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Effects of two exercise programmes on joint position sense, dynamic balance and countermovement jump in male amateur football players. A randomised controlled trial.

Running title: Effects of two exercise programmes on JPS, LSDT and CMJ in football.

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Abstract

Introduction: The injury prevention and warm-up exercises programmes improve physical performance and injury ratio, but it is poorly investigated in amateur football. Objectives: To assess the effects of two warm-up multi-station programmes (IAI-Programme and FIFA11+) through JPS, LSDT and CMJ. Study design: Randomised controlled trial. Methods: 36 football players were randomised into 2 groups: IAI-Programme (n=18) and FIFA11+ (n=18) and performed the intervention protocol for 6 weeks. JPS, LSDT and CMJ were measured at baseline, after 6, 10 and 18 weeks (from baseline). The inter-group and intra-group differences were assessed by repeated-measures analysis of variance test (ANOVA). Results: Significant differences between groups were found after 18 weeks in the absolute angular error (-2.18[-4.33,-0.047],d=0.69,$p<0.05$) of the JPS and in the CMJ ($p=0.001$,$\eta^2_{p=}$,0.298) in favour of IAI-Programme when compared to FIFA11+. No significant differences between groups were found in the LSDT. There were also intra-group differences observed in the LSDT in both groups. Conclusions: IAI-Programme can provide sensitive benefits with respect to the proprioceptive ability of knee flexion and CMJ than FIFA11+. Both IAI-Programme and FIFA11+ present improvements in the dynamic postural control measured by the LSDT. Due to the limitations of the study, these findings should be interpreted with caution.

Keywords: FIFA 11+; IAI-Programme; injury prevention programme; warm-up programme; proprioception.

Introduction

Warm-up and injury prevention programmes that include multi-station exercises (exercises distributed in sections (stations), thus, a multi-station programme is a programme with various sections) as a warm-up or as a prior part to the training session can have great influence on physical performance (proprioception, strength, dynamic balance… etc). One of the effects of these programmes is that they appear to reduce the injury incidence rate (Hübscher & Refshauge, 2013), however, the reason why this happens is unknown. It can only lead to suppositions such as physical improvements these programmes provide (neuromuscular, physical performance and proprioception improvements) having direct impact on injury incidence rate decrease. (Bittencourt, Meeuwisse, Mendonça, Ocarino, & Fonseca, 2016; Meeuwisse, Tyreman, Hagel, & Emery, 2007). Hamstring flexibility, lower body power, slow sprint speed and poor performance on a single-leg balance has been associated with musculoskeletal injury risk (de la Motte, Lisman, Gribbin, Murphy, & Deuster, 2019)

FIFA11+ is the most studied programme among the injury prevention and warm-up programmes in football. At a broader level, those multi-station protocols reduce in a 30-50% the injuries in football players, prevent and reduce risk factors of potential injuries and provide neuromuscular, physical performance and proprioception improvements (Al Attar, Soomro, Pappas, Sinclair, & Sanders, 2016; Ayala, Pomares-Noguera, et al., 2017; Bizzini et al., 2013; Daneshjoo, Mokhtar, Rahnama, & Yusof, 2012; Impellizzeri et al., 2013; Lopes, Simões, Rodrigues, Costa, & Ribeiro, 2018; Owen et al., 2013; Pánics, Tállay, Pavlik, & Berkes, 2008; Pérez-Silvestre et al., 2018; Sadigursky et al., 2017; Thorborg et al., 2017).

However, the effects of the FIFA11+ programme on adult amateur football players are poorly investigated. In our knowledge, there is a limited number of randomized trials that have studied its physical effects in comparison with a control group (Hwang & Kim, 2019; Impellizzeri et al., 2013; Nawed, Khan, Jalwan, Nuhmani, & Muaidi, 2018) or other interventions (Ayala, Calderón-López, et al., 2017). These trials have only studied its acute effects (Ayala, Calderón-López, et al., 2017) or post-intervention follow-ups (Hwang & Kim, 2019; Impellizzeri et al., 2013; Nawed et al., 2018). In addition, nobody has ever studied its effects in a mid-term follow-up in amateur football players. The FIFA11+ prevention and warm-up programme provides a limited number of exercises focused on sprinting, agility (in the first and last part of the programme), strength, plyometrics, balance and stability (in the second part of the programme) (Impellizzeri et al., 2013). It is possible that the second part of this exercise programme may be crucial with respect to physical performance improvements and to injury incidence reduction. For example, changing the second part of the FIFA11+ at the end of the training would improve its effectiveness on reducing injuries and the player's adherence to the programme (Whalan, Lovell, Steele, & Sampson, 2019). Furthermore, the second part of FIFA11+ does not include football-specific or coordination exercises or exercises oriented to specific match situations. Including this type of exercises could provide a higher physical performance improvement than the traditional exercises of the FIFA11+.

Our hypothesis is that a warm-up programme that includes sports-related, coordination and match situations exercises could provide more effective changes with respect to physical performance; for example in the joint position sense (JPS), in dynamic balance and in the jump height, post-intervention and in a mid-term

follow-up. The main objective of this study is to compare the effects of two warm-up multi-station programmes (experimental warm-up programme - IAI warm-up programme (IAI-Programme) – designed by one of the authors of the present paper; I.A.I., and a comparative warm-up programme - programme FIFA11+), performed for 6 weeks as a routine warm-up, on physical performance; proprioception as measured by knee JPS in closed-kinetic-chain, dynamic balance as measured by the lateral step-down test (LSDT) and jump height as measured by countermovement jump (CMJ) at the end of the exercise programme (6 weeks from baseline), 10 and 18 weeks follow-up from baseline. In addition, the secondary objective is to describe the physical demands of these warm-up multi-station programmes (FIFA11+ and IAI-Programme).

