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Football players' combined effect of coordination, balance, proprioception and core stability exercises in terms of injury prevention and improvement of performance: A randomised trial

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Abstract
Purpose: The goal of the current study was to compare the combined effects of coordination, balance, proprioception, and core stability training to home-bound strengthening exercises in terms of lower limb injury prevention and performance of football player.
Materials and Methods: Randomised trial, thirty football players aged 15 to 17 years**.** The experimental team was preferred with the combined exercises of coordination, balance, proprioception, and core stability and the control team was preferred with the lower limb home-bound strengthening exercises. After four weeks, the outcome measures were noted down in terms of the prevention of lower limb injuries and performance of football player.
Results: In the cardiovascular endurance outcome variable, the average ladder drill time for the experimental team was 3.58 seconds with a SD of 0.95 and for the control; the team was 4.14 seconds with a SD of 0.59. The mean difference ($p = 0.062$) was not statistically significant. In the speed outcome variable, the average 40 yard speed test time for the experimental team was 4.77 seconds with an SD of 0.05 and 4.83 seconds with an SD of 0.07 for the control team. For speed, the mean difference ($p = 0.012$) was statistically significant. In the agility outcome variable, the average agility T-test time for the experimental team was 16.76 seconds with a SD of 0.58 and for the control; the team was 17.41 seconds with a SD of 0.44. In terms of agility, the mean difference ($p = 0.002$) was statistically significant. In the Power outcome variable, the average Wingate power test time for the experimental team was 11.52 seconds with a SD of 0.89 and for the control; team was 10.80 seconds with a SD of 0.75. For power, the mean difference ($p = 0.023$) was statistically significant.
Conclusion: This study showed that the combined effect of coordination, balance, proprioception, and core stability exercises was an effective and feasible method of reducing the number of lower limb injuries and improving the performance of football players.

Keywords: Co-ordination, balance, proprioception, core stability training, football players

Introduction
Due to the financial and competitive repercussions of lost time, injury prevention is still a hot topic in professional football. The two main current approaches to reducing injury burden are either reducing primary injuries through prevention-based strategies or reducing the risk of secondary injuries when they do occur. Primary injury reduction strategies seem to be largely successful and may have contributed to a decrease in incidence over the past 20 years. However, recurrent and/or severe muscle and ligament injuries make for less-than-ideal re-injury risk management strategies [1]. These days, performance optimization is a crucial, data-driven technique in any competitive sport. It is a widely used technique to gather intricate data about the player's performance and physiological characteristics. Ultimately, the aim is to maximize the player's performance, so this is done to develop a personalized training programme [2].
The degree of adaptability and complex reaction time is significant for a player's effectiveness in a one-on-one football game in attack, and complex reaction time is significant for a player's effectiveness in the game in defence. The degree of coordination motor skills, such as adaptability and complex reaction time, is related to a player's overall effectiveness in a one-

On-one football game [3]. In soccer, maintaining a single-leg stance while shooting, dribbling, and passing the ball requires balance. The dynamic process of balance, also known as postural control, keeps the body in balance. Static, dynamic, and functional balance can all be categorized. Static balance is less important for player movement than dynamic and functional balances, which involve maintaining the centre of gravity (COG) over a moving base of support [4].

Proprioceptive control is essential for all complex motor activities, including riding a bicycle and sports like football that are characterized by situational variables. Proprioceptive sensitivity is essential for all sports, including figure skating, which requires a strong sense of balance and complete mastery of technical movements [5]. The idea of core stability (CS) has gained popularity in recent years, and exercises to improve central stability are frequently included in physical conditioning, training, and sports medicine regimens. However, there are disagreements and misunderstandings regarding how to train the stability, strength, power, and resistance of the core structures because the concept of CS is ambiguous in the scientific literature and the professional world [6].

Leg strength increases metabolism, enhances balance and coordination, and safeguards our joints from harm. Leg exercises can help keep our ankles, knees, and hips in good condition as we age. Despite the fact that walking is a great cardiovascular exercise, it doesn't tone the legs as much as targeted leg exercises do [7]. Technical and tactical skills, as well as physical fitness, have been extensively studied over the past 20 years and are important game-time factors that distinguish elite, sub-elite, and non-elite youth soccer players. However, conflicting results make it challenging for soccer coaches and other people involved in sports (such as talent agents and sports club managers) to put the findings about the relationship between skill and fitness into practise [8].

