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Endurance performance adaptations between SSG and HIIT in soccer players: A meta-analysis

Abstract

The objective of this systematic review with meta-analysis was to compare the endurance performance chronic adaptations induced by running-based high-intensity interval training (HIIT), small-sided games (SSGs), and combined HIIT+SSGs in male and female youth and adult soccer players. The studies included in this review followed the PICOS criteria: (i) healthy soccer players; (ii) interventions based on SSGs; (iii) comparators exposed to only HIIT or combined SSGs+HIIT; (iv) endurance performance variables. Studies were searched for in the following databases: (i) PubMed; (ii) Scopus; (iii) SPORTDiscus; (iv) Web of Science. After conducting an initial database search that retrieved a total of 5,389 records, a thorough screening process resulted in the inclusion of 20 articles that met the eligibility criteria. Sixteen studies reported outcomes related to endurance performance measured through field-based tests, while 5 studies provided results from direct measurements of maximal oxygen uptake (VO2max). Results showed a non-significant small-magnitude favoring effect for the HIIT groups compared to the SSGs groups (ES=0.37, *p*=0.074) for endurance, while a non-significant small-magnitude favoring SSGs was observed (ES=–0.20, *p*=0.303) for VO2max. Despite the very low certainty of evidence, the findings suggest similar effects induced by both SSG and HIIT on improving endurance performance and VO2max.

Keywords: football; high-intensity interval training; aerobic exercise; athletic performance; physical fitness.

Introduction

Soccer is characterized by intermittent activities that require players to switch frequency between low and near-to-maximum-intensity activities [1]. From the range distance of 10-14 kilometers covered in a soccer match, players can be subjected to more than 1 kilometer of high-intensity running demands [2]. These high-intensity activities, such as sprints and explosive movements, are crucial for players to effectively compete. High-intensity activities place significant demands on the cardiovascular and muscular systems, therefore soccer players need to have a well-developed endurance fitness level to perform such high-intensity activities throughout the competition [3]. For example, previous research indicated that a higher maximum oxygen uptake (VO2max) is linked to covering a greater distance during a game [4], whereas better results on intermittent fitness tests are associated with a greater number of high-intensity activities [5]. Indeed, well-developed endurance fitness may improve the ability of players to cope with match demands (e.g., repeated high-intensity efforts) [6].

One of the most popular training methods for improving endurance performance is high-intensity interval training (HIIT) [7], which involves short bursts of intense exercise followed by periods of rest or low-intensity exercise [8]. This type of training has been shown to improve cardiovascular fitness, endurance, increase muscle power, enhance speed and agility [7,9,10]. Regarding endurance performance, this type of training has been shown to be particularly effective, increasing maximal oxygen uptake (VO2max) [11] and enhancing anaerobic threshold [12]. Moreover, HIIT can be tailored to the specific demands of soccer by incorporating drills that simulate the movements and energy demands of the sport [13]. For example, a HIIT session for soccer players might include exercises such as shuttle runs, box-to-box sprints, repeated sprint efforts, or high-intense efforts made in drill-based exercises [14]. Typically, HIIT applied to soccer training can be classified into five types: 1) short HIIT involves sub-maximal efforts, lasting 10-60 seconds, and performed between 100 and 120% of maximal aerobic speed [15]; 2) long HIIT also involves sub-maximal high-intensity efforts (<95 of maximal aerobic speed), usually lasting 1-4 minutes [15], 3) repeated sprint training (RST) involves performing a series of all-out sprints (<4 seconds or >30 m) with short rest periods in between (<20 seconds) [15]; 4) sprint interval training (SIT) involves short, all-out sprints (>20 seconds) followed by a longer period of rest or low-intensity exercise (>2 min) [15]; 5) finally, game-based training (or, in the case of soccer, small-sided games [SSGs]) involves periods >2-3 minutes with a rest of <2 minutes performed in small formats of play (thus, increasing specificity) [15].

Despite the varied acute impacts of the HIIT types, a recent systematic review with a meta-analysis conducted in soccer players found that different types of HIIT were equally effective in improving endurance fitness, including maximal oxygen uptake (VO2max), and performance in field-based tests [7]. One way in which HIIT improves aerobic fitness is by increasing the body's ability to transport and utilize oxygen during exercise [16]. This is reflected in the increased VO2max seen in many studies of HIIT. By stressing the body at high intensities, HIIT stimulates muscle oxidative capacity [17], leading to improved endurance and overall aerobic fitness. Additionally, HIIT can improve the body's ability to buffer and clear lactic acid [18], a byproduct of intense exercise that can cause fatigue and muscle soreness. This allows athletes to perform at higher intensities for longer periods of time and can improve overall endurance [19].

