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# Evaluation of how different implementation strategies of an injury prevention program (FIFA 11+) impact team adherence and injury risk in Canadian female youth football players – a cluster-randomized trial

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## Abstract

Background: Injury prevention program delivery on adherence and injury risk, specifically involving regular supervisions with coaches and players on program execution on-field has not been examined.

Aim: The objective of this cluster-randomized study was to evaluate different delivery methods of an effective injury prevention program (FIFA 11+) on adherence and injury risk among female youth football teams.

Method: During the 4-month 2011 football season, coaches and 13-18-year old players from 31 Tier 1-3 level teams were introduced to the 11+ through either an unsupervised website ("control") or a coach-focused workshop with ("comprehensive") and without ("regular") additional supervisions by a physiotherapist. Team and player adherence to the 11+, playing exposure, history and injuries were recorded.

Results: Teams in the comprehensive and regular intervention groups demonstrated adherence to the 11+-program of 85.6% and 81.3% completion of total possible sessions, compared to 73.5% for teams in the control group. These differences were not statistically significant, after adjustment for cluster by team, age, level, and injury history. Compared to players with low adherence, players with high adherence to the 11+ had a 57% lower injury risk (IRR 0.43, 95% CI 0.19 to 1.00). However, adjusting for covariates, this between-group difference was not statistically significant (IRR=0.44, 95% CI 0.18 to 1.06).

Conclusion: Following a coach-workshop, coach-led delivery of the FIFA 11+ was equally successful with or without additional field involvement of a physiotherapist. Proper education of coaches during an extensive pre-season workshop was more effective in terms of team adherence than an unsupervised delivery of the 11+-program to the team.

## Background

There is consistent evidence, based on prospective evaluation studies, that multi-faceted neuromuscular warm-up programs can reduce the risk of injury in youth football players.[1-6] Among Norwegian 14 to 16-year old female football players, Soligard et al.[3] demonstrated an overall 32% reduction in injury risk in female youth football players participating in the FIFA 11+ injury prevention program. Soligard et al.[7] further showed a greater protective effect in players with high adherence to the 11+, estimating a risk reduction of all injuries by 35% for those players participating in at least 1.5 structured warm-up sessions/week.

Despite the protective effect of many football injury prevention warm-up programs, previous investigations among youth football players have suffered from moderate or unknown adherence to the injury prevention programs.[1-6] These and similar injury prevention interventions will not have significant public health impact if they are not widely accepted and adopted by the target population; coaches, athletes and other stakeholders in the sports community.[8-10]

In previous projects in community-based youth football, injury prevention programs were largely delivered by coaches who initially were educated by clinical research personnel. Mostly, coaches were introduced to the injury prevention program individually or through an instructional workshop where they had received theoretical and practical training in the program and instruction on how to teach it to the team.[2-6;9;11] Some research teams have in addition used combinations of a DVD/video and other educational material (brochures/bookletes, posters) to inform and teach coaches and players about the exercise programs.[2;3;6;12] Emery & Meeuwisse[4] and Steffen et al.[9] also implemented a review of their injury prevention programs with players and coaches at regular intervals on the field by a physiotherapist or other study personnel to ensure proper movement quality during exercise completion, and to provide motivation. However, there is a paucity of information in the literature regarding the coaches´ delivery of the program to the team and the quality of the exercise execution by athletes on the field. This knowledge gap has also been recognized as an issue for sports injury research more generally.[13]

Based on the positive effects of the FIFA 11+ football injury prevention program, and as part of its implementation strategy, the Federation Internationale de Football Association (FIFA) has developed educational material and created a website where all 11+ resources can be downloaded free of charge (i.e. videos explaining the exercises, pocket-sized exercise cards for the training field, posters detailing the exercises and their common performance errors) (http://f-marc.com/11plus/11plus/). The success of delivery an injury prevention program implementation through an unsupervised approach (i.e. website delivery only) has not previously

been evaluated. Injury prevention of football-realted injuries through extensive coach education was successfully implemented in a countrywide campaign in Switzerland,[11] but there are no prospective intervention studies evaluating different coach education or team implementation strategies in maximizing team and player adherence and ultimately reducing injury risk in youth football, or in any other sport.[13] Furthermore, the added effect of a program delivery, specifically involving regular follow-up with coaches and players on the field to ensure proper execution and progression of exercises, has not previously been examined.

