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Efficacy of a new injury prevention programme (FUNBALL) in young male football (soccer) players: a cluster-randomised controlled trial

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ABSTRACT

Objectives To evaluate the efficacy of a new multicomponent, exercise-based injury prevention programme in football players 13–19 years old.

Methods Two-arm cluster-randomised controlled trial with clubs as the unit of randomisation. 55 football teams from Kosovo of the under 15, under 17 and under 19 age groups were randomly assigned to the intervention (INT; 28 teams) or the control group (CON; 27 teams) and were followed for one football season (August 2021–May 2022). The INT group performed the 'FUNBALL' programme after their usual warm-up at least twice per week, while the CON group followed their usual training routine. The primary outcome measure was the overall number of football-related injuries. Secondary outcomes were region-specific injuries of the lower limbs (hip/groin, thigh, knee, lower leg, ankle and foot) and injury severity.

Results 319 injuries occurred, 132 in the INT and 187 in the CON group. The INT group used the 'FUNBALL' programme in 72.2% of all training sessions, on average 2.2 times per week. There was a significantly lower incidence in the INT group regarding the overall number of injuries (incidence rate ratio (IRR) 0.69, 95% CI 0.55 to 0.87), the number of thigh injuries (IRR 0.62, 95% CI 0.39 to 0.98), of moderate (time loss between 7 and 28 days) (IRR 0.65, 95% CI 0.44 to 0.97) and of severe injuries (time loss >28 days) (IRR 0.51, 95% CI 0.28 to 0.91).

Conclusion The 'FUNBALL' programme reduced the incidence of football-related injuries among male adolescent football players, and its regular use for injury prevention in this population is recommended.

Trial registration number NCT05137015.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Youth football (soccer) is associated with a significant injury risk.
⇒ Various multicomponent exercise-based injury prevention programmes may reduce the risk of football-related injuries, but evidence is conflicting. Implementation of and adherence to these programmes can be challenging.

WHAT THIS STUDY ADDS

⇒ The 'FUNBALL' programme is an effective intervention used after the usual warm-up which lowers the injury incidence in male young football players.
⇒ The overall injury incidence was lowered by one-third when the 'FUNBALL' programme was applied for one season.
⇒ Preventive benefits were also found for thigh injuries, and for moderate and severe time-loss injuries.
⇒ The positive effect on injury burden led to better player availability.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Male adolescent football players should be encouraged to perform the 'FUNBALL' programme at least twice per week to induce maximal benefits.
⇒ More research is needed on the efficacy of the 'FUNBALL' programme in other age groups (senior and veteran players) as well as in female football players.
⇒ The 'FUNBALL' programme is more football specific compared with existing injury prevention programmes. Future studies should explore whether this aspect improves compliance and adherence compared with previous programmes.

INTRODUCTION

Youth football (soccer) is associated with a significant injury risk. The overall injury incidence in youth male football players has been reported between 2.4 and 12.0 injuries per 1000 football hours.[1 2] The majority of injuries concern the lower extremity,[1–4] especially the thigh region.[1 3–5] Severe injuries accounted for 21–37% of all injuries,[1 3] or 0.78 injuries per 1000 hours.[6] This aligns with injury locations and injury severity reported in adult professional football players.[6–8]

With the aim to reduce the number of football-related injuries, many exercise-based injury prevention programmes (IPPs) have been established. Some of them targeted specific injuries, for example, adductor,[9] hamstring[10 11] and knee injuries.[12–14] Others aimed to reduce the overall number of lower limb injuries.[15–18] In the above-mentioned cluster-randomised controlled trials (cluster-RCTs), the highest efficacy reported was a 77% reduction in injury rates.[14] Several meta-analyses supported the efficacy of IPPs.[19–21] A more cautious interpretation of their efficacy emerged recently when other meta-analyses included the calculation of prediction intervals.[22 23] Despite available evidence of their efficacy,[9–14 16–18 24–26] and the importance of good compliance for injury reduction,[27–29] many studies

