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# Effect of high-intensity training on physiological parameters among soccer referee: A systematic review

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## ABSTRACT

This study explores the psycho-physiological impact of High-Intensity Interval Training (HIIT) on soccer referees, aiming to inform the development of training programmes that integrate educational psychology principles. It investigates how HIIT influences both mental health and physical performance, compared to alternative training methods, such as Small-Sided Games (SSG). A comprehensive review of 60 studies on the effects of HIIT on soccer referees was conducted, with 15 studies selected through rigorous screening. Credible databases were systematically searched, and biases were evaluated using the PICO (Patients, Intervention, Comparison, Outcome) framework to ensure methodological robustness. The study compared the physiological and psychological effects of HIIT and SSG therapies on soccer referees, incorporating funnel plot analysis to assess potential publication bias. The results indicated that SSG sprint training outperforms alternative methods in terms of sprint ability. However, HIIT was found to yield higher mental component summary scores, suggesting potential mental health benefits. The funnel plot revealed potential publication bias, and moderate heterogeneity was observed across studies, raising caution in interpreting the results. Despite these variations, HIIT demonstrated significant improvements in mental health and sprint performance compared to controls. The findings suggest that HIIT can be an effective method for enhancing both the mental and physical fitness of soccer referees. However, the observed heterogeneity and potential biases indicate the need for further research to validate these results and optimise training programmes. Tailored interventions based on these findings could improve officiating efficacy and promote the overall well-being of referees.

**Contribution/ Originality:** This study uniquely compares the physiological and psychological effects of High-Intensity Interval Training (HIIT) and Small-Sided games (SSG) on soccer referees. Using educational psychology principles and the PICO framework, it offers fresh insights into optimal training methods.

## 1. INTRODUCTION

Official soccer players are responsible for making sure that games are played according to the rules of the game (Alvira, Tobalina, Castagna, Casajús, & Irigoyen, 2020). While such goals seem simple, match play's psycho-physiological settings make officials' jobs quite tough. Field referees (FRs) cover 9-11 kilometers, including high-intensity activities like running and sprinting, in addition to their decision-making duties. During matches, assistant referees (ARs) cover around 5 kilometers with a movement limit of half the pitch. With players, managers, and fans scrutinizing football referees' actions, their psychological demands are high (Alvurdu et al., 2022; Arazi et al., 2017). In addition, soccer officials need technical knowledge and game management abilities to "manage" the game. To handle the variety of demands during match play and execute well, football officials need a comprehensive skill profile with strong physical, decision-making, psychological, and technical skills. Deliberate practice effortful and organised action to improve performance—has long been advocated for acquiring such skills (Bonato et al., 2017). According to deliberate practice theory, between-group disparities in skilled performance are mostly due to training volume over time. To develop the abilities and traits needed to officiate at the highest level, football officials must commit to long-term training and practice.

The amount and direction of adaptations that are achieved as a result of training are contingent upon a wide variety of variables (Castillo, Yanci, Cámara, & Weston, 2016; Dragijsky, Maly, Zahalka, Kunzmann, & Hank, 2017; Işıldak & Suna, 2020). The training load imposed over time shapes the training response in physical training. To maximize training-performance potential, volume, and intensity must be adjusted carefully. Therefore, measuring football officials' training volume and intensity is crucial to training management. Consider the specificity of training, or how well the stimulus matches competition (Da Silva et al., 2015). The idea of specificity states that football officials' training programs should reflect their multifaceted job. It seems vital to monitor a football official's training and preparation, including physical, decision-making, psychological, and technical activities. With such information, trainers and practitioners working with match officials may be able to prescribe and diversify training to improve performance (Castillo et al., 2016). Increases in heart rate of over 80% and oxygen uptake of 75% are indicative of varying intensities, necessitating the use of anaerobic and aerobic energy production mechanisms. High-intensity training for new or prospective referees improves "anaerobic threshold," "oxygen uptake (VO2 peak)," and "maximal velocity" endurance performance. HIIT comprises intensive exercise with a heart rate of over 90% and reduced-intensity activity to improve football players' fitness (Işıldak & Suna, 2020). There is an unlimited range when it comes to rest interval, training period length, interval number, high-intensity interval training sessions, team size, and pitch size. Several high-intensity interval training (HIIT) programs improve endurance performance metrics (Dragijsky et al., 2017). Physiological aspects, in addition to tactical and technical potentials, are thus highlighted as major determinants.