A better understanding of the impact of an optimal delivery strategy as well as the relationship between adherence and injury risk would allow stakeholders to optimize current injury prevention programs and their delivery to targeted teams.[14] The aim of the present study was to investigate whether a comprehensive, player-focused delivery of the FIFA 11+ injury prevention program with regular on-field follow-up has a more significant effect on maximizing team adherence as compared to either a self-regulated delivery (website) or a self-regulated coach-delivered program following a coach-training workshop. In addition, the effect of program delivery on injury risk in youth football players is explored.

## Methods

### Design and subjects

A cluster-randomized controlled trial (RCT) was conducted during one outdoor season (May-August) in 2011. The study population consisted of consenting coaches and youth female football players (ages 13 to 18) coaching and playing for teams from the Calgary and Edmonton Minor Football Associations, or the Edmonton Inter-district Youth Football Association, Alberta, Canada. Teams were randomly approached by club for recruitment in the early season after teams were formed (April to May 2011), and followed through the regular playing season and play-offs (August 2011). After receiving agreement from the head coach and a team designate to record exposure data for the study, the following inclusion criteria were met: playing in the top three divisions of play (Tier 1-3), belonging to the under 16 (U16) or under 18 years (U18) age-group, providing written informed consent to participate. Player exclusion criteria were: being injured or having had a systemic disease (e.g. cancer, arthritis, heart disease) or neurological disorder (i.e. head injury), which prevented full participation in all organized football activities at the commencement of the 2011 outdoor season.

Included teams were randomized to three study groups. These included an unsupervised control group or one of two intervention groups with a regular, coach-focused or a comprehensive, player-focused delivery of the 11+ program. Ethics approval was granted from the Conjoint

Health Research Ethics Board at the University of Calgary, Canada. To avoid contamination, teams were randomized by club to a study group by a random number generation conducted by study personnel (CE) not involved directly in recruitment or intervention delivery.

### Intervention

The FIFA 11+ is a 20 minute warm-up program with neuromuscular training consisting of 15 exercises developed to prevent lower extremity injuries in football players. Exercises taught are grouped into three parts including initial and final running exercises with a focus on cutting, jumping and landing technique (Parts 1 and 3) and strength, plyometrics, agility, and field balance components (Part 2). For each of the six conditioning exercises in Part 2, the 11+ program offers three levels of variation and progression.[3]

Coaches from teams randomized to the "control" group were provided with details for online access to the 11+ program website (i.e. videos detailing the exercises and other educational material for free downloading) (http://f-marc.com/11plus/). They were given no additional information or support regarding 11+ delivery. Team coaches randomized to the "regular, coach-focused intervention group" were provided with one pre-season 11+ coach workshop by study personnel and with copies of 11+ material (DVD, poster), which also were available on the 11+ website. In addition to a pre-season 11+ workshop for coaches and receiving copies of the 11+ material, teams in the "comprehensive, player-focused intervention group", were assigned a study physiotherapist who assisted the coach in the instruction and supervision of the 11+ program to the players at team sessions following the workshop. These physiotherapists also attended a separate workshop to learn the 11+ program and discuss the correct execution of the exercises prior to their contact with the study team. The role of the physiotherapist was to attend the team's practice sessions weekly to facilitate correct technique and progression of the program components. Coaches otherwise led the warm-up program.

All participating coaches were asked to perform the 11+ injury prevention program with their team as a warm-up at the beginning of all practice sessions and Parts 1 and 3 before match play (2-3 times a week). All coaches in any of the three study groups were given contact information for study personnel to clarify questions and provide support by telephone when needed.

### Exposure, 11+ adherence, and injury surveillance

The total player exposure to practice, game play and to the 11+ program was completed from the time of delivery of the coach workshop (coach and player-focused intervention groups) or delivery of information for access to the 11+ website materials following baseline performance testing (control group) until play-offs were completed. All teams identified a team designate (i.e.

team trainer, coach, or manager) to be responsible for exposure data collection for every practice and game (i.e. player attendance, time spent in practices and matches, and number of 11+ sessions and single 11+ exercises performed). Team adherence to the 11+, the main outcome, was defined by three outcomes: team adherence to the 11+ (proportion of all possible sessions where the 11+ was delivered), the number of team 11+ sessions per week, and mean number of team 11+ exercises per session. Completeness of data collection was reviewed regularly as submitted by study personnel.