Hence, the purpose of this study was to find out the combined effect of Co-ordination, Balance, Proprioception and Core stability exercises when compare to lower limb home-bound strengthening exercises in order to prevent the injuries and improve the performance of football players. The primary objective was to compare the number of lower-limb injuries sustained by a football players between experimental and control team during a game. The secondary objective was to compare the various skills of the players between experimental and control team during a game through observation.

Materials and Methods

Study Design

Randomized Trial

Intervention

This research study was conducted at the SVJCT's sports academy in December 2022. The study protocol was approved by the institutional scientific and ethics committee of SVJCT's BKL Walawalkar College of physiotherapy, Sawarde, Maharashtra on 30/09/2022 (EC/NEW/INST/2020/320) before the commencement of the study. The total sample size for this study was thirty football players with a normal physique.

The inclusion criteria were 15 to 17-year-old male football players with normal physique, no recent injury or lower extremity pain in the previous six months, and no history of vertebral column surgery in their lifetime.

Football players with scoliosis, kyphosis, lordosis, or chronic low back pain, musculoskeletal injuries within the last six months, any mental disorders, or limb length discrepancy were excluded.

The two teams had been selected from SVJCT's CBSE School who are studying 9th and 10th standard. The informed consent form was taken from all players before the assessment. The pre-participation screening was done using Physical Readiness Questionnaire (PAR-Q form) Performa for assessment was filled by interviewing the players which include information about Age, Gender, Height, Weight, BMI, Dominant leg for kick, years of experience, history of injury and surgery. Randomly, one team was selected as the experimental team and the other team was selected as the control team. The experimental team consisting of 15 players attended an individual session with a physiotherapist to learn how to effectively do the combined exercises of co-ordination, balance, proprioception, and core stability and the control team consisting of 15 players attended an individual session with a physiotherapist to learn how to effectively do the home bound strengthening exercises. The training protocol for both interventions comprised the same standardized educational and exercise components.

As shown in Figure 1, thirty players had undergone football training under the same coach. The coach had trained the two teams on a football field. The experimental team was trained with the combined exercises of coordination, proprioception, balance, and core training and the control team was trained with the lower limb home-bound strengthening exercises only.

Experimental team

The experimental team's intervention was combined exercises of coordination, balance, proprioception, and core stability provided by a student physiotherapist. Each co-ordination exercise, balance exercise, proprioception exercise, and core training consist of Rapid response stationary speed cones and hurdles drills (3 times within 3 minutes), side lunge (10 rep in each leg), Wobble board squats (10 rep × 1,2 & 3 sets) and Knee tuck crunches (10 rep × 1,2 & 3 sets) respectively. In Rapid response stationary speed cones and hurdles drills, The 10 cones were placed in a line 1 foot distance between each cone similarly and the 10 hurdles were placed in a line 1 foot distance between each hurdle similarly. The team was asked to side run on the line of the cone 3 times and further jump over the hurdle for 3 times within 3 minutes. Then, the team was instructed to do side lunges for 10 repetitions in each leg. Later, the team was allowed to do squats on the wobble board for 10 repetitions in 3 sets. Finally, the team was encouraged to do knee tuck crunches for 10 repetitions in 3 sets. These all exercises were worked out in one session. Like this, 4 sessions per week for 4 weeks. Along with these exercises, the team was practised with a usual football training program.

Control team

The control team was not shown, taught, or prescribed the combined exercises of coordination, balance, proprioception, and core stability that were prescribed for the experimental group. The control team underwent to strengthen their lower limbs by doing home-bound strengthening exercises such as heel rise, marching, mini squat, and step up. In heel raise, the team was asked to lift their heels and hold them for 10 seconds in 10 repetitions. In Marching, the team was asked to raise their knees to waist level repeatedly and alternatively for 1 minute. In Mini squat, the team was instructed to squat half and hold it for 10 seconds in 10 repetitions. Finally, in Step

up, the team was asked to step on the staircase repeatedly and alternatively for 1 minute. These exercises were completed in a single session. As in, four sessions per week were for four weeks. Along with these drills, the team went through a standard football training program.

The teams were then evaluated using manual muscle testing (MMT) for hamstring/quadriceps ratio, cardiovascular endurance by Ladder drills in seconds, Speed by 40 Yard test in seconds, Agility by T-Test in seconds, and Power by Wingate test in watts/kg. Before the play, all of the values were recorded.