The transfer of oxygen to muscles is carried out by haemoglobin. Aerobic exercise raises oxygen demand in working muscles, which means that optimal levels of haemoglobin are required for high-intensity performance (Diker et al., 2023; Fang, Kim, & Choi, 2021; Gökkurt & Kıvrak, 2021). The ability of both players and officials to maintain an aerobic state is crucial to the success of soccer games. Just as athletes need to keep their haemoglobin levels at an optimal level to perform well, referees need to keep their mental and physical capacities, especially stamina, consistent throughout the contest (Da Silva et al., 2015). Serum concentrations of uric acid and urea are quantifiable markers for training-associated stress. Athletes' training loads can be measured by methodically evaluating these metrics at regular intervals throughout training sessions. FIFA(Fédération Internationale de Football Association)suggests and facilitates high-intensity interval training (HIIT) and continuous endurance training for referees (Da Silva et al., 2015; Diker et al., 2023). Triglycerides and adipose tissue fat storage, cholesterol and phospholipids, and steroid hormone production are all important biological uses of lipids. Coronary artery dysfunction is caused by an increase in plasma cholesterol concentration (Fang et al., 2021). In order to gain significant insights into the cardiovascular status, overall health, and metabolic function of football referees, it is essential to regularly evaluate their health markers (Diker et al., 2023).

Football is an "energy-demanding sport" that allows athletes to perform at higher intensities, improving performance (Gökkurt & Kıvrak, 2021). The aerobic system is the main energy source in football, according to the study. VO2 max is a measure of maximal oxygen consumption that indicates the upper limit. Improved aerobic capacity allows for quicker recovery times and post-game weariness (Ishihara, Naito, Ozaki, & Yoshimura, 2015). The outcomes are determined by the team's equal tactical and technical potential. The "aerobic fitness training" that football players undergo regularly involves the use of "pseudo-ramp test protocols" to gauge their aerobic potential (Adams et al., 2018). Those football referees who have a VO2max more than "60 ml/kg/min" are regarded as elite athletes. Aerobic fitness is positively impacted by the amount of sprints, distance traversed, and time spent with the ball during games (Dragijsky et al., 2017). Aerobic metabolism is boosted when there is an "insufficient recovery phase" after exercise. Athletes' ability to neutralise H+ is associated with their ability to sustain performance throughout repeated sprints. One well-known kind of training for football referees and players is high-intensity interval training (HIIT).

This study compares High-Intensity Interval Training (HIIT) and Small-Sided Games (SSG) therapies on football referees' psychological and physiological responses. This study's methodical approach, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement and filtering 15 relevant studies from 60, is its advantage. The study addresses missing data and publication bias by using reliable databases and smart search strategies, improving reliability. Studies are examined using the PICOframework to reduce bias and ensure methodological transparency. SSG therapies work well in sprints, but funnel plot asymmetry suggests publication bias. Higher Mental Component Summary scores indicate mental health advantages from HIIT. Despite heterogeneity, the study recommends cautious interpretation and more research to confirm findings and uncover the best training methods. This research improves football referee training by mixing psychological and physiological factors.

## 2. METHOD

### *2.1. Study Selection*

The review based on the impact of high-intensity training on the physiological parameters of soccer referees was conducted following the PRISMA statement (Figure 1). PRISMA statement emphasised reporting reviews while assessing the impacts of interventions and leading to obtaining quality content (Fang et al., 2021; Gökkurt & Kıvrak, 2021). The authors initiated the review process with an initial pool of 60 studies sourced from online libraries. Subsequently, 10 duplicate records were identified and removed, with an additional 10 studies deemed ineligible for various reasons. Following a meticulous screening process, 40 studies underwent evaluation, leading to the exclusion of 10 for non-compliance with eligibility criteria. Ultimately, after the further exclusion of studies conducted before 2015 or characterized by unclear or unavailable data, the current review comprehensively evaluated a final selection of 15 studies.

Figure 1 depicts the PRISMA-based study selection procedure. There were a total of 32 records found in the first step, which was to identify them from databases. At this stage, seven records were found to be duplicates, and two were marked as ineligible by the automation tools. Three closed-access records were excluded from the 23 records screened. There were still 20 records that needed to be located and reviewed. 12 reports were examined in order to determine eligibility, whereas 8 reports were inaccessible. Three reports were not included in the eligibility evaluation because the data was either conflicting or inaccessible. In the end, the review only included 9 research that met the predetermined criteria. Following the PRISMA criteria for openness and rigor in study selection, the flow diagram graphically depicts the systematic process of record identification, screening, eligibility assessment, and study inclusion in the research review.