Injury surveillance included a baseline medical questionnaire (including player demographics and injury history in the past six weeks), baseline on-field performance assessments, and the completion of a player and coach survey regarding safety knowledge, attitudes and behaviors (data not included here). Daily participation exposure sheets and injury report forms, previously validated in youth community football,[15] were completed throughout the season by a team designate and followed up and collected by a study therapist (separate to the 11+ physiotherapists). Players sustaining a football injury were directed by the team designate to a study therapist (physiotherapist or athletic therapist assigned to the team for the study) for assessment within one week of the injury event. While an injury report form was initiated by the team designate for details surrounding the injury event (session type, location, type, and cause of the injury etc.), the team´s study therapist completed the details of the injury report form including specific location, diagnosis, and severity of injury. The injury definition included any football-related injury requiring medical attention and/or removal from a session and/or resulting in time-loss from subsequent sessions.[15] For any injury resulting in expected time loss of more than one week or any suspected concussion, the injured player was referred to a study sport medicine physician. Players could alternatively choose to follow-up with a family physician. Injury severity was classified based on the consensus agreement of injury definitions as slight, minimal or mild (0-7 days absence from football), moderate (8-28 days), and severe (>28 days).[16] All study therapists and physicians examining the injury, were blinded to study group allocation.

Prior to the initiation of the 11+ program, all teams were asked to participate in field performance testing.[17] The test session included the Single-leg eyes-closed balance on an Airex Balance Pad® (seconds),[18] the Star Excursion Balance Test (cm),[19;20] the Single-leg triple hop (cm),[21] and the Jump-over-a-bar test (total number of 2-leg jumps in 15 seconds).[22]

### Validation of team adherence

In addition to the team designate report, study personnel made random unannounced visits to study teams to validate team adherence and observe the execution of the program. Study

personnel observed the beginning of the practice or game session from a location where the coach would be unaware of their observation.

### Sample size and statistical analysis

The sample size was based on a recent report using a similar approach with a mean team adherence of 77%.[3] Given an estimated inflation factor of 1.88 for randomization by cluster,[3;9] a sample size of 30 teams and 360 players (120 players in each group) was estimated to detect a 20% difference in team adherence between the teams in the regular, coach-focused intervention group and the control group (estimated team adherence of 40%). The estimation was based on 14 players per team and an estimated player drop-out rate of 15% (2-sided test; $\alpha$=0.05, $\beta$=0.20).

All statistical analyses were performed using STATA 10.0 (StataCorp, College Station, Texas, USA). Baseline characteristics, including pre-season field tests were compared among the three randomization groups, and data are presented as means with corresponding 95% confidence intervals (CI), or frequencies and proportions.

Team adherence to the 11+ was treated as a continuous outcome and analyzed using multiple linear regression to estimate the mean group-differences with 95% confidence intervals and adjustment for clustering by team. Following Soligard et al.[7], player adherence to the 11+ program was categorized into high, medium, and low adherence tertiles according to the players´ number of single 11+ exercises completed across all team sessions, independent of study group.

The team designates´ reports on teams´ performed 11+ exercises were validated based on the agreement between teams´ reported and externally observed 11+ exercises. Data are presented as proportions of agreement.

Injury rates in each of the three randomization and adherence groups were estimated with clustering by team and player hours as denominator. A Poisson regression model was used to estimate crude and adjusted incidence rate ratios (IRR) with corresponding 95% confidence intervals (CI) for each intervention group compared to the control group. These IRRs were also estimated using a similar model to compare the risk of injury based on tertiles of adherence according to the number of 11+ exercises completed (low adherence as reference group). Data are presented as mean values with corresponding 95% CI or frequencies with proportions, and significance was determined by non-overlapping confidence intervals. All analyses incorporated team cluster effects and were adjusted for age group, level of play, and injury history. The level of significance was chosen to be $\alpha$=0.05, and all tests were two-tailed.

## Results

A total of 385 football players from 29 teams (11 teams in the control group, 8 in the regular, coach-focused intervention group, and 10 in the comprehensive, player-focused intervention group) were included in the final analysis (Figure 1). By the end of the pre-season period to the beginning of the season in May, a total of 7 workshops were delivered to 35 head and assistant coaches from the 20 intervention teams and to study physiotherapists following the 10 teams in the comprehensive, player-focused intervention group. The median time to pre-season baseline testing was 5 days following the 11+ workshop, ranging from 11 days before to 28 days after the workshop. For the 10 teams in the comprehensive intervention group, the median number of supervised on-field sessions by physiotherapists was 6, ranging from 3 to 8 team supervisions.

