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Physiological adaptations and endurance unveiled: The impact of structured fitness training on elite youth soccer players

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ABSTRACT

Fitness training enhances endurance in soccer players. The study aimed to determine the effect of a Motophysic Fitness (MPFIT) training program on the physical and technical skills of twenty youth soccer players with an average age 20±1 years, height 1.71 ± 0.5 m, and weight 64.3 ± 5.7 kg. It consisted of a 12-week intervention period during the off-season. The MPFIT training was designed to improve physical fitness in terms of endurance, taking into account the players' positional differences. Yo-Yo Intermittent Recovery Test Level-1 (Yo-YoIRT1) was implemented to measure endurance before and after training. The outcome of Yo-YoIRT1 was assessed in terms of total distance covered in meters, the level achieved and estimated VO2max. Maximum heart rate was also measured to analyse the impact of MPFIT training. The MPFIT regime offered an average of 2% increase in fitness level of the players in all positions. Z-test revealed that significance p-values for the level achieved and VO2max were determined to be p=0.004 and p=0.02, respectively. The study provided substantial evidence supporting the viability of MPFIT regime as an innovative form of high-intensity training and implemented by individual players for self-assessment and by trainers for enhancing the soccer player fitness.

KEYWORDS

Heart Rate; High Intensity Training; Physical Fitness; Yo-Yo Intermittent Recovery Test

1. INTRODUCTION

Physical fitness plays a vital role in sports activities. It focusses on health and skill related fitness. Cardiovascular stamina, strength, endurance, flexibility, Body Mass Index (BMI), muscular endurance, balance, and coordination contribute towards health-related fitness. These factors determine the overall health and well-being of individuals. On the other hand, skill-related fitness focuses on specific abilities related to coordination, agility, power, reaction time, balance, and speed. These skills are often important for specific sports or activities. Developing these fitness skills is achievable through a variety of exercises, including cardiorespiratory activities, strength training, flexibility training, balance and coordination exercises, and sport-specific training. Enhancing these fitness skills not only benefits physical health but also contributes to mental well-being and improved overall functioning in daily life (Brandes et al., 2019). In certain sports such as soccer, basketball, and handball, players are consistently challenged to perform rapid sprints, quick changes in direction, with their balance and coordination at peak levels throughout the entire duration of the game. Among the above-mentioned sports, soccer needs good speed endurance as the player has to perform the transitions at a high level without experiencing fatigue. This helps them to maintain a competitive edge over opponents (McCormack et al., 2022). In soccer, players with good speed endurance can make swift transitions and are less prone to injuries because they can retain their fitness even when fatigued (Thron et al., 2022). Soccer is one of the intermittent sports that requires a combination of various abilities from players. It includes the physical attributes such as endurance, speed, agility, BMI and strength, and technical attributes like dribbling, passing, shooting, and ball control. Tactical understanding and decision-making are also crucial in soccer, as players need to read the game, anticipate movements, and make effective choices on the field.

Furthermore, cognitive abilities such as concentration, spatial awareness, and quick thinking are essential for success in soccer game (Sporis et al., 2008). In terms of physical demand, on an average, a professional male soccer player will run 9-12 kilometres throughout the duration of a game. The ferocity of a soccer game is often close to the anaerobic threshold, which means players operate around 80 to 90% of their maximum heart rate (HRmax). This level of intensity requires a high level of cardiovascular fitness. The ability to sustain intense efforts throughout the game requires endurance (Mohr et al., 2003; Stone et al., 2009). High-intensity interval training (HIIT) and SSGs improve athletes' endurance in football game. Both methods can effectively enhance fitness components (Kellmann, 2010; Clemente et al., 2022). A study was carried out to measure the stability and flexibility of soccer players using the FIFA 11+ warm up exercise. It provided

information regarding the players' ability for coaches, trainers, and players who wish to implement effective warm-up strategies into their workout schedules (Asgari et al., 2022). A study investigated the performance and physical characteristics of distinct positions of Gaelic football players. They evaluated anthropometric measurements and examined the players' fitness and their performance (Shovlin et al., 2018). A study assessed the maximal strength, explosive strength, and aerobic endurance of the players through various tests and measurements. The analysis provided valuable insights about the importance of strength and endurance in the performance of elite soccer players. It highlighted the need for appropriate training and conditioning strategies to enhance these attributes and optimize player performance on the field (Helgerud et al., 2011). From the aforementioned review of the scientific literature, it is inferred that endurance is important for soccer players to execute powerful movements during play. Hence there is a necessity to evaluate the endurance of the player with appropriate method.

An exhaustive survey was conducted to examine the various available methods for measuring endurance. Endurance can be measured using various tests which include Yo-Yo Intermittent Recovery Test (Yo-YoIRT), cooper test, shuttle run test, and beep test. All these tests fundamentally use different analysis methods to measure endurance. The various analysis methods include assessing of VO2max, distance covered and time taken for completion. VO2max represents the maximum amount of oxygen that an individual can consume while doing intense exercise. It is a crucial indicator of aerobic endurance and cardiovascular fitness. The Cooper test, a widely used field test to measure aerobic fitness, is employed in a study to examine the biomechanical aspects that affect endurance performance (Apte et al., 2022). The shuttle run test is widely used to measure the individual's endurance capacity. The test's goal is to perform as many shuttles as possible within a set period of time or until the individual reaches' exhaustion (Brito et al., 2022). The beep and bleep tests are commonly used fitness assessments for evaluating the endurance and performance of athletes in various sports. These tests are employed to evaluate a swimmer's overall swimming performance as well as their aerobic capacity and endurance (Corry et al., 1982; Bujnovky et al., 2019). A detailed analysis was conducted to understand the usage of Yo-Yo Intermittent Recovery Test (Yo-YoIRT) by various studies for measuring the endurance. Based on an analysis of annual publication trends (Figure 1), it is evident that the first article on Yo-YoIRT was published in Scopus in 2003. From that point until 2009, the growth rate remained relatively constant but insignificant. From 2010 to 2021, the average number of papers that incorporated Yo-YoIRT published in Scopus ranged from the upper nine articles to the lower five articles. However, between 2013 and 2020, there

has been a notable increase in the number of researchers concentrating on this research topic. This interest surge led to an exponential increase in the quantity of articles published in the Scopus database, which reached nearly 9 in 2020. From this analysis the authors are able to infer that, Yo-YoIRT is used extensively by various researchers to measure endurance. Visualization Of Similarity (VOS) viewer software helps to visualize the research carried out in a particular field using appropriate keywords (Yuetian Yu et al., 2020).