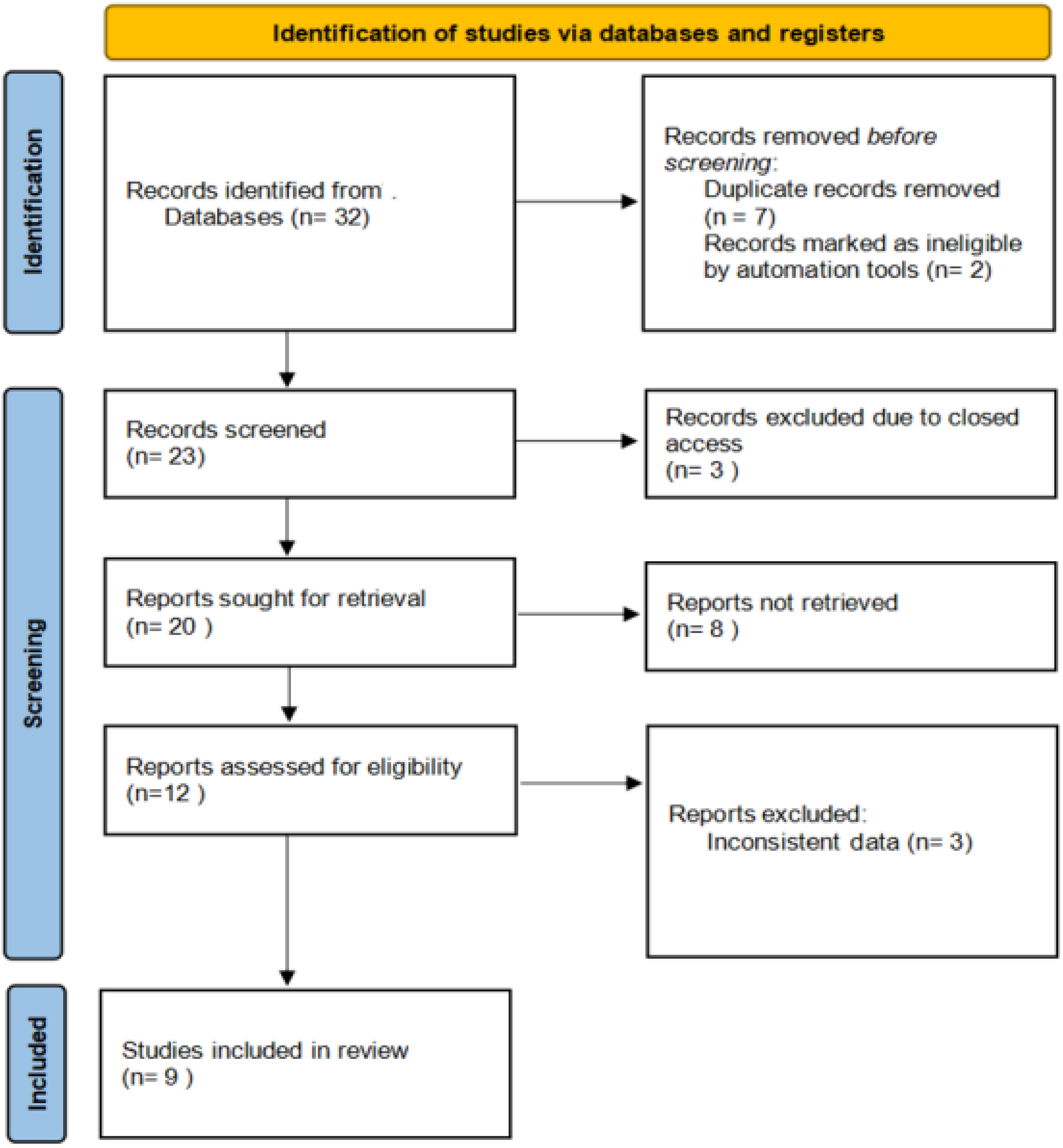


**Figure 1.** PRISMA flow chart for research study selection.

### *2.2. Search Strategy*

The authors utilized various online libraries such as Cochrane, EBSCO (Elton B. Stephens Company), PubMed, and SPORTDiscus(Sports Discus), as well as additional resources like Research Gate and Google Scholar to access authentic articles. The keywords employed for the search included terms such as “high intensity,” “soccer training,” “physiological parameters,” “anaerobic threshold,” “lean body mass,” and “lipoprotein cholesterol.” The Boolean method was used to refine the search and acquire authentic journals discussing the impact of "high-intensity training" on soccer referees. Search queries such as "Physiological changes,""high-intensity training in soccer players,""HIIT and physiological changes in soccer players,""HIIT and changes in Mean Changes in Sprinting Ability and Mental Component Summary Scoring in soccer players," and "HIIT or physiological or psychological changes among soccer referees" were deployed to retrieve relevant journals and articles. The search equation utilized was ("Physiological changes" or "changes in sprinting" or "changes in MCS") AND ("high-intensity training" or "HIIT") and ("soccer players" or "soccer referees").

The articles included in this systematic review were assessed following the PICO framework, where the athletes constituted the population, with various interventions outlined in Table 1 and Table 2 for each study, either comparing two groups or including a control group. However, this review displays potential bias due to the inclusion of studies with incomplete or missing data, which may limit the overall reliability and accuracy of the findings. Additionally, some studies lacking specific information on heart rate and lactate levels might introduce a bias when interpreting the results.

P = Soccer Players.

I = HIIT.

C = Control or SSG.

O = Sprinting ability and Psychological Status.

### *2.3. Data Collection and Risk of Bias*

The authors categorized and derived findings from each selected study, focusing on various physiological and psychological variables. Physiological variables like duration of training, Hedge's g and Standard Error between the two groups (HIIT group and Control group) of each included study. While the psychological variables like Mental Component Summary (MCS) scoring (Standardized Mean Difference and Standard Error) were obtained.

