

REVIEW ARTICLE

FIFA 11+ Prevention Programme in Preventing Anterior Cruciate Ligament Injury among Soccer Players: A Scoping Review

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ABSTRACT

Soccer players are highly exposed to injuries due to the nature of the sport. Knowing the preventive measures of injury in soccer players is therefore crucial. FIFA 11+ improves the neuromuscular properties of the stabilising muscles of the joints. Numerous studies have generally investigated the effects of FIFA 11+, however, evidence for ACL injury prevention is still limited. Therefore, this review aims to investigate the effects of FIFA 11+ as the ACL injury prevention programme among soccer players. Online databases (ScienceDirect, Springer, Scopus, Web of Science, PubMed, and Google Scholar) were used in the search for relevant publications. The quality of the literature was assessed using the Critical Assessment Score System of the Physiotherapy Evidence Database (PEDro) for randomised controlled trial papers. Twelve articles showed a consistent and positive effect of FIFA 11+ on reducing injuries among soccer players. Four studies showed its significant effect on knee strength and balance, two studies discussed on biomechanical performance, while six studies provided information on FIFA 11+ with exposure to ACL injuries after long-term training. Implementing the FIFA 11+ programme in the intervention group positively reduced exposure to ACL injury, with improved strength, balance, and biomechanical performance.

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Keywords: Anterior Cruciate Ligament, FIFA 11+, Injury, Prevention, Risk, Soccer

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INTRODUCTION

Soccer, often known as football, is one of the world's most popular sports, with more than 400 million men and women participating in 208 countries (1). More than 270 million soccer players are registered worldwide, according to the International Federation of Association Football (FIFA). Furthermore, according to the Brazilian Football Confederation, Brazil, the country with the top ranking in football worldwide, has 2.1 million federation athletes and 11.2 million amateur athletes, excluding those playing recreationally(1). In the United

States (USA), nearly 13 million Americans play soccer at all levels of the population, and approximately 435,000 high school and college players compete in National Collegiate Athletic Association soccer in the United States (2). Yet, soccer is a contact sport that requires physical strength and intense play (3). Soccer, like most other sports, has a high risk of injury for both professional and amateur players (4).

To meet the demands of this high-performance sport, successful soccer players must have endurance, agility, strength, speed, and a strong foot swing. According to Mohr et al., the aerobic metabolism of soccer players contributes to more than 90% of their game performance, with an average level of energy expenditure hanging around the anaerobic lactate threshold (5). During a match, the defender players travel approximately

10-12 kilometres, with the midfield player travelling approximately 10 kilometres and the goalkeeper traveling approximately 4 kilometres (6). Hence, the activation of significant amounts of energy systems, namely aerobic and anaerobic, is necessary throughout a 90-minute game to fulfil the muscles' energy needs during the game.

Owing to the rough nature of soccer activities, many injuries, such as anterior cruciate ligament (ACL) injury, have been reported. The ACL is a crucial component in knee stabilisation. ACL injuries in soccer matches are more likely to occur during noncontact movements such as fast acceleration and deceleration (e.g., running), rapid changes in direction (e.g., side cutting), jumping, and landing (7,8). ACL rupture causes incapacity to play sports, reconstruction surgery, and extensive recovery (9). Whether or not an ACL repair is performed, practically all ACL tears increase the risk of osteoarthritis and disability (10), which is further enhanced by concomitant meniscal damage (9).

ACL injury negatively affects the physical and psychological health of soccer players. Concerned with this issue, the FIFA Medical Assessment and Research Centre, the Oslo Sports Trauma Research Centre, and the Santa Monica Orthopaedic and Sports Medicine Centre established the FIFA 11+ injury prevention programme in 2006 (1). According to Lypez-Valenciano et al., FIFA 11+ aims to prevent two most prevalent types of soccer-specific injury, namely, injuries to surrounding ligaments of the knee and ankle. FIFA 11+ also aims to strengthen and improve the neuromuscular properties of the stabilising muscles of the joints (11). FIFA 11+ consists of 15 structured routines included in the programme, and it is suggested to substitute the normal warm-up routine pre-training, instead of being performed post-training or post-match to prevent the occurrence of fatigue (1). FIFA 11+ begin with an initial warm-up, followed by a specific dynamic routine for strengthening of lower extremities, soft landings which are emphasised by plyometrics routines, agility drills, and lower muscle stretching. The overall programme takes approximately 30 minutes to complete (11).