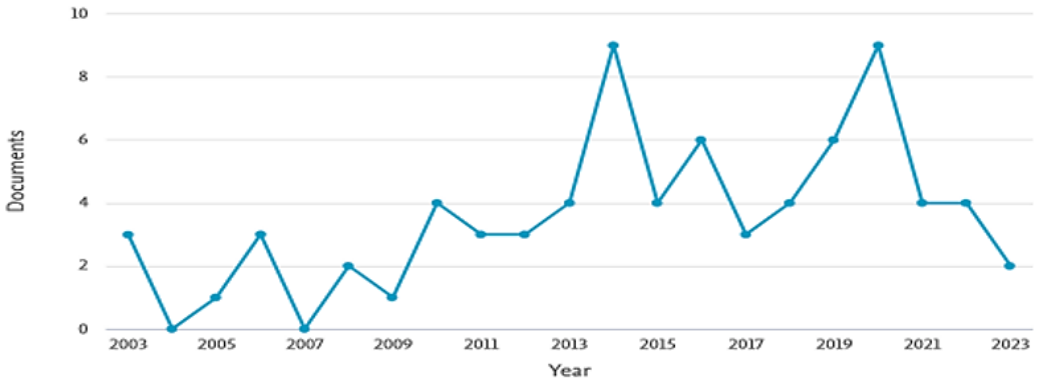

Figure 1. Yo-YoIRT's Annual Publication Growth, 2003– 2023

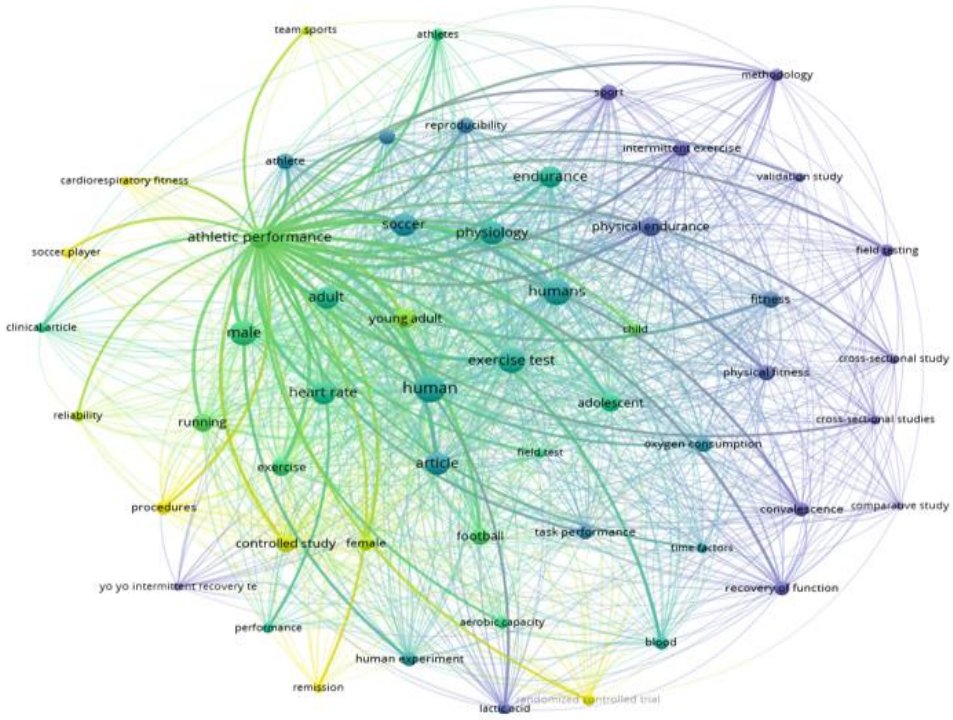

Figure 2. Yo-YoIRT – co-occurrence keyword network

It provides valuable insights about the relationships between different keywords in the form of a network. In this network, keywords are depicted as coloured circles, and the shape of each circle is proportional to the frequency with which each term appears in the titles and abstracts of the publications. In this study, the authors used VOS viewer software for reviewing the context of each research sample record, and examining the selected articles' content. In this regard, the authors identified the acceptability and adoption for Yo-YoIRT by researching keyword co-occurrences. Around 896 publications used 4,420 keywords. Figure 2 represents network analysis of keyword occurrences. The keyword Yo-YoIRT was extensively used by various authors who performed endurance related studies. From the extensive study it can be clearly inferred that Yo-YoIRT is used widely for endurance measurement.

In sport activities, training plays a vital role to improve the players' performance. The duration of training and the type of workouts to be given are crucial aspects in training. It helps to determine and analyse the players' fitness condition. Most of the fitness evaluation studies implement 3-weeks, 6-weeks or 8 weeks training program to analyse the technical skills (Sporis et al., 2008; Stone et al., 2009; Kellmann, 2010). The YoIRT1 was used by various studies to assess endurance level of soccer players (Castagna et al., 2009; Buchheit et al., 2013; Eken et al., 2022). Hence, the proposed study aims to develop a 12-week MPFIT training for soccer players and analyse their endurance using Yo-YoIRT1.

2. METHODS

2.1. Design

The present study adopted a single-group observational approach to evaluate the impact of a 12-week MPFIT training regimen on the performance of elite soccer players. The training schedule was divided into two key phases: the 0th week, which served as the control period prior to the implementation of MPFIT regime, and the 12th week, marking the post-intervention phase. Players' endurance levels were assessed using the Yo-YoIRT1, conducted at specified points during the training period. To support effective recovery and physiological adaptation, a mandatory 24-hour rest period was incorporated each week. Additionally, to preserve the consistency and accuracy of the study outcomes, players were restricted from participating in competitive matches throughout the entire 12-week program.

2.2. Participants

The study was conducted at Hindustan Institute of Technology and Science, a reputed private university in Chennai, India. Prior to the commencement of the research, institutional approval and a no-objection certificate were obtained to ensure ethical compliance (Ref No: HITS/SPESS/I/22). Informed written consent was collected from each participant after a detailed explanation of the study's objectives, procedures, and timeline. This process ensured transparency and confirmed their voluntary participation. A total of 30 elite soccer players were initially considered for the study. Following a preliminary screening for availability, 25 players were shortlisted, as 5 were unavailable due to national-level tournaments and training camps. Further assessment of health status led to the exclusion of 5 players who were either recovering from injuries or under rest. Consequently, 20 healthy and eligible players were selected and completed the entire 12-week training program. The participants had a mean age of 20 ± 1 years, an average height of 1.75 ± 0.05 meters, and a BMI of 21.6 ± 1.6. All were professionally trained athletes with an average of 6.7 years of competitive soccer experience, having participated in All India Inter-University and National-level tournaments. As part of their regular regimen, the players were already familiar with structured strength and conditioning practices. To preserve the consistency and validity of the intervention, participants were instructed to refrain from taking part in any competitive matches or tournaments throughout the study period.

2.3. Procedure for MPFIT Training

The present study was conducted during the off-season phase, a period when no official matches were scheduled. This allowed uninterrupted implementation of the training program, which was specifically designed to enhance the fitness levels of soccer players in preparation for the upcoming competitive season. The primary focus was on a structured 12-week MPFIT regimen aimed at improving the players' overall physical development. The MPFIT training program addressed multiple facets of soccer-specific fitness, including strength, endurance, agility, and coordination. By systematically integrating these components, the regimen sought to elevate the players' physical conditioning and on-field performance. Figure 3 shows the integration of workout in the MPFIT training. It is essential that such training protocols are customized based on individual needs and are implemented under the supervision of qualified professionals to ensure effectiveness and safety. Figure 4 presents the complete 7-day MPFIT training schedule, whereas Table 1 outlines the detailed training activities conducted on Day 1. Each session lasted approximately two hours and included dedicated warm-up and cool-down phases. Agility, Balance, and Coordination (ABC) drills were emphasized on four days each week, alongside targeted workouts designed to improve sprint

endurance and muscular strength. The MPFIT sessions combined both physical and technical training elements, incorporating exercises such as running, jumping, coordination, balance drills, and dynamic stretching. Notably, FIFA 11+ routines were included as part of the warm-up protocol under the guidance of a certified coach. This inclusion was intended to enhance injury prevention while supporting progressive improvements in the players' fitness throughout the training period.