Hedge's g is a measure of effect size that corrects for bias, especially in small sample sizes. It is often used when comparing two groups. The formula for calculating Hedge's g from the mean difference (such as the difference in sprint ability between the HIIT group and the control group) is as follows:

$$g = d \times (1 - \frac{3}{4(df - 1)}$$

- *d* = Cohen's d, the standardized mean difference between the two groups. It is calculated as the mean difference divided by the pooled standard deviation.
- *df* is the degrees of freedom, calculated based on the sample sizes of the two groups.

If you have the mean difference and standard deviation, you can use these to calculate Cohen's *d*, and then use Cohen's *d* in the formula above to obtain Hedge's *g*. Hedge's g is particularly useful when dealing with small sample sizes as it adjusts for potential biases in the estimation of the population effect size.

This presents a risk of selection bias, as studies with incomplete data might be excluded, potentially skewing the overall results. It is vital to note that incomplete data is a common issue in research, and transparent reporting of any limitations in the included studies is crucial. The study's reliance on keywords and Boolean methods for the search strategy is another potential source of bias. Choosing keywords and search terms may inadvertently exclude related studies or use different terminology. Consequently, this might introduce selection bias as studies not captured by the chosen search terms could be overlooked. Despite these potential biases, the study maintained a rigorous methodology by applying clear inclusion and exclusion criteria to select relevant articles for analysis. This approach helped mitigate some of the risks associated with bias by establishing transparent criteria for study inclusion.

### *2.4. Inclusion and Exclusion Criteria*

The systematic review investigating the influence of High-Intensity Interval Training (HIIT) on the physiological parameters of soccer players, analyzed a curated selection of 9 articles. These articles specifically addressed the physiological adaptations observed in soccer referees following the implementation of HIIT protocols. Inclusion criteria included: (1) Articles that were published after 2000 onwards. (2) Articles investigating HIIT's impact on soccer referees' physiological parameters. (3) Articles that were published in English. (4) Original studies or reviews were included. (5) Studies that have projected the relevant results were considered. Conversely, the exclusion criteria omitted all articles published before 2000. The articles that were case series or case reports had unclear data or did not match the analysis or suspicious data, were excluded from this review.

