+	−	+	+	+	+	+	+
Timing of the outcome assessment similar	+	+	+	−	+	−	+	+	+
Score maximum	12	12	12	12	12	12	12	12	12
Study score	5	9	9	5	9	9	11	7	7
Percentage	41.6	75	75	41.6	75	75	91.6	58.3	58.3

'+' = Yes, '−' = no and '?' = unsure. For each question only Yes received a point. In case it was a no or unsure no points were awarded

screened for relevancy. After duplicates were removed, 3460 articles were screened. Forty-five articles were chosen for full-text review, 36 articles were excluded because F-MARC IPP was not prescribed to modify injury risk, or exposure hours were not mentioned, or only abstracts were available. Thus, a total of nine studies were included in the current analysis.

3.2 Study Characteristics

The study design in six of the studies was a cluster-randomized controlled trial [3, 11, 13, 15–17], there was one prospective controlled intervention study [18], and two cohort studies [19, 20]. Two studies were conducted in Norway [3, 11], one in Switzerland [18], one in Italy [19], one in the Netherlands [13], one in the US [20], one in Canada [15], one in Germany [17], and one in Nigeria [16]. Six studies included male participants [13, 16–20] and three studies included female participants [3, 11, 15]. The duration of the IPP ranged from 12 weeks to 12 months. Five studies used the '11+' [3, 15–17, 20], three studies used the '11' [11, 13, 19] and one study used FIFA 'F-MARC Bricks' [18] for warm-up in the intervention groups. Eight studies used their usual warm-up programs [3, 11, 13, 15–19] and one used a traditional dynamic warm-up program [20] in control groups. Table 2 summarizes the characteristics of the nine included studies and Table 3 shows the injury rates and hours of exposure for intervention and control groups.

Gatterer et al. [19] evaluated three amateur soccer teams, two of which played at a regional level (6th Italian league) and one at a provincial level (7th Italian league).The comparison between the 6th Italian league intervention group and the 6th Italian league control group was selected for the meta-analysis. Steffen et al. [15] analyzed two intervention groups (regular and comprehensive) and one control group. The control group was provided only with online access to the '11+' website (http://f-marc.com/11plus/) [14], the regular intervention group was provided with one coach's workshop for the '11+' and the website information, and the comprehensive intervention group had an assigned physiotherapist who taught the '11+' to the players and participated in weekly practice sessions. The comprehensive group versus the control group was selected for the meta-analysis. Grooms et al. [20] evaluated one American collegiate soccer team followed for two seasons and only lower extremity injuries were recorded. Season one was compared with season two in this meta-analysis.

3.3 Pooled Injury Estimates

Pooled data of 5481 individuals, 428,633 exposure hours and 1753 overall injuries were collected from the nine included studies. The pooled IRR of the intervention group was 3.89 injuries per 1000 h of exposure and 5.35 injuries per 1000 h of exposure for the control group, and the rate of lower extremity injuries per 1000 h was 3.31 for the intervention group and 5.16 for the control group (Table 3).

3.4 FIFA Medical and Research Centre (F-MARC) Injury Prevention Programs (IPPs) Meta-Analysis Results

3.4.1 F-MARC IPPs Overall and Lower Extremity Injuries Reduction

The pooled results showed 23 % overall injury reduction per 1000 h of exposure in the F-MARC IPPs compared with the control group (IRR 0.771; 95 % CI 0.647–0.918, $p = 0.003$) (Fig. 2).

F-MARC IPPs showed 24 % lower extremity injury reduction per 1000 h of exposure in the F-MARC IPPs compared with the control group (IRR 0.762; 95 % CI 0.621–0.935, $p = 0.009$) (Fig. 3).

3.4.2 F-MARC IPPs Subgroup Analysis '11+' Versus '11'

The '11+' showed 35 % overall injury reduction per 1000 h of exposure (IRR 0.654; 95 % CI 0.537–0.798, $p < 0.001$), while the '11' (IRR 0.923; 95 % CI 0.786–1.083, $p = 0.327$) was associated with 8 % overall injury reduction per 1000 h of exposure compared with the control group (Fig. 4).

The '11+' showed 39 % reduction in lower extremity injuries per 1000 h of exposure (IRR 0.612; 95 % CI 0.475–0.788, $p < 0.001$), while the '11' (IRR 0.961; 95 % CI 0.776–1.191, $p = 0.717$) was associated with a 4 % reduction in lower extremity injuries per 1000 h of exposure compared with the control group (Fig. 5).