When comparing running-based HIIT to SSGs, both methods have been shown to improve endurance fitness, which represents the ability to sustain effort over time. However, there is ongoing debate regarding the most appropriate approach to use in soccer. On the one hand, HIIT may be more time-efficient and allow for individualized load and intensity [20,21], while SSGs offer the added benefit of practicing specific soccer skills and tactics in a game-like environment [22]. This can be particularly beneficial for improving technical ability [23,24] and tactical awareness [25] on the field, which are important for overall soccer performance.

SSGs in soccer involve playing on a smaller field with fewer players, creating a more specific and dynamic training environment than traditional running-based training methods [26,27]. Some studies have tested the effects of SSG play formats for improving critical fitness variables such as aerobic capacity [28,29]. Some physiological explanations for the improvements in aerobic capacity observed after SSGs in soccer players can be related to increased oxygen uptake [30]. SSGs require repeated bouts of high-intensity exercise, which leads to increased oxygen uptake by the body. This, in turn, improves the body's ability to utilize oxygen during exercise, leading to increased aerobic capacity and so, it may improve endurance capacity considering the enhanced cardiovascular function [31]. The repeated changes in direction, acceleration, and deceleration during SSGs require the body to work harder to supply oxygen to the working muscles [32]. Moreover, due to the high accelerations and decelerations occurring in SSGs [33,34], improved muscle function can be observed by increasing muscle fiber recruitment, improving muscle endurance, and enhancing muscle energy production [35].

Given the ongoing debate over which approach may be superior between running-based HIIT and SSGs, some studies have compared the effects of both on the endurance chronic adaptations of soccer players [26,27,36,37]. Also, some experimental approaches have been testing the possibility of combining both (i.e., SSGs + running-based HIIT) against using only one type [38,39]. Despite that, no systematic review has summarized the evidence for comparing the endurance chronic adaptations between SSGs and running-based HIIT. An unique systematic review with meta-analysis was dedicated to comparing the endurance chronic adaptations induced by SSGs to those induced by conventional endurance training (i.e., continuous running or extensive interval training) [40]. Another meta-analysis was conducted comparing SSGs and running-based HIIT, but it did not include any measures of endurance performance [41]. A systematic review conducted on male soccer players examined various forms of HIIT but focused solely on males and did not specifically explore the relationship between SSGs and running-based HIIT [7].

Given the importance of endurance performance for soccer players and the various HIIT training options available, it is crucial to synthesize the evidence and compare the endurance chronic adaptations induced by SSGs vs. running-based HIIT, while also considering the possibility of combined SSGs+HIIT against a single HIIT type. Conducting a systematic review with meta-analysis is essential for synthesizing the evidence and providing a quantitative analysis of the results of individual studies, which can offer a more precise estimate of the overall effect of the interventions and generate useful information for coaches to make informed decisions in their daily practices. Therefore, the objective of this systematic review with meta-analysis is to compare the endurance performance chronic adaptations induced by running-based HIIT, SSGs, and combined HIIT+SSGs in male and female youth and adult soccer players who are classified at a minimum of tier 2 on the Participant Classification Framework [42]. By including a range of populations of both sexes and competitive levels, the study can provide a comprehensive summary of the evidence, identify potential gaps, and guide future research directions.

Methods

This systematic review adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) [43] and Cochrane guidelines [44].

Protocol and registration

The systematic review protocol was initially submitted and published on the Open Science Framework under the registration number DOI 10.17605/OSF.IO/A6TPW on 1st June 2023. The protocol is accessible through the web address osf.io/a6tpw and the registration number 10.17605/OSF.IO/CZQJ6.

Eligibility criteria

General eligibility criteria: original studies published in peer-reviewed journals, including those with the status of "in press" or "ahead-of-print". No other study types were considered. Studies undertaken in all languages were also included, and no date limitations were set [45].