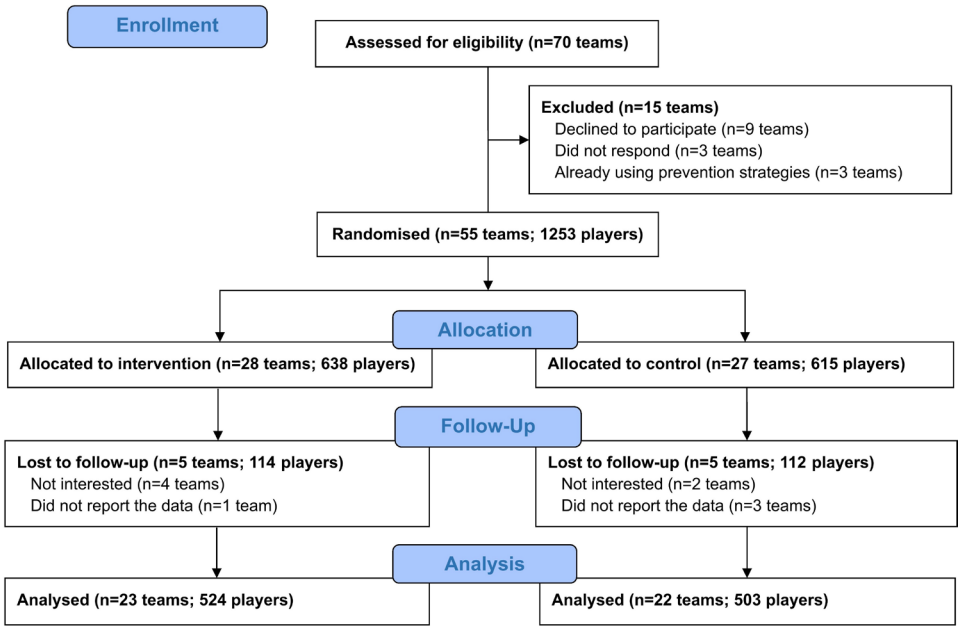

Figure 1 Consolidated Standards of Reporting Trials flow diagram of teams and players through trial.

highlighted a low programme compliance.[15 30 31] Efforts have been made to optimise strategies for increasing compliance and adherence.[32 33] Nonetheless, achieving broad-scale effectiveness of IPPs remains challenging.[34–37] The main perceived barriers to low compliance and adherence include time constraints, physical complaints (eg, fatigue and soreness) caused by exercises, lack of awareness and knowledge about the programmes' execution, and low motivation due to the absence of football-specific activities within the IPPs.[29 32]

We developed a multicomponent exercise-based IPP specifically targeting youth football players. The intention was to use as many football-specific elements as possible, based on the assumption that they increase motivation and compliance. Exercise categories were based on scientific evidence that has previously shown good efficacy in injury prevention in football. By means of a cluster-RCT, we aimed to evaluate the efficacy of the 'FUNBALL' programme to reduce injuries in male football players 13–19 years old.

METHODS

Study design and participants

The design of the study was a two-arm, cluster-RCT. It was chosen to reduce contamination bias within clubs. The study is reported according to the Consolidated Standards of Reporting Trials statement for cluster-randomised trials.[38] The study protocol was registered within ClinicalTrials.gov (NCT05137015).

At the beginning of 2020, 21 football clubs (with 70 teams in total) from different regions in Kosovo that fulfilled all inclusion criteria were invited to participate in our study, with their under 15s, under 17s and under 19s male teams (figure 1). All teams participated either in the Super League and/or Regional Leagues, organised by the Football Federation of Kosovo. To be included, teams had to: (1) be officially registered in the above-named football association, (2) train at least twice per week and (3) participate in regular matches of the above-named leagues. We excluded clubs that were already using a structured IPP. All the clubs that enrolled for the study were randomised either into the intervention or the control group. All teams from one club were randomised into the same treatment arm. Computer-generated randomisation stratified by league level (Super League or Regional League) was performed. The stratification was chosen to account for possible differences in competition level. The randomisation was performed by one researcher (RM), who was blinded to the identities of the clubs and who was not involved in the intervention.

Intervention

The intervention consisted of six **fun**damental exercise categories with the intention of preventing foot**ball**-related injuries, hence the abbreviation 'FUNBALL'. In addition, the programme contained one optional game. The following mandatory exercise categories were included: (1) balance, (2) core stability, (3) hamstring muscles eccentrics, (4) gluteal muscle activation, (5) plyometrics and (6) running/sprinting. The optional category (7) 'games' (three games included) reflected the intention to increase the attractiveness of the programme (table 1). Each mandatory category contained two different exercises to offer more variability. The coach was free to decide which of the two to choose for each training session. All exercises were organised in five or six progressive levels with increasing physical and cognitive difficulty, and were required to be performed in order (from 1 to 5/6). The exercises started on the first level and moved to the next one when exercises were executed with a proper technique as assessed by the coach. The programme took about 15–20 min to complete after familiarisation.

