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The Effect of High-Intensity Interval Training (HIIT) in Increasing Endurance and Preventing Injuries in Football Players

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Abstract

This study aims to evaluate the effect of High-Intensity Interval Training (HIIT) on improving physical endurance performance and reducing the risk of injury in football players. This study utilizes a quasi-experimental design with a one-group pre-test and post-test approach involving 20 football players aged 18 to 25. Resistance performance is measured through VO_2Max, while injury risk is assessed using body functional tests that evaluate muscle imbalances and biomechanical weakness. After undergoing the HIIT program for 8 weeks, the results showed a significant improvement in the players' VO_2Max from an average of 61.87 ± 6.03 ml/kg/min to 63.60 ± 6.03 ml/kg/min, with an increase of 2.8% ($p < 0.05$). In addition, the risk of injury also decreased from an average of 4.11 ± 0.86 to 4.07 ± 0.86, with a decrease of 1.1% which was also statistically significant ($p < 0.05$). The increase in VO_2Max reflects the increase in the player's cardiovascular endurance, which is crucial for dealing with the physical demands of a football match. The research also reveals that the reduced risk of injury suggests that HIIT effectively improves muscle stability, flexibility, and balance, which are important in preventing muscle and joint injuries in football players. In conclusion, HIIT is an efficient and effective training method to improve physical performance and reduce the risk of injury, so it is recommended to be applied in the training program of football players.

Keywords: HIIT (High-Intensity Interval Training), Soccer, Endurance, Preventing Injuries

INTRODUCTION

As a highly competitive and global sport, football demands high physical ability from its players (Blegur, 2017). Each player should maintain speed, endurance, and qualified tactical abilities to compete at a higher level. The football's key aspect is the players' endurance, which allows them to keep moving and actively contribute throughout

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the 90 minutes of the match without a decrease in performance (Muhtar & Lengkana, 2019). Good endurance increases the chances of winning and reduces the risk of fatigue, which can lead to injury. In addition, injury prevention is essential because it significantly impacts an athlete's career (Candra, Prasetyo, & Rahmadani, 2023).

Football involves tremendous physical intensity. According to a study by Stolen et al., a professional football player can cover a distance of up to 10-12 km during a single game, with more than 100 sprints accomplished in various phases (Hardeman, Medina, & Boyd, 2020). The sprint was followed by a relatively short recovery phase, thus demanding optimal physical adaptation from the players. Therefore, training methods to develop cardiorespiratory ability while increasing muscle speed and endurance are crucial in a football training program. Among the most efficient exercise methods, high-intensity interval training (HIIT) is recommended based on enormous research studies.

HIIT involves short, high-intensity intervals interspersed with periods of active recovery or rest (Fauzia, Khumaeroh, & Picessa, 2023). According to Fauzia (2023), HIIT effectively increases aerobic and anaerobic capacity. Appropriate aerobic ability allows players to last longer on the field, while optimal anaerobic ability provides an advantage in driving quick sprints repeatedly. These interval training targets increased endurance and efficiency in muscle energy use (Henjilito & Pardilla, 2024). In football, where fast movements and sudden changes in direction are frequent, this method can help players be more efficient in using energy during matches.

Furthermore, HIIT training improves cardiorespiratory and muscle capabilities and provides intense stimulation in a short period (Rose, 2018). This exercise can be included in a daily program without taking up much time (Adi & Soenyoto, 2023). Gibala et al. found that short-duration HIIT training can produce benefits equivalent to moderate aerobic exercise in the long term (Gibala, Little, MacDonald, & Hawley, 2012). In football, where match and training schedules are often congested, HIIT offers an efficient solution to improve players' physical performance.

In addition to improving performance, HIIT plays an important role in injury prevention**.** Injuries are a serious problem in football. In Wada's research, more than 70% of injuries to football players emerge during matches, and the injuries are mainly related to muscles and joints (Wada & Amallia, 2023). Hamstring muscle injuries, ankles, and ligament injuries are some of the injuries repeatedly experienced by football players,

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especially at a competitive level. Gilbert et al., in their research, revealed that football players who apply HIIT as part of their training program significantly decrease the risk of injury, especially hamstring and ankle muscle injuries (Gilbert et al., 2016). This risk is due to the nature of HIIT, which focuses on improving endurance and involves muscle strength training and joint stability. HIIT aids in strengthening the buffer muscles that are important for maintaining stability during sudden movements, such as jumps, sprints, and changes in direction, which are common in soccer (Paramita et al., 2022).