Methods

Design

A triple-blinded randomised controlled trial was designed for this investigation. The participants (amateur football players) were randomly allocated into the experimental or comparative group. Both experimental and comparative players continued their football training routines and the participants included a multi-station programme. The experimental group performed IAI-Programme as their warm-up and the comparative group performed FIFA 11+ as their warm-up, twice a week for 6 weeks. Outside the multi-station programme, training routines were similar for all football players, who trained 3 times (90 minutes long) per week and played 1 competition match per week. Training routines and both experimental and comparative multi-station programmes were delivered by a physical trainer and physiotherapists external to the investigation. JPS, LSDT and maximum CMJ were

measured in all players at baseline, 6 weeks after baseline, 10 weeks after baseline and 18 weeks after baseline. Evaluators did not know the group to which participants belonged. In addition, football players did not know about the existence of another intervention group to guarantee the adherence to the prevention programme that was assigned to them, and the blinding of the participants. We considered the JPS errors as primary outcomes and the LSDT and CMJ as secondary outcomes. This study took place during the football season and post-season to avoid the influence of physical preparations for competitions. More concretely, the recruitment period took place in April 2018; the intervention period started in May 2018 (season) and finished in June-July 2018 (end of season), and the follow-up finished in August-September 2018 (beginning of the next season). The intervention and assessment sessions were carried out in each of the clubs´ football field. This study was guided by the CONSORT guideline (Schulz, Altman, & Moher, 2010).

Participants

For this study, 36 amateur football player volunteers were randomly allocated into the experimental group (n=18) (IAI-Programme) or the FIFA 11+ group (n=18) (FIFA11+ programme). The participants performed the programme they were allocated to as their warm-up routine, for 6 weeks. All players completed at least the 80% of the training sessions. The characteristics of the sample can be seen in Table 1. The randomisation was carried out with the Epidat 4.0 (Galicia, Spain) programme. An external clinical assistant randomly assigned the intervention group-by-group, where each group is a football club, by using a computer-generated random sequence of numbers. The randomisation was carried out group-by-group to guarantee the blinding of all participants. The required

sample size was calculated using G*Power 3.1.9.2 Software for Windows. Repeated-measures analysis of variance test (ANOVA) within-between interaction was used in the system with absolute angular error (AAE) as the primary outcome measure. We considered an effect size of 0.25 for the AAE. Furthermore, we assumed an α level at 0.05 and a desired power (β) at 80. The correlation between repeated measurements was assumed at 0.5. Taking into consideration four measures and two treatment groups, the sphericity correction was determined at 0.75. We estimated a sample size of at least 30 participants, and 36 in case of dropout out of the 20%. The final sample comprised 36 participants.

Regarding the inclusion criteria, all participants had to be male, between 18 and 40 years old, be fit to participate in full training and match-play, have at least three years of experience in a regional level of football, be free of previous injury for at least the previous three months and have been training regularly for the last 6 weeks. The excluded participants included: those that have suffered a serious lower limb injury in the last 6 months, such as (1) fracture of the lower limb, (2) knee ligament injury, (3) grade 3 ankle sprain or (4) any surgical intervention in the lower limb. Prior to the beginning of the study, all participants signed the informed consent according to the Helsinki Declaration. This study is registered in the clinical trials database ClinicalTrials.gov (NCT03513978) and has received a favourable report from the Ethical Committee of the University of Alcalá (CEID-HU-2018-04).

Variables

Primary variables

- Knee JPS in closed-kinetic-chain: Use of a digital inclinometer (0.3° precision Limit® mini, 50 mm x 50 mm x 32 mm, Alingsas, Sweden) (range measured in degrees^{o}) to actively asses the knee JPS of the dominant lower limb in closed-kinetic-chain, following the method proposed by Romero-Franco, Montaño-Munuera, & Jiménez-Reyes (2016). The participants wore a mask throughout the entire JPS test to obstruct their vision. The participants had the dominant leg propped on a 5 cm high inclined surface and the non-dominant leg propped on a 30 cm high step. Their dominant limb´s knee was extended at the start. Afterwards, the knee was led to the target position (knee flexion angle of 45^{o} of the assessed limb), allowing them to memorise it in 5 seconds. Following this, participants returned to the initial position (knee extended) and were asked to actively bend the knee until the target position was achieved. Three attempts with a 2 seconds rest between each try were allowed. The achieved range of knee flexion during the reposition task in each attempt was registered. The average flexion range of the three attempts was compared to the target position, which allowed to obtain the JPS absolute angular error (AAE) and the JPS relative angular error (RAE). This procedure has shown to be a reliable tool to obtain proprioceptive errors (ICC=0.980) (Romero-Franco et al., 2016).

Secondary variables

- Dynamic balance as measured by LSDT: A 1 cm sticker was attached to each participant's tibial tuberosity to facilitate the visual assessment during the LSDT, and another sticker was attached to the step at second toe level. The LSDT was verbally explained to each participant and a simulation of it was done to make certain it was understood by all participants. As a

preparation, participants had 3 experimental try-outs before it commenced. After that, 5 consecutive trials were performed. During the LSDT, the examiner was located 3 m from the participant, while giving instructions about the motion speed and recording their performance on video. Each participant placed his dominant leg on a 20 cm height step, left the non-dominant leg hanging in the air and positioned their hands on both hips. To the examiner's sound signal, each participant lowered his non-dominant leg, maintained the position once touched the floor with the heel (without stepping on it) and stepped up to the examiner's second sound signal. The participants followed the examiner's instructions and lasted 2 seconds to step down and 2 seconds to step up. Subsequently, the examiner evaluated the LSDT performance and wrote it down on a 7-point scale (0-6). According to the criteria established by Piva et al. (2006), a total score of 0-6 is considered "good" movement quality, a total score of 2-3 is considered "moderate" movement quality and a total score of ≥4 is considered "bad" movement quality. This test has proven sufficient reliability to measure dynamic postural balance during the functional task (Piva et al., 2006; Rabin & Kozol, 2010; Rabin et al., 2014) and a minimal detectable change (MDC) of 0.6 (Bagherian, Ghasempoor, Rahnama, & Wikstrom, 2018).

- CMJ: The application MyJump2 v5.0.6 for iOS 11.0 or higher (provider Carlos Balsalobre-Fernández, 2016, Spain, Madrid) was used to assess CMJ and it was recorded with an iPhone 6S with 720p camera at 240 fps. This app has shown a high level of reliability (ICC >0.99) with the force platform and the intra- and inter-operator agreement (ICC = 0.98-0.99) to assess jump (Rogers et al., 2018) and coefficient of variation percentage is 4.5-4.9%. The

CMJ test was performed following the protocol suggested by Balsalobre-Fernández, Glaister, & Lockey (2015). The CMJ was evaluated using the maximum jumping height (cm) reached in two attempts. Rago et al., 2018 showed that the minimal detectable change in jump height, measured with CMJ, is 1.5 centimetres, turning CMJ into a reliable test–retest (ICC [95% CI] = 0.97 [0.91; 0.99]) when realised with MyJump2 app.