Compared with the normal warm-up practised by athletes, FIFA 11+ was mainly intended to be used as a warm-up instead of performed after the training or match to avoid the effects of fatigue and risk of injury among athletes (12). Numerous studies worldwide have investigated the effectiveness of FIFA 11+ as an injury prevention programme versus the normal warm-up routine (2,13–17). However, most previous reviews focused on the effects of the injury prevention programme in general, instead of a specific injury that is highly prevalent, such as ACL injury. Therefore, this study aims to investigate the effects of FIFA 11+ as the ACL injury prevention programme among soccer players.

MATERIALS AND METHODS

The scoping study pursued Arksey and O'Malley's five-step approach system, comprising the following steps: (i) identifying the research questions; (ii) identifying relevant studies; (iii) study selection; (iv) charting the data; and (v) collating, summarising, and reporting the results (18). The Preferred Reporting Items for Systematic Reviews and Meta-analysis for Scoping Reviews (PRISMA-ScR) was used to construct our protocol (19). The final protocol was published with the Open Science Framework on 16 June 2021 (<https://osf.io/2g3ha>).

Search strategy

The search was done on the ScienceDirect, Springer, Scopus, Web of Science, PubMed, and Google Scholar online databases. The reviewers examined the titles, abstracts, and keywords individually. The PICOS framework is used in determining the key concepts used in the article search. The participants were soccer player, the intervention was the FIFA 11+ injury prevention programme, the results were muscle strength, balance, performance, and injury rate, and the study was randomized control trials (RCT). The following are some of the key concepts used in the article search: FIFA 11+, prevention, anterior cruciate ligament, risk factor and soccer player. The Boolean terms "AND" and "OR" were used to segregate search terms. In summary, the following keywords were combined with Boolean terms, MeSH and synonyms (incidence, injury prevention, risk of injury, sports injury, and football player) to broaden the search. The connected descriptive key search keywords that were created to guide the search are listed below:

(FIFA 11+) AND (prevention OR injury prevention) AND (anterior cruciate ligament) AND (risk factor OR risk of injury OR sports injury) AND (soccer player OR football player)

Study selection

The studies are evaluated based on the FIFA 11+ injury prevention programme. The reviewers searched for all English-language academic journals between 2011 and 2021, and experimental study design papers were chosen while systematic reviews and review papers were excluded from this study.

Each reviewer pre-screened publications from two search databases: Azhar, I. (reviewer 1) pre-screened article from Scopus and WoS, Othaman, N. (reviewer 2) pre-screened articles from ScienceDirect and Springer, and Zainuddin, Z. (reviewer 3) pre-screened articles from PubMed and Google Scholar. Three reviewers evaluated each article's title, abstract and full text. The reviewers extracted data from the included trials using a pre-tested electronic data collection tool. After the three reviewers discussed it, the fourth reviewer with clinical or research methodology experience was invited to help resolve any disagreements or conduct further

adjudication. The reviewers agreed on study selection and data extraction after consulting another reviewer. The main trial publication, as well as any referenced protocols and supplementary materials, were used. Analysis of the quality of each article was done using the Critical Evaluation Rating Scheme of (PEDro). The article selection process followed the PRISMA statement that illustrates the article selection process (Figure 1).

Quality Assessment of the Studies

The reviewers analysed each paper's methodological quality of each article using the Critical Appraisal Ratings Scheme of the Physiotherapy Evidence Database (PEDro).

Data Extraction

The author(s), publication year, study design, study objective, and prevention strategies for soccer players were extracted from potentially recovered articles. The study settings, populations, and designs for each objective were summarised, as were the outcome measures, results, and findings. Three reviewers created a data-charting form to select variables, tabulated the details independently, deliberated about the findings, and iterated the form. An outline of each of these pieces of information is provided in detail in Table I.