Table 1 summarizes baseline characteristics of all players. There were significant between-group differences for age group, playing level and injury history, while the distributions of playing position, as well as pre-season performance measures were similar among the 3 randomized groups.

The mean number of match hours for players in the control and comprehensive, player-focused groups was similar, whereas players in the regular, coach-focused intervention group had a lower match exposure. For practice exposure, players in the two intervention groups had more hours of practices during the season than players in the unsupervised control group (Table 2).

### Team adherence to the 11+

Teams in both intervention groups completed a higher absolute number of 11+ sessions than control teams. However, based on a varying intervention length of these teams in the study, the relative number of 11+ sessions, measured as the number of team 11+ sessions per week, was similar between groups. Examination of the number of team 11+ exercises per session reveals that teams in the control group performed on average a significantly lower number of 11+ exercises per 11+ session compared to the teams in the regular, coach-focused and comprehensive, player-focused intervention groups (Table 2).

Teams in the comprehensive, player-focused and regular, coach-focused intervention groups had a respectively 12% and 8% higher team adherence to the 11+ warm-up program than teams in the control group, although these differences were not statistically significant, when adjusted for age group, level of play, and injury history (Table 3). Teams with a comprehensive, player-focused delivery of the intervention, conducted 3.5 (95% CI 0.6 to 6.4) and teams with a regular, coach-focused delivery of the intervention performed 4.7 (95% CI 1.9 to 7.5) more 11+ exercises per session than teams in the control group, corresponding to on average of 10.8 and 11.5

compared to 8.2 exercises per 11+ session. However, adjusted for age group, level of play (tier), and previous injury in the past 6 weeks, these between-group differences were not statistically significant (Table 3).

### Injury risk among players

As many as 67 (81.7%) of the total 82 injuries were lower extremity injuries. The injury incidence rates (IRR) did not differ by study group (Table 4). Most of the injuries (n=69, 84.1%) were of mild severity, resulting in 0-7 days absence from play.

Player adherence to the 11+ varied, and cut-off values for the three groups of adherence based on tertiles were: low adherence group of players (0 to 108 11+ exercises during the season), medium adherence (109 to 209 exercises), and high adherence group of players (210 to 435 exercises). The unadjusted overall injury rate for players categorized into the high adherence group was 57% lower than injury rate for players in the low adherence group (IRR=0.43, 95% CI 0.19 to 1.00). However, adjusting for cluster, age group, level of play, and injury history, this between-group difference in injury risk was not statistically significant (IRR=0.44, 95% CI 0.18 to 1.06). No other dose-response relationship between high and low adherence to the 11+ and injury risk could be identified (Table 4).

### Validation of team designate report forms

During the season, the project team conducted a total of 30 observations (11 practices, 19 matches) on 20 of the 29 study teams. These observations represented 4% of all 707 potential sessions. The teams with no observation (n=9) were three teams from each of the control and the two intervention groups. A team designate report was missing for 2 observed sessions.

For the remaining 28 sessions, 85% of 11+ exercises were correctly reported (range: 60-100%). There were no significant between-group differences in agreement between reported and observed 11+ exercises. There was no clear pattern identified in 11+ exercises where team reports and observations disagreed. The observation also identified modifications of 11+ exercises as well as additional exercises performed during warm-up.

## Discussion

This cluster-RCT is among the first to report results from a comparison of intervention delivery methods, focusing specifically on delivery of the FIFA 11+ to Canadian female youth football teams. So far, the extent to which knowledge of effective injury prevention programs has been translated to the sporting field has not been known.[10;23] The main finding of this investigation was that the method of delivery 11+ injury prevention program aimed at coaches with coach

education, including a practical workshop at the beginning of the season, was more effective based on team adherence to the intervention than a web-based delivery of the program to the team. There was no additional benefit from the regular involvement of a physiotherapist on adherence or injury risk for the teams in the comprehensive, player-focused intervention group. Analyzing the number of team 11+ exercises per session, teams in the coach- and player-focused intervention groups performed a higher number of 11+ exercises per session compared to the teams in the control group who had unsupervised online access to the 11+. In addition, there seems to be a trend of a dose-response relationship between higher player adherence to the intervention exercises and a lower risk of injury, when adjusted for covariates. With caution, this could be interpreted as an important message for coaches: The more exercises a player does, the more effective the injury program becomes, regardless of the method of program delivery.