Based on the latest evidence regarding the challenge of long-term adherence,[34 35] and in accordance with what the implementation science has proposed in relation to IPP development,[33 35] it was decided among the coauthors who were involved in the development of the programme (RO, RM, TM and KadF) to include a football coach within the team for the development and refinement of the intervention. This with the intention to secure the end users' perspective throughout the whole process. The coach was not part of any team later included in the study, nor in the piloting or intervention period. In addition, a psychologist provided input for the neurocognitive demands of the programme. Prior to its implementation, the programme was piloted on two football teams. One exercise was replaced with

Table 1 Multicomponent exercise-based programme 'FUNBALL' used to prevent injuries in young football players

Exercises	Repetitions/duration	Number of levels
Balance		
a. Single-leg stance	2 sets×30 s (on each leg)	6
b. Y-balance	3 sets×6–8 repetitions (on each leg)	6
Core stability		
a. Plank and side plank	2 sets×20–40 s (on each position)	6
b. Straight arm plank	2 sets×8–12 repetitions	6
Hamstring muscles eccentrics		
a. Nordic hamstring	1–2 sets×3–10 repetitions	5
b. Hamstring walk-outs	2–3 sets×30 s	5
Gluteal muscle activation		
a. Head, shoulder, hip, knee, ankle	2 sets×6–10 repetitions	6
b. Squat lunges	2–3 sets×8–12 repetitions	6
Plyometric		
a. Forward jumps	4 sets×3 jumps	5
b. Skater jumps	4 repetitions (2 on each leg)	5
Running/sprinting		
a. Diagonal running/sprinting	3 repetitions	6
b. Forward running/sprinting	3 repetitions	6
Games		
a. Tic-tac-toe	3–5 games	n.a.
b. Header game	4–5 repetitions for each player	n.a.
c. Dribbling game	3 games	n.a.

n.a., not applicable.

another after the suggestions from the coaches as it was reported as too time-consuming. The pilot teams were not invited to participate in the study. To further address the compliance issue, we tried to make the programme as football specific as possible. We introduced exercises requiring competition between the players, offered two variations for each exercise category and cognitive challenges in the majority of exercises. Furthermore, the ball was included as often as possible. Previous IPPs replaced the warm-up.[15 16 18] However, coaches may take this as a restriction, which may affect the long-term compliance. Therefore, we designed the 'FUNBALL' programme to be used after the usual warm-up. In order to maintain the benefits of warm-up, most of the 'FUNBALL' exercises were of relatively high intensity, especially the last three (plyometrics, running/sprinting and games).

During the pre-season, the programme was introduced to the coaches of the intervention teams according to previous research.[15 16] Within the club facilities, the research staff (led by first author, RO) provided instructional courses. They included theoretical and practical training. Coaches received a detailed manual of the programme (online supplemental file 2) and an 'on pitch' card (online supplemental file 3). They were advised to use the programme at least twice a week. During the coaches' instructional courses, there was a focus on the key aspects of the programme, correct postures and movement patterns. Coaches were explicitly instructed to pay attention to those aspects while performing 'FUNBALL'. The correct posture was illustrated and described in detail in the manual of the programme (figure 2). The intervention started 1 week before the clubs' first official match. Research staff visited the intervention teams several times, that is, three to four visits per team in season, to monitor

Figure 2 Example of correct (left) and incorrect (right) posture alignment for one of the exercises provided in the programme (core stability; exercise a).

the quality of programme execution. If coaches needed clarification regarding the exercises, they were advised to contact the research staff, who were continuously available throughout the study period. The coaches of the control group were instructed to perform their training as usual. Prior to the start of the intervention, we gathered more detailed information regarding the training 'routine' of control teams, by interviewing 11 of the 22 coaches. The aim was to collect information whether they performed specific exercises similar to the categories used in the programme. The control group received the programme after the end of the study.

Outcome measures

The primary outcome measure was the overall number of football-related injuries that occurred during the season. Secondary outcomes were region-specific injuries of the lower limbs (hip/groin, thigh, knee, lower leg, ankle and foot) and injury severity (minimal, mild, moderate and severe injuries).