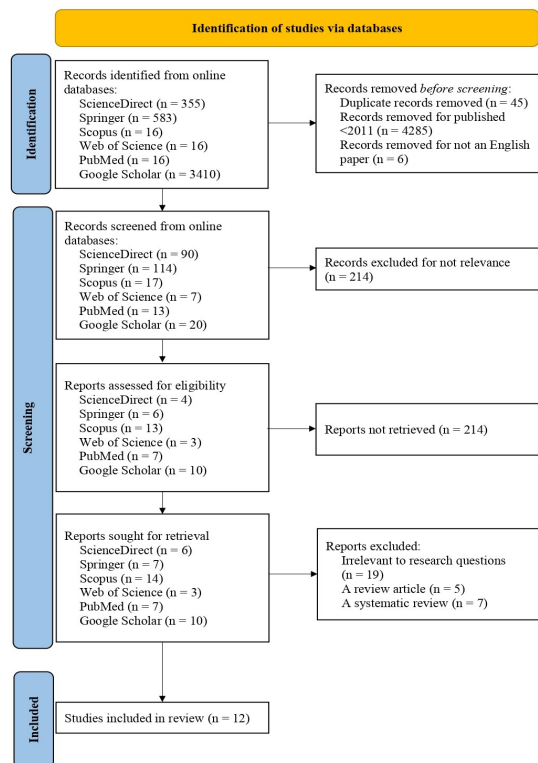


Figure 1: PRISMA Flow Chart for Identification of Studies via Databases

RESULT

Eligible articles

From 4,396 potentially relevant articles, 261 remained after removal of three criteria: duplicates, papers published in 2011 and earlier, and papers not in English (Fig. 1). After a thorough review of the titles, abstracts, and / or bodies of the articles, 249 were excluded due to eligibility criteria, leaving 12 articles eligible for data extraction (Table I).

Study characteristics

All 12 studies are randomized controlled trials that evaluated the effects of the FIFA 11+ injury prevention programme. The total sample size of the included studies consisted of 4,614 players, of which 2,113 (45.79%) belonged to the intervention group, 2,476 (53.66%) belonged to the control group, and 25 (0.54%) belonged to the other injury prevention programme group. The mean age of the subjects ranges from 12 to 24 years. Furthermore, ten studies have composed only male athletes (2,13–16,20–24) and two studies composed only female athletes (17,25). Four studies recruited professional soccer players (13,21,24,25), two studies recruited elite soccer players (14,20), two reported on amateur soccer players (15,22), and the remaining four studies do not report on level of athletes (2,16,17,23). The study setting analysis of 12 studies performed in varies countries, with 4 in Asia (21–23,25), 2 in Africa (13,14), 3 in North America (2,16,17), 1 in South America (24), 1 in Europe (20) and 1 in Australia (15).

Publication themes

Through the thematic analysis, the theme was observed from the scoping review results to identify the consistency on the effect of the FIFA 11+ warm-up prevention programme among soccer players and shows positive effect on strength, balance and performance.

Physiotherapy Evidence Database (PEDro) Critical Appraisal

Twelve articles on FIFA 11+ injury prevention programmes among soccer players were analysed for their quality using the 11-item PEDro appraisal tool with higher scores indicating better methodology quality. The study critical appraisal score is recorded in Table II. Overall, the cumulative score of the included studies ranges from the lowest score of 5/11 to the highest score of 9/11. Five studies score as fair, six studies score as good, and one study score as excellent in the PEDro appraisal tool.

Table II: PEDro score for critical appraisal

Reviewed Studies	PEDro scale											Total Scores
	1	2	3	4	5	6	7	8	9	10	11	
Granelli et al., 2017	X	X		X				X		X	X	6
Hwang & Kim, 2019	X	X		X				X		X		5
Nuhu et al., 2021	X	X		X	X		X	X		X	X	8
Arsenis et al., 2020		X	X	X	X	X	X	X		X	X	9
Granelli et al., 2015	X	X		X				X		X		5
Owoeye et al., 2014		X	X	X				X		X	X	6
Whittaker & Emery, 2015		X	X	X	X		X	X		X	X	8
Silva et al., 2015	X	X		X				X		X	X	6
Kerman et al., 2018	X	X		X				X		X		5
Al Attar et al., 2017	X	X	X	X				X		X	X	7
Dunsky et al., 2017	X			X				X		X	X	5
Daneshjoo et al., 2013	X	X		X						X	X	5