### Program delivery and team adherence

There is solid evidence in the literature that injury risk can be effectively reduced in youth football by implementing a neuromuscular prevention program in randomized controlled trial settings, when performed on a regular basis.[3-6] However, there is a paucity of information examining the quantity and quality of exercise performance on the field. Furthermore, it is difficult to evaluate a dose-response relationship related to the effectiveness of an intervention program without data examining adherence to the program.[10] Despite a mean adherence of 74% for teams in the control group, we found that an unsupervised delivery of the 11+ to control teams was not sufficient to attain as high adherence to the intervention as the two supervised intervention groups did. While the web-based material used in the control group delivery may have been thorough in content, it seems that a practical 2.5 hour coach workshop, as was offered for both the coach- and the player-focused intervention teams, including take-home program resources, seem to be favorable in improving adherence to the 11+. In addition to creating awareness among coaches for regular warm-up through neuromuscular training exercise programs and providing continuous player feedback alongside, involving parents and other stakeholders and policy makers could also be useful to increase program uptake at the community level.[24]

The present findings suggest that coaches trained to deliver a team-based prevention program following a theoretical and practical workshop are effective in attaining adherence regardless of additional follow-up by a physiotherapist. Similar adherence proportions in the two intervention groups give additional support to the strength of the 11+ as being a program that coaches can deliver regularly. Future research should be directed at identifying factors, such as coach and

player barriers and motivation that may moderate the success of coach workshops and the distribution of program resources.[10;23;25;26]

### Adherence and injury risk

The reported injury rates among players in the present study are consistent with a previous RCT using a comparable age-group performing a neuromuscular training prevention program in Canada.[4] The present findings also support the work of Soligard et al.,[7] who in a recent report on the 11+ revealed that the risk of overall and acute injuries was reduced by more than a third among players with high adherence compared to players with medium adherence, measured by the number of 11+ sessions throughout an 8-month season. Interestingly, for the present investigation, the risk of injuries was 56% (all injuries) and 48% (lower extremity injuries) lower among players with high compared to low adherence to the 11+ exercises, although this risk reduction was not statistically significant. Based on the promising results from several neuromuscular football intervention studies,[1-6] it appears that the observed results related to injury risk reduction most likely are related to the multifaceted content of exercise programs, proper coach education, and to player adherence itself.

### Methodological implications

Strengths of this study include the comprehensive evaluation of the effectiveness of implementation of the 11+ across several delivery methods, on the adherence and prevention of injury in a real world setting.[10] This is the first study to directly examine the association between intervention delivery methods, intervention adherence and injury outcomes. As highlighted by others in the field,[10;27] the present study examines effectiveness rather than efficacy in evaluating the most effective delivery mechanisms to inform coaches and support them in maximizing uptake of such intervention by their players. Another strength of the present study is its design. A cluster randomisation of clubs was chosen to avoid contamination between the control and the two intervention groups, and careful monitoring of adherence. Also, the validation of the team designate report on adherence with high levels of agreement (81-89% agreement in the three study arms), based on researcher observation, suggests that the team designate report of adherence is reasonable.

The major limitation in this study relates to the potential bias of the availability of the 11+ resources previously, if coaches sought them out. It is possible that participating coaches may have been exposed to the 11+ or similar neuromuscular injury prevention programs before the study. This bias could explain a dilution in effect, leading to non-significant results.

Also, differences in mean total team participation weeks in the control group (7 weeks) compared to the two intervention groups (10 and 11 weeks respectively) is a limitation of this study. This difference is related to the random allocation of teams to study group by club and the lag time between club agreement for participation in the study and team agreement through the head coach. Accessing the website materials later in the season by the coach, as was the case for most of the control teams, was maybe less likely, as the website information was provided at the time of recruitment. Regardless, a mean of 74% team adherence among the control teams is high compared to other youth football studies that have reported adherence.[3;7;9]

Another limitation of this study relates to the logistical challenges introduced by the inclement weather that was experienced throughout the football season, especially in the early season. This situation led to cancellations of many practice sessions and to rescheduling of games and practices. Also, related to the weather, rescheduling or cancellations, communication from the coaches to the field physiotherapists in the comprehensive, player-focused intervention group, was poor. As such, the opportunities to complete and maintain the 11+ injury prevention warm-up sessions, as intended were decreased, and the opportunity for 11+ physiotherapists to follow-up their allocated teams on the field diminished. As a result, the team 11+ physiotherapists attended a team session on average only once every two weeks (median 6 supervised sessions in total). These logistical challenges, however, speak to the feasibility of such follow-up by a physiotherapist and of performing structured warm-up exercises regularly in community-based teams. Also, the exploratory analysis on the relationship between player adherence and injury risk might be biased, as most players with low adherence in this analysis are from the control group where team adherence was lowest. Player group allocation might not only have had an effect on adherence, but also on the quality of the exercises conducted. This can subsequently have affected player injury incidence as well and need to be interpreted with caution.