Data collection procedures and definitions

The data collection procedures and definitions used in our study were in line with the consensus statement on injury definitions and data collection procedures.[39] This entailed injury definition, injury severity, mechanism of injury, injury type and location, and definitions for training and match exposure (online supplemental table 1). We collected data during an entire competitive season from August 2021 to May 2022. During the pre-season, the research staff and research assistants collected players' baseline characteristics. The baseline questionnaire included name, age, weight, height, playing position, history of injuries and current health conditions. Throughout the competitive season, the coaches or team's physiotherapists reported to the research assistants team exposure hours, programme execution (compliance) and the new injuries that occurred on a weekly basis. If reporting was delayed for more than 1 week, an automatic message was sent to them. The original plan was to record the injuries and individual exposure hours and report them weekly to the research team via mail. However, most coaches reported that it was too time-consuming. That led to a shift in data reporting practices. The data exchange was subsequently carried out via telephone and we collected team exposure hours instead of individual ones. When new injuries were reported, two research assistants (physiotherapists) blinded to group allocation contacted the injured players (or their parents if players were underage) to obtain the detailed information regarding the injury and its diagnosis, by use of a standardised injury registration form.[18] To increase the accuracy of the data collection, thorough clarification of the protocols for injury classification and injury definitions was carried out for the research assistants before the season started. The exact diagnosis was required in case the player required medical treatment. Most of severe

injuries (92%) were diagnosed by a physician, partially by one of the coauthors, BS, not connected to any of the clubs assigned for the study and blinded to the group allocation, or other doctors not included in the study. Additionally, the research staff visited all participating teams at the end of the season to add missing or to clarify unclear information by use of individual discussions with involved players. Data on players who dropped out or changed the teams during the season were included until then.

Eight research assistants (two physiotherapists, five students of the last year of physiotherapy school, and one strength and conditioning coach) blinded to group allocation registered the players' basic information and injuries on prepared Excel datasets. We registered all injuries reported from the start of the intervention (1 week ahead of the season, 23 August 2021) until the last match of the season (22 May 2022). If players were already injured at the start of the study, they were included in the study; however, that injury was excluded.

Sample size

A pre-trial sample size calculation based on the data on the incidence of injuries in male adolescent footballers was performed.[2 3] For the primary outcome (overall injuries), we estimated that 78.5% of the players in the control group will sustain an injury during the season.[2] Sample size calculation (comparison of two proportions) revealed that a total of 366 (183 per arm) players are required to achieve 80% power in detecting an estimated 30% reduction in injury rate in the intervention group with an alpha level of 0.05. This is based on the assumption that the team comprises 22 players on average and taking into account an estimated design effect of 2.95. For the second outcome (region-specific injuries), 620 players are required based on the assumption that 64% of players would report a thigh, knee or ankle injury during one season[3] and a similar reduction in injury rate and design effect as above. Based on an expected dropout rate of 30%, we aimed to recruit 806 (403 per arm) football players (approximately 37 teams). We used G*Power software with two-sided Z-test to generate the required sample size.

Statistical methods

All statistical analyses were conducted using Stata statistical software V.17 BE (Stata Corp, Texas, USA). Descriptive statistics were reported for baseline characteristics. Continuous variables (age, height, weight, body mass index and football experience) were reported as mean and SD and were checked for normal distribution. Normal distribution was determined using a histogram, QQ plot and Shapiro-Wilk test. Incidence rate ratios (IRRs) with 95% CIs were calculated according to the intention-to-treat principle for each outcome and compared between the intervention and control groups. We used a Poisson regression model with adjustment for cluster effect. Team was considered as cluster variable. Two-tailed p values were considered significant when the alpha error had a level of less than 0.05. Training exposure was calculated by multiplying the number of training sessions, training time and mean training attendance rate.[14] Match exposure was calculated by multiplying the number of matches, match duration and the number of players on the field.[14] The total football comprised the sum of training and match exposure hours.[14 39] The injury incidence rate (IR) is presented with 95% CI and was calculated according to the formula IR=(n/e)×1000, where (n) is the number of soccer injuries and (e) the total exposure time expressed as total hours of football exposure.[16] Injury burden was calculated as the number of days lost to injury per 1000 hours of football ('injury incidence×mean absence per injury').[40]