Before the match, the warm up was done by both the teams as per coach guidelines for 10 to 15 minutes [9]. Later, the football match was played between the experimental team (n=15) and the control team (n=15) in SVJCT's BKL Sports complex grass football ground of Walawalkar campus for 1 hour, with 30 minutes for each session. There was a 10-minute break between the two sessions. The entire match was captured on camera in order to analyse the team's performance. Several injuries were reported during the game, including quadriceps strain, hamstring strain, calf strain, ankle sprain, and ACL tear. Ball possession, Passing accuracy, number of tackles, number of saves, and number of shots were used to create post-match statistics.

Data analysis

The collected data were entered into Excel software and analysed using R software version 4.0.1. Continuous variables were presented as mean and standard deviation, while categorical variables were presented as count and percent. The means of the experimental and control groups were compared using an independent student t-test. $p < 0.05$ was considered statistically significant.

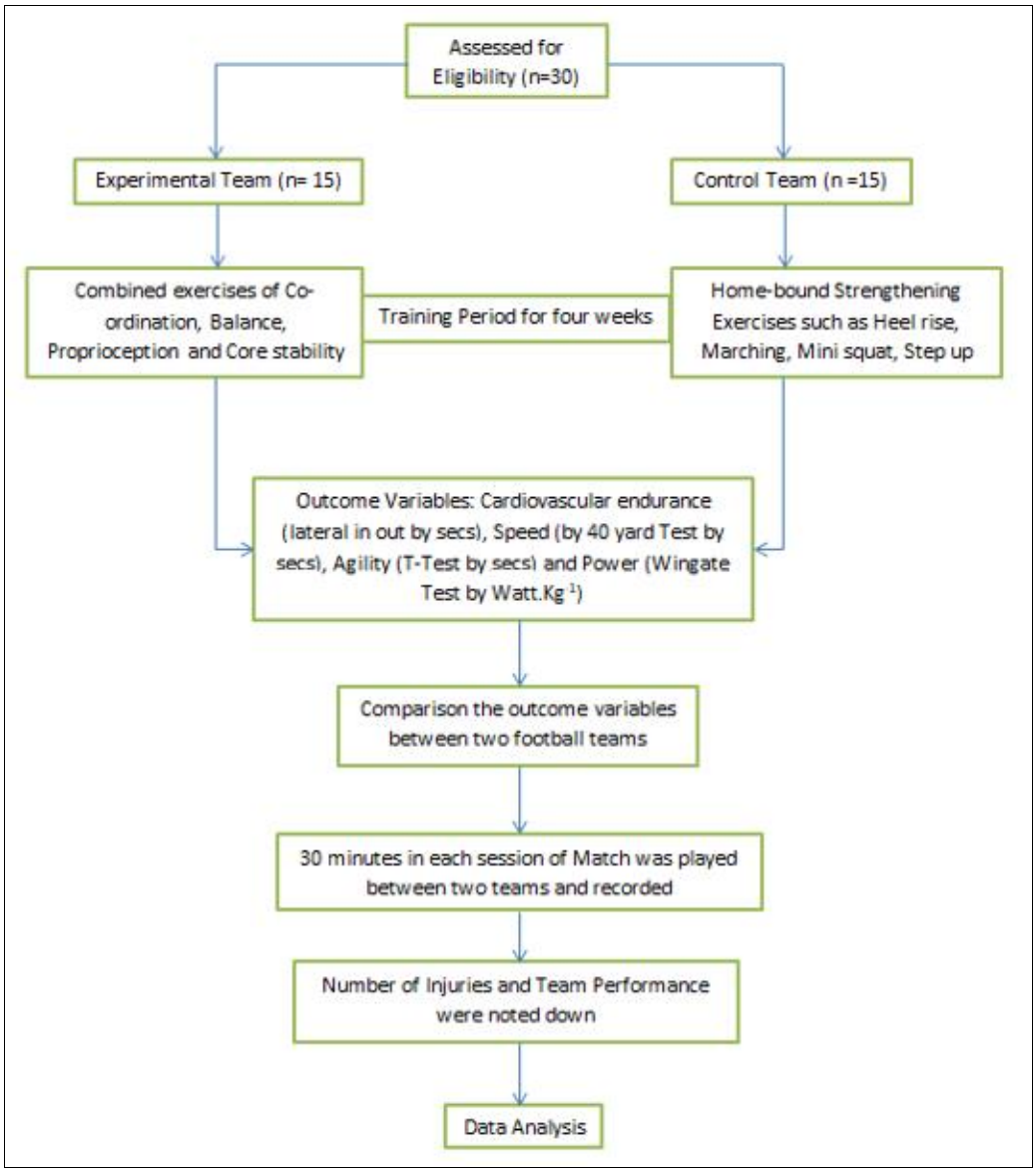

Fig 1: Consort diagram illustrating the study design

Results

Table 1: Baseline characteristics of the football teams

Characteristics	Experimental team		Control team	
	Average	SD	Average	SD
Age (Years)	15.80	0.41	16.07	0.26
BMI (Kg/m^2)	19.38	2.63	20.37	3.99