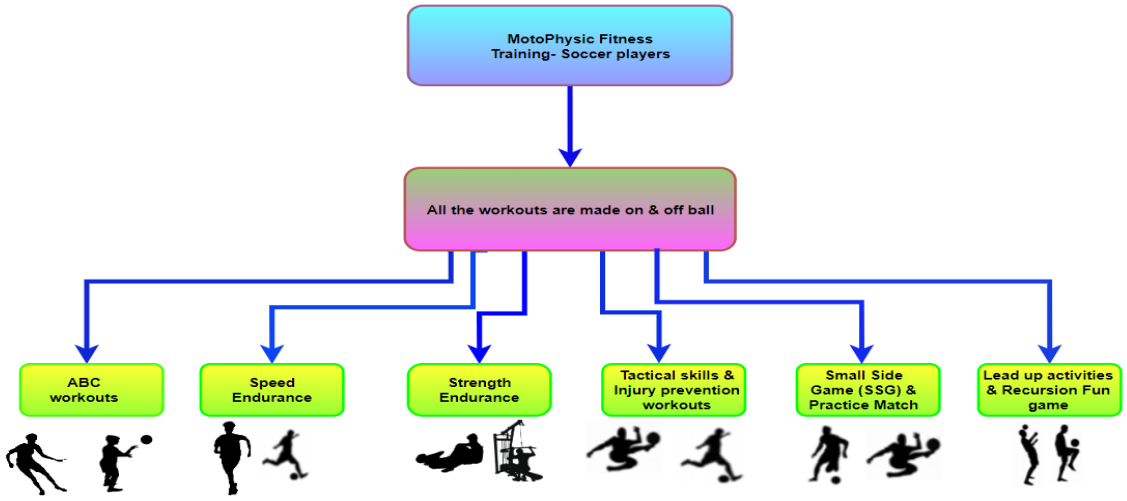

Figure 3. Classification of workouts integrated in the MPFIT regimen

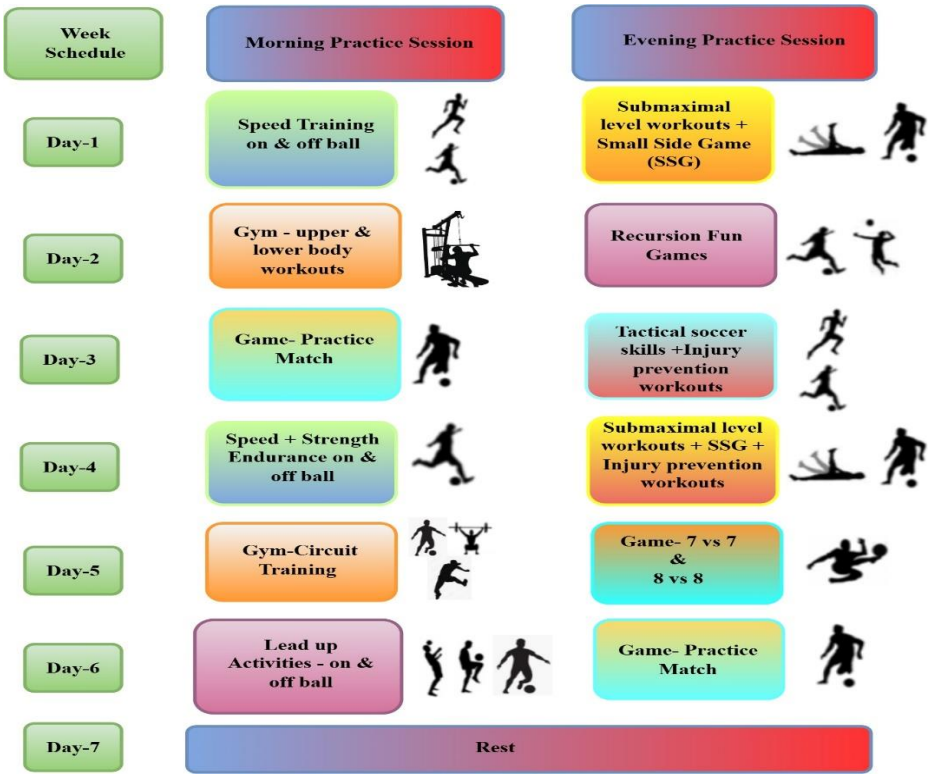

Figure 4. Day-Wise Weekly schedule of the MPFIT training program

Table 1 presents the structured MPFIT training schedule for Day 1, outlining the planned activities for both the morning and evening sessions.

Table 1. Structured MPFIT training schedule – Day 1 (morning and evening workouts)

.0.0				**Evening Practice Session- Submaximal level workouts and Small Side Game**			
Component	**Exercise**	**Sets**	**Reptations**	**Component**	**Exercise**	**Sets**	**Reptations**
Activation & Warm-up	Foam rolling	-	-	**Activation & Warm-up**	Foam rolling	-	-
	Mobility exercises	-	-		Mobility exercises	-	-
	Loop band Activation	-	-		Loop band Activation	-	-
	General	-	-		General	-	-
	Specific Warm-up – Dribbling and passing to nearby players	-	-		Specific Warm-up – Dribbling and passing to nearby players	-	-
Speed Training – without ball	6x10 Agility Run	3	3	**Skill Drills & Games**	Daimond passing drills	-	-
	20 m dash	2	8		2 vs 2	-	-
	30 m dash	2	6		3 vs 3 + Neutral	-	-
Speed Training – with ball	6x10 Agility Run (up- dribbling, down -sprint)	3	3		SSG 7 vs 7+2 goal keeper	-	-
	20 m dash (up – dribbling down – Turn & hard push pass followed by sprint)	2	8	**Cool Down & Recovery**	Static Stretching (Hold for 8 seconds per movement)	-	-
	30 m dash (up - dribbling, down- Chipping the ball to the opposite end)	2	6		Meditation 10 minutes	-	-
Cool Down & Recovery	Static Stretching (Hold for 8 seconds per movement)	-	-	-	-	-	-
	Meditation 10 minutes	-	-	-	-	-	-

The training program for speed endurance was strategically structured to include high-intensity sessions in the mornings, followed by relatively lower-intensity workouts in the evenings. On the following day, morning session intensity was deliberately reduced to approximately 30% of the prior high-intensity session to facilitate active recovery. Strength and power development were

addressed through gym-based training sessions scheduled twice a week. These sessions focused on both upper and lower body exercises to enhance overall muscular strength and power endurance. Weekend sessions were designed to balance competitive engagement and recovery. One session included a full practice match, offering players an opportunity to apply their physical conditioning and technical skills in a simulated game environment. Another session was dedicated to recreational activities such as foot cricket, head volleyball, or volleyball, providing a fun and engaging break from intense training while still maintaining physical activity. To ensure optimal recovery and prevent overtraining, one full rest day was incorporated into the weekly schedule. Throughout the MPFIT program, all training activities incorporated a mix of ball-related and non-ball-related drills, ensuring improvements not only in general fitness but also in position-specific soccer skills. After completing each practice sessions in the morning and evening, players performed warm-down routines followed by a 10-minute guided meditation. This mindfulness practice involved sitting comfortably, closing the eyes, and engaging in rhythmic breathing exercises. The goal of this meditative cooldown was to promote mental relaxation, reduce stress, improve focus, and enhance overall psychological well-being following physical exertion.

2.4. Test for MPFIT Training

Physical fitness is essential for tournament success among football players. The Yo-YoIRT, cooper test, shuttle run test, and beep test are few methods used to assess aerobic endurance and estimate VO2max values. The Yo-YoIRT has two levels (Yo-YoIRT1-level1 and Yo-YoIRT2-level2) and can determine an individual's capacity to conduct repeated high-intensity efforts with brief recovery periods. In this study Yo-YoIRT1 is carried out to assess the endurance of players. The Yo-YoIRT1 is a widely used fitness test to assess an individual's aerobic fitness endurance capacity for various sports, namely soccer, basketball, hockey, handball, and rugby. Figure 5 shows the measurement area of Yo-YoIRT1. In this test, individual players are required to perform as many shuttles as they can in the specified period of time. Due to the demanding nature of the test, it is highly improbable for an individual to complete the entire test successfully.