Table 2 Player and injury characteristics of the intervention and control groups

Variable	Intervention group	Control group
Player characteristics		
No of teams	23	22
No of players	524	503
Mean (SD) age (years)	15.2 (1.6)	15.3 (1.6)
Mean (SD) height (cm)	171 (9.1)	172 (7.9)
Mean (SD) weight (kg)	60.2 (8.6)	60.5 (8.3)
Mean (SD) BMI (kg/m^2)	20.4 (1.5)	20.3 (1.7)
Mean (SD) football experience* (years)	5.0 (1.8)	4.9 (1.6)
Exposure characteristics		
Total exposure (hours)	53 454	52 938
Match exposure (hours)	9 017	8 666
Training exposure (hours)	44 437	44 272
Injury characteristics		
No of total injuries	132	187
No of match injuries	65	91
No of training injuries	67	96
No of injured players	124	172
Injury burden (SD) (days)	40 (3.4)	74 (5.4)

*Football experience taking into account the years since the player has trained at least three times per week.
†Number of injury days lost per 1000 hours.
BMI, body mass index.

Equity, diversity and inclusion statement

The study included a variety of race/ethnicities and socioeconomic levels. The research team consists of two women and four men from different disciplines (physiotherapy, sports psychology, medicine, sports medicine and orthopaedics). It included two junior researchers (RO and RM). As our study was conducted on male football players only, we cannot extrapolate findings to female players. We expand on the exclusion of female players in the discussion.

RESULTS

Participants

The final sample consisted of 45 football teams (1027 players), with 23 teams (524 players) in the intervention group and 22 teams (503 players) in the control group (figure 1). In both clusters, the dropout rate was similar (17.9% in the intervention group and 18.2% in the control group). The players in the two groups who completed the study were similar in terms of baseline characteristics (table 2).

Exposure and injury characteristics

During the season, 106 392 hours of football were recorded. The players in the intervention group were involved in 53 454 hours (44 437 training and 9017 match hours), the players in the control group in 52 938 hours (44 272 training and 8666 match hours) (table 2). 319 injuries occurred: 132 in the intervention and 187 in the control group. The overall injury IR per 1000 football hours for both groups was 2.99 (95% CI 2.68 to 3.34); the training injury IR was 1.83 (95% CI 1.57 to 2.14) and the match injury IR was 8.82 (95% CI 7.54 to 10.32). 296 (28.8%) of the 1027 players suffered an injury. The thigh was the most injured region (n=80; 25.1%; IR 0.75), followed by knee (n=62; 19.4%; IR 0.58) and ankle (n=57; 17.9%; IR 0.53). Players of the age group of the under 19s sustained the highest number of injuries (n=122; 38.2%; IR 4.49) versus the

Table 3 Effectiveness of the 'FUNBALL' programme in adolescent male football players according to intention to treat