## 3. RESULT

Table 1 presents selected physiological analysis studies' key findings. Participants in the RCTs average 14.2 to 19 years old. HIIT, SSGT, and SSG training were used for 2–6 weeks. Hedges' g was 0.776 and the standard error was 0.446 in a 5-week HIIT intervention that Arslan, Orer, and Clemente (2020) performed with 20 participants. Eniseler, Şahan, Özcan, and Dinler (2017) achieved a Hedges' g of 0.466 with a standard error of 0.445 after 2 days of high-intensity small-sided games training (SSGT) over 6 weeks. Mohr and Krustrup trained 18 subjects in speed endurance production (SEP) or maintenance (SEM) for 4 weeks, resulting in a Hedges' g of 0.155 and a standard error of 0.450. After 6 weeks of Small-Side Game (SSG) training, Safania, Alizadeh, and Nourshahi (2011). obtained a Hedges' g of -0.180 with a standard error of 0.049. These numerical data indicate the variety of training methods, durations, and physiological effects in the included research, aiding physiological analysis.

**Table 1.** Included studies considered for physiological analysis.

| Study | Study type | Mean age (Years) | Training type | Training duration | No. of participants | Intervention | Duration of training (Weeks) | Hedges' g | Standard error |
|---|---|---|---|---|---|---|---|---|---|
| Arslan et al. (2020) | RCT | 14.2 | High-intensity interval training (HIIT) | 5-week | 20 | SSG and HIIT | 5 | 0.776 | 0.446 |
| Eniseler et al. (2017) | RCT | 16.9 | high-intensity small-sided games training (SSGT) | 2 days | 19 | SSG and HIIT | 6 | 0.466 | 0.445 |
| Mohr and Krustrup (2016) | RCT | 19 | speed endurance production (SEP) or speed endurance maintenance (SEM) training | 4 weeks | 18 | SSG and HIIT | 4 | 0.155 | 0.450 |
| Safania et al. (2011) | RCT | 15.7 | Small-Side game (SSG) | 6 weeks | 20 | SSG and HIIT | 6 | -0.180 | 0.049 |

Table 2 shows that the study included 4 studies such as Eniseler et al. (2017); Mohr and Krustrup (2016) and Safania et al. (2011). By using these RCTs, physiological variables including sprint ability between the two groups of each study (HIIT and control group) was considered. Furthermore, this meta-analysis used a fixed-effects model, using which, the statistical analysis was conducted. Table 2 shows the forest plot of the included studies which reveals that the overall effect is a statistically significant difference in sprint ability favoring HIIT over SSG (mean difference = -0.16, 95% CI [-0.25, -0.06], p = 0.001). There is moderate heterogeneity among the studies ($I^2$ = 57%), suggesting some variation in the effect sizes. But Individual study results show that Safania et al. (2011) (largest study, 96.5% weight) found a significant effect favoring SSG. Again, Other studies had smaller sample sizes and did not find significant differences. Based on the available evidence, SSG appears to be more effective than HIIT for improving sprint ability. However, the moderate heterogeneity suggests that the effect may vary depending on the specific training protocols or populations studied. More research is needed to confirm these findings and to explore potential moderators of the effect.

**Table 2.** Forest plot showing the mean difference of the effect size of the HIIT group and SSG group in sprint ability.

| Study or subgroup | Std. mean difference | SE | Weight | Standard mean difference IV, fixed, 95% CI |
|---|---|---|---|---|
| Arslan et al. (2020) | 0.776 | 0.446 | 1.2% | 0.78 [-0.10, 1.65] |
| Eniseler et al. (2017) | 0.466 | 0.445 | 1.2% | 0.47 [-0.41, 1.34] |
| Mohr and Krustrup (2016) | 0.155 | 0.45 | 1.1% | 0.15 [-0.73, 1.04] |
| Safania et al. (2011) | -0.18 | 0.049 | 96.5% | -0.18 [-0.28, -0.08] |
| Total (95% CI) | | | 100.0% | -0.16 [-0.25, -0.06] |

**Note:** Heterogeneity: $Chi^2$ = 7.04, df = 3 (P = 0.07); $I^2$ = 57%; Test for overall effect: Z = 3.27 (P = 0.001).

Figure 2 shows the funnel plot of this meta-analysis comprising of 4 studies that has shown the Small-Sided Games (SSG) were more effective than High-Intensity Interval Training (HIIT) at improving sprint ability (mean difference = -0.19, 95% CI [-0.32, -0.06], p = 0.003) but that HIIT was still effective. However, asymmetry is hinted at by the funnel plot analysis, which graphically depicts the link between research effect sizes and precision (sample size). This imbalance suggests that studies that support HIIT but have smaller effect sizes may be underrepresented in the published literature, which could lead to publication bias. Hence, although there is evidence that SSG is better at improving sprint ability, it is important to be cautious because of the influence of publication bias.