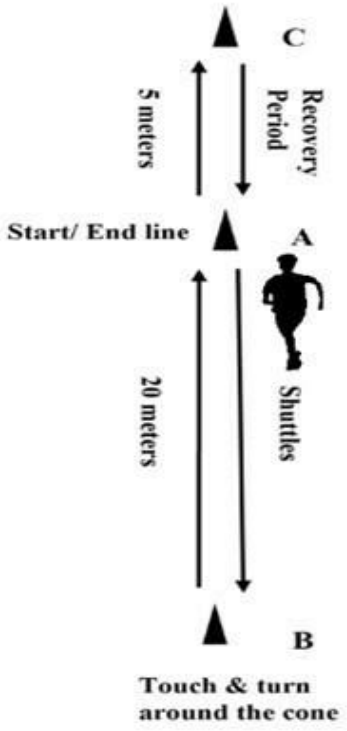

Figure 5. Test measurement & players performing the Yo-YoIRT1

The purpose of the Yo-YoIRT1 is to make the players reach their maximum ability while assessing their level of fitness through the number of completed shuttles or the level attained. There are three ways to present the test scores,

- Total distance covered in meters.
- The level achieved.
- The estimated VO2max

Determining the level achieved is challenging for players to complete the test and the level of test ranges between 5 to 23. With respect to estimation of VO2max value, a formula is used for its estimation as given below.

VO2max (ml/min/kg) = IR1 distance (m) × 0.0084 + 36.4 (Beard et al., 2022)

Measurement of maximum heart rate (HRmax) during Yo-YoIRT1 also plays a significant role in determining the players endurance level. It is vital to keep track of each player's HRmax throughout the test, because if the HRmax exceeds their individual limit the trainer will immediately stop the player from the test. Moreover, HRmax can be measured manually by taking the pulse at certain points on the body, or it can be monitored using smart wearable devices. In this proposed study, HRmax was monitored via a smart watch. During testing or training, HRmax should

not surpass an individual's maximum. During the Yo-YoIRT1 test, players wear a smartwatch to monitor their maximum heart rate (HRmax). The smartwatch serves the purpose of continuously tracking and recording the players HRmax during the test. This allows for real-time monitoring of the players physiological response and helps ensure that their HRmax remains within safe limits throughout the test. The test was conducted at 3 intervals namely before MPFIT, midlevel MPFIT, and after MPFIT. Baseline fitness of the players are noted down before the start of MPFIT program. The following estimations were used for determining the aerobic endurance level.

- Influence of MPFIT training on distance covered and level achieved.
- Influence of MPFIT training on VO2max.
- Influence of MPFIT training on HRmax

2.5. Statistical Analyses

The Z-test, a statistical analytic method that determines if a sample's mean significantly differs from a known population mean, was used to examine the Yo-YoIRT1 test data. This test is used when the sample size is either high or the population distribution is normal. The Z-score will be compared to the crucial value during the analysis at a selected significance level, which is typically less than 0.05 (Sommer Jeppesen et al., 2022). In this study, the Z-test was used to determine the corresponding p-values. Equation 1 is utilized for computing the Z-score, while Equation 2 is employed to determine the corresponding p-value. By analysing these p-values, it was possible to determine the significance of the study.

$$Z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}} \quad (1)$$

$\bar{x} =$ Mean of the samples
$\mu_0 =$ Mean population
$\sigma =$ SD of population
$n =$ Number of samples

$$\text{P value} = 2 \times (\text{CDF}(|Z|)) \quad (2)$$

$\text{CDF} =$ Cumulative distribution function
$|Z| =$ Z score

2.6. Ethics and Consent

The research study adhered to ethical standards as approved by the Hindustan Institute of Science and Technology, Chennai, Tamil Nadu, India (Approval Reference: HITS/SPESS/I/22). On September 1, 2022, permission was granted by the Director of Sports to use the sports facilities and to conduct EEG-based cognitive and reaction time tests with sports & non-sports individuals (male

and female). Informed consent was obtained in writing from all participants, confirming their voluntary involvement and compliance with ethical guidelines.

3. RESULTS

Despite a higher training volume during the control phase, greater improvements in Yo-YoIRT1 performance were observed after the MPFIT training intervention, demonstrating its effectiveness.

3.1. Influence of MPFIT training on distance covered

The progression in distance covered by players before and after the MPFIT training was evaluated to determine improvements in sprint execution and endurance. Table 1 presents a comparative analysis of the distance metrics recorded pre- and post-intervention. The players' capacity to perform repeated sprints in a short duration, along with the total distance covered, was assessed. As illustrated in table 1 and figure 6, notable improvements were observed following the 12-week MPFIT training across all playing positions. Initially, performance levels varied by position: defenders and goalkeepers were rated below average, whereas centre halves, strikers, midfielders, wing backs, and wingers were rated as average. Post-training, substantial improvements were evident across all categories. Particularly, players in positions such as centre halves, wing backs, and wingers demonstrated marked progression, likely due to their existing playing potential and better adaptability to the MPFIT regimen. Players in other roles also exhibited noticeable improvements, transitioning from below average to average, or from average to good. Overall, the MPFIT program had a positive impact on player performance, enhancing both physical capability and positional effectiveness.

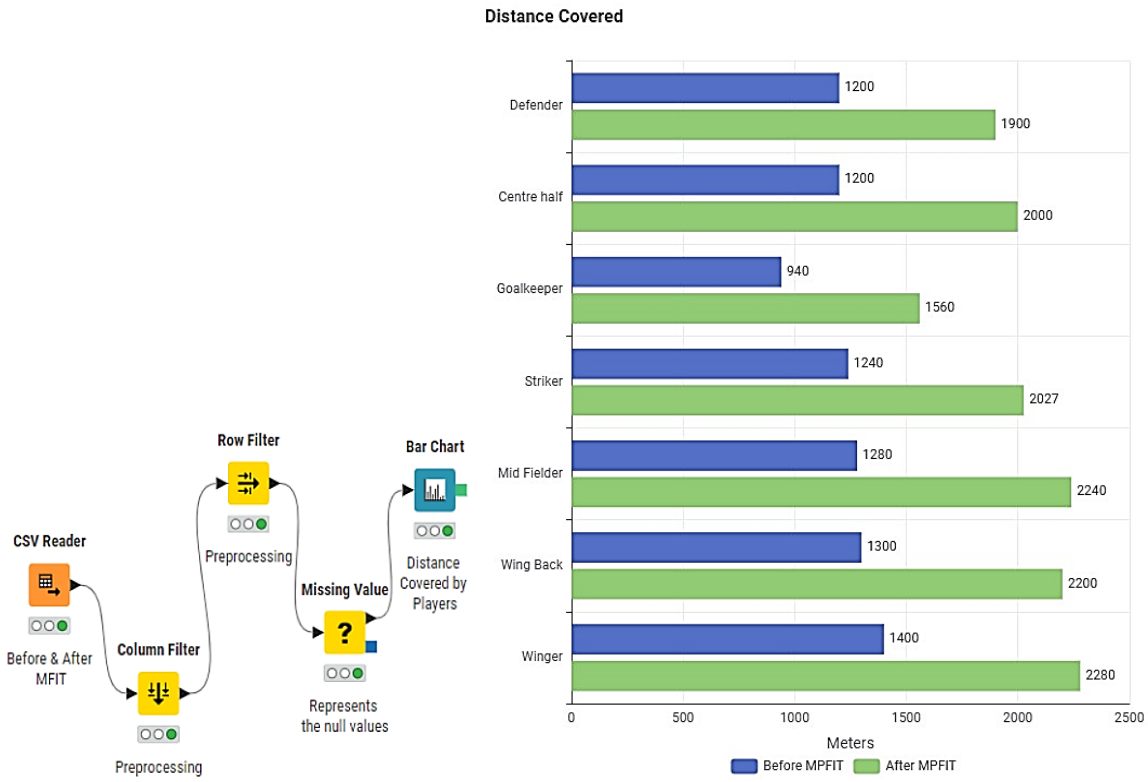

Figure 6. Graphical representation of distance covered before and after – MPFIT

Table 2 presents the performance outcomes of participants in terms of distance covered, measured both prior to and following the MPFIT training program.