PEDro: Physiotherapy Evidence Database; X: yes score; blank: no score; 1: eligibility criteria; 2: random allocation; 3: concealed allocation; 4: baseline comparability; 5: blind subject; 6: blind clinician; 7: blind assessor; 8: adequate follow-up; 9: intention-to-treat analysis; 10: between-group analysis; 11: point estimates and variability

Individual Study Results

In this review, 12 studies reported the main interventions that had the effect of strength, balance, and biomechanical performance after FIFA 11+ as the ACL injury prevention programme among soccer players (n = 12). Twelve articles showed FIFA 11+ provided a consistent and positive effect on soccer players, significantly reducing injuries. FIFA 11+ showed a significant effect on knee strengthening and balance after performing within a short duration of six to eight weeks of the intervention programme compared to a normal warm-up programme

(20–22,25). Next, two studies found that the FIFA 11+ warm-up prevention programme affected the development of biomechanical performance associated with reducing the risk of injuries among soccer players (23,24). Six articles provided information on FIFA 11+ associated with the exposure to ACL injuries after a long-term duration of training (2,13–17). Table I describes the evidence of the included studies related to the effect of FIFA 11+ as an injury prevention programme among soccer players.

Table I: Evidence on The Effectiveness of FIFA 11+ Injury Prevention Programs among Soccer Players

Author(s)	Year	Study Design	Study Population	Study Setting	Intervention	Outcome Measure	Result
Granelli et al.	2017	Prospective cluster RCT	Age mean: 20 years IG Division I: 16 teams (400 players) Division II: 11 teams (275 players) CG Division I: 17 teams (425 players) Division II: 17 teams (425 players)	University of Delaware, Newark, DE, USA	FIFA 11+ / IG (5 months) F: 3 times/week I: - T: 5-45 minutes T: - Part 1: 8 minutes jogging - Part 2: Strength training, balance, jumping - Part 3: Speed running combined by bounding, planting-cutting	Secure internet-based system Athletic exposures Specific injuries ACL injuries Time loss resulting from injury	A lower proportion of athletes in the IG experienced knee injuries (25% [34 of 136]) compared with the CG (75% [102 of 136]; RR, 0.42; 95% CI, 0.29-0.61; p < 0.001).

CONTINUE

Table I: Evidence on The Effectiveness of FIFA 11+ Injury Prevention Programs among Soccer Players (cont.)

Author(s)	Year	Study Design	Study Population	Study Setting	Intervention	Outcome Measure	Result
Hwang & Kim	2019	RCT	Age mean: 20 years IG Ten healthy male soccer players CG Ten healthy male soccer players	University in North Gyeongsang Province	FIFA 11+ / IG (12 weeks) F: 5 times/week I: - T: 20-25 minutes T: - Part 1: Running, - Part 2: Strength, plyometrics, balance - Part 3: Running CG (12 weeks) Normal warm-up	Performance test 10m and 30m sprint test Coordination test Arrowhead agility test Yo-Yo intermittent recovery test level 1 (Yo-Yo IR test level 1) Functional movement Deep squat Hurdle step In-line lunge Shoulder mobility Straight-leg raise Trunk stability push-up Rotary stability	Significant Improvement: 30m sprint (p=0.027) Coordination test (p=0.021) Arrowhead agility test (Rt: p=0.009; Lt: p=0.004) Deep squat (p=0.035) Hurdle step (p=.0005) Rotary stability (p=.0005) Total FMS scores (p=0.001)
Nuhu et al.	2021	Cluster RCT	Age mean: 20 years IG 309 players CG 317 players	University of Cape Town, Groote Schuur Hospital, Cape Town, South Africa	FIFA 11+ / IG (7 months) F: 3 times/week I:- T: 20-25 minutes T: - Part 1: Running - Part 2: Strength, plyometrics, balance - Part 3: Running CG (7 months) Normal warm-up	Primary The overall incidence of training and match injuries Secondary Injuries, training and match exposure as well as severity categories were recorded per the F-MARC guidelines	A lower proportion of players sustained injuries in the IG (52%) compared to the CG (63%) (Odd ratio: 0.7; 95% CI: 0.5–0.9). A significantly lower rate ratio was observed in the IG for overall (RR = 0.6; 95% CI: 0.5–0.8) and match (RR = 0.6; 95% CI: 0.5–0.8) injuries. Compliance to the injury prevention programme was 77%.
Arsenis et al.	2020	RCT	Age mean: 19 years IG Sixteen young male soccer players CG Sixteen young male soccer players	Democritus University of Thrace, Komotini, Greece	FIFA11+ Training / IG (8 weeks) F: 3 times/week I: - T: 20-25 minutes T: - Part 2: Strength, plyometrics, balance CG (8 weeks) Traditional warm-up (20-25 minutes)	Strength Isokinetic dynamometer Balance Biodex stability system	Significant improvement: Stability index (total and anterior – posterior) (p < 0.05). Concentric and eccentric flexors strength (p < 0.05). Conventional H/Q ratio (p < 0.05).