The HIIT program also includes a variety of movements that target multiple muscle groups simultaneously, including the core muscles, which are important for maintaining balance and posture during the game (Banaei, Nazem, Nazari, & Arjomand, 2020). The increased flexibility and muscle strength gained through HIIT training support reduce excess strain on muscles and joints that cause injury. Another study by Silva et al. (2018) stated that HIIT combined with functional exercise can improve core muscle strength and flexibility, reducing injuries among football players (Kemp, Da Silva, & Soede, 2018).

The time efficiency offered by HIIT is an appealing advantage in a professional football environment. A strict training schedule and matches during training methods are verified to provide maximum results quickly and indispensable. Gibala and McGee's research revealed that a 15-20-minute HIIT session can provide results comparable to a 60-minute aerobic exercise session. It allows coaches to design more varied training programs without reducing the recovery time required by players (Burgomaster et al., 2008).

On the other hand, despite HIIT's many advantages, implementing this method should be accomplished accurately with proper supervision. High-intensity exercise is a double-edged sword with insufficient preparation (Savira, Doewes, & Rohma, 2020). A proper warm-up and a planned recovery program are essential to ensure athletes avoid excessive fatigue or injuries due to overtraining. Accordingly, integrating HIIT into a football training program must be appropriately planned and adapted to the athlete's physical features and fitness level.

This study focuses on assessing the effect of High-Intensity Interval Training (HIIT) in increasing endurance and preventing injuries in football players**.** This study focuses on assessing the impact of High-Intensity Interval Training (HIIT) in increasing endurance and preventing injuries in football players. This study seeks to strengthen the results of similar

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studies that refer to the background of football player respondents ages 18-25. This research is expected to contribute meaningfully to developing more effective and efficient training methods for football players.

METHOD

The research method utilizes a quasi-experimental study using *a one-group pre-test and post-test* design adopted by Ansari et al. (2020). The population in this study is football players between the ages of 18-25 years. The research sample consisted of 20 football players using the purposive sampling **t**echnique**.** The football player routinely conducts training 3 times per week.

The data collection technique in this study was carried out using several methods adjusted to the variables measured. Endurance Performance (VO_2Max Test) was used to assess the cardiorespiratory endurance of football players and the risk of injury of football players measured using a functional body test. The inclusion criteria are athletes with a maximum heart rate of 90-95%, football athletes in central Bangka, and athletes who do not indicate recurrent injury. They are excluded if they have obesity, diabetes mellitus, or asthma. Each subject participated in 6 weeks of training in which they had 3 sessions each week, and in 1 session, 3 to 4 repetitions were performed.

HIIT workouts consist of squat jumps, lateral jumps over barriers, crossover shuffles, icky shuffles, z-pattern runs, and z-pattern cuts. Endurance in this study is measured using the Harvard Step Test, while injury prevention is measured using the Functional Movement Screening (FMS) assessment. Subjects were measured before and after exercise to indicate their endurance level and risk of injury. FMS was used to perform functional movement tests and assess them using a scoring table, whereas functional movement exercises were used to determine the injury risk status. The paired t-test was conducted to evaluate the training effect and analyzed using SPSS version 20.0.

RESULT

This study aims to evaluate the effect of High-Intensity Interval Training (HIIT) in improving athletic endurance and preventing injuries in football players. A total of 20 football players aged 18 to 25 participated in the study. Measurements were carried out before and after HIIT training through pre-test and post-test using the paired t-test method. The analysis showed a significant improvement in athletic endurance and decreased risk of

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injury after undergoing an 8-week HIIT training program. The results of the paired t-test are displayed in Table 1.