Table 2. Distance covered before and after MPFIT training

Average of Distance Covered - (Elite(E) > 2400, Excellent (Ex) 2000 - 2400, Good(G) 1520 - 1960, Average (A)1040 -1480, Below Average (BA)520 - 1000)					
Positions	**Players**	**No Players**	**Before MPFIT**	**After MPFIT**	**Improvements**
Defender	PL1, PL6, L13	3	1200	1980	A to Ex
Centre half	PL11, PL17	2	1200	2000	A to Ex
Goalkeeper	PL2, PL9	2	940	1560	B to G
Striker	PL8, PL16, PL19	3	1240	2027	A to Ex
Mid Fielder	PL5, PL10, PL20	3	1280	2240	A to Ex
Wing Back	PL3, PL4, PL7, PL15	4	1300	2200	A to Ex
Winger	PL12, PL14, PL18	3	1400	2280	A to Ex
No of players involved in Testing = 20					

3.2. Influence of MPFIT training on VO2max: Positional Trends in Players

In soccer, positional roles such as defender, centre half, goalkeeper, striker, midfielder, wing back, and winger demand varied physical and aerobic capacities. Evaluating position-specific fitness, particularly VO_2max, is critical for effective player rotation and substitution during matches. In such scenarios, insights from MPFIT training outcomes can assist coaches in selecting players based on aerobic readiness and technical proficiency. Figure 7 illustrates the predicted VO_2max across different positions.

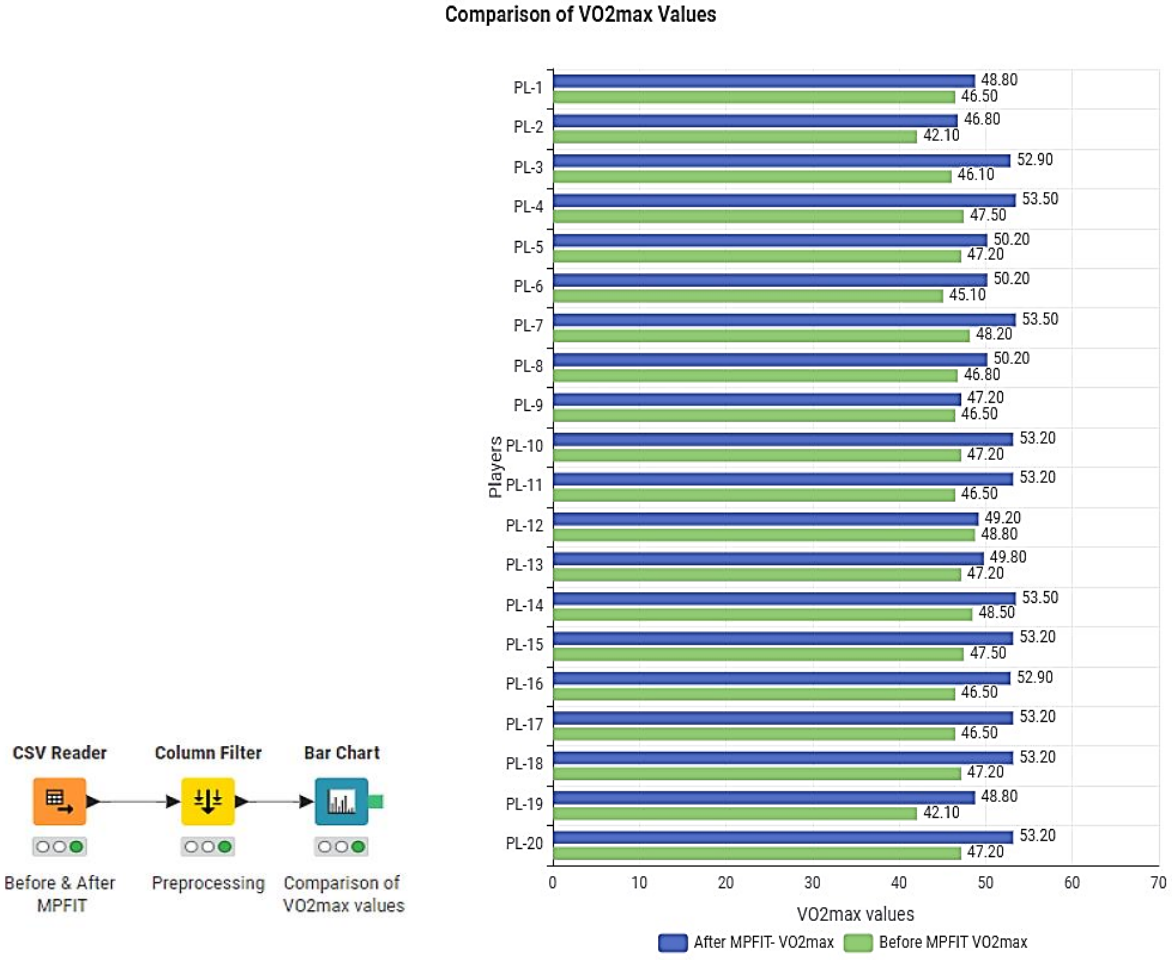

Figure 7. Position wise comparison of MPFIT drill for twenty players -VO2max values

Before the intervention, goalkeepers and strikers recorded the lowest VO_2max values (42.1 ml/min/kg), while wingers exhibited the highest (48.8 ml/min/kg). After 12 weeks of MPFIT training, notable improvements were observed: the VO_2max of goalkeepers increased to 47.2 ml/min/kg, while wingers demonstrated a marked increase to 53.5 ml/min/kg, reflecting their high endurance demands and potential for speed-based roles. These findings emphasize the

effectiveness of MPFIT training in improving aerobic capacity across all player positions. A detailed breakdown of player numbers corresponding to their positions is provided in table 1.

3.3. Influence of MPFIT training on level achieved

The Yo-YoIRT1 includes a standardized scale with 15 levels ranging from 5.1 to 23.8, which serves as a benchmark for evaluating aerobic endurance in athletes. In the present study, each player's performance level was recorded both before and after the 12-week MPFIT training intervention. Beyond level estimation, the number of shuttles completed also contributes to evaluating a player's aerobic fitness. Therefore, a comprehensive assessment was performed based on both the test level and the number of shuttles completed. Figures 8 and 9 illustrate the comparison of players' performance before and after MPFIT training in terms of Yo-YoIRT1 levels achieved, total distance covered, and number of successful shuttles within the specified time. The post-training data demonstrate measurable improvements in aerobic capacity and endurance levels across all players, validating the effectiveness of the MPFIT regimen.