3.4.3 F-MARC IPPs Subgroup Analysis Male Versus Female

F-MARC IPPs showed 30 % overall injury reduction per 1000 h of exposure in males (IRR 0.705; 95 % CI 0.534–0.929, $p = 0.013$) and 22 % overall injury reduction in females (IRR 0.818; 95 % CI 0.603–1.110, $p = 0.197$) (Fig. 6).

F-MARC IPPs showed 31 % lower extremity injury reduction per 1000 h of exposure in males (IRR 0.692; 95 % CI 0.500–0.957, $p = 0.026$) and 20 % lower extremity injury reduction in females (IRR 0.803; 95 % CI 0.556–1.159, $p = 0.241$) (Fig. 7).

Table 2 Characteristics and moderators of the included studies

Study	Location	Sex	Study design	Compliance (%)	Duration	Level	Type of warm-up in intervention group	Type of warm-up in control group	Frequency (no. per week)	Quality score
Junge et al. [18] (2002)	Switzerland	M	Prospective controlled intervention study	No data	12 months	Youth	FIFA F-MARC Bricks	As usual	No data	5
Soligard et al. [3] (2008)	Norway	F	Cluster-randomized controlled trial	77	8 months	Youth	FIFA 11 + 20 min	As usual	3	9
Steffen et al. [11] (2008)	Norway	F	Cluster-randomized controlled trial	52	8 months	Youth	FIFA 11 20 min	As usual	1	9
Gatterer et al. [19] (2012)	Italy	M	Cohort study	>90	14 weeks	Youth	FIFA 11 20 min	As usual	3–5	5
van Beijsterveldt et al. [13] (2012)	Netherland	M	Cluster-randomized controlled trial	73	33 weeks	Youth	FIFA 11 10–15 min	As usual	2	9
Grooms et al. [20] (2013)	USA	M	Cohort study	100	12 weeks	Youth	FIFA 11 + 20 min	Traditional dynamic warm-up	5–6	9
Steffen et al. [15] (2013)	Canada	F	Cluster-randomized controlled trial	85	4.5 months	Youth	FIFA 11 + 20 min	As usual	2–3	11
Hammes et al. [17] (2014)	Germany	M	Randomized controlled trial	98	9 months	Veteran	FIFA 11 + 20 min	As usual	1	7
Owoeye et al. [16] (2014)	Nigeria	M	Cluster-randomized controlled trial	60	6 months	Youth	FIFA 11 + 20 min	As usual	2	7

The FIFA 11+, the FIFA 11, and the FIFA F-MARC Bricks are all FIFA injury prevention programs

F female, FIFA Fédération Internationale de Football Association, *F-MARC* FIFA Medical and Research Centre, *M* male

Table 3 Injury rates per 1000 h of exposure in the intervention and control groups of the included studies

Study	Warm-up subjects	Overall injuries	Lower extremity injuries	Exposure hours	Overall injuries per 1000 h	Lower extremity injuries per 1000 h	Control subjects	Overall injuries	Lower extremity injuries	Exposure hours	Overall injuries per 1000 h	Lower extremity injuries per 1000 h
Junge et al. [18] (2002)	101	77	65	11,475	6.71	5.66	93	111	92	13,090	8.48	7.02
Soligard et al. [3] (2008)	1055	161	121	49,899	3.23	2.42	837	215	143	45,428	4.73	4.73
Steffen et al. [11] (2008)	1073	242	181	66,423	3.64	2.72	947	241	173	65,725	3.67	3.67
Gatterer et al. [19] (2012)	20	6	5	1818	3.3	2.75	20	8	7	1860	4.3	4.3
van Beijsterveldt et al. [13] (2012)	223	207	206	21,562	9.6	9.55	233	220	202	22,680	9.7	9.7
Grooms et al. [20] (2013)	41	4	4	2703	1.48	1.48	30	13	13	1605	8.1	8.1
Steffen et al. [15] (2013)	78	14	10	2700	5.19	3.70	80	16	15	2493	6.42	6.42
Hammes et al. [17] (2014)	146	51	43	4172	1.22	1.03	119	37	30	2937	1.25	1.02
Owoeye et al. [16] (2014)	195	36	26	51,017	0.7	0.50	190	94	76	61,045	1.5	1.5
Pooled data	2932	798	661	211,769	3.89	3.31	2549	955	751	216,864	5.35	5.16