- GPS physical demands assessment. The measurements were taken using the GPS & GNSS OptimEye S5 CatapultSport tool with a 10Hz GPS and an inertial system: 10 Hz 3D accelerometer 100Hz, 100Hz 3D gyroscope, 10 Hz 3D magnetometer, an automatic synchronisation polar system for the measurement of the players, which is a valid tool for this type of assessment (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014; Luteberget, Holme, & Spencer, 2017; Nicolella, Torres-Ronda, Saylor, & Schelling, 2018) taken in different training days to observe the training load during the sessions. The variables registered was the average time in minutes, average total distance in metres, average heart rate in beats per minute, average time in maximum heart rate zone (≥80%), average maximum velocity in km/h, average number of jumps, average distance covered >13.9 km/h in metres, average total number of accelerations and decelerations, TRIMP (Edwards, 1993), average total PlayerLoad, average PlayerLoad (up direction%), average PlayerLoad (forward direction%) and average PlayerLoad (side direction%).

- ***Interventions***

Both exercise programmes have a similar organization. Both are divided into three parts. The first and third part consist in a general warm-up. The second part (the main one) is the one that differs in the two programmes. It includes three

levels of progressions. The second part of FIFA11+ consists of six body-load exercises that all players perform simultaneously. The second part of IAI-Programme consists of 22 stations (sections) in which the players rotate to different sections, in addition, exercises are carried out with external load (unstable surface and weights) and match-situations. Both programmes intend to improve mainly physical performance and strength, however, as explained before, the main difference between them is the second part (See Table 2) which may be relevant for the results. IAI-Programme (I.A.I. programme; the experimental programme) includes more sport-specific exercises such as match-context exercises like jump and head-butt or neuromuscular control exercises like controlling the landing during a jump, in comparison with the FIFA11+ programme, which seems to focus more on general strength, agility and neuromuscular exercises (control and stability exercises).

The IAI-Programme (experimental group). The experimental programme of exercises consisted in a multi-station programme designed for agility, plyometrics, strength and balance training according to prior studies (Daneshjoo, Mokhtar, Rahnama, & Yusof, 2013; Pánics et al., 2008). As mentioned before, it was designed by one of the authors of the present study (I.A.I.). The innovative features of this programme are the incorporation of unstable surfaces and exercises related to specific match situations. The exercises of the programme can be seen in **Table 2**, its level of difficulty increased every 2 weeks. The protocol was performed 2 times per week. All players completed at least the 80% of the training sessions.

FIFA11+ warm-up program (comparative group*).* The program players followed was the one proposed by FIFA 11+ (Sadigursky et al., 2017), its level of difficulty increased every 2 weeks. The protocol was performed two times per

week. The measurement of the players (n=18) was taken to observe the program load. All players completed at least the 80% of the training sessions

Data collection protocol

All players were evaluated before the training session that took place 72 hours after a previous competition and 96 hours before the next competition. One week before the first evaluation, players were asked to participate in the study, and we collected descriptive data (demographic data and data related to previous injuries) through a questionnaire. After that, the initial assessment of the players was carried out. The CMJ, LSDT and JPS tests were carried out, in that order, ending with a second CMJ. We used the maximum jump height reached for the data analysis.

Prior to the training, with the objective of standardising the measurements, all players performed a standardised warm-up before each measurement in order to avoid muscular post-activation which can occur due the differences between both warm-ups (FIFA11+ and IAI-Programme). The warm-up lasted 15-20 minutes and included running (5 minutes of moderate intensity continuous running) and running and mobility exercises: 2x15 metres of skipping, 2x15 metres of contra-skipping, 2x15 front leg lifts, 2x15 metres of posterior leg lifts, 2x15 metres running hip-out y 2x15 metres running hip-in. Later, players continued with a specific high intensity strength and running part, in which they performed: 2x6 squats, 2x6 split squat, 2x6 ankle flexion-extension with jump, 2x6 horizontal jumps, 2x6 jumps with shoot with head gesture and sprint of 4x10 metres (40 seconds recovery between exercises and 20 seconds recovery between series). Once performed the proposed warm-up,

they rested for 5 minutes before performing the assessment. This procedure was equal in all the measurements.

Statistical Analyses

Descriptive statistics were used to describe the baseline characteristics of the sample. Shapiro Wilk test and symmetry graphs were performed to check the data for normality. Student's t-test and Fisher exact tests were applied to determine if there were baseline differences between groups.

An intra-rater reliability analysis of LSDT and CMJ test was conducted. An intraclass correlation coefficient (ICC) was calculated under the assumption of a two-way mixed model with absolute agreement and average score for LSDT (ICC3,5) and single score for CMJ test (ICC3,1) with 95% confidence intervals. The standard error of measurement (SEM) was calculated as the squared root of the mean squared error of the mixed-model analysis of variance. The minimal detectable change with 95% confidence bounds was calculated using the formula SEM*√2*1.96.

To analyse the effects of the two interventions, an intention-to-treat analysis was performed. Analysis of the variance (ANOVA) was performed to determine the between-group and within-group differences because of the study design. One-way repeated measures ANOVA was used to evaluate within-group differences, as the within subject factor (the time of measurement with four levels: baseline, 6 weeks after baseline, 10 weeks after baseline, 18 weeks after baseline). Two-way ANOVA with intervention (experimental group, comparative group) as the between-subject factor, and time (mean difference 6 weeks to baseline, 10 weeks after, 18 weeks after, respectively) as the within-subject factor. ANOVA was

followed by post-hoc Bonferroni pair-wise comparison. The effect size (ES) was calculated as the Partial Eta Squared (η^2_p). An effect size of 0.01 was considered small, 0.06 medium and 0.14 large (Gray & Kinnear, 2012). Furthermore, ES was calculated for CMJ, proprioception changes and LSDT when pairwise comparison showed significant differences, according to the procedure proposed by Cohen, considering the following criteria: ≤ 0.2 (small), >0.2 and <0.8 (moderate) and ≥ 0.8 (large) (Sullivan & Feinn, 2012).

Statistical analyses were performed using SPSS 22 (SPPS Inc, Chicago, IL, USA). The significance level was set at $p<0.05$.

Results

Fifty participants were screened in the study, but only 36 volunteers participated in the investigation and 4 dropped out of the trial. No participant showed harms or unintended effects during the intervention period of study. The Figure 1. Flow Diagram shows the process.