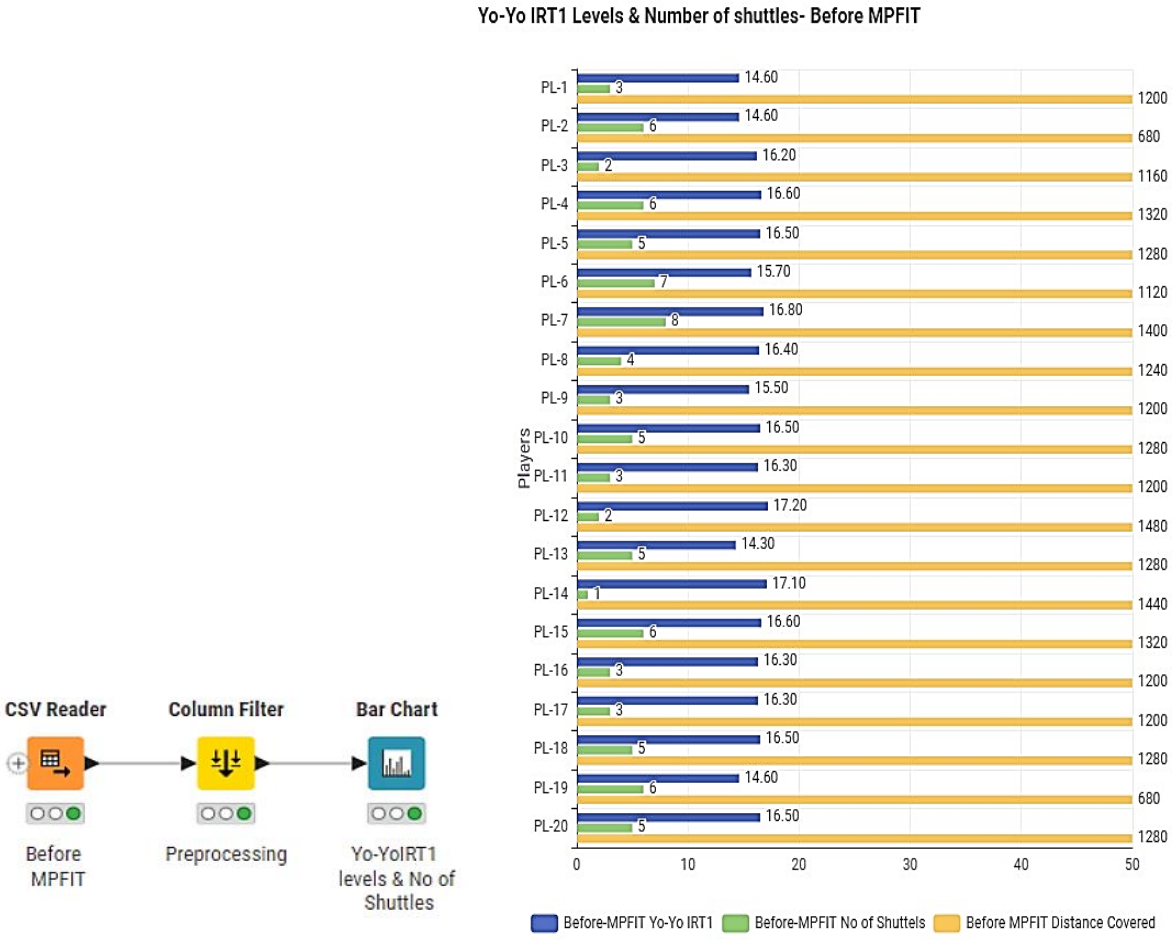

Figure 8. Number of shuttles in Yo-YoIRT1 levels – Before MPFIT

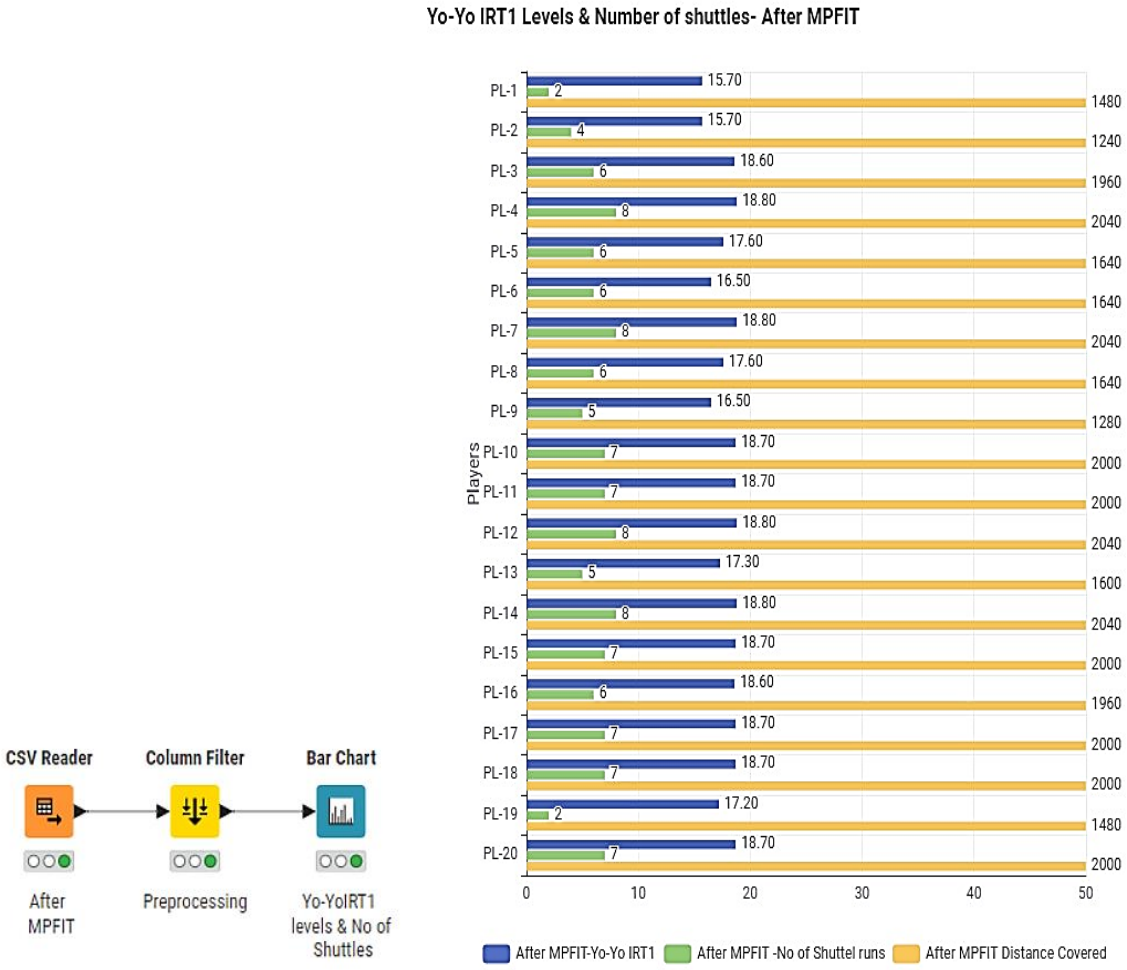

Figure 9. Number of shuttles in Yo-YoIRT1 levels – After MPFIT

3.4. Influence of MPFIT training on Heart Rate (HRmax)

Maximum heart rate (HRmax) was assessed during the Yo-YoIRT1 for all players, both before and after the 12-week MPFIT training intervention. In athletes with lower fitness levels, HRmax is typically reached more rapidly, which may compromise endurance and overall performance. MPFIT training aims to delay the onset of HRmax by enhancing cardiovascular efficiency and physical conditioning. In the present study, MPFIT regimen provided optimal training intensity, effectively stimulating the desired cardiovascular adaptations. The variability in HRmax among players was minimal, with coefficients of variation calculated at 1.26% pre-training and 2.57% post-training. This low variability, as shown in Figure 10, reflects the consistency of the physiological response elicited by the MPFIT program across all participants. Figure 10 demonstrates a positive shift in HRmax values following the intervention, indicating improved cardiovascular

efficiency and resilience. These results highlight the MPFIT program's efficacy in enhancing heart rate response and sustaining performance levels under physical exertion.