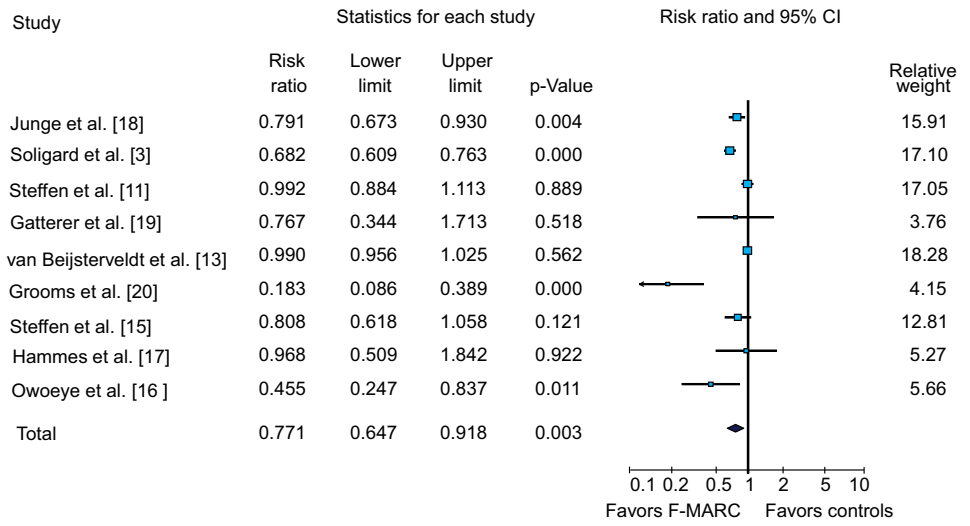

Fig. 2 Forest plot illustrating the effect of F-MARC injury prevention programs versus controls on overall injury rate ratio. *F-MARC* Fédération Internationale de Football Association Medical and Research Centre

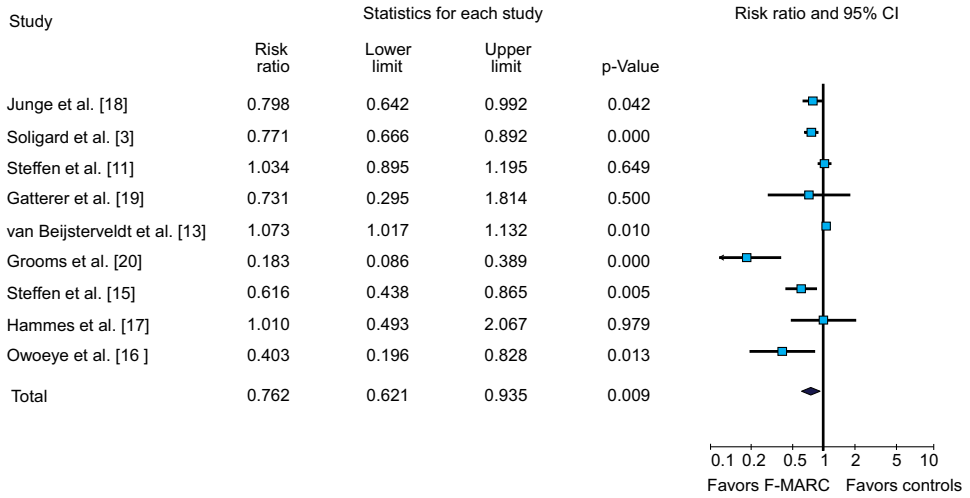

Fig. 3 Forest plot illustrating the effect of F-MARC injury prevention programs versus controls on lower extremity injury rate ratio. *F-MARC* Fédération Internationale de Football Association Medical and Research Centre