No between-group differences were found at baseline (Table 3). Table 4. shows values of the JPS, CMJ and LSDT.

Reliability of the measurements

Regarding the intratester intraclass correlation coefficient, we analysed the same video recording (of the LSDT of ten amateur football players) twice and it reported a reliability of 0.98 (95% CI= 0.94; 0.99), the error standard of the measurement was 0.11 (5.09% error of measurement percentage) and a MDC of 0.33 (14.12% MDC percentage) in our study.

The intraclass correlation coefficient of CMJ was calculated using the data of the two attempts of ten amateur football players. The CMJ reported a reliability of ICC= 0.98 (95% CI = 0.89 – 0.99), an error of measurement of 0.98 (2.94% error of measurement percentage) and MDC of 2.73 cm (8.15% MDC percentage) in our study.

Proprioception precision (Joint position sense in closed-kinetic-chain)

In AAE, within-group showed that the IAI-Programme group exhibited decreased values and a large ES over time (F=3.868, gl=2.23, P=0.026, η^2_p=0.185). The pairwise comparison showed significant differences and a moderate ES after 6 weeks from baseline, compared to baseline (P=0.048, d=0.781). No group-by-time significant differences were found in the IAI-Programme group (F=1.46 gl=3, P=0.234, η^2_p=0.08). No major group-by-time differences were found in the mean difference when compared to baseline (F=0.62 gl:2 P=0.541, η^2_p =0.018). The between-subjects effect of interactions per group was not meaningful (F=2.84, P=0.101, η^2_p=0.077). The pairwise comparison showed a significant decrease and a moderate ES in favour of the IAI-Programme (P=0.045, d=0.69) 18 weeks after baseline.

In RAE, no differences within-group were found neither in the IAI-Programme group (F=0.033, gl=3, P=0.992, η^2_p=0.002.) nor in the FIFA11+ group (F=1.11, gl=3, P=0.351, η^2_p=0.062). The group-by-time interaction (F=0.06, gl=1.6 P=0.994, η^2_p<0.001) and the between-subjects effect of interactions per group (F=1.51, P=0.227, η^2_p=0.043) were not meaningful.

Dynamic balance (Lateral step-down test)

In LSDT, statistically significant within-group differences and a large ES were found in the IAI-Programme group (F=12.45, gl=3, P<0.001, η^2_p= 0.423) and in the FIFA11+ group (F=7.24 gl=3, P<0.001, η^2_p=0.299). The pairwise comparisons in the IAI-Programme showed significant differences and a large ES 6 weeks after baseline (P<0.001, d=1.54), 10 weeks after baseline (P<0.001, d=1.57) and 18 weeks after baseline (P=0.007, d=1.02) compared to baseline. The FIFA11+ group showed significant differences and a large and moderate ES 10 weeks after baseline (P=0.005, d=0.91) and 18 weeks after baseline (P=0.034, d=0.69) compared to baseline. Neither a significant group-by-time interaction was found (F=0.335, gl=2, P=0.717, η^2_p =0.010) nor a significant between-subjects effect of interactions per group (F=2.37, P=0.132, η^2_p =0.065).

Countermovement jump (CMJ)

In CMJ, statistically significative within-group differences and a large ES were found in the IAI-Programme group (F=7.85, gl=3, P<0.001, η^2_p=0.316) but not in the FIFA11+ group (F=1.86 gl=3, P=0.147, η^2_p= 0.09). The pairwise comparisons in the IAI-Programme group showed significant differences and a moderate ES 6 weeks after baseline (P=0.006, d=0.612), 10 weeks after baseline (P=0.024, d=0.584) and 18 weeks after baseline (P=0.011, d=0.62) compared to baseline. No significant group-by-time differences were found (F=1.23, P=0.297, gl=2, η^2_p=0.035). Significant differences between-subjects effect of interactions per group were found and large ES (F=14.43, P=0.001, η^2_p=0.298). The pairwise comparisons between-groups showed statistically significant differences and a large ES 6 weeks after baseline (P=0.009, d=0.92), 10 weeks after baseline (P=0.002, d=1.14) and 18 weeks after baseline (P<0.001, d=1.33).

Physical demands of the warm-up exercise programme

Regarding the IAI-Programme, there were 24 players with different training days in order to observe the training load during the sessions. The results are the following: average time of 28:18 (1:55) minutes, average total distance of 1,003.53 (183.31) metres, average heart rate of 126.83 (13.38) beats per minute, average time in maximum heart rate zone (≥80%) of 2.85 (3.67) minutes, average maximum velocity of 19.85 (2.98) km/h, average number of jumps 37.71 (16.90), average distance covered >13.9 km/h 44.72 (24.95) metres, average total number of accelerations 282 (35.62) and decelerations 306.92 (43.64), TRIMP (Edwards, 1993) 48.75 (17.44), average total PlayerLoad 139.98 (24.97), average PlayerLoad (up direction %) 45.64 (1.93), average PlayerLoad (forward direction %) 28.01 (2.06) and average PlayerLoad (side direction %) 26.34 (1.18).

Regarding FIFA11+ warm-up programme, there were 18 players performing their training in different days in order to observe the training load during the sessions. The results are the following: average time of 22:17 (1:01) minutes, average total distance of 1,149.81 (110.14) metres, average heart rate of 105.62 (39.56) beats per minute, average time in maximum heart rate zone (≥80%) of 0.65 (0.88) minutes, average maximum velocity of 22.49 (1.76) km/h, average number of jumps 30.67 (7.50), average distance covered >13.9 km/h 44.49 (23.96) metres, average total number of accelerations 235.39 (38.38) and decelerations 265.83 (45.10), TRIMP (Edwards, 1993) 27.50 (13.78), average total PlayerLoad 140.00 (16.40), average PlayerLoad (up direction %) 47.54 (2.55), average PlayerLoad (forward direction %) 27.35 (2.74) and average PlayerLoad (side direction %) 25.09 (1.83). All players completed at least the 80% of the training sessions.

Discussion

To the best of our knowledge, this is the first research that investigates the effects of two multi-station exercise programmes for 6 weeks (FIFA11+ and IAI-Programme, performed as part of the training routine of football 11vs11 players) on physical performance in post-intervention and mid-term follow-ups. The main finding is that IAI-Programme can increase the proprioceptive ability, in mid-term follow-up, along the season and at the beginning of the next season. With respect to the dynamic balance, during the mid-term follow-up, significative improvements were obtained in both groups. Only IAI-Programme showed statistically significant improvement in the jump height over time. In addition, the IAI-Programme provides better results on the vertical jump height measured with CMJ and on the proprioceptive precision measured with JPS in comparison with the FIFA11+ programme.