CONTINUE

Table 1: Evidence on The Effectiveness of FIFA 11+ Injury Prevention Programs among Soccer Players (cont.)

Author(s)	Year	Study Design	Study Population	Study Setting	Intervention	Outcome Measure	Result
Graneli et al.	2015	Prospective cluster RCT	Age mean: 20 years	University of Delaware, Newark, DE, USA	FIFA 11+ Training/ IG (5 months) F: 3 times/week I:- T: 5-45 minutes T:	Secure internet-based system AEs Athlete compliance Athlete rate of injuries and time-loss due to injury	CG: 665 injuries (mean ± SD, 19.56 ± 11.01) with an IR 15.04 injury/1000 Aes. IG: 285 injuries (mean ± SD, 10.56 ± 3.64) with an IR 8.09 injury/1000 Aes.
			IG 31 teams (675 male soccer players)		- Part 1: 8 minutes jogging - Part 2: Strength training, balance, jumping	Time-loss: Significantly higher for the CG (mean ± SD, 13.20 ± 26.6 days) than for the IG (mean ± SD, 10.08 ± 14.68 days) (P = .007)	
Owoeye et al.	2014	Cluster RCT	Age mean: 17 years	University of Lagos, Nigeria	FIFA 11 + Training / IG (6 months) F: 2 times/week I: - T: 20-25 minutes T:	Primary Any time-loss injury to the players, injuries by type of exposure (match/training) and all injuries to the Les.	Primary: Significantly reduced the overall rate of injury in the IG by 41% [RR = 0.59 (95% CI: 0.40 – 0.86; p = 0.006)] and all lower extremity injuries by 48% [RR = 0.52 (95% CI: 0.34 – 0.82; p = 0.004)].
			IG 10 teams (212 young male soccer players)		- Part 1: Running - Part 2: Strength, plyometrics, balance	Secondary Body location Injuries by onset (acute or overuse) Injuries by aetiology Mechanism Severity	Secondary: No significant.
Whittaker & Emery	2014	Larger cluster RCT trial	Age mean: 15 years	University Sport Medicine Centre, Calgary, Alberta, Canada	Normal warm-up F: 3 times/week; 4 months I: Level of difficulty increase by Coach supervision T: 20-25 minutes T: FIFA 11+ training	Pre- and post-season sonographic measures Abdominal (rectus abdominis, external oblique, internal oblique, transversus abdominis, and IRD)	Both low (mean = 149 ± 9 exercises/year) and high (mean = 314 ± 15 exercises/year) 11+ EG demonstrated significant post-season decreases in IRD at rest (p < 0.001) and during a leg lift (p < 0.001).
			Low 11+ EG Ten healthy female soccer players		- Part 1: Running - Part 2: Strength, plyometrics, balance	Lumbar (L5 multifidus) Hip (gluteus medius and gluteus minimus)	No other between or within group differences existed.
			High 11+ EG Thirteen healthy female soccer players		- Part 3: Running	Knee (vastus medialis)	

CONTINUE

Table I: Evidence on The Effectiveness of FIFA 11+ Injury Prevention Programs among Soccer Players (cont.)