"Finally, we also need to keep in mind that simply participating in a research study may change study person´s behavior. In our case, coaches might have positively changed their willingness to incorporate the 11+ program into their practice routines. This could artificially increase compliance in the control group. If this bias existed, it would hide differences between the groups, meaning that there may be more dramatic differences between groups than we observed in this study".

### Practical implications

Coach education should continue to play an important role in the way a new neuromuscular injury prevention exercise program is delivered to football teams and players. Experiences from

Switzerland demonstrated how an injury prevention program successfully could be implemented countrywide by coaches.[11] Knowledge of injuries, injury prevention, attitudes and beliefs to the importance of injury prevention training is likely to be variable among coaches and players in youth sports.[4;7;9;23;25] It is speculative whether or not coaches who are educated to a prevention program through a practical approach including a coach workshop will be more likely to deliver the prevention program with a better understanding of correct technique execution. Given the paucity of resources for injury prevention training and medical follow-up in youth community football, it is of major importance to establish injury prevention as a mandatory part of the coach education certification at all levels. More evidence is also needed to identify potential barriers and motivators for coaches in the use of an injury prevention program, and to measure determinants of change of behavior over time.[23-25;28] This would facilitate a better understanding of coach willingness to change current practices and behavior and adopt such an intervention, thus establishing effective implementation strategies outside a controlled research environment.[10]

## Conclusion

Comprehensive education of coaches during an extensive workshop at the beginning of the season proved to be more effective in subsequent team adherence to the coach-led injury prevention program compared to being exposed to a web-based unsupervised delivery of the program content. There was no additional benefit on team adherence or reduced injury risk with the on-field involvement of a physiotherapist to supplement coach delivery of the program to players.


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## Competing interests statement

This project has received a grant from F-MARC, who is presented with two co-authors (MB, JD). No other relationships or activities that could appear to have influenced the submitted work.

## Contributor statement

KS, WM, MR, JK, MB, JD, CF, GM, and CE were responsible for the conception and design of the study. KS, MR, and CE coordinated the study and managed all aspects, including data collection. KS initialized, and JK conducted the analyses, which were planned and checked with the other co-authors. KS, MR, and CE wrote the first draft of the manuscript. All authors had full access to all data and contributed to interpretation of the findings and critical revision of the manuscript. KS, WM, and CE are the guarantors.

## What are the new findings?

- Following a coach-workshop, coach-led delivery of an injury prevention program was equally successful with or without addition field involvement of a physiotherapist
- Proper education of coaches during an extensive pre-season workshop was more effective in terms of team adherence than an unsupervised delivery of the 11+-program to the team

## How might this paper impact on clinical practice in the near future?

- Coach education should continue to play an important role in the way a new neuromuscular injury prevention exercise program is delivered to football teams and players

Table 1. Baseline characteristics for players in the control, in the regular, coach-focused, and in the comprehensive, player-focused intervention groups, presented as frequencies (%) and means (95% CI).