In addition, it is the first research that investigates the physical demands of injury prevention and warm-up programmes, more specifically, the FIFA11+ and IAI-Programme programmes. Also, with respect to the characteristics of these programmes, both are adequate for inclusion in a warm-up before training or match as their duration is short (range between 22 min (FIFA11+) and 28 min (IAI-Programme)) and the total distance covered is short as well (around 1000 metres in both cases).

Proprioception ability

Despite the lack of prospective studies, the proprioceptive precision changes in patients with a knee pathology as cruciate ligament injury before surgery (Mir, Talebian, Naseri, & Hadian, 2014; Suarez et al., 2016) and after rehabilitation

(Relph & Herrington, 2016), in patients with severe and chronic cruciate ligament rupture (Lee, Lee, Ahn, & Park, 2015), as well as in patients with patellofemoral syndrome (Baker, Bennell, Stillman, Cowan, & Crossley, 2002) or after exhausting exercise (Mohammadi, Azma, Naseh, Emadifard, & Etemadi, 2013; Salgado, Ribeiro, & Oliveira, 2015). These findings denote that the loss of JPS caused by fatigue or previous musculoskeletal disorders may be crucial in the occurrence of future injuries, (Mir et al., 2014; Mohammadi et al., 2013; Suarez et al., 2016) as well as in the sports performance (Sevrez & Bourdin, 2015). During the JPS test the IAI-Programme group showed an improvement of about 33% to 44%, while the FIFA 11+ group showed merely about -17% to 20%. Only the IAI-Programme showed significant within-group differences and a large ES, however, significant between-group differences were only observed after 18 weeks from baseline. Our results are similar to other studies' results that have assessed the effects of the warm-up programmes in open kinetic chain (Daneshjoo et al., 2012; Pánics et al., 2008; Pérez-Silvestre et al., 2018). Pérez-Silvestre et al. (2018) found an improvement of 27% in the AAE using a multi-station protocol with a follow-up of 10 weeks in futsal players. Panics et al. (2008) found an improvement of 64% in the AAE in the JPS test after the entire season of handball players. Daneshjoo et al. (2012) found an improvement of 2.8-3% after 2 weeks.

RAE is another variable that determines the proprioceptive ability. This variable helps us determine whether proprioceptive errors overestimate or underestimate the target position along the JPS test. Some studies associate a large RAE to persons that do not exercise, elderly persons (Ribeiro & Oliveira, 2010; Venâncio, Lopes, Lourenço, & Ribeiro, 2016) and to moments right after a football match (Salgado et al., 2015). There is a lack of normal data in open kinetic chain,

nevertheless, on the one hand, there are normal RAE data in open kinetic chain ranging from $0.02^{o} \pm 1.65^{o}$ and $4.18^{o} \pm 3.40^{o}$, in healthy persons that exercise and that do not exercise respectively (Ribeiro & Oliveira, 2010). On the other hand, Salgado et al.(2015) reported a $-1.5° \pm 4.2°$ RAE in football players. Our results do not show differences in the RAE. A possible reason for the lack of differences in this variable is that specific and individual interventions aimed to the direction of the error are required, which can be useful when performing treatments and prevention strategies in players that present an altered JPS (Pérez-Silvestre et al., 2018). Future investigations are needed to observe the effects of fatiguing efforts performance on the RAE and to determine whether implementing exercise programmes can decrease the changes caused by the RAE. Our results are similar to the ones obtained by Pérez-Silvestre et al. (2018) that neither showed significant differences.

Dynamic balance

The poor score in LSDT has been associated to persons with knee (Ferreira et al., 2018; Mostaed, Werner, & Barrios, 2018) and ankle (Grindstaff, Dolan, & Morton, 2017; Rabin & Kozol, 2010; Rabin et al., 2014; Rabin, Portnoy, & Kozol, 2016) disorders. Several studies have proved neuromuscular programmes to have an effect on dynamic balance and stabilisation (Ayala, Pomares-Noguera, et al., 2017; Bagherian et al., 2018; Bizzini et al., 2013; Daneshjoo et al., 2013). Bagherian et al. (2018) showed a 1.9 score on LSDT improvement with a motor control program, our results showed a 0.84 and 0.46 change with IAI-Programme and FIFA11+ programmes, respectively, at the end of intervention (6 weeks). Bagherian et al. (2018) obtained a MDC of 0.61, in our study the MDC was 0.33. In the results of this study, both groups show major changes on each of the follow-up stages when

compared to MDC of our study, in addition IAI-Programme shows major changes on each follow-up stage when compared to MDC of Bagherian et al. (2018) while FIFA 11+ only shows greater changes than MDC of Bagherian et al. (2018) after 10 weeks from baseline. It is for this reason that IAI-Programme indicates a greater improvement of the dynamic balance than FIFA11+, despite the lack of statistical significance.

Jump height

Regarding to CMJ, FIFA11+ programme did not show changes in the vertical jump height, furthermore, the FIFA11+ group diminished 2.19 cm the jump height, which is not statistically relevant and this change is not greater than the MDC obtained in our study (2.73cm), but it is greater that the MDC reported by Rago et al 2018 (1.5cm). Furthermore, the IAI-Programme group enhanced 3.38 to 3.75 cm the jump height over time, which is statistically significant and greater than the MDC obtained in our study and Rago et al. 2018. This finding is similar to the ones reported by other studies that have examined the influence of FIFA11+ protocol (Ayala, Pomares-Noguera, et al., 2017; Impellizzeri et al., 2013; Lopes et al., 2018) or other programmes similar to FIFA11+ (Pérez-Silvestre et al., 2018; Vitale, La Torre, Banfi, & Bonato, 2018). There are other programmes, as the Harmoknee programme (Ayala, Pomares-Noguera, et al., 2017) that have showed an improvement of the jump height which was measured with a 2.1 cm drop jump after 4 weeks of training (Ayala, Pomares-Noguera, et al., 2017). We obtained a similar finding in the IAI-Programme group, which obtained an improvement of 3.44 cm after 6 weeks of performance of the exercise programme. The jump significantly improved in the IAI-Programme group, in which the ES obtained was large within and between-groups. The lack of statistical significance in the

difference between mean time values suggests that the change is due to the intervention and that these changes persevere over time. This finding reveals a strength improvement in players after performing the IAI-Programme. Śliwowski, Grygorowicz, Wieczorek, & Adczak (2018) found a relation between the strength of the right and left leg knee extensor muscles (quadriceps) and the CMJ in young elite players. This improvement indicates that the features of this new programme, as the planning, the use of sport-related activities, plyometric type exercises and unstable surfaces that intend to improve the players power, lead to greater changes in the physical performance. This may be crucial in the IAI-Programme, as the improvement of these variables is related to the physical fitness and it can have a positive impact on sports performance.