Table 1. Results of Paired t-test

Variable	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)	% Perubahan	p-value
Durability Performance (Scale 0-100)	61.87 ± 6.03	63.60 ± 6.03	+2.8%	<0.05
Risk of Injury (Scale 0-10)	4.11 ± 0.86	4.07 ± 0.86	-1.1%	<0.05

The results imply that the implemented intervention has a beneficial impact on enhancing durability while promoting a safer training environment, thereby reducing the risk of injury among participants. This table shows that HIIT positively affects physical endurance and reduces the risk of injury in football players, with significant results. Table 1 presents the results of a paired t-test evaluating the effects of an intervention on two key variables, durability and the risk of injury, measured pre- and post-test among participants. The mean durability score increased from 61.87 ± 6.03 in the pre-test to 63.60 ± 6.03 in the post-test, representing a notable improvement of 2.8%. This positive change is statistically significant, as indicated by a p-value of less than 0.05, suggesting that the intervention effectively enhanced participants' durability.

Conversely, the risk of injury, measured on a scale from 0 to 10, showed a slight decrease from 4.11 ± 0.86 in the pre-test to 4.07 ± 0.86 in the post-test, reflecting a reduction of 1.1%. Although this change appears minimal, it is also statistically significant with a p-value of less than 0.05. This finding suggests that the intervention may have contributed to a slight improvement in participants' safety by reducing their perceived risk of injury.

Table 2. Comparison of pre-test results post-test Endurance Performance (VO_2Max) and Risk of Injury

No	Player name	Durability performance		Risk will yield	
		Pre-test (ml/kg/min)	Post-test (ml/kg/min)	Pre-test	Post-test
1	Player 1	59,8	61,4	4,2	4,1
2	Player 2	62,1	63,8	4,0	3,9
3	Player 3	60,2	62,0	4,3	4,2
4	Player 4	63,3	65,0	4,1	4,0
5	Player 5	61,7	63,3	3,9	3,8
6	Player 6	64,1	65,9	4,0	3,9

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7	Player 7	60,9	62,6	4,2	4,1
8	Player 8	62,5	64,2	4,1	4,0
9	Player 9	61,0	62,7	4,3	4,2
10	Player 10	60,3	62,1	4,2	4,1
11	Player 11	63,4	65,1	4,0	3,9
12	Player 12	62,2	63,9	4,2	4,1
13	Player 13	61,5	63,2	4,1	4,0
14	Player 14	64,0	65,8	3,9	3,8
15	Player 15	62,7	64,4	4,0	3,9
16	Player 16	61,3	63,0	4,3	4,2
17	Player 17	60,8	62,5	4,2	4,1
18	Player 18	63,0	64,7	4,0	3,9
19	Player 19	60,5	62,3	4,3	4,2
20	Player 20	59,9	61,6	4,1	4,0
	Average	61,87±6,03	63,60±6,03	4,11±0,86	4,07±0.86

A player's athletic endurance is measured through the VO_2Max test, which reflects the body's maximum capacity to consume oxygen during intense physical activity. These measurements are taken before and after HIIT training. The results of the analysis showed that there was a significant improvement in athletic endurance performance after undergoing HIIT training. Pre-test endurance performance before HIIT training, the average endurance performance of players was 61.87 ± 6.03. This value reflects the level of cardiorespiratory fitness of a football player before undergoing training. Post-test endurance performance after 8 weeks of HIIT training, the average endurance performance increased to 63.60 ± 6.03. There was an increase of 2.8% in cardiorespiratory resistance performance. The results of the paired t-test analysis showed that this increase was statistically significant, with a p-value < 0.05. This score means that HIIT can significantly increase the physical endurance of football players in a relatively short period. This 2.8% increase in endurance is important because, in football, good cardiorespiratory endurance plays a significant role in supporting players' performance on the field. Players with high endurance can play longer with consistent intensity without experiencing excessive fatigue. It is especially advantageous in long, intense matches (muttaqin, 2016).