| | Control (n=135) | Regular (n=121) | Comprehensive (n=129) |
|---|---|---|---|
| ***Age group*** | | | |
| U16 | 89 (65.9) | 70 (57.9) | 55 (42.6) |
| U18 | 46 (34.1) | 51 (42.2) | 74 (57.4) |
| ***Playing level*** | | | |
| Tier 1 | 78 (57.8) | 37 (30.6) | 31 (24.0) |
| Tier 2 | 31 (23.0) | 0 (0) | 71 (55.0) |
| Tier 3 | 26 (19.3) | 84 (69.4) | 27 (20.9) |
| ***Playing position*** | | | |
| Forward | 38 (28.6) | 29 (25.0) | 25 (19.7) |
| Midfield | 51 (38.1) | 41 (35.3) | 53 (41.7) |
| Defense | 36 (26.8) | 37 (31.9) | 43 (33.4) |
| Goal keeper | 9 (6.7) | 9 (7.7) | 6 (4.7) |
| Missing | 1 (0.7) | 5 (4.1) | 2 (1.6) |
| ***Previous injury*** | | | |
| Yes | 36 (26.7) | 10 (8.3) | 14 (10.9) |
| Missing | 0 (0) | 1 (0.8) | 1 (0.8) |
| ***Single-leg Balance (s)*** | | | |
| Left | 6.3 (5.2-7.4) | 5.9 (5.2-6.7) | 5.7 (4.9-6.5) |
| Right | 5.6 (5.0-6.2) | 5.8 (5.1-6.4) | 6.0 (5.2-6.7) |
| Missing (%) | 27 (20.0) | 10 (8.3) | 12 (9.3) |
| ***Star Excursion Balance Test (cm)*** | | | |
| Left | | | |
| Anterior | 76.4 (75.3-77.6) | 74.0 (72.9-75.2) | 76.1 (75.0-77.3) |
| Posterolateral | 81.3 (80.0-82.6) | 79.9 (78.5-81.3) | 82.3 (80.8-83.7) |
| Posteromedial | 78.6 (77.1-80.1) | 77.2 (75.7-78.8) | 79.4 (77.8-81.0) |
| Missing (%) | 27 (20.0) | 10 (8.3) | 12 (9.3) |
| Right | | | |
| Anterior | 75.7 (74.5-77.0) | 74.2 (73.0-75.4) | 74.9 (73.8-76.1) |
| Posterolateral | 80.1 (78.8-81.4) | 80.3 (78.8-81.7) | 80.9 (79.5-82.3) |
| Posteromedial | 78.8 (77.2-80.3) | 77.4 (75.7-79.0) | 79.4 (77.9-81.0) |
| Missing (%) | 27 (20.0) | 12 (9.9) | 12 (9.3) |
| ***Single-leg Triple hop (cm)*** | | | |
| Left | 434.0 (423.3-444.7) | 427.4 (416.8-438.0) | 442.9 (431.3-454.6) |
| Right | 443.0 (431.7-454.3) | 437.4 (425.9-448.9) | 450.7 (438.5-463.0) |
| Missing (%) | 28 (20.7) | 13 (10.7) | 12 (9.3) |
| ***Jump-over-a-bar (number)*** | 35.0 (34.0-36.1) | 36.3 (35.5-37.0) | 38.6 (37.9-39.3) |
| Missing (%) | 27 (20.0) | 13 (10.7) | 12 (9.3) |

Table 2. Individual player exposure hours, injuries, team and individual adherence to the intervention for players in the control, and in the regular, coach-focused and comprehensive, player-focused intervention groups.

| | **Control (n=135) Mean (95% CI)** | **Regular (n=121) Mean (95% CI)** | **Comprehensive (n=129) Mean (95% CI)** |
|---|---|---|---|
| ***Exposure (hours)*** | | | |
| Total | 29.6 (27.5 - 31.7) | 29.9 (27.6 - 32.3) | 33.7 (31.5 - 35.9) |
| Practice | 12.6 (11.2 - 14.0) | 15.0 (13.7 - 16.2) | 16.9 (15.5 - 18.2) |
| Match | 17.1 (16.1 - 18.1) | 15.0 (13.7 - 16.3) | 16.8 (15.5 - 18.1) |
| ***Injured players*** | | | |
| All injuries (n, %) | 21 (15.6) | 25 (20.7) | 22 (17.2) |
| LE injuries (n, %) | 18 (13.3) | 21 (17.4) | 16 (12.5) |
| ***Adherence to 11+*** | | | |
| Weeks | 7.3 (6.9 - 7.7) | 11.4 (10.8 - 11.9) | 10.0 (9.7 - 10.4) |
| Team sessions | 16.3 (14.8 - 18.0) | 22.7 (20.9 - 24.5) | 23.7 (22.4 - 25.1) |
| Team sessions (%) | 73.5 (67.4 - 79.6) | 81.3 (75.7 - 86.9) | 85.6 (81.8 - 89.4) |
| Team sessions per week (#) | 2.3 (2.1 - 2.5) | 2.0 (1.8 - 2.2) | 2.4 (2.3 - 2.5) |
| Team 11+ exercises (#) | 127.1 (112.9 - 141.3) | 271.2 (246.5 - 295.8) | 258.3 (238.8 - 277.7) |
| Team 11+ exercises per session | 8.2 (7.6 - 8.8) | 11.5 (11.1 - 11.8) | 10.8 (10.4 - 11.2) |
| Player sessions (#) | 12.7 (11.3 - 14.1) | 16.7 (15.0 - 18.4) | 18.1 (16.9 - 19.2) |
| Player sessions (%) | 65.3 (59.0 - 71.5) | 74.0 (69.3 - 78.8) | 76.4 (73.2 - 79.6) |
| Player 11+ exercises (#) | 98.4 (86.4 - 110.4) | 196.4 (175.1 - 217.6) | 196.0 (180.2 - 211.8) |
| Player 11+ exercises per session (#) | 6.5 (5.8 - 7.3) | 11.0 (10.4 - 11.5) | 10.9 (10.5 - 11.4) |
| Adherence (n, %) | | | |
| High | 12 (8.9) | 63 (52.1) | 53 (41.1) |
| Medium | 47 (34.8) | 28 (23.1) | 53 (41.1) |
| Low | 76 (56.3) | 30 (24.8) | 23 (17.8) |