Author(s)	Year	Study Design	Study Population	Study Setting	Intervention	Outcome Measure	Result
Silva et al.	2015	RCT	Age mean: 18 years IG Nine young male soccer players CG Eight young male soccer players	University federal de santa Catarina, Brazil	FIFA 11+ Training / IG (9 weeks) F: 3 times/week I: Level of difficulty increase every 3 weeks T: 20-25 minutes T: - Part 1: Running - Part 2: Strength, plyometrics, balance - Part 3: Running CG (9 weeks) Normal warm-up (20 minutes)	Maximum jump height (pre and post) CMJ SJ	Significant improvement: IG in both both types of jumps (CMJ: p<0.01; SJ: p<0.01)
Kerman et al.	2018	RCT	Age mean: 24 years IG Fifteen female soccer super league players CG Fifteen female soccer super league players	Ferdowsi University of Mashhad, Iran	FIFA 11+ Training / IG (8 weeks) F: 2 times/week I:- T: 20-25 minutes T: - Part 1: 8 minutes jogging - Part 2: Strength training, balance, jumping - Part 3: Speed running combined by bounding, planting-cutting CG (8 weeks) Normal warm up	Knee muscle strength Dynamic balance	IG shows significant increase flexion and extension strength and dynamic balance in the posterior and postero-lateral directions (p>0.05).
Al Attar et al.	2017	Cluster-RCT with concealed allocation	Age mean: 18 years IG 10 teams (160 male amateur soccer players) CG 11 teams (184 male amateur soccer players)	The University of Sydney, Australia	IG (6 months) - Pre-training FIFA 11+ exercises for 20 minutes - Post-training FIFA 11+ exercises for 10 minutes CG (6 months) - Pre-training FIFA 11+ exercises for 20 minutes	Primary Incidence of overall injury Incidence of initial and recurrent injury Injury severity Secondary Compliance to the FIFA 11+ program	The pre and post FIFA 11+ program reduced the total number of injuries ($\chi^2(1) = 11.549, p = 0.001$) and the incidence of initial injury ($\chi^2(2) = 8.987, p = 0.003$) significantly more than the pre-FIFA 11+ program alone.

CONTINUE

Table 1: Evidence on The Effectiveness of FIFA 11+ Injury Prevention Programs among Soccer Players (cont.)

Author(s)	Year	Study Design	Study Population	Study Setting	Intervention	Outcome Measure	Result
Dunsky et al.	2017	RCT	Age mean: 12 years IG 10 young soccer players CG 10 young soccer players	Wingate Institute, Netanya, Israel	FIFA 11+ Training / IG (6 weeks) F: 2 times/week I: - T: 20-25 minutes T:- - Part 1: 8 minutes jogging - Part 2: Strength training, balance, jumping - Part 3: Speed running combined by bounding, planting-cutting CG (6 weeks) Normal warm up	Pre and post-measurement Kicking accuracy Static balance Dynamic balance	Static balance: Improved significantly among the IG with significant interaction with the CG and with high effect size. Dynamic balance: The left leg of the IG with the medium effect size for interaction between groups.
Dane-shjoo et al.	2013	RCT	Age mean: 18 years FIFA 11+ Group Twelve male professional soccer players HarmoKnee Group Twelve male professional soccer players CG Twelve male professional soccer players	University of Malaya, Kuala Lumpur, Malaysia	FIFA11+ Group (8 weeks) F: 3 times week I: Level of difficulty increase by Coach supervision T: 20-25 minutes T: - Part 1: Running - Part 2: Strength, plyometrics, balance - Part 3: Running HarmoKnee Group (8 weeks) F: 3 times/week I: - T: 20-25 minutes. T: Warm-up, muscle activation, balance, strength, and core stability CG (8 weeks) Normal warm-up (20 minutes)	Isokinetic test Biodex isokinetic dynamometer (hamstring and quadriceps)	Significant improvement in concentric quadriceps PT in the FIFA 11+ group: dominant leg (p<0.05). The concentric hamstrings strength was significantly different between the FIFA 11+ group in the dominant (p=0.01) and non-dominant legs (p=0.02). The HarmoKnee programme enhanced the concentric strength of quadriceps.