Additionally, we followed the PICOS (Participants, Intervention, Comparator, Outcomes, Study Design) approach to establish the specific eligibility criteria (Table 1). Of note, an evidence-based decision [46] was considered to determine the minimal effective HIIT duration (weeks) for the improvement of endurance performance (i.e., > two weeks).

It is noteworthy that the evaluation and analysis of the SSGs will be conducted without regard to their specific format, encompassing variations from 1v1 to 10v10. In this context, the term "SSG" will be utilized to denote a delimited task or activity, dissociated from its classification according to the specific play format employed. This approach is aimed at ensuring an impartial scrutiny of the SSGs, emphasizing their inherent characteristics and constraints rather than placing undue emphasis on the diversities arising from format discrepancies.

TABLE 1

Information Sources

The search for relevant studies was conducted using the following databases: PubMed, Scopus, SPORTDiscus, and Web of Science (Core collection). The searches were performed on June 02, 2023, the day after the protocol registration (ID: 10.17605/OSF.IO/CZQJ6) was completed. In addition to the database searches, manual searches were conducted on the reference lists of included studies to identify potentially relevant titles. The abstracts of these articles were reviewed for relevant inclusion criteria, and if necessary, the full-text was obtained. Additionally, snowballing citation tracking was performed, with a preference for Web of Science. Two external experts, recognized by Expertscape at the worldwide level, were also consulted. As part of the review process, articles that were included in the review were also examined for any errata or retractions [44].

Search strategy

The Boolean operators AND/OR were utilized in the search process, and no filters or limitations such as date, language, or study design were employed to enhance the probability of identifying relevant studies. The following search strategy was used as the primary method of identifying relevant studies:

[Title/Abstract] soccer OR football*

AND

[All fields/Full text] "small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR SSGs OR SSG OR "drill-based game*" OR "conditioned-game*"

AND

[All fields/Full text] aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness

The full search strategy can be observed in the following Table 2.

TABLE 2

Selection process

The retrieved records, including titles and abstracts, were screened independently by two authors (FMC and JA). The same authors also independently screened the full texts of selected studies. In case of any disagreements, the two authors discussed and reanalyzed the studies together. If no consensus was reached, a third author (RRC) made the final decision. Throughout the selection process, all co-authors shared their opinions and provided support as needed. The EndNote 20.5 software (Clarivate) was used to manage records and remove duplicates, both manually and automatically.

Data collection process

The lead author (FMC) conducted the initial data extraction process, which was then reviewed for accuracy and completeness by two co-authors (JA and RRC). A Microsoft Excel datasheet was developed specifically for this purpose, containing all relevant data and key information. The supplementary material includes a sample of this Excel datasheet. If important data were absent from a full text, the primary author (FMC) contacted the corresponding author of the study directly via email and/or ResearchGate to obtain the necessary information. In this particular case, there was a unique situation where one study presented challenges in communication and data accessibility. Despite efforts to reach out to the main author over a period of three weeks, there was no response. Additionally, the last author mentioned that they no longer had access to the database and had lost contact with the first author.

Data items

To provide a comprehensive contextual overview, the collection of study- and participant-related data will encompass the following variables: sport discipline, age, gender, competitive level as defined by the Participant Classification Framework (PCF) [42], regular training frequency, and volume (calculated as the product of frequency and duration of training) within their respective clubs. It is important to note that these data points are independent of the intervention-based information. Additionally, the period of the season, including phases such as competitive season and off-season, will also be considered as a vital component of the contextual framework, further enhancing the holistic understanding of the study's findings.

Randomization of the participants was also registered. The competitive level was classified based on the Participant Classification Framework [42]: Tier 0 and Tier 1:

sedentary and recreationally active (not included, considering the context of this systematic review); Tier 2: trained/developmental; Tier 3: highly trained/national level; Tier 4: elite/international level; Tier 5: world class. Moreover, competing interests and funding information will be reported.

Intervention-related information: The information related to the intervention included, but was not limited to, adherence/compliance, program duration (in weeks), number of sessions, training frequency (sessions per week), training volume (in minutes per session), training prescription (sets, number of repetitions, time of effort in each repetition, time of recovery between and within sets), training intensities, and type of field (e.g., synthetic turf, natural turf). In the case of SSGs, the information included, but was not limited to, format of play (e.g., numerical relationship) in which between 1v1 and 4v4 were considered small formats, 5v5 to 6v6 medium formats and > 7v7 were considered large formats; pitch configuration (e.g., width and length, area); task goals (e.g., using small-goals, regular goals, number of passes); use of goalkeepers; use of neutral players/floaters; specific constraints on time or actions, and specific instructions.