	Intervention group		Control group			
Variable	No of injuries (%)	IR (95% CI)	No of injuries (%)	IR (95% CI)	IRR (95% CI)	P value
Total injuries	132 (100)	2.46 (2.08 to 2.92)	187 (100)	3.53 (3.06 to 4.07)	0.69 (0.55 to 0.87)	0.002
Under 15s injuries	29 (22)	1.43 (0.99 to 2.06)	49 (26.2)	2.77 (2.09 to 3.67)	0.51 (0.32 to 0.82)	0.005
Under 17s injuries	49 (37.1)	2.49 (1.88 to 3.30)	70 (37.4)	3.21 (2.54 to 4.05)	0.77 (0.53 to 1.11)	0.175
Under 19s injuries	54 (40.9)	3.95 (3.03 to 5.16)	68 (36.4)	5.04 (3.97 to 6.39)	0.78 (0.54 to 1.12)	0.184
Location						
Thigh	31 (23.5)	0.57 (0.40 to 0.82)	49 (26.2)	0.92 (0.69 to 1.22)	0.62 (0.39 to 0.98)	0.042
Knee	26 (19.7)	0.48 (0.33 to 0.71)	36 (19.3)	0.68 (0.49 to 0.94)	0.71 (0.43 to 1.18)	0.193
Ankle	23 (17.4)	0.43 (0.28 to 0.64)	34 (18.2)	0.64 (0.45 to 0.84)	0.66 (0.39 to 1.13)	0.138
Hip/groin	15 (11.4)	0.28 (0.16 to 0.46)	21 (11.2)	0.39 (0.25 to 0.60)	0.70 (0.36 to 1.37)	0.306
Lower leg/Achilles tendon	6 (4.6)	0.11 (0.05 to 0.24)	10 (5.4)	0.18 (0.10 to 0.35)	0.59 (0.21 to 1.63)	0.313
Foot/toe	7 (5.3)	0.13 (0.06 to 0.27)	9 (4.8)	0.17 (0.08 to 0.32)	0.77 (0.28 to 2.06)	0.605
Forearm	5 (3.8)	0.09 (0.03 to 0.22)	6 (3.2)	0.11 (0.05 to 0.25)	0.82 (0.25 to 2.70)	0.751
Hand/finger/thumb	5 (3.8)	0.09 (0.03 to 0.22)	6 (3.2)	0.11 (0.05 to 0.25)	0.82 (0.25 to 2.70)	0.751
Head/face/neck	5 (3.8)	0.09 (0.03 to 0.22)	5 (2.7)	0.09 (0.03 to 0.22)	0.99 (0.28 to 3.42)	0.988
Lower back/sacrum/pelvis	4 (3)	0.07 (0.02 to 0.19)	4 (2.1)	0.07 (0.02 to 0.20)	0.99 (0.24 to 3.95)	0.989
Shoulder/clavicle	2 (1.5)	0.03 (0.00 to 0.14)	4 (2.1)	0.07 (0.02 to 0.20)	0.49 (0.90 to 2.70)	0.417
Elbow	1 (0.8)	0.01 (0.00 to 0.13)	1 (0.5)	0.01 (0.00 to 0.13)	0.99 (0.06 to 15.83)	0.995
Wrist	1 (0.8)	0.01 (0.00 to 0.13)	1 (0.5)	0.01 (0.00 to 0.13)	0.99 (0.06 to 15.83)	0.995
Abdomen	1 (0.8)	0.01 (0.00 to 0.13)	1 (0.5)	0.01 (0.00 to 0.13)	0.99 (0.06 to 15.83)	0.995
Injury mechanism						
Trauma	114 (86.4)	2.13 (1.77 to 2.56)	165 (88.2)	3.11 (2.67 to 3.63)	0.68 (0.53 to 0.86)	0.002
Overuse	18 (13.6)	0.33 (0.21 to 0.53)	22 (11.8)	0.41 (0.27 to 0.63)	0.81 (0.43 to 1.51)	0.508
Injury occurrence						
Training	67 (50.8)	1.50 (1.18 to 1.91)	96 (51.3)	2.16 (1.17 to 2.64)	0.69 (0.50 to 0.94)	0.022
Match	65 (49.2)	7.20 (5.65 to 9.19)	91 (48.7)	10.50 (8.55 to 12.89)	0.68 (0.49 to 0.94)	0.021
Injury severity						
Minimal (1–3 days)	18 (13.6)	0.33 (0.21 to 0.53)	22 (11.8)	0.41 (0.27 to 0.63)	0.81 (0.43 to 1.51)	0.508
Mild (4–7 days)	56 (42.4)	1.04 (0.80 to 1.36)	70 (37.4)	1.32 (1.04 to 1.67)	0.79 (0.55 to 1.12)	0.194
Moderate (8–28 days)	41 (31.1)	0.76 (0.56 to 1.04)	62 (33.2)	1.17 (0.91 to 1.50)	0.65 (0.44 to 0.97)	0.035
Severe (>28 days)	17 (12.9)	0.31 (0.19 to 0.51)	33 (17.6)	0.62 (0.44 to 0.87)	0.51 (0.28 to 0.91)	0.024

IRs are reported per 1000 hours of football play and are unadjusted.
IRRs are adjusted for team.
IR, incidence rate; IRR, incidence rate ratio.

under 17s (n=119; 37.3%; IR 2.87) and the under 15s (n=78; 24.5%; IR 2.06) (table 3). Further injury characteristics data are presented in tables 2 and 3.

Compliance with the 'FUNBALL' programme and training 'routine' of the control teams

The intervention group used the 'FUNBALL' programme in 72.2% of all training sessions, on average 2.2 times per week (online supplemental table 2). The average player attendance for training sessions was 17.2 in the intervention group and 17.5 in the control group. All the interviewed coaches (n=11; 50%) of the control teams reported that they used exercises of similar categories that are contained in the 'FUNBALL' programme. The coaches of the under 15s (n=4; 18.2%) reported they perform balance, core stability and running/sprinting exercises in their training. The coaches of the under 17s and under 19s teams (n=7; 31.8%) reported that they employ core stability, hamstring eccentric, plyometric and running/sprinting exercises, but very rarely balance exercises. The majority of them applied these exercises at least once a week. However, their use was not structured with regard to the number of repetitions, duration and types of exercises.