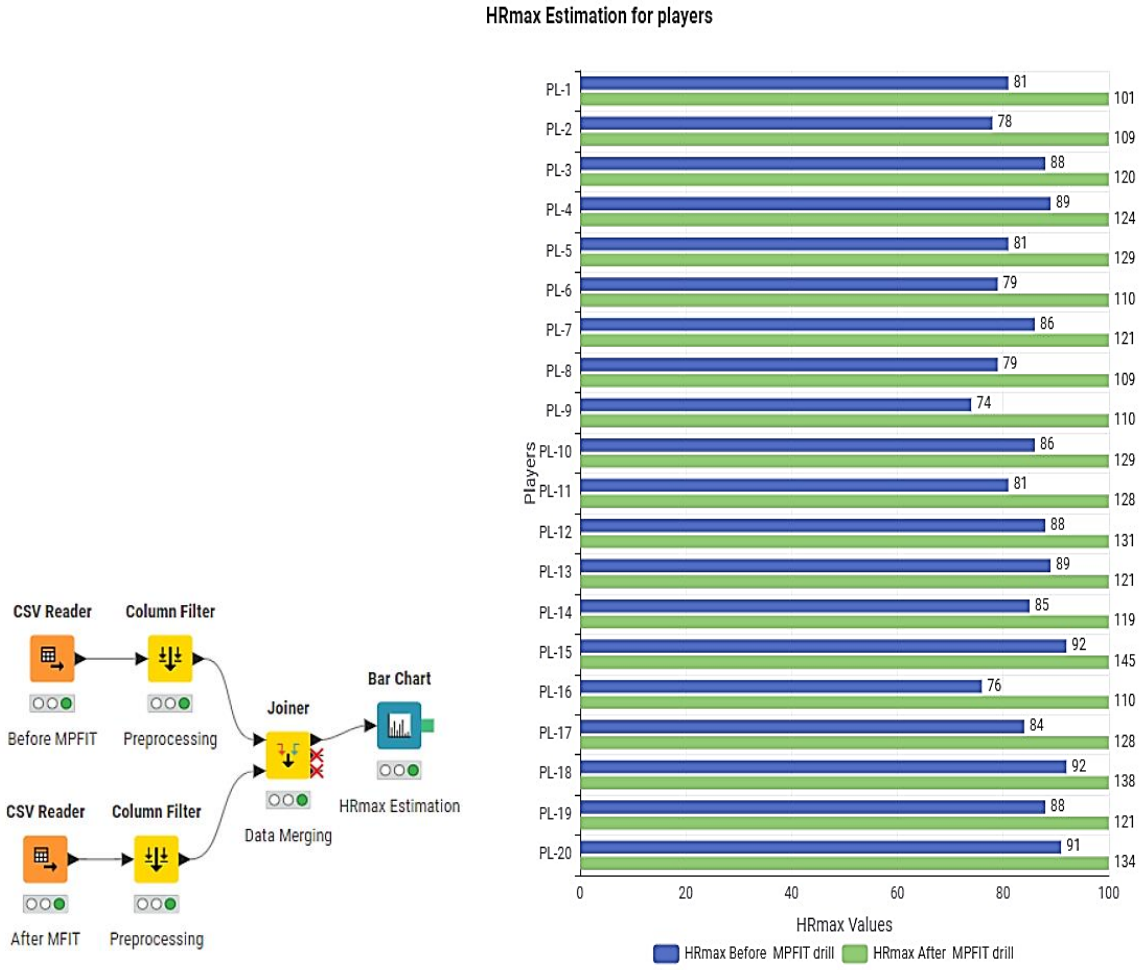

Figure 10. Before and after MPFIT training – HRmax estimation

3.5. Comparison of before and after MPFIT Training Fitness Metrics: Incorporating Standard Deviation for Variability

Statistical measures such as standard deviation and Z-test were computed to analyse the efficiency of the MPFIT training. The before and after test results of MPFIT training were compared for BMI, level achieved and VO2max completed by the players in a certain time period. As shown in figure 11, MPFIT influence in the BMI values were 21.96±1.65 and 21.087±1.61, the values for level achieved were 15.63±0.81 and 16.97±0.79, and the VO2max values were 44.6±2.15 and 49.12±11.24, respectively. Using MPFIT training led to significant improvements in the player

fitness level and it will help them to perform well in the soccer matches. The Z-test revealed that the p-values for the level achieved and VO2max were determined to be p=0.004 and p=0.02 respectively.

Inferential statistical techniques were utilized to determine whether the observed effects of the MPFIT training protocol could be generalized to a broader population of elite soccer players within the same age group. A total of 20 male soccer players participated in the study, and the fitness metrics were assessed before and after a 12-week MPFIT intervention. A Z-test was employed to evaluate differences in key variables, including BMI, the Yo-Yo IRT1 level achieved, and VO_2max. The resulting p-values were statistically significant, with $p = 0.004$ for the level achieved and $p = 0.02$ for VO_2max. These findings suggest that the MPFIT program had a positive impact on physical fitness. By applying inferential methods, the results can be reasonably extended to similar populations of elite soccer players in this age group. This supports the external validity of the study and highlights the program's potential application in broader athletic conditioning frameworks.

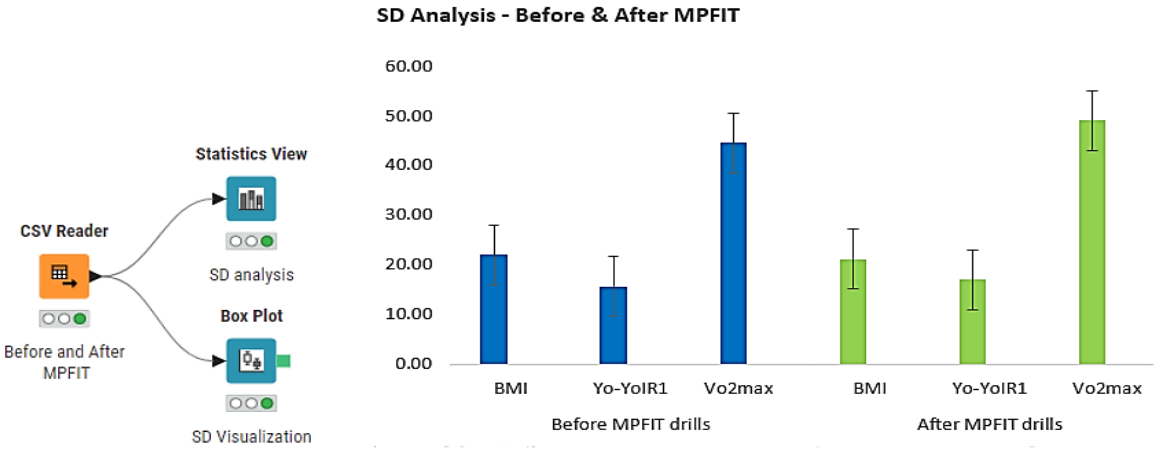

Figure 11. Comparison of before and after MPFIT training with SD

4. DISCUSSION

The principal finding of the present investigation was that the 12-week MPFIT program significantly enhanced the intermittent running performance of soccer players aged between 19 to 21 years. A related study evaluated the effects of a 10-week training program focused solely on repeated 40-meter sprints, without incorporating any strength training. The results indicated that weekly sprint sessions led to a moderate improvement in sprint performance over 40 meters (Tønnessen et al., 2011; Pavillon et al., 2021; Ulupınar et al., 2021). Although the aforementioned study emphasized sprint-specific training, it is widely recognized that combining sprint exercises with strength training is essential for achieving optimal athletic development. In the present investigation, both sprint and