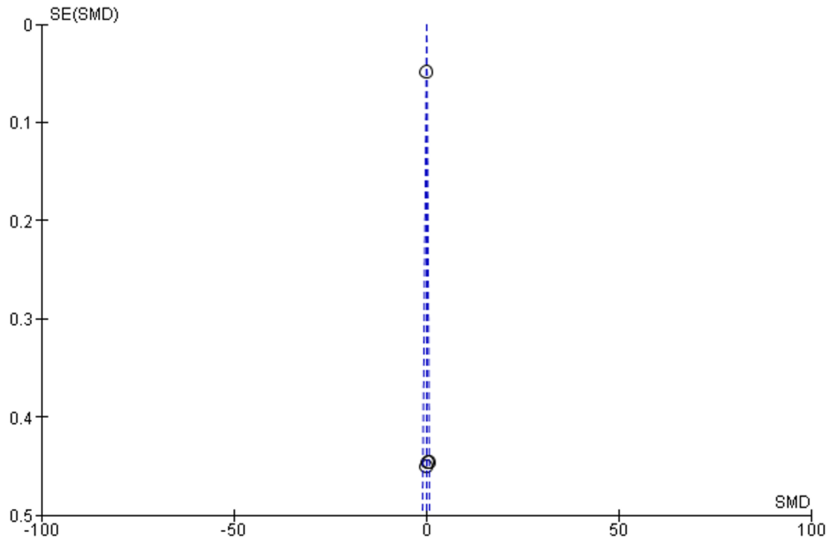


**Figure 2.** Funnel plot showing the mean difference of the effect size of HIIT group and SSG group in sprint ability.

Table 3 provides an overview of the studies that were considered for the psychological evaluation.

**Table 3.** Included studies considered for psychological analysis.

| Study | Mean age of the participants | Study type | Study place | Sample size (HIIT/Control) | Training duration | Mean difference in MCS scoring | SE |
|---|---|---|---|---|---|---|---|
| Adams et al. (2018) | HIIT group: 44±1.6 years, Control: 43.7±10.8 years | Two armed RCT | Turkey | 35/28 | 12 weeks of HIIT | 1.3 | 0.25 |
| Egegaard, Rohold, Lillelund, Persson, and Quist (2019) | HIIT group: 64±5.8 years, Control: 65±4.7 years | Two armed pilot RCT | Turkey | 7-Aug | 7 weeks | 0.64 | 0.51 |
| Chou et al. (2019) | HIIT group: 60.9±0.5 Control group: 59.7±5.3 years | | Sweden | 17/17 | 12 weeks | 8.8 | 1.51 |
| Hurst, Weston, and Weston (2019) | HIIT group: 61.9±0.5 Control group: 62.8±6.2 years | Two armed RCT | | 18/18 | 12 weeks | 2.9 | 0.48 |
| Malmo et al. (2016) | HIIT group: 62±9 Control group: 56±8 years | Two-armed RCT. | | 26/25 | 12 weeks | 2.2 | 0.43 |

Mean participant age, study type (RCT or pilot RCT), study location, sample size (HIIT group/Control group), training time, and mean MCS rating differences are listed. Adams et al. found that a 12-week HIIT intervention increased MCS by 1.3 and SE by 0.25 in a two-armed RCT in Turkey with 44-year-old participants. In a pilot RCT in Turkey with 64-year-olds, Egegaard et al. (2019) found a 7-week HIIT intervention with a mean MCS difference of 0.64 and SE of 0.51. In two-armed RCTs in Sweden with 61-year-old participants.

Chou et al. (2019) and Hurst et al. (2019) found 12-week HIIT treatments with mean MCS differences of 8.8 (SE 1.51) and 2.9 (SE 0.48). In a two-armed RCT in an unclear location with 62-year-old participants, Malmo et al. (2016) presented a 12-week HIIT intervention with a mean MCS difference of 2.2 and SE of 0.43. This table summarises each study's psychological features, including age, study methodology, location, sample size, intervention duration, and MCS score differences.