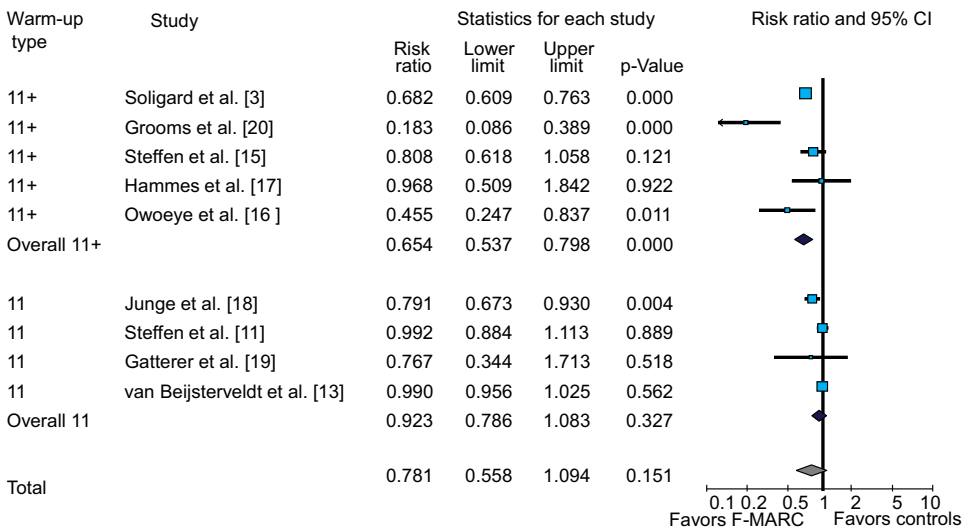

Fig. 4 Forest plot illustrating the effect of F-MARC '11+' and '11' injury prevention programs versus controls on overall injury rate ratio. *F-MARC* Fédération Internationale de Football Association Medical and Research Centre

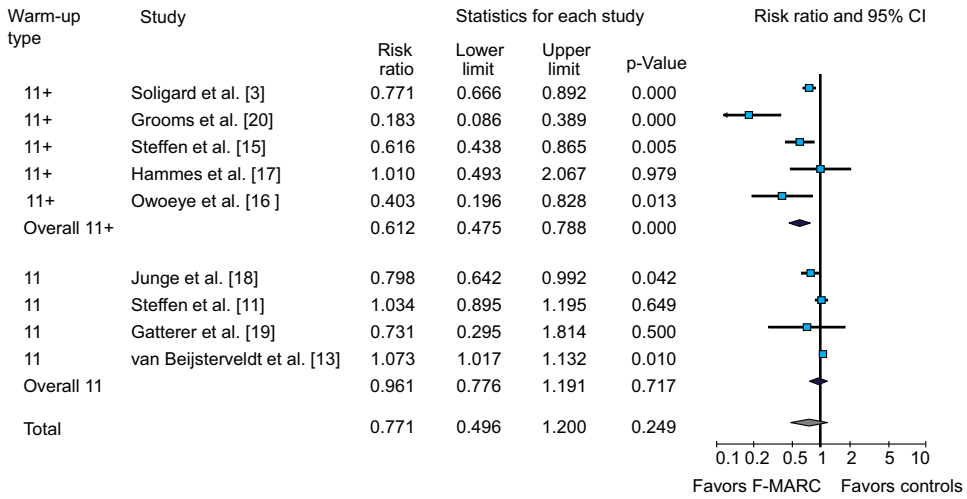

Fig. 5 Forest plot illustrating the effect of F-MARC '11+' and '11' injury prevention programs versus controls on lower extremity injury rate ratio. *F-MARC* Fédération Internationale de Football Association Medical and Research Centre