strength-based components were integrated into the training protocol. This holistic approach led to improved muscular strength and reduced injury risk among the players. Another study explored the effects of an 8-week plyometric training program targeting the lower limbs of soccer players. These sessions were incorporated into the in-season conditioning routines. However, a key limitation of that program was its narrow focus on enhancing core strength, without addressing the broader technical skills required for optimal soccer performance (Chelly et al., 2010; Ramírez-Campillo et al., 2014; Rodríguez-Fernández et al., 2020). In contrast, the current study included speed drills as well as with and without ball related exercises, alongside plyometric routines. This diversified approach contributed to observable improvements in players' technical abilities, particularly during practice matches.

Additionally, a separate study investigated goalkeeper performance by examining their responses to the Yo-YoIRT1 test, emphasizing the test's reliability and individual variability (Ehlert et al., 2019). However, no specific training was provided in that context. While the findings offered valuable insights about the effectiveness of the Yo-YoIRT1 test in assessing physical readiness and adaptability, they did not demonstrate performance improvement due to the absence of structured training. In contrast, the present study implemented a comprehensive training program and evaluated endurance across all player positions. Notably, all the positions exhibited a marked improvement in overall performance, as demonstrated in Table 1. Previous studies have also evaluated short-duration training programs of 2 weeks (Buchheit et al., 2013), 4 weeks (Eken et al., 2022), and 5 weeks (Castagna et al., 2009). A common limitation across these studies is the brief intervention period, which restricts the potential for sustained physiological adaptation. Effective fitness development generally requires a progressive training model where exercise intensity increases incrementally each week. Such a gradual progression not only enhances physical fitness but also reduces the risk of injury.

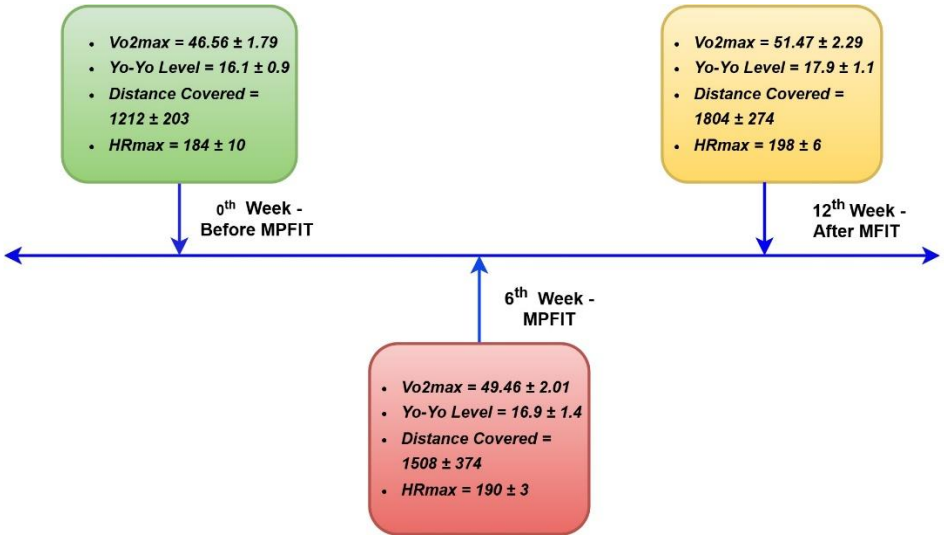

Figure 12. Progression of endurance parameters over the 12-Week MPFIT Program

The MPFIT training protocol in the present study incorporated a wide range of physical exercises specifically tailored to meet the demands of soccer. This comprehensive approach supported consistent improvement in players' fitness levels and also contributed to the development of technical skills. As illustrated in figure 12, there was a clear temporal progression in key endurance parameters including VO_2max, Yo-Yo test level, distance covered, and HRmax measured at the 0th, 6th, and 12th weeks. The visual trend highlights the structured and effective nature of the program in driving measurable physiological gains. Based on the study's findings, the 12-week MPFIT regimen led to an approximate 2% improvement in overall fitness among youth soccer players. These results underscore the importance of long-term, structured fitness training in sustaining and enhancing performance throughout the competitive season.

5. CONCLUSIONS

The research centred on a 12-week MPFIT regimen, with the Yo-YoIRT1 test serving as a measure of individual aerobic endurance. The study evaluated the MPFIT program's varied range of endurance levels among soccer players in all positions. A 40-meter shuttle sprint and a 5-meter breathing recovery interval were both part of this study. Monitoring maximum heart rate during the examination of Yo-YoIRT1 provided insights about physiological responses. The study included a MPFIT training with the goal of enhancing core strength, muscular endurance and speed endurance. The program included both on- and off-the-ball workouts that were meant to include players in

MPFIT training for boosting their technical proficiency and physical health. Overall, the study's findings imply that the repeated MPFIT program produced successful outcomes for a number of evaluated parameters. The results indicated that implementing the 12-week MPFIT training for soccer conditioning has the potential to enhance players' physical fitness. The proposed MPFIT program will give a significant improvement in the fitness levels of players and can be effectively implemented by soccer trainers and coaches.

However, the study has certain limitations that should be acknowledged. These include the absence of a control group, a relatively limited sample size, and the lack of direct quantitative assessment of technical skills. Additionally, the observational nature of the study and the exclusion of cognitive performance measurements constrain the generalizability of the results. Addressing these limitations in future studies will provide a more comprehensive understanding of training impacts.

For future studies, it is recommended to incorporate a control group to strengthen the validity of the findings. Additionally, assessing cognitive abilities in conjunction with physical fitness particularly through methods such as Electroencephalography (EEG) could provide deeper insights about the overall impact of structured fitness programs on player's performance. Furthermore, incorporating standardized assessments of technical skills such as dribbling accuracy, passing consistency, and shooting precision would offer a more comprehensive evaluation of training effectiveness from both physiological and performance standpoints.

6. Practical Applications

Coaches and trainers play a critical role in implementing targeted fitness training programs to uphold and enhance player performance standards. The proposed 12-week MPFIT regimen offers a structured and effective approach for improving player efficiency and readiness. By adopting this training model, coaches can make informed decisions during matches, particularly when substitutions are required, by selecting players who have demonstrated improved fitness and endurance through MPFIT training participation. Additionally, the program allows individual players to monitor and evaluate their own fitness progression, fostering a proactive approach to performance enhancement. The MPFIT framework is particularly beneficial for emerging players who exhibit strong technical potential but lack optimal physical conditioning. Integrating this training strategy can elevate their tournament readiness by simultaneously improving overall fitness and technical execution. Importantly, the inclusion of FIFA 11+ exercises within the MPFIT protocol contributes significantly to injury prevention during training, thereby ensuring greater consistency and safety throughout the

program. Collectively, these elements support both players and coaches in effectively assessing and enhancing performance capability.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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