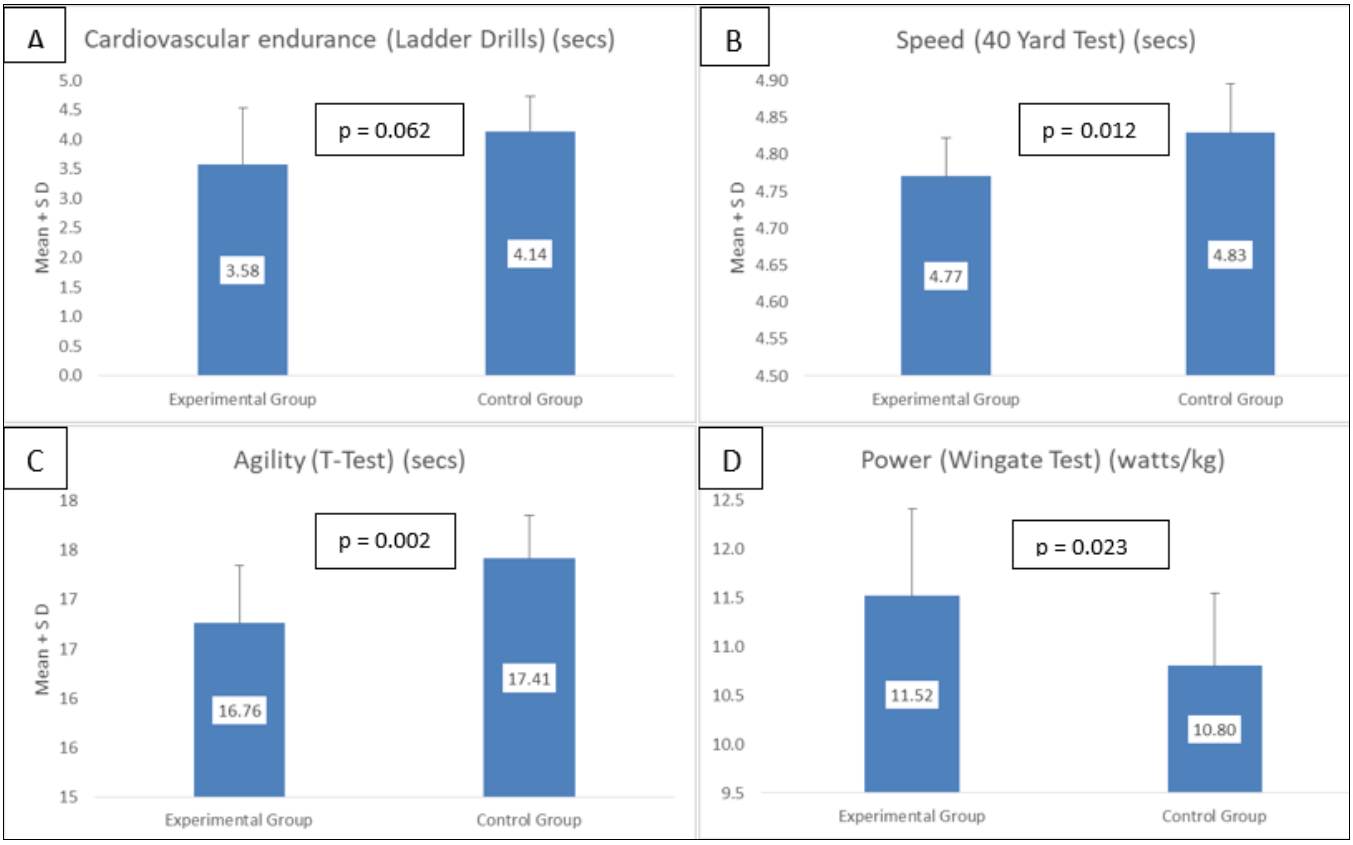

Fig 2: Outcome variables between two football teams

Players in the experimental and control teams are listed by their initial characteristics in Table 1. In the experimental group, the average age was 15.80 years with standard deviation of 0.41, the average height was 161.53 cm, the average weight was 50.53 kg, and the average BMI was 19.38 kg/m^2 with standard deviation of 2.63. In the control group, the average age was 16.07 years with standard deviation of 0.26, the average height was 158.73 cm, the average weight was 52.2 kg, and the average BMI was 20.37 kg/m^2 with standard deviation of 3.99.

Figure 2.A provides values of outcome variables in Cardiovascular endurance (Ladder drill) (Sec) between the experimental and control team. Figure 2.B provides values of outcome variables in Speed (40 Yard Test) (Sec). Figure 2.C provides values of outcome variables in Agility (T-Test) (Sec). Figure 2.D provides values of outcome variables in Power (Wingate test) (Watts/Kg).

The average ladder drill time for the experimental team was 3.58 seconds with a standard deviation of 0.95, and for the control team it was 4.14 seconds with a standard deviation of 0.59 for the cardiovascular endurance outcome variable. A statistically not significant difference in the mean was found ($p = 0.062$). The average 40 Yard Speed Test time for the experimental team was 4.77 seconds with a standard deviation of 0.05 and 4.83 seconds with a standard deviation of 0.07 for the control team in the speed outcome variable. Speed had a statistically significant mean difference ($p = 0.012$). The average Agility T-Test time for the experimental team was 16.76 seconds with a standard deviation of 0.58, while the time for the control team was 17.41 seconds with a standard deviation of 0.44 for the Agility outcome variable. The mean difference in agility ($p = 0.002$) was statistically significant. The average Wingate power test time for the experimental team in the Power outcome variable was 11.52 seconds with a standard deviation of 0.89 and was 10.80 seconds with a standard deviation of 0.75 for the control team. The mean difference for power was statistically significant ($p = 0.023$).

Injury and performance data were recorded throughout the match. Comparing the experimental team to the control team, fewer injuries occurred. The team's performance was also superior in the experimental team compared to the control team. The match ended with a 2-1 victory for the experimental team.

Table 2: Post-match statistics of the football teams

Sr. No	Variables	Experimental team	Control team
1	Quadriceps strain	0	1
2	Hamstring strain	0	1
3	Calf strain	1	2
4	Ankle sprain	1	2