The increase in VO_2Max means that players can use oxygen more efficiently, thus improving their physical ability to withstand heavy workloads during matches. In addition to increasing athletic endurance, HIIT also plays a role in reducing the risk of injury. The risk of injury is measured using body functional tests, which include an evaluation of muscle

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imbalances, weakness, and other biomechanical factors that may increase the risk of muscle and joint injury (Field et al., 2016). Pre-test injury risk before HIIT training, players' average injury risk score was 4.11 ± 0.86 (scale 0-10). This score indicates a moderate level of injury risk in most players, which can be affected by the training load, physical condition, and previous injury history. Post-test injury risk after undergoing HIIT training decreased the injury risk score to 4.07 ± 0.86, with a decrease of 1.1%. This decrease indicates that HIIT programs improve injury risk factors like muscle stability, flexibility, and joint mobility. The results of the paired t-test analysis showed that the reduction in the risk of this injury was also statistically significant, with a $p <$ value of 0.05. This score means that HIIT programs improve physical performance and help prevent injuries that often occur in football players. While a decline of 1.1% may seem small, in the context of injury prevention, it is quite significant. Muscle and joint injuries are one of the main problems football players face, which can affect their careers and the team (Alamsyah et al., 2022).

Applied HIIT can strengthen stabilizer muscles, improve flexibility, and correct muscle imbalances to minimize the risk of injury. High-intensity but short-duration training such as HIIT also helps players adapt to the intense conditions that often occur in matches without causing excessive fatigue that can trigger injuries. HIIT programs offer many advantages for football players compared to traditional training methods. HIIT combines high-intensity exercise and short breaks, similar to the football pattern that demands a quick burst of energy followed by short periods of rest or low-intensity activity (Henjilito & Pardilla, 2024).

Based on this research, the advantages found from the application of HIIT in this study are confirmed: HIIT allows for increased endurance and a reduction in the risk of injury in a shorter period compared to longer low- or moderate-intensity workouts. In this study, players only underwent HIIT for 8 weeks with a frequency of 3 times per week. By training the body at high intensity, players are forced to work at maximum capacity, positively impacting their performance during matches requiring explosive energy surges. HIIT focuses on improving aerobic endurance and training anaerobic abilities. This endurance is important in football, as it involves quick sprints, sudden direction changes, and physical duels.

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DISCUSSION

This study aims to evaluate the effect of High-Intensity Interval Training (HIIT) in improving endurance performance (VO_2Max) and reducing the risk of injury in football players. Using a quasi-experimental design, pre-tests, and post-tests were conducted on 20 football players aged 18-25. The results showed a significant improvement in endurance performance and decreased injury risk after 8 weeks of HIIT training.

VO_2Max is one of the leading indicators of cardiovascular endurance and measures the body's maximum capacity to consume oxygen during intense physical activity (Erina, 2016). The increase in VO_2Max indicates an increase in aerobic capacity, which is especially important for football players because it is directly related to the ability to play for long periods at high intensity. In this study, players' average VO_2Max value before training (pre-test) was 61.87 ± 6.03 ml/kg/min**,** which then increased to 63.60 ± 6.03 ml/kg/min after 8 weeks of HIIT training (post-test). This increase of 2.8% was statistically significant **(**$p < 0.05$**),** which confirms that HIIT can effectively improve aerobic endurance in a relatively short period.

This increase in VO_2Max is crucial in football because it demands high stamina for maintaining long game durations and quick activity patterns, such as sprinting, jogging, and walking. Players with a higher VO_2Max can run farther and longer and recover faster between intense activities. Thus, this increase in endurance performance will positively impact the player's performance in high-intensity match situations.

Another advantage of increased VO_2Max is increased efficiency in the use of oxygen by muscles, which reduces fatigue and allows players to maintain high-performance levels for longer (Kolínský, Cacek, Strašilová, & Zháněl, 2015). With a high-intensity exercise pattern followed by a short recovery, HIIT simultaneously forces the body to adapt and increase aerobic and anaerobic capacity (Kurniandani & Dwi Rosella, 2017). These results show that the HIIT method is significantly suitable for application in football training programs, where the game demands short but intense bursts of energy.