Physical demands of warm-up exercise programmes

The differences between the two programmes could justify the differences in the physical performance. The GPS data provide enough data to consider both exercise programmes as warm-up programmes, as these last 20-30 minutes (the duration of warm-ups normally oscillates between 20-30 minutes) and the total distance covered is less than 2 kilometres, which does not allow for severe fatigue. The IAI-Programme includes specific exercises oriented to the competition, for example clash and fight for the ball, with the objective to improve the anticipation and to prevent contact injuries. The main finding of the GPS data is that the IAI-Programme exercises are more intense in comparison with the FIFA11+ exercises. IAI-Programme showed a greater value in TRIMP and heart rate. Also, the number of jumps was greater in the IAI-Programme, which may justify the greater improvement in the CMJ performance in the IAI-Programme group. With respect to these findings, Hewett et al. (1996) observed that with a training focused on

jump, the hamstring activation improves, and the ACL load (Hewett et al., 1996) and the incidence of injuries are reduced (Hewett, Lindenfeld, Riccobene, & Noyes, 1999). However, the total distance is greater in the FIFA11+. Other of the interesting variables is the number of deacceleration, there was a greater number of deacceleration in the IAI-Programme than in the FIFA 11+. Considering that the deacceleration is one of the mechanisms of non-contact injuries (Klein, Henke, & Platen, 2018) in special of the ACL, IAI-Programme can provide better prevention strategy for this injury as it contains a more specific training workload related to deacceleration. All these results suggest that IAI-Programme could be more adequate in high intensity activities (e.g, a match) that FIFA11+. However, FIFA11+ is a warm-up and injury prevention programme highly contrasted and provides a great benefit in the decrease of the injury rate (Al Attar et al., 2016), thus, we cannot recommend the IAI-Programme above the FIFA11+, nevertheless, as mentioned before, it provides better results in high intensity activities which are more similar to real match situations. More investigation about the effects of IAI-Programme in injury rate is necessary to confirm our hypothesis. IAI-Programme performed as a warm-up, can be useful for coaches, amateur, and elite players to improve general strength. In addition, our results suggest that at the end of the season, it could be beneficial for the players to be more prepared for trainings and matches, which could reduce injuries, as it may reduce risk factors related to them (JPS, postural control, strength, etc.).

Strengths, limitations, considerations for practice and future directions

The strengths of this study are the following: the methodological rigour, the carefully developed design (selection criteria), as well as the blinding of the examiners, participants and the persons in charge of the intervention performance.

Nevertheless, our investigation has some limitations. For example, the lack of a control group without intervention does not allow us to observe the effect of time on the groups, however, the reason for not including a control group without intervention is the evidence of FIFA11+ decreasing the number of injuries, therefore, measuring a control group without intervention would be ethically wrong. Also, our inclusion age criteria were wide, from 18 to 40 years. Physical performance may be affected by the age of the player, however, no differences in age were found between the groups we compared. It would be important to divide the groups by age range in future investigations. Although the training of all teams had the same duration and was performed 3 times per week, and all played one competition match, there may be differences in the training planning, the groups may be different, and this may affect the results of the study. However, these factors are impossible to control due to the different objectives and managements of each team.

This research showed that warm-up programmes can positively influence the physical performance of amateur football players. The most well-known and studied warm-up and prevention programme is FIFA11+. Its benefits on the injury incidence and its ease of implementation make it a great option for the daily practice in amateur football. However, according to the findings of this research, adding more sports-related, coordination and match situations exercises could provide a better improvement in physical performance. Nevertheless, increasing the number of sections in a warm-up certainly requires coaches' and physical trainers' effort and external resources (sport equipment for example), therefore, the implementation of the IAI-Programme could be slightly harder than the implementation of FIFA11+. In addition, although the CMJ values (3.38; 3.23 and

3.75 cm) and the LSDT values (-0.84; -0.86; -0.67) in the IAI-Programme are greater than the MDC (CMJ MDC: 2.73 cm; LSDT MDC: 0.33), they are close to it. However, the IAI-Programme showed statistically significant results in comparison with FIFA11+: after intervention (Mean difference: 3.44 cm), after 4 weeks (Mean difference: 4.24 cm) and 12 weeks of follow-up (Mean difference: 5.08 cm). Nevertheless, more research with a greater number of participants and different population is necessary to extrapolate and confirm our findings.

Conclusion

In conclusion, IAI-Programme can provide sensitive benefits with respect to the proprioceptive ability of knee flexion and CMJ than FIFA11+. Both IAI-Programme and FIFA11+ present improvements in the dynamic postural control measured by the LSDT. Due to the limitations of the study, these findings should be interpreted with caution. Further investigation is necessary to confirm these findings through a new line of study.

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Table 1. Sample characteristics.

Variable (N = 36)		Mean	±SD
Age (years)		24.97	3.54
Weight (kg)		73.06	7.94
Height (m)		177.50	7.72
BMI kg/m^2		23.13	1.31
Experience (years)		16.83	5.92
Player's position*	Goalkeeper	3	8.3%
	Full-back	5	13.9%
	Center	4	11.1%
	Midfielders	11	30.6%
	Wingers	3	8.3%
	Withdrawn striker	4	11.1%
	Center - Forwards	6	16.7%
Dominant limb*	Right	24	66.7%
	Left	12	33.3%

*Absolute frequency and percentage of the categories are presented.