5	ACL tear	0	0
6	Ball possession (As team)	63%	37%
7	Passing accuracy (As team)	67%	33%
8	Number of tackles (As team)	9	5
9	Number of saves (As team)	4	2
10	Number of shots	8	4

According to Table 2, the experimental team suffered fewer lower limb injuries than the control team, including quadriceps strains, hamstring strains, calf strains, ankle sprains, and ACL tears. Furthermore, it states that the experimental team performed better than the control team in terms of ball possession, passing accuracy, number of tackles, number of saves, and number of shots.

Discussion

This randomized trial was the first to examine how coordination, balance, proprioception, and core stability training affect football players' performance and injury risk. According to analyses of the trial's data, the exercise program generally harms injury rates in this population. Additionally, the player's performance was enhanced by the exercise regimen. As a result, the exercise program may be very important in preventing injuries during football game. Finally, baseline values and outcome values were contrasted. It demonstrated that there were sizable differences between these values.

Football players aged 10 to 13 was improved all-around football skills when coordination drills were used in conjunction with structured football training. [10]. Proprioceptive ability can be improved by applying for a 20-minute balance training program throughout at least 18 training sessions. The daily balance program and the three-times-per-week program both led to improvements in balance. So, knowing that the effectiveness was the same for both frequencies, the soccer coach can choose the right frequency of balance exercise based on their own training schedule. [11]. The level of physical fitness development and performance for abilities specific to soccer can both be improved through the design and implementation of a Proprioceptive Training (PT) programme. To maximise the development of skills before reaching the age of performance and to maximise sport performance, coaches should incorporate such programmes as a part of the standard soccer training programme. The effects of implementing a PT programme depend on the age characteristics, level of training, and characteristics of the soccer game [12]. Although not statistically significant, Core stability (CS) programmes with high levels of specificity would be better suited to produce improvements in change-of-direction manoeuvrability, while general CS programmes with lower levels of specificity would produce higher improvements in sprint ability. Sports-specific actions in young male soccer players could be improved by both general and targeted CS programmes [13].