Efficacy of the intervention programme

For the primary outcome investigated, there was a significantly lower incidence in the intervention group for the overall number of injuries (IRR 0.69, 95% CI 0.55 to 0.87, p=0.002). Secondary outcomes that reached significantly lower incidences in the intervention group were thigh injuries (IRR 0.62, 95% CI 0.39 to 0.98, p=0.042), moderate injuries (IRR 0.65, 95% CI 0.44 to 0.97, p=0.035) and severe injuries (IRR 0.51, 95% CI 0.28 to 0.91, p=0.024). Moreover, a significantly lower incidence was found for match (IRR 0.68, 95% CI 0.49 to 0.94, p=0.021), training (IRR 0.69, 95% CI 0.50 to 0.94, p=0.022) and traumatic injuries (IRR 0.68, 95% CI 0.53 to 0.86, p=0.002). The subgroup analysis according to age groups showed a significantly lower incidence for the overall number of injuries among the under 15 players (IRR 0.51, 95% CI 0.32 to 0.82, p=0.005). The incidence of knee and ankle injuries did not reach significance (table 3). The injury burden was 40 days lost per 1000 hours in the intervention group and 74 days lost per 1000 hours in the control group (table 2). No harmful events associated with the use of the programme, for example, injuries during their execution, were reported by the coaches.

DISCUSSION

Principal findings

The main finding of this study among male young football players is a lower overall injury incidence by one-third in the group that used the 'FUNBALL' programme. Also, training and match injuries were lower in the intervention group when considered separately. Further relevant findings were the programme's efficacy in reducing the incidences of one of the most frequently affected injury regions (thigh), injuries causing the longest time loss in football (moderate and severe injuries) and the injury burden. Thus, players' availability was higher in the teams of the intervention group.

Efficacy of the programme and comparison with previous research

The 'FUNBALL' intervention proved to be successful in a number of aspects. The inclusion of evidence-based exercise categories for prevention of football-related injuries may be one of the main reasons. The first two categories included balance and core stability exercises. Previous studies reported on the efficacy of balance training in reducing ankle ligament injuries in football,[41 42] and the association between impaired core stability and the development of lower extremity injuries in healthy athletes.[43] Hamstring eccentrics were also included in our programme. Their efficacy in preventing hamstring injuries is well-known.[10 11] Even though there is limited evidence regarding the role of gluteal activation for injury prevention, there is evidence that reduced activity represents a risk factor for hamstring injuries.[44] Moreover, the crucial role of gluteal muscles in maintaining a correct knee position, that is, avoiding a dynamic knee valgus, during activities such as walking, running, jumping and landing has been reported.[45] Incorporating plyometric exercises in IPPs has been shown to effectively decrease the risk of anterior cruciate ligament injuries.[46] Finally, and for the first time in connection with IPPs, we introduced sprinting exercises to mitigate hamstring injury risk.[47] Combining many exercise categories makes it (more) difficult to understand which categories provide the highest benefit for reducing injury risk.

A comparison with existing studies is difficult as only very few of them considered our specific age group and male players. The preventive effect on the overall injury incidence is in accordance with two large RCTs investigating the efficacy of 'FIFA11+' in youth female and male football players, respectively.[16 25] Similar to the 'FIFA11+' study conducted in females,[16] 'FUNBALL' reached a significantly positive effect on overall and severe injuries, furthermore on thigh injuries. This may be expected as this type of injury occurs more often in male footballers.[6] Owoeye *et al*[25] investigated youth male football players. They reported an even higher efficacy if the 'FIFA11' programme was employed. The efficacy rate was higher for overall and match injuries compared with our findings. Their figures were 41% and 65%, respectively, as compared with 31% and 32% in our study. In contrast to the 'FUNBALL' study, neither of the two above-mentioned 'FIFA11+' studies reached significant effects with regard to training injuries.[16 25] Additionally, 'FUNBALL' lowered the injury burden and the number of injuries lasting >8 days by about 50%. This can be a highly important point, knowing that a team with lower injury burden and less severe injuries has a better chance of improved team performance.[40] Injury patterns and frequencies differ among different age groups and sexes. Forearm fractures are quite common in children, whereas anterior cruciate ligament ruptures are more common in females aged 16 years and above.[48 49] This (together with lacking statistical power for these particular injury types) may explain why 'FUNBALL' did not show a significant preventive effect in several secondary outcomes, especially in reducing knee injuries.