Table 3: Adherence among players randomized to the control, and to the regular, coach-focused and comprehensive, player-focused intervention groups. The control group served as reference group. Mean differences in adherence are presented with 95% CI. Negative values for confidence intervals are truncated at 0.

| | **Team adherence (%)** | | **Team sessions per week** | | **Team exercises per session** | |
|---|---|---|---|---|---|---|
| | Crude | Adjusted[1] | Crude | Adjusted[1] | Crude | Adjusted[1] |
| Comprehensive | 12.1 | 4.9 | -0.03 | 0.06 | 3.5 | 1.5 |
| | (0 - 37.9) | (0 - 36.0) | (0 - 0.7) | (0 - 1.1) | (0.6 - 6.4) | (0 - 4.1) |
| Regular | 7.8 | 6.4 | 0.1 | -0.3 | 4.7 | 2.7 |
| | (0 - 39.9) | (0 - 51.7) | (0 - 0.9) | (0 - 1.0) | (1.9 - 7.5) | (0 - 5.8) |
| Control | - | - | - | - | - | - |

[1]Adjusted for cluster, age group, level of play (tier), and previous injury in the past 6 weeks

Table 4: Injury risk (injury incidence per 1000 hours with 95% CI) among players randomized to the control, and to regular, coach-focused and comprehensive, player-focused intervention groups, and among players stratified into high, medium and low adherence groups. The control and low adherence groups served as respective reference groups. Crude and adjusted incidence rate ratios (IRR) are presented with 95% CI.

| | **Randomization** | | | | **Adherence** | | |
|---|---|---|---|---|---|---|---|
| | **Injury incidence** | **Crude IRR** | **Adjusted IRR[1]** | | **Injury incidence** | **Crude IRR** | **Adjusted IRR[1]** |
| ***All injuries*** | | | | | | | |
| Comprehensive | 6.5 (3.0 - 13.9) | 1.08 (0.46 - 2.53) | 1.37 (0.64 - 2.95) | High | 3.7 (2.1 - 6.5) | 0.43 (0.19 - 1.00) | 0.44 (0.18 - 1.06) |
| Regular | 8.4 (4.6 - 15.1) | 1.39 (0.69 - 2.82) | 1.61 (0.59 - 4.43) | Medium | 9.6 (6.6 - 14.1) | 1.11 (0.53 - 2.32) | 0.97 (0.47 - 2.00) |
| Control | 6.0 (3.8 - 9.3) | - | - | Low | 8.7 (4.6 - 16.5) | - | |
| ***Lower extremity injuries*** | | | | | | | |
| Comprehensive | 4.8 (2.2 - 11.0) | 0.97 (0.38 - 2.47) | 1.26 (0.57 - 2.78) | High | 3.4 (1.8 - 6.4) | 0.48 (0.19 - 1.16) | 0.52 (0.21 - 1.31) |
| Regular | 7.2 (4.1 - 12.8) | 1.43 (0.68 - 3.03) | 1.64 (0.63 - 4.24) | Medium | 7.6 (5.0 - 11.6) | 1.08 (0.51 - 2.30) | 0.97 (0.46 - 2.01) |
| Control | 5.0 (3.0 - 8.6) | - | - | Low | 7.0 (3.7 - 13.3) | - | - |

[1]Adjusted for cluster, age groups, level of play (tier), and previous injuries in the past 6 weeks

Figure 1: Flow of clubs through the study

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