Table4 shows a Forest Plot showing the Standard Mean Difference of mental component summary scores between the two groups (HIIT and Control). This study found that HIIT is linked with significantly higher mental segment scores than the control group. The standardized mean difference (SMD)" was 1.72, the HTT score was (95% CI: 1:36 to 2.08, and the P value was <0.00001. Furthermore, this study is aligned based on the overall findings with positive effects of HIIT. In addition, a moderate to high heterogeneity score was also included in this study, and the I2 statistic score was 89%, which was considerably variable in the result. As per the findings, Adams et al. (2018) SMD =1.30 favoring HIIT, Chou et al. (2019) SMD=0.64 favoring HIIT (non-significant); Egegaard et al. (2019) SMD=8.80 strongly favoring HIIT. Hurst et al. (2019) SMD=2.90, strongly favoring HIIT, Malmo et al. (2016) SMD=2.20, strongly favoring HIIT. This finding suggests that HIIT has a beneficial effect on mental health. Therefore, further research is needed to identify the mechanisms underlying the effect and confirm the findings in larger and more diverse populations. It is also essential to assess the heterogeneity among these studies and carefully evaluate the individual study design and methodological quality when interpreting the result. Moreover, further research can explore the optimal HIIT protocols for enhancing mental health outcomes. Five studies were included in the meta-analysis to analyze the psychological status (MCS scoring). These studies exhibited a range of standard errors from 0.25 to 1.51, indicating relatively low biases overall. Notably, one out of the 5 studies displayed results outside of the expected funnel, suggesting potential publication bias.

**Table 4.** Forest plot showing the standard mean difference of mental component summary scores between the two groups (HIIT and control).

| Study or subgroup | Std. mean difference | SE | HIIT total | SSG total | Weight | Standard mean difference IV, fixed, 95% CI |
|---|---|---|---|---|---|---|
| Adams et al. (2018) | 1.3 | 0.25 | 35 | 28 | 53.3% | 1.30 [0.81, 1.79] |
| Chou et al. (2019) | 0.64 | 0.51 | 8 | 7 | 12.8% | 0.64 [-0.36, 1.64] |
| Egegaard et al. (2019) | 8.8 | 1.51 | 17 | 17 | 1.5% | 8.80 [5.84, 11.76] |
| Hurst et al. (2019) | 2.9 | 0.48 | 18 | 18 | 14.5% | 2.90 [1.96, 3.84] |
| Malmo et al. (2016) | 2.2 | 0.43 | 26 | 25 | 18.0% | 2.20 [1.36, 3.04] |
| **Total (95% CI)** | | | 104 | 95 | 100.0% | 1.72 [1.36, 2.08] |

**Note:** Heterogeneity: $Chi^2 = 36.58$, $df = 4$ ($P < 0.00001$); $I^2 = 89\%$; Test for overall effect: $Z = 9.42$ ($P < 0.00001$).

## 4. DISCUSSION

The study was to record and analyse the methods used to train football referees across the country. Our research shows that football officials, regardless of job or officiating category, focus mostly on physical conditioning and spend little attention on decision-making, psychological, and technical skills training (Da Silva et al., 2015; Işıldak & Suna, 2020). We also examined respondents' estimates of optimal performance abilities and traits and how often they received instruction to acquire them. Decision-making, psychological, and game management skills were considered "very important" to "extremely important" by both FRs and ARs, yet they received less than monthly instruction. Such findings may have significant implications for both the growth of football officials and their readiness to handle the demands of match play. This is because the nature of football officiating is multidimensional, and such findings will likely have such ramifications.

In this study, decision-making training was little compared to physical fitness training (Mohr & Krustrup, 2016). Decision-making training research has advanced in the recent decade therefore it is strange that referee training procedures have not improved. However, officials' high physical training volumes may be due to match play's increased physical and physiological stresses. Football has become faster and more dynamic, so national and international referee governing bodies now include routine fitness testing in match selection criteria. Match officials usually acquire elite status at an age when their physical capacities begin to deteriorate, thus they may prioritise physical training to retain their fitness and ability to meet match demands. When it comes to playing football, body composition is a very important element (Safania et al., 2011). Kicking, trapping, quick sprints, and catching make football physically demanding. Players and officials cover large areas on the pitch during defense and attack using aerobic and anaerobic fitness (Diker et al., 2023). Playing involves deceleration, acceleration, and directional shifts, which strains muscles. Aerobic workouts for referees and players enhance oxygen demand in working muscles, requiring adequate hemoglobin concentration for peak performance (Egegaard et al., 2019; Safania et al., 2011). To perform well, football referees need normal hemoglobin levels. Training stress is measured by uric acid and urea levels. The training load is determined by evaluating these characteristics during training. Uric acid and urea buildup are used to monitor protein catabolism and ATP (Adenosine Triphosphate)degradation (Chou et al., 2019). Energy production, steroid hormone synthesis, and fat storage in adipose tissues are all functions of lipids.