The efficacy of 'FUNBALL' differed between age groups. The highest efficacy was found among the under 15 players in comparison with under 17 and under 19 players (IRR 0.51 vs 0.77 and 0.78). The reason for this might be the previously mentioned fact by the interviewed coaches that they use similar categories of our programme in their training routine, especially in the older age groups. Therefore, the significant lower injury incidence due to the use of 'FUNBALL' might be mainly attributed to the large effect in the youngest age group. There were no indications that differing compliance with the conduction of the programme was a relevant confounder.

Strengths and limitations

Our study has several strengths. First, the IPP was investigated through a large cluster-randomised trial. We followed good practice by cluster-randomising the clubs to avoid contamination between the control and intervention groups and by blinding the injury data collection assistants. In-season, we regularly visited the clubs without previous announcement to monitor the implementation of the programme. Moreover, we were in contact with players and their parents with regard to detailed injury information in addition to the data provided by coaches or the teams' physiotherapists. Finally, we collected detailed information from the coaches of the control group regarding the exercises that they usually perform during the season with a focus on exercises similar to those used in our intervention programme. This provided a possibility of a more accurate assessment of the efficacy found in our study since an unintentional use of similar exercises would have lowered the effect of the investigated programme.

This study also has some limitations. Despite the inclusion of a football coach, we lacked the input of footballers themselves in the process of developing the intervention. We knew in advance that most of the participating clubs lacked female teams. Thus, it was a conscious decision to confine the study to male teams only. This impacts the strength of clinical recommendations for the programme implementation. We relied on an older version of the data collection methodology[39] as the planning of the study took place before a more sophisticated version[50] was available. The older version lacks some details, especially with regard to 'overuse/growth-related injuries'. Collecting team exposure hours instead of individual exposure hours as it was originally planned is a further limitation, since playing and training time alike can vary greatly among players.[16]

After the start of the study, some barriers appeared in both groups. Four coaches of the intervention teams decided to stop the programme implementation. For them, the small number of coaching staff within the team as well as the limited time for training was the main reason for terminating the programme. In both groups, several coaches presented low motivation for providing the exposure hours and injuries that occurred. Some coaches did not report the data on a weekly basis. We excluded teams from the study if they did not provide the data for a period of 4 weeks. Moreover, the decision of when to progress to the next exercise level was left to the coaches without any guidance from the study assistants. In some cases, we recognised a big difference. Some clubs moved rapidly, within the first weeks of the study, to the most advanced levels, while other clubs still used the initial levels. Finally, the additional time that is required to perform the programme (15–20 min) may be considered as a

downside, which however should be weighed against less injured players. The vast majority of the limiting factors listed above potentially impact the programme's success.

Clinical implications, applicability and future research

Reducing football-related injuries holds many benefits both individually for the players as well as for the team. A lower number of injuries, apart from the health benefits, will contribute to the performance of the teams and the financial-related aspects, but it will also increase the likelihood that the young footballers will reach their highest potential. Early adaptation to preventative exercise might, thus, be highly valuable especially at younger ages, as they may serve as a blueprint for an application later in the career. The 'FUNBALL' was investigated among male adolescent football players (aged 13–19 years). Its efficacy in other age groups (seniors and veterans) or female football players was not investigated in our study. This calls for future studies to evaluate the efficacy within these groups. Furthermore, it is recommended investigating the efficacy of the 'FUNBALL' in an even larger cohort and possibly over a longer period of time. This will enable making a comprehensive evaluation of its potential in reducing severe injuries that are less frequent such as anterior cruciate ligament ruptures.

CONCLUSIONS

The 'FUNBALL' programme was effective in lowering the overall injury incidence by 31% in male adolescent football players over an entire season. This also referred to thigh injuries as one of the most frequent football-related injury types, and to moderate and severe injuries, which cause longest absence from football. Therefore, we recommend its implementation in male adolescent football players.

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