The body mass index, body fat percentage, sit and reach, standing long jump, Yo-Yo intermittent recovery level 1 (VO2max), 5 metre sprint, 30 metre sprint, T-test (left), and T-test (right) had a significant influencing effect on the football playing ability among male players under the age of 14 [14]. According to the study's findings, the tested groups of wide midfielders (WM), central midfielders (CM), attackers (AT), and goal keepers (GK) performed significantly different when it came to flying sprints, with WM showing significantly better ability than the other groups and GK performing significantly worse than central defenders (CD) and full backs FB. In the A505N test, midfielders outperformed goalkeepers, and in the YYIR1 test, goalkeepers had significantly slower completion times than outfield players. [15] A majority of biomechanical and a few physical measures improved with the 11+'s medium-to-long-term implementation, but technical skills did not change. Utilizing the 11+ before competitions requires caution because it may significantly impair technical/physical performance [16].

The FIFA 11+ is a warm-up programme that every team should use because it lowers the likelihood of injuries and improves football players' performance [17]. For soccer players of both sexes older than 13, the FIFA 11+ warm-up program was effective in preventing injuries [18]. The study's findings suggested that while a multicomponent injury prevention training program may be suitable for lowering the number of muscle injuries sustained throughout a season, it might not be enough to lower all injuries [19]. One year after a hip fracture, force production, gait speed and endurance, and physical performance were all improved by a 10-week program of twice-weekly progressive homebound strengthening exercises for the leg muscles [20]. Structured neuromuscular training lasting a longer amount of time was superior to training lasting a shorter amount of time for increasing lower extremity flexibility during a single training session [21]. Soccer clubs and coaching programs should concentrate on improving coaches' education in three key areas: reinforcing the effectiveness of interventions, altering coaches' perceptions of the amount of time needed to carry out these interventions, and providing access to intervention resources. And finally, all youth soccer coaches should be required to take coaching courses that emphasize intervention programs [22]. The development of skills most likely to lower players' risk of lower limb injuries was not given enough focus in current football training sessions. The most recent scientific findings regarding efficient injury prevention need to be better translated into coaching methods [23].

The information gleaned from this investigation's data can be used in several real-world ways to enhance elite teams' football performance. To boost the effectiveness of offensive sequences, it may be particularly important to use training techniques that increase shooting accuracy. It may be advised to use quick attacking routines (with and without opponents) with the main goal of shooting on goal with a minimal amount of passes to enhance the team's offensive play. Utilizing drills to sharpen tactical skills during corners (both when attacking and defending) could be crucial for football performance because this aspect of the game is a blatant indicator of successful and unsuccessful teams in La Liga [24]. The importance of this position for team success should also be taken into consideration by coaches and scouts given the correlation between the total number of points earned at the end of the season and the number of shots on goal saved by the goalkeeper in this league. Therefore, these observations may have useful ramifications that indicate how professional soccer teams—particularly weaker teams—might advance the sport. [25] Our findings identified 4 key variables that were associated with team function and performance across a variety of industries; (i) leadership styles, (ii) supportive team behaviour, (iii) communication, and (iv) performance feedback. High-performance teams wishing to improve performance should examine these factors within their team and its environment. It was widely acknowledged that the dynamics of team function was important for outcomes in high-performance sports, yet there was little evidence to provide guidance [26].

Limitations

There were a few limitations in this study: One camera was used to record the game, and one sports analyst evaluated the post-match statistics. Players' diets were not taken into account during the four weeks of training. During the match

break, drinks and refreshments were not noted. The quality of player's football spikes shoes were not taken into consideration. The findings of this study were based solely on one match.

Conclusion

The results of this study demonstrates that the combined effect of coordination, balance, proprioception, and core stability exercises decreased lower limb injuries in experimental teams compared to control teams. Additionally, the experimental team performed better than the control team in terms of team performance. These drills might prevent unnecessary injuries in young football players during a game. To confirm this finding, further studies are needed with multiple teams and matches, among professional football, rugby, basketball, and hockey players.

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Conflict of Interest

There is no conflict of interest among the authors.

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