Football referees lost body fat from baseline to prepared and competitive phases. When PP(Prepared Phase)was compared to CP (Competitive Phase), however, there were no discernible differences found. U19, U23, and U16 athletes' heart rate and VO2max rose with training. On the other hand, the older players showed no signs of major alteration. Anaerobic power increases in U23 and U19 players but not in U16 and senior players (Hurst et al., 2019). Football referees are dominated by size. Body mass is important in football because of contact. There were no significant changes in referee's body mass after training. Incorrect training load optimisation or short training time may cause it Egegaard et al. (2019). A number of studies have shown that athletes perform better when their body fat percentage is lower (Chou et al., 2019; Egegaard et al., 2019; Hurst et al., 2019; Malmo et al., 2016; Safania et al., 2011). Referees lose fat through training. Lack of training makes football referees obese in the off-season. Therefore, they should exercise to build body fat in the off-season. Aerobic capacity affects referee tactics and technique. VO2 max increases post-training due to "systemic a-v O2 difference" and stroke volume (Chou et al., 2019). Aerobic training increases circulatory activity and skeletal muscle oxidative capability, increasing muscle oxygen delivery (Jensen, Randers, Krustrup, & Bangsbo, 2008). Work intensity raises football referees' heart rates. "Recovery heart rate" dropped in all age groups after training. Freeing "parasympathetic inhibition" accelerated cardio, but activating it post-exercise slowed it Jensen et al. (2008).

Football takes a significant amount of anaerobic power at a rapid pace. Football referees need "tolerance to lactic acid" and quickness, even though they mostly do low-level activity. The ability to generate power without oxygen is known as anaerobic power. One of the most important aspects of football training is building strength. Referees need back strength to change pace and kick. Training increases anaerobic power in U19 and U16 players but not in older players. Senior referees may have lower anaerobic power due to motivation. High VO2max needs more oxygen (Kunz, Engel, Holmberg, & Sperlich, 2019). Haemoglobin is responsible for transporting oxygen. Performance improved during the competitive phase, and hemoglobin levels dropped more during the transition period. Hemolysis and hem dilution, common after endurance training, reduced hemoglobin. Referees' metabolic and cardiovascular health is indicated by lipids and lipoproteins. Activity impacts athlete lipoprotein and lipid levels (Aquino et al., 2016). Due to improved performance throughout the preliminary period, LDL-C(Low-Density Lipoprotein Cholesterol), cholesterol, and triglycerides decreased and HDL-C(High-Density Lipoprotein Cholesterol)increased. Increased training load and performance raise triglycerides and cholesterol while lowering

LDL-C and raising HDL-C. Exercise may lower LDL-C, cholesterol, and triglycerides (Mohr & Krustrup, 2016). Other studies have shown high HDL-C and low LDL-C without triglyceride alterations following training. Another study found training programs that raise HDL-C and lower LDL-C and cholesterol (McEwan, Unnithan, Easton, & Arthur, 2023). Regular lipoprotein profiles and lipid monitoring of football players are essential to optimise referees' health and performance (McEwan, Unnithan, Easton, Glover, & Arthur, 2023; Nobari, Silva, Vali, & Clemente, 2023).

## 5. CONCLUSION

The meta-analysis has concluded that High-Intensity Interval Training (HIIT) is associated with significantly higher mental component scores compared to the control group, with an overall standardized mean difference (SMD) of 1.72 favoring HIIT. Also, the meta-analysis suggests a statistically significant difference in favor of HIIT over Small-Sided Games (SSG) for sprint ability. This finding is consistent across individual studies, all of which demonstrate a positive effect for HIIT on mental health outcomes. However, the analysis also identifies moderate to high heterogeneity among the studies, indicating considerable variability in the results. It's crucial to interpret these overall findings with caution, considering the potential impact of this heterogeneity. The study recommends further research to explore the mechanisms underlying the observed mental health benefits of HIIT, emphasizing the need for confirmation in larger and more diverse populations. Additionally, careful consideration of individual study designs and methodological quality is advised. The findings highlight the need for more research to confirm these results, considering the moderate heterogeneity among the studies. The conclusion underscores the potential effectiveness of HIIT over SSG for improving sprint ability but calls for further investigation into training protocols and population-specific effects.

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