Table 2. IAI-Programme multi-station prevention programme

	Type of exercise	Level 1	Level 2	Level 3
Warm-up **[2x40m/1x40m]x2**	Running: soft	Forward		
	Running: moderate	Forward		
	Running: moderate	Hip out/hip in		
	Running: moderate	Running technique: hip flexion/ extension – forward and backwards		
	Running and jump with shoulder contact	External leg drop/ lateral running changes	Inner leg drop/ lateral running changes	Shoulder contact and drop in countermovement/ lateral running changes
	Running: lateral	Low hip lateral straight ahead and backwards running	Low hip lateral forward and backwards running	Low hip lateral forward and backwards running
	Running: quick	Forward and backwards plant & cut	Forwards and backwards plant & cut, jump at the frontal cut	Forwards and backwards plant & cut, jump at the back cut
IAI-Programme* **[22 stations]**	Front bench	Static	Unstable surface	Alternate supports (arms and legs) on unstable surface
	Sideways bench	Static	Unstable surface	Lateral and rotatory trunk movements on unstable surface
	Squats	Resistance belt	Resistance belt	Resistance belt with external load (disk or medicine ball) depending on the participant´s physical ability
	Hamstrings	Resistance belt	Resistance belt	Nordic exercise
	Gluteus, abductors and external rotators	Isometric with resistance band	Dynamic with resistance band	Side steps with resistance band
	Gluteus, adductors and internal rotators	Isometric with resistance band	Dynamic with resistance band	Hip extension with resistance band
	Proprioception and balance	Jump and double-leg landing on unstable surface	Jump and single-leg landing on unstable surface	Jump and landing on unstable surface with closed eyes
	Lumbo-pelvic stability	Balance on fitball (on knees) with external supports	Balance on fitball (on knees) without external supports	Balance on fitball (the between legs) without external supports – Isometric adduction hip strength
	Competition related exercises: jumps and receiving	Jump and head the ball	Jump and head the ball after it bounced (imbalance provoked by the trainer when jumping)	1v1 competitive jump and receiving
	Recovery and competitive jumps and receiving	Throw ball to partner	Throw ball to partner with bounce	1v1 competitive jump and receiving
	Quadricep and iliopsoas	Quadriceps with resistance band	Hip flexors and psoas with resistance band	Hip flexors and psoas with resistance band
	Coordination: practice with stairs	Frontal variations	Lateral variations	Single leg and backwards variations
	Gluteus	Lying down, hip abduction with resistance band (lateral lifts of legs)	Lying down, hip adduction lifting both legs	Raised position, hip abduction lifting both legs
	Lumbo-pelvic stability	Quadruped superman	Sideways hip swings on fitball	Hip swings and mobility on fitball, holding a 2 kg medicine ball
	Competition related exercises: plyometric jumps and run	Skipping with hurdle front and lateral jumps	Plyometrics with hurdles and sprint	Plyometrics with hurdles and sprint driving the ball
	Hamstring and gluteus	Bridge	Single leg bridge with resistance band	Bridge on fitball
	Squats, calf and soleus	Isometric squat	Dynamic squat with ankle extension	Squat with jump

	Abdomen and hip abductors	Eccentric abdominal exercise and abduction with resistance band	Eccentric abdominal exercise, abduction with resistance band	Eccentric abdominal exercise, abduction with resistance band
	Competition related exercises: 1v1 drills	1v1 shielding the ball with semi-passive defender	1v1 keeping possession of the ball	1v1 small-sided game (SSG) in tight space with small goalposts
	Competition related exercises: 1v1 drills	1v1 contact and unbalance a player with football ball	1v1 keeping possession of the ball	1v1 small-sided game (SSG) in tight space with small goalposts
	Gluteus and quadriceps strength	Lunge with rotation	Lunge with rotation (medicine ball 2kg)	Lunge with rotation (4 kg medicine ball)
	Proprioception and balance	Double-leg standing on unstable surface	Single leg on unstable surface	One leg on unstable surface, imbalance (passing the ball to the hands or feet)
High intensity [2x40m/1x40m]	Running: bounding	Front and lateral		
	Running: jumps	Vertical jumps and pull out when drop		
	Running: bounding and sprint	Speed progression/ backwards bounding half of the distance and sprint till the end		
	Running: sprint	Speed progression to sprint		

*30 seconds for each exercise station, 20 seconds recovery between stations

Table 3. Baseline homogeneity between groups.

Variable		IAI-Programme group (n = 18) Mean (±SD)	FIFA 11+ group (n = 18) Mean (±SD)	P value
Age (years)		25.83 (3.98)	24.11 (2.88)	P=0.148$
Weight (kg)		73.35 (7.08)	72.77 (8.91)	P=0.829§
Height (cm)		176.83 (6.56)	178.16 (8.88)	P=0.612§
BMI kg/m^2		23.42 (1.33)	22.85 (1.27)	P=0.197§
Dominant limb†	Right	13 (72.2%)	11(61.1%)	P=0.725‖
	Left	5 (27.3%)	7(38.9%)	
EAA (º)		4.46 (2.97)	3.80 (2.30)	P=0.466§
EAR (º)		1.29 (4.87)	-0.91 (4.17)	P=0.154§
LSDT (0-6)		2.00 (0.54)	2.29 (0.67)	P=0.168§
CMJ (cm)		35.30 (5.84)	37.34 (5.62)	P=0.293§

† Absolute frequency and percentage for the categories are represented. § Student's t-test for independent samples was used. $ Welch's t-test for independent samples was used ‖ Fisher's exact test was used

Table 4. Values of joint position sense test, lateral step-down test and countermovement jump