Abbreviations: IG: intervention group; CG: control group; FIFA: Fédération Internationale de Football Association; FITT: frequency, intensity, time, type; ACL: anterior cruciate ligament; RR: relative risk; CI: confident interval; Rt: right; Lt: left; FMS: functional movement screen; F-MARC: FIFA Medical and Research Centre; H/Q: hamstring/quadriceps; AEs: athlete-exposures; SD: standard deviation; IR: incidence rate; LEs: lower extremities; CMJ: countermovement jump; SJ: squat jump; PT: peak torque; EG: exposure group; IRD: inter recti distance

DISCUSSION

This scoping review was carried out to investigate the efficacy of the FIFA 11+ programme as an ACL injury prevention programme among soccer players. FIFA 11+ is a complete dynamic warm-up program that includes physical exercises that involve agility, plyometrics, proprioception, and strength and is designed to prevent or reduce injuries in soccer players (26). The implementation of the FIFA 11+ programme in the intervention group positively reduced exposure to ACL injury (2,13–17), with improved strength (25,27), balance (25,27,28), and biomechanical performance (23,24).

Exposure to ACL injury

Several studies showed the long-term duration (four to seven months) effect of FIFA + on the overall reduction of injuries, specifically decreasing the rate of ACL injuries among soccer players (2,13–17). A recent study by Nuhu et al. highlighted the compliance of 309 players in the intervention group by 77% and found a significant decrease in injuries (moderate and severe) 55% and 71%, respectively (13). Al Attar et al. showed a significant effect of compliance two to three times a week for six months (one season); FIFA+ was able to decrease overall injuries and improve neuromuscular control, balance, and thigh muscle strength among amateur soccer players (15). The implementation of FIFA 11+ consisted of multicomponent exercises that resulted in a decrease in the number of injured players during soccer matches (25).

Silvers-Granelli et al. found a significant effect of reducing overall ACL injury and noncontact ACL injury among male soccer players; they also observed significantly higher incidence of ACL injury from grass compared to turf (16). A previous study emphasised the role of the field surface in the incidence of ACL injury due to its friction coefficient from the surface of the shoe and the maximum torques measured between the shoe and the surface of the play (14). Further clinical research is needed to understand better how these variables may influence the rate of ACL injury.

Strength

Hamstring and quadriceps (H:Q) ratios were acknowledged to determine the effects of fatigue on muscle balance and knee joint stability (29–31). These strength ratios are often measured to assess the strength balance between reciprocal muscle groups because they may identify injuries at a specific joint. The ratios of the maximum torque are derived from the greatest torques produced within the range of motion, which significantly show different angles depending on the contraction modes (32).

Arsenis et al. and Daneshjoo et al. investigated the knee joint muscle strengthening in concentric flexors/

extensors and eccentric flexors at two different angular velocities, 60°/s and 180°/s, by using an isokinetic dynamometer (15,33). Both studies showed an increase in concentric eccentric flexor strength and conventional ratio (HQCONV) after eight weeks of the FIFA 11+ prevention programme, specifically in the dominant leg. The findings indicated an improvement in the flexibility of the hamstring and its ability to absorb more energy during deceleration running, thus reducing the risk of ACL injuries (34). The ratio HQCONV with values ranging from 0.50 to 0.65 is necessary to prevent injuries to the flexor muscles. The ideal functional hamstring and quadriceps ratio (HQFUNC), which is 1:1, can limit anterior displacement of the tibia in injured knees (20,35). However, none of the articles mentioned HQFUNC.

Balance

The FIFA 11+ injury prevention programme was created as a concise and comprehensive warm-up programme to address soccer-related lower extremity injuries. Kerman et al. found a significant improvement in dynamic balance for the posterior and posterolateral direction among female soccer players after they completed eight weeks of FIFA 11+ (25). A similar intervention programme was applied in Arsenis et al.; the intervention group found a statistically significant improvement in the total stability index (SI) and the anterior-posterior stability index (AP-SI) for dominant and nondominant legs (20). Several factors, including dynamic balance, proprioceptive receptors, the preparation of motor neurons in a group of muscles and muscle tone, can be considered plausible explanations for the vast effect of the FIFA 11+ injury prevention programme on balance (36). The programme includes eccentric and concentric contraction training and coordination of these exercises; such activities could also be used to demonstrate an improvement in balance (13).