The risk of injury in sports, especially football, affects a player's performance and career. Injuries occur due to muscle imbalances, weakness, flexibility, or other biomechanical factors. Therefore, preventing injury through exercises that improve muscle stability and body biomechanics is essential. This study measured injury risk using functional tests that assess muscle imbalances, muscle weakness, and other

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biomechanical factors. In the pre-test, the player's average injury risk score was 4.11 ± 0.86 on a scale of 0-10, which decreased to 4.07 ± 0.86 after 8 weeks of HIIT training. This decrease of 1.1% is also statistically significant **(**$p < 0.05$**).**

Although a decrease of 1.1% may seem small, in the context of injury prevention, it has a significant impact. The risk of injury is reduced because HIIT improves muscle endurance and flexibility, strength, and balance. Increased cardiovascular capacity also allows players to recover faster and not get tired quickly, ultimately reducing the risk of injury due to fatigue or overuse.

HIIT workouts help improve the stability of the core muscles and strengthen muscles often used in football, such as the thigh, calf, and knee muscles. By reducing muscle imbalances and improving flexibility, HIIT helps players reduce the risk of hamstring injuries, ankle sprains, or knee injuries, often due to muscle strain or sudden and uncontrolled movements (Wahyudi, 2018).

HIIT offers a massive advantage for football players because it simulates a high and low-intensity game pattern. Football is a sport that demands a constant change of rhythm; players have to sprint, stop, change direction, and move quickly in a short period. HIIT, with an intense training pattern interspersed with short breaks, can mimic these physical needs, making the player's body better prepared to face the demands of the game (Dian, Saphira, Widodo, Wati, & Sumekar, 2021).

Additionally, HIIT allows for improved performance in a shorter time compared to traditional low- or moderate-intensity training methods. In this study, players only underwent HIIT for 8 weeks with a frequency of 3 times per week, but the results showed significant improvements in endurance and reduced risk of injury. It shows that HIIT is more efficient and effective in preparing players for intense matches.

CONCLUSION

Based on the results of this study, High-Intensity Interval Training (HIIT) significantly improves physical endurance performance and reduces the risk of injury to football players. The results showed that HIIT could significantly increase VO_2Max and lower the risk of injury in football players. HIIT training has increased cardiovascular endurance as measured through VO_2Max, indicating the body's maximum capacity to consume oxygen during intense physical activity. Before training, the average VO_2Max value of the players was 61.87 ± 6.03 ml/kg/min, and after training, the value increased to

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63.60 ± 6.03 ml/kg/min, with an increase of 2.8%. This increase was statistically significant ($p < 0.05$), suggesting that HIIT training effectively increases the aerobic capacity of soccer players in a relatively short period.

Football requires muscular physical endurance to run continuously with varied activity patterns. Football players with a higher VO_2Max can last longer on the field with consistent performance. Additionally, the increased efficiency of oxygen use allows players to recover more quickly between periods of high intensity, improving their performance in demanding gaming situations. In addition to increasing physical endurance, HIIT training effectively reduces the risk of injury. This decrease is measured through the body's functional tests that assess muscle imbalances, weakness, and other biomechanical factors. Before training, the average risk of injury for players was 4.11 ± 0.86, and after training, this figure dropped to 4.07 ± 0.86, with a decrease of 1.1%, which is also statistically significant ($p < 0.05$). While a 1.1% reduction in injury risk may be insignificant, it is valuable for injury prevention in football.

Football players can improve muscle stability and flexibility and reduce muscle imbalances, which are the leading causative factors for muscle and joint injuries. High-intensity but short-duration training, such as HIIT, helps the body adapt to the high workload that often occurs in matches without causing excessive fatigue that can trigger injuries. HIIT has many advantages for football players compared to traditional training methods. First, HIIT allows for improved physical performance in a shorter period than low- or moderate-intensity workouts that typically take longer.

In this study, players only underwent a HIIT program for 8 weeks, but the results showed significant improvements in endurance performance and decreased injury risk. This time efficiency is invaluable in sports, where training programs must often adapt to tight competition schedules. Second, the HIIT training pattern consisting of high-intensity intervals followed by short recoveries is very much in line with the characteristics of the game of football, where players often have to make quick sprints, stop, and then get back to running. HIIT teaches the body to adapt to rapid rhythm changes, which makes players better prepared to face physical demands during matches. HIIT trains aerobic and anaerobic abilities simultaneously, which is ideal for football players.

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