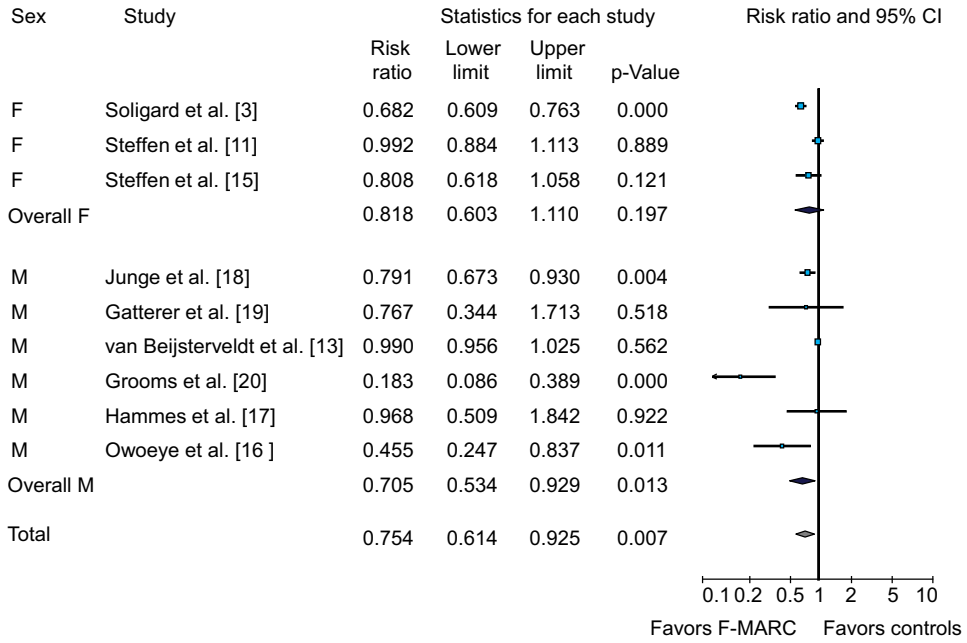

Fig. 6 Forest plot illustrating the effect of F-MARC injury prevention programs versus controls on overall injury rate ratio in males and females. *F* female, *F-MARC* Fédération Internationale de Football Association Medical and Research Centre, *M* male

4 Discussion

Up to the present time, no meta-analysis was available that specifically evaluated the effects of F-MARC injury prevention programs in soccer. This is the first meta-analysis relating to the efficacy of the FIFA programs in preventing injuries and provides an in-depth analysis of key moderators affecting the F-MARC IPPs in sports.

This meta-analysis supported a fresh evaluation of the effect of IPPs on the rates of injuries among soccer players. Many of the studies gave an understanding of the effectiveness of IPPs but did not consider an athlete's exposure hours [26–35]. By considering them, the injury rate gives a better understanding of the IPP.

4.1 Principal Findings

In this systematic review and meta-analysis, we included six cluster-randomized controlled trials [3, 11, 13, 15–17], one prospective controlled intervention study [18], and two cohort studies [19, 20] investigating the effects of F-MARC IPPs on soccer. According to the available data, F-MARC IPPs appear to be effective in reducing the risk of overall and lower extremity injuries for soccer players.

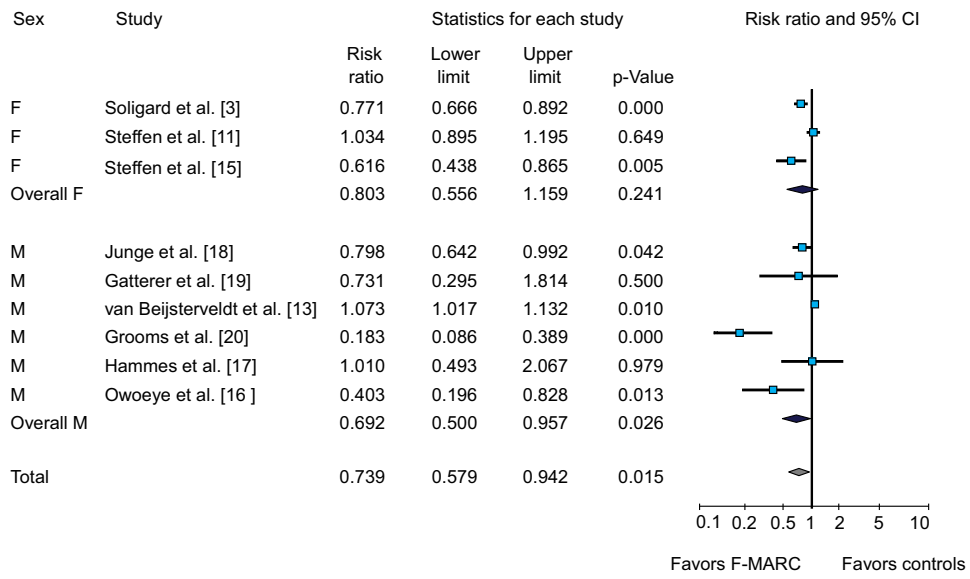

Fig. 7 Forest plot illustrating the effect of F-MARC injury prevention programs versus controls on lower extremity injury rate ratio in males and females. *F* female, *F-MARC* Fédération Internationale de Football Association Medical and Research Centre, *M* male

4.2 Subgroup Analysis

4.2.1 F-MARC (the '11+' Versus the '11')

The '11+' and the '11' have the same target for injury prevention. Therefore, these two programs were analyzed with respect to their effects on injury reduction. The reduction in injuries in the '11+' program reached statistical significance for overall and lower extremity injuries. The reduction in injuries of the '11' did not reach statistical significance. A likely explanation for the differing results between '11' and '11+' is that additional exercises, increased intensity, and progression in the number of repetitions of some exercises in the '11+' improved the preventive effect. A key point in the '11+' was using proper technique during all of the exercises with correct posture and neuromuscular control.