Accordingly, soccer players who had implemented FIFA 11+ had an immediate effect on functional performance, physiological effects, and static and dynamic balance (37). Dunskey et al. supported the previous finding that a substantial improvement in dynamic balance was measured using the Y balance test, particularly for the left leg in the FIFA 11+ group among youth soccer players (28). The second part of the FIFA 11+ exercise programme concentrated on the core and hip musculature, including the surrounding and functional muscle strength in the joint contracting muscles. This FIFA 11+ injury prevention programme helps to stabilise the lower limb joints, and deep receptor activity facilitates neuromuscular control (38).

A meta-analysis by Sugimoto et al. demonstrated that neuromuscular training had a better prophylactic effect in reducing ACL injuries when combined with plyometric exercise, balance, and strengthening interventions (39). Thus, combination of exercises may

be beneficial synergistic and help protect the knee joint during dynamic movements; the FIFA 11+ prevention programme was found to be a valuable exercise intervention to reduce the risk of ACL injury (39).

Biomechanical Performance

The effects towards the end of actual soccer games include reduced physical performance, decreased work rate, reduced muscle force output and decreased performance in high intensity exercise (5). Two studies found that the FIFA 11+ warm-up prevention programme affected the development of biomechanical performance and reduced the risk of injuries among soccer players (23,24). Hwang and Kim showed that various movements in soccer matches had been implemented in FIFA 11+, particularly the static bench and side bench, leading to an improvement in soccer-specific physical performance, functional performance, and functional movement after 12 weeks of participation. In FIFA 11+ part 2, the core stabilisation exercise was the target (23). These exercises are defined as dynamic trunk control of the distal kinetic chain, including the trunk and pelvic muscles (40). Poor stability of the trunk and pelvic stabiliser reduces performance and control of the center of mass and increases the risk of ACL injury in athletes (41).

A study by da Costa Silva et al. found a significant improvement in functional performance for the intervention group, which was monitored by a countermovement jump and a squat jump. FIFA 11+ warm-up training among youth soccer players showed improvements in producing high force and improved neuromuscular control (24). Plyometric training in the FIFA 11+ component is beneficial in reducing the prevalence of ACL injury among athletes, especially soccer players. After performing plyometric training, the ground reaction force and asymmetrical landing patterns were reduced, thus reducing the side-to-side asymmetry landing force (42). Increasing the knee flexion range can help reduce the ground response force, which is essential because a limited range of motion in the knee is a major risk factor for ACL injuries in female athletes (43).

Limitation

Owing to financial and capacity restrictions, this scoping review only considered papers written in English. As a result, publications in certain languages that met the eligibility requirements could have been omitted from the search method. Another restriction is that the timeline was set to the last 10 years, eliminating previous publications that met the eligibility requirements. Although current data are scarce, the scoping review strategy, instead of a systematic review, enabled commentary and debate of a wide range of diverse research using distinct approaches. Numerous studies have mentioned the effect of FIFA 11+ on lowering the rate of lower limb injuries and improving

strength, balance, and biomechanical performance, but there have been few studies that specifically mentioned the effect of FIFA 11+ on preventing ACL injuries. Future research may investigate the effect of the FIFA 11+ prevention programme among soccer players of various levels who are at high risk of ACL injuries.

The implication of the findings

This literature survey found that the dynamic FIFA 11+ prevention programme has a positive effect on ACL injuries among soccer players. This information significantly affects the development and enhancement of an injury prevention protocol that consists of multiple components (agility, balance, strength, plyometric, and specific movement) that may influence the participant who practises the programme. This information may help to reduce the rate. Knowledge of ACL injury in soccer players by improving the efficacy of current ACL injury prevention protocols and developing more effective secondary prevention strategies.

CONCLUSION

The current scoping review provides an overview of the effects of the FIFA 11+ injury prevention programme among soccer players on strength, balance and biomechanical performances. Given that most studies investigate the related area broadly, the small number of available studies that are specific to the effects of FIFA 11+ as an ACL injury prevention strategy have shown limited results. Future research should explore more about the positive effects of FIFA 11+ and exposure to ACL injury to reduce the risk of inadequate eccentric muscular strength, reduce dynamic balance, and biomechanical performances which induce fatigue.

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