Comparator-related information: In the case of HIIT, the information included, but was not limited to, type of running-based HIIT (e.g., short, long, repeated sprint training or sprint interval training), distance covered, pace, and changes-of-direction per set.

Outcomes: The main outcome measures collected were related to endurance performance, including but not limited to: (i) VO_2max measured directly or indirectly; (ii) maximal aerobic speed (MAS) measured directly or indirectly; (iii) distance covered in an endurance field-based test; (iv) time to exhaustion in a test; or (v) ventilatory threshold.

Outcome-related information: to ensures a comprehensive understanding of the outcomes, the outcome-related information will encompass various crucial elements. These include the context of the assessment, including the duration of rest preceding the analysis and the specific time of day during which the testing occurred. Additionally, the presence or absence of a familiarization period prior to the physical tests will be noted, as it can influence participant performance. Moreover, meticulous attention will be given to blinding procedures implemented to ensure that the observers conducting the tests remain unbiased and uninfluenced by prior knowledge of the test conditions.

Data management

All variables pertinent to endurance performance were systematically gathered and subsequently categorized for analysis. The data from each individual test will be recorded in terms of the mean value and standard deviation, capturing the variability observed across different assessment moments. In instances where data is presented graphically, diligent efforts will be made to extract the necessary information using specialized software tools such as the WebPlotDigitizer (version 4.6). This approach ensures that data points from graphical representations are accurately estimated, maintaining the integrity and precision of the collected data for further analysis and interpretation [47]. Randomised and non-randomised trials will be initially compared for each main outcome, and that grouped vs separated analyses will be decided upon the results of such preliminary analyses.

Study risk of bias assessment

Using Cochrane's Risk of Bias tool, version 2 (RoB 2) [48], parallel randomized studies were assessed for bias in five domains, namely, randomization process, deviations from intended interventions (intention-to-treat analysis), missing outcome data, measurement of the outcome, and selection of the reported result. Non-randomized studies, on the other hand, were evaluated for bias in seven domains using Cochrane's Risk of Bias In Non-Randomized Studies of Interventions (ROBINS-I) [49], which included confounding, selection of the participants, classification of interventions, deviations from intended interventions, missing data, measurement of outcomes, and selection of the reported result. Risk of bias was evaluated at outcome- and study-levels, with the worst-case scenario per study presented. In the absence of a pre-registered protocol, the risk of bias in selection of the reported result was deemed to have at least some concerns (RoB 2) or moderate risk (ROBINS-I). Two authors (JA and FMC) independently evaluated the risk of bias, with a third author (RRC) serving as an arbitrator when necessary. The overall summaries of risk of bias evaluations were presented by main outcome.

Summary measures, synthesis of results, and publications bias

To ensure adequate statistical power, we performed our meta-analyses only when at least three studies were available [50], in accordance with the Cochrane Handbook [51]. Effect sizes (ES; i.e., Hedges' g) for endurance-based variables in the intervention and comparator groups were calculated using means and standard deviations from pre- and post-intervention values, and data were standardized using post-intervention standard deviation values. To account for differences between studies that may affect the SSGs effects, we used the DerSimonian and Laird random-effects model [52,53]. ES values were presented with 95% confidence intervals (95% CIs), and their interpretation was based on the following scale: <0.2 trivial, 0.2-0.6 small, >0.6-1.2 moderate, >1.2-2.0 large, >2.0-4.0 very large, >4.0 extremely large [54]. A posteriori, it was considered pertinent to exclude a study from a given meta-analysis if the study yielded an ES value ≥3, considering that such result in strength and conditioning research studies is unlikely after most interventions, and thus may be considered an outlier [55]. For studies that included more than one intervention group, the sample size in the control group was proportionally divided to facilitate comparisons across multiple groups [56]. To assess the impact of heterogeneity, we used I^2 statistics, with values of <25%, 25-75%, and >75% representing low, moderate, and high impact of heterogeneity, respectively [57]. We explored the risk of publication bias for continuous variables (≥10 studies per outcome) using the extended Egger's test [58], and to adjust for this risk, we conducted a sensitivity analysis using the trim and fill method [59] with L0 as the default estimator for the number of missing studies [60]. All analyses were conducted using the Comprehensive Meta-Analysis Software (Version 2, Biostat, Englewood, NJ, USA), and statistical significance was set at $p \leq 0.05$.

Subgroup analyses

In this study, potential sources of heterogeneity that were likely to influence the effects of training were selected a priori. Given that adaptive responses to intervention programs may be influenced by individual factors such as competitive level [61], total sessions, SSG playing formats organized in accordance to previous study [62] (small formats (1v1 to 4v4); medium formats (5v5 to 8v8); large formats (9v9 to 11v11) (large formats); mixed SSG (combining different playing formats), and HII types in accordance to Buchheit and Laursen [15] (i.e., short intervals, long intervals, repeated sprint training and sprint interval training), we have considered them as potential moderator variables. We compared the results of studies conducted with participants classified in Tier 2 or higher to investigate the impact of competitive level on the outcomes. Moreover, total number of training sessions (≤ 12 vs. >12; criteria defined as the median of total sessions found in the articles included) type of SSGs formats and HIIT were also compared. Ultimately, in the event of necessitation, we shall duly contemplate a sub-group analysis with respect to the studies that were subjected to randomization, juxtaposed with those studies that were not subjected to randomization.

Single training factor analyses

For subgroup analyses and single training factor analyses, we utilized the median split technique [63–65] when it was deemed appropriate. To calculate the median, at least three studies with relevant data were required for a given moderator. It is important to note that if a study included two experimental groups with identical information for a given moderator, only one of the groups was considered to prevent an exaggerated influence on the median calculation. Additionally, instead of using a global median value for a given moderator (e.g., median age, derived from all included studies), we calculated median values considering only those studies that provided data for the analyzed outcome. If the median split technique was not deemed appropriate, we used a logically defensible rationale for subgroup analysis.

Sensibility analyses

Sensitivity analyses were conducted to evaluate the robustness of the summary estimates (such as p-value, effect size, and I^2). To assess the impact of each individual study on the overall findings, we conducted an automated leave-one-out analysis, whereby the results were analyzed with each study removed from the model. This allowed us to examine the effect of each individual study on the summary estimates and evaluate the overall robustness of the findings.

Certainty assessment

Using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) [66], two authors (JA and FMC) assessed the certainty of evidence and resolved any disagreements through consensus. The assessment focused on four out of five GRADE dimensions [67,68], namely, risk of bias, inconsistency, risk of publication bias, and imprecision. Based on these four domains, GRADE assigns a rating of high, moderate, low, or very low quality to the body of evidence for each outcome of interest. This rating is used to guide recommendations for practice and future research. For the case of non-randomized studies, they started with very low and suffered upgrades based on large effect size, control of plausible confounders and verification of dose-response gradient. In the case of non-randomized studies, they initially began with low levels of evidence and underwent significant improvements based on three factors. These factors include the identification of large effect sizes, control of plausible confounding variables, and verification of a dose-response gradient.

The following criteria were established to assess the certainty of evidence in our analysis: i) Risk of bias in studies: If there were some concerns, the evidence was downgraded by one level, and if there was a high risk of bias, it was downgraded by two levels; ii) Indirectness: The evidence was considered low due to the eligibility criteria used in the studies; iii) Risk of publication bias: We did not assess this due to the availability of fewer than 10 studies for each comparison. However, if the Egger's test indicated a p-value of less than 0.05, the evidence was downgraded by one level; iv) Inconsistency: If the statistical heterogeneity, as indicated by the I2 statistic, was moderate (>25%), the evidence was downgraded by one level. If it was high (>75%), it was downgraded by two levels; v) Imprecision: If there were fewer than 800 participants in a comparison or if the effects had no clear direction, the evidence was downgraded by one level. If both factors were present, the evidence was downgraded by two levels.

Results

Study selection

The initial database search yielded 5,389 records, with 2,634 identified as duplicates. After screening the remaining 2,755 records based on article type or PICOS criteria, 2,366 records were excluded. The screening process took place from June 15, 2023, to June 16, 2023. Subsequently, a full-text analysis was conducted on 47 studies, out of which 18 studies met the eligibility criteria and were included in the review. The remaining 29 studies were excluded for various reasons, which can be found in the supplementary material 1. The full-text analysis phase lasted from June 17, 2022, to June 20, 2023. Additionally, two independent researchers, who are experts in this topic, identified two additional eligible articles, which were confirmed through full-text analysis. Consequently, a final list of 20 articles was included in the current systematic review (Fig. 1).

FIGURE 1

Studies characteristics

Table 3 provides a comprehensive summary of the main study design characteristics of the included studies in the current systematic review. Most of the included studies focused on tier 2 competitive level players, representing those classified as trained/developmental with a local-level representation (85% of studies). The overall sample size per study, including participants from both experimental and control groups, ranged from 16 to 73, with a median of 21 participants per study. Regarding the age of participants, seven studies included individuals above 18 years old, indicating that 65% of the studies focused on youth participants. It is worth noting that nine studies did not report the sex of the participants, highlighting a lack of description in this regard. Among the remaining 11 studies, only one included female participants. In terms of study design, the prevalent type was the two-arm parallel group design (18 studies), and 17 of the 20 included studies declared the use of randomization. In terms of the timing of interventions, five studies started during the pre-season, five started during the early season and/or first half of the season, and five started during the second half of the season and/or end season. The most employed assessment tests included the Yo-Yo intermittent recovery test level 1 (n=6), incremental exhaustive treadmill tests (n=5), Yo-Yo intermittent recovery test level 2 (n=3), the 30-15 intermittent fitness test (n=3), the University of Montreal Track Test (n=2), and the Vameval (n=2). The most prevalent outcomes measured were the distance covered in the Yo-Yo intermittent recovery test level (both levels 1 and 2, n=8) and direct measurement of VO_2max (n=5).

TABLE 3

Methodological characteristics of the interventions

The interventions included in the analysis spanned a range of 3 to 12 weeks, with a median duration of 6 weeks across the 20 studies. The weekly frequency of intervention sessions varied from 1 to 4, with a median total number of 12 sessions per study. However, detailed information on adherence to the interventions was limited, as only four studies reported adherence rates, which ranged from 86.4% to 100%.

Table 4 provides a summary of the main methodological characteristics of the interventions utilizing SSGs. Eight studies exclusively utilized playing formats ranging from 1v1 to 3v3, while two studies exclusively employed playing formats between 4v4 and 6v6. Three studies employed combinations of playing formats that included formats larger than 7v7, although always in combination with smaller formats. In terms of the relative area of play (calculated by dividing the area of play by the number of players), ten studies exclusively used areas equal to or below 100 m^2 per player, while four studies exclusively used areas above 100 m^2 per player.

Regarding the training regimen, the studies utilizing SSGs employed 1 to 8 sets per session, with the majority (n=12) exclusively using 4 or fewer sets per session. The duration of work per set varied between 45 second and 8 minutes, although 13 studies exclusively used ≤4 minutes per set.

TABLE 4

Table 5 presents a summary of the methodological characteristics of the running-based HIIT interventions included in the analysis. The most prevalent type of HIIT used was short sub-maximal intervals, which was employed in 8 studies. This was followed by long sub-maximal intervals, which were used in 6 studies. Repeated sprint training was exclusively utilized in three studies, while sprint interval training was exclusively employed in two studies.

Regarding the number of sets performed in the interventions, it varied from 1 to 10 across the included studies. However, most studies (16 out of 20) utilized 5 or fewer sets per session. When prescribing the HIIT regimen, the most employed approach for short intervals was the 15 s: 15 s work-to-rest ratio, which was utilized in 6 studies.

TABLE 5

Study risk of bias assessment

Table 6 provides an assessment of the risk of bias for the randomized studies using the RoB2 instrument. The table focuses on the studies that examined endurance performance and VO_2max.

Among the included studies that analyzed endurance performance, 16 out of 17 were found to have an overall high risk of bias. This high risk of bias was primarily influenced by concerns in dimension 1, which relates to the lack of information provided about the randomization techniques and allocation concealment. Specifically, 15 out of the 17 articles analyzed did not provide sufficient details regarding these critical aspects of the study design. Another consistent concern observed across the studies was in dimension 4, which pertains to the blinding of assessors to the tests and intervention. Many studies did not implement blinding measures, introducing the potential for biased assessments of outcomes. Concerns were also noted in dimension 5, which deals with the selection of the reported results. The main reason for these concerns was the absence of information regarding pre-specified analyses, making it unclear whether the reported results were selectively chosen from a larger set of outcomes. Overall, the assessment of risk of bias indicates that the majority of the included studies had limitations in key methodological aspects, particularly in randomization, allocation concealment, blinding, and reporting of results. These limitations should be taken into consideration when interpreting the findings and assessing the overall quality of the evidence presented in the meta-analysis.

Similarly, the assessment of risk of bias for the four randomized studies that examined VO2max revealed an overall high risk of bias, consistent with the concerns identified for the endurance performance outcome.

TABLE 6

Table 7 provides an assessment of the risk of bias for the non-randomized studies included in this systematic review, utilizing the Cochrane's Risk of Bias in Non-Randomized Studies of Interventions (ROBINS-I) tool. The findings indicate that the non-randomized studies were classified as having a serious overall risk of bias. This classification was primarily influenced by the ambiguity and lack of clarity in the classification of the experimental groups, which introduces uncertainty and potential bias into the study designs.

TABLE 7

Summary of the main results

Table 8 provides a summary of the main findings regarding the adaptations induced by SSG-based and running-based HIIT interventions on field-based test outcomes. Studies utilizing the Yo-Yo Intermittent Recovery Test Level 1 (the most frequently employed field-based test) demonstrated improvements ranging from 1.8% to 18.1% following SSG-based interventions, while enhancements ranging from 0.3% to 23.4% were observed when participants underwent running-based HIIT interventions.

TABLE 8

Moreover, when analyzing studies that directly measured maximal oxygen uptake (VO2max) through incremental exhaustive treadmill tests (as presented in Table 9), fluctuations between –0.7% and 8.6% were observed following SSG-based interventions, while changes between –1.6% and 8.3% were observed after participants underwent running-based HIIT interventions.

TABLE 9

Results of the meta-analysis: field-based tests performance

Results (Fig. 2) showed a non-significant small-magnitude favoring effect for the HIIT groups compared to the SSGs groups: ES = 0.37, 95% CI = –0.04-0.77, p = 0.074, I^2 = 72.9%, total participants n = 366, Egger test two-tailed = 0.899. Of note, the study conducted by Arianto et al [69] was excluded from the analysis due to the lack of reported standard deviations.

FIGURE 2

After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates (e.g., *p* value) was confirmed, except for the removal of two trials [70,71] producing an ES = 0.42-0.45, p = 0.028-0.041, I^2 = 70.6-71.6%, total participants n = 337-347, Egger test two-tailed = 0.651-0.916-7.

Regarding non-randomized trials, a moderator analyses was precluded because only 2 non-randomized trials were included. However, when the 2 non-randomized trials were removed from the analysis, the robustness of the summary estimates (e.g., *p* value) was confirmed: ES = 0.37, 95% CI = -0.09–0.82; p = 0.118; I^2 = 76.3%).

Regarding participants sex, a moderator analyses was precluded because only 1 trial [72] included female participants. However, when the trial was removed from the analysis, the robustness of the summary estimates (e.g., *p* value) was confirmed: ES = 0.38, 95% CI = -0.05–0.81; p = 0.086; I^2 = 74.6%).

Regarding moderator analyses according to the duration (weeks) of the interventions, similar changes in the field-based tests performance were noted after >12 total sessions (5 groups; ES = 0.08, 95% CI = –0.29-0.46; I^2 = 5.7%) compared to ≤12 total sessions (11 groups; ES = 0.49, 95% CI = –0.07-1.04; I^2 = 78.9%), with a between-moderator category *p* value of 0.239.

Regarding moderator analyses according to the type of SSG intervention, similar changes in the field-based tests performance were noted after mixed SSGs (5 groups; ES = 0.37, 95% CI = –0.66-1.39; I^2 = 88.2%) compared to small formats of SSGs (10 groups;

ES = 0.33, 95% CI = –0.09-0.75; I^2 = 57.2%), with a between-moderator category *p* value of 0.950.

Regarding moderator analyses according to the type of HIIT intervention, similar changes in the field-based tests performance were noted after HIIT-RST (3 groups; ES = 0.86, 95% CI = –0.41-2.13; I^2 = 81.6%), HIIT-long intervals (4 groups; ES = 0.40, 95% CI = –0.47-0.54; I^2 = 27.0%), and HIIT-short intervals (7 groups; ES = 0.16