	Baseline	Post6Wk	Post10Wk	Post18Wk
AAE (degrees)				
FIFA11+ Group‡	3.80 (2.30)	3.32 (1.68)	3.03 (2.17)	4.49 (2.57)
IAI-Programme Group‡	4.46 (2.97)	2.47 (1.74)	2.47 (2.03)	2.95 (1.54)
Within-group differences compared to baseline†				
FIFA11+ Group		-0.48 (-2.59, 1.62)	-0.77 (-3.28, 1.74)	0.68 (-1.65, 3.02)
IAI-Programme Group		**-1.98 (0.10, 3.96)***	-1.98 (-4.77, 0.797)	-1.507 (-3.61, 0.597)
Between-group differences compared to mean differences to baseline†		-1.5 (-3.47, 0.47)	-1.21 (-3.77, 1.337)	**-2.18 (-4.33, -0.047)***
RAE (degrees)				
FIFA11+ Group‡	-0.91 (4.17)	0.86 (3.60)	0.59 (3.67)	0.8 (5.1)
IAI-Programme Group‡	1.29 (4.87)	1.25 (2.68)	1.02 (3.03)	1.09 (3.14)
Within-group differences compared to baseline†				
FIFA11+ Group		1.78 (-1.93, 5.49)	1.50 (-1.84, 4.85)	1.71 (-2.29, 5.72)
IAI-Programme Group		-0.033 (-3.66, 3.60)	-0.27 (-3.75, 3.20)	-0.2 (-3.14, 2.74)
Between-group differences compared to mean differences to baseline†		-1.81 (-5.35, 1.72)	-1.77 (-5.06, 1.51)	-1.91 (-5.31, 1.47)
LSDT (0-6)				
FIFA11+ Group‡	2.29 (0.67)	1.83 (0.78)	1.66 (0.69)	1.84 (0.62)
IAI-Programme Group‡	2 (0.54)	1.16 (0.54)	1.14 (0.54)	1.33 (0.73)
Within-group differences compared to baseline†				
FIFA11+ Group		-0.46 (-0.97, 0.50)	**-0.62 (-1.09, -0.16)****	**-0.45 (-0.87, -0.02)***
IAI-Programme Group		**-0.84 (-1.18, -0.48)****	**-0.86 (-1.33, -0.38)****	**-0.67 (-1.18, -0.16)****
Between-group differences compared to mean differences to baseline†		-0.37 (-0.8, 0.044)	-0.23 (-0.68, 0.21)	-0.22 (-0.67, 0.23)
CMJ (cm)				
FIFA11+ Group‡	37.34 (5.62)	36.81 (4.70)	35.93 (4.43)	35.14 (4.47)
IAI-Programme Group‡	35.30 (5.84)	38.68 (4.54)	38.54 (5.05)	39.05 (4.89)
Within-group differences compared to baseline†				
FIFA11+ Group		-0.52 (-3.99, 2.93)	-1.40 (-4.64, 1.83)	-2.19 (-5.8, 1.41)
IAI-Programme Group		**3.38 (0.85, 5.92)****	**3.23 (0.33, 6.14)***	**3.75 (0.716, 6.79)***
Between-group differences compared to mean differences to baseline†		**3.44 (0.917, 5.97)****	**4.24 (1.61, 6.87)****	**5.08 (2.48, 7.67)****

Baseline = prior intervention measurement; Post6Wk = measurements six weeks later; Post10Wk = measurements ten weeks later; Post18Wk = measurements eighteen weeks later; AAE = absolute angular error; RAE = relative angular error; LSDT = lateral step down test; CMJ = countermovement jump †Values are given as mean (95% confidence interval); ‡Values are given as mean (standard deviation); * $p < 0.05$ Adjusted with Bonferroni; ** $p < 0.01$ Adjusted with Bonferroni;

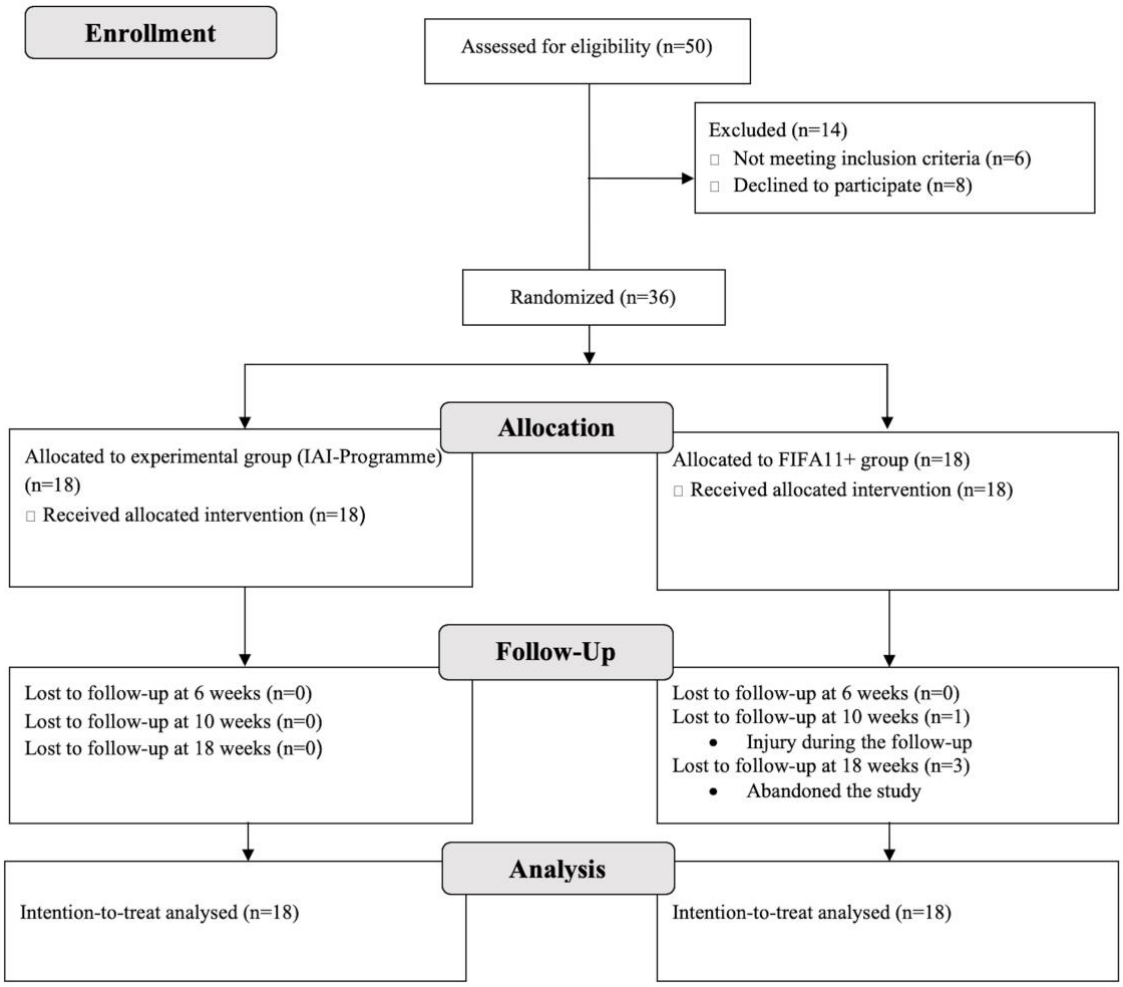

Figure 1. Flow Diagram shows the process.