4.2.2 Male Versus Female

F-MARC IPPs provide highly effective results in male soccer in overall and lower extremity injury reduction. As we compared studies including male participants [13, 16–20] and studies included female participants [3, 11, 15], the reduction in injury rate was greater among the males with a significant reduction in injury risk for overall and lower extremity injury, while the females overall and lower extremity injury reduction did not reach significance. This, however, might have been expected because data for the females' studies were under-represented and most of the studies involved male participants. Only three studies investigated female subjects compared with six male studies. Even though the 18–20 % reduction in injuries that was detected in females may be important, it is possible that the three studies that met our criteria did not provide sufficient power to detect a statistical effect.

4.3 F-MARC Number of Sessions and Compliance

We did not conduct a separate analysis based on compliance or number of sessions per week due to lack of information. However, we should point out that the '11+' showed potential benefits with a higher number of training sessions per week. Grooms et al. [20] indicated that performing the '11+' five to six times per week can reduce lower extremity injuries by 82 % while Hammes et al. [17] did not show these benefits due to the low number of sessions per week. The '11' failed secondary to the content and decreased compliance. Better marketing of the '11+' for coaches and players was used to address the issue of compliance. That was obvious in two studies conducted by Steffen et al., where compliance with the '11' was 52 % [11] versus 85 % [15] for the '11+'.

High attention should be given to issues of compliance and education of coaches, which appear to be essential elements that made the '11+' successful. A low number of sessions per week and a lack of compliance were significant limiting factors.

4.4 Directions for Future Research

In the long term, teams involved in the F-MARC IPPs would be expected to have a competitive advantage.

The '11+' was designed to be a warm-up before soccer training sessions. The rationale for using these IPPs for dynamic warm-up was to increase compliance and perform

neuromuscular activities in an unfatigued state; ensuring proper technique and favoring optimal motor planning from a cortical control and motor cortex perspective. However, it is possible that performing neuromuscular exercises in a state of fatigue may help improve and maintain muscle strength [36]. Research is required to explore whether similar benefits of a program administered after training could be obtained among soccer players.

4.5 Strengths and Limitations

Our meta-analysis included sub-groups such as sex and type of study (the '11+' vs the '11') to give a broad insight into factors that can affect the injury risk. The effectiveness and validity of the analysis was optimized by expressing injury incidence relative to the hours of exposure.

The inclusion criteria allowed only nine studies related only to soccer. However, the '11+' program may be adapted for many other sports. While it was necessary in this study to limit the analysis to studies of the effect of the '11' and '11+' programs in relation to soccer, in accordance with the stated purpose, it remains unknown whether these programs, or sport-specific adaptations of them, would be effective in reducing injuries in other sports. Thus, similar studies are required across a range of sports.

4.6 Recommendations

New high-quality randomized trials are needed to identify which components of these programs are most effective by comparing different types of interventions, rather than comparing F-MARC IPPs with usual warm-up programs. Future studies should also determine which exercise intensities, frequencies and durations lead to preventive effects.

5 Conclusions

We have conducted the first level 1 meta-analysis of F-MARC injury prevention programs among soccer players. These results suggest that teams involved in F-MARC IPPs, particularly the '11+', could reduce injury rates by up to 50 % in the long term compared with teams that do not engage in F-MARC IPPs.

The results of these meta-analyses indicate that the F-MARC injury prevention programs can be successful in reducing soccer injuries. Moreover, results suggest that these programs may have a strong effect on the reduction of lower extremity injury for both males and females.

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Compliance with Ethical Standards

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Conflict of interest Wesam Saleh A. Al Attar, Najeebullah Soomro, Peter Sinclair, Evangelos Pappas and Ross Sanders declare they have no conflicts of interest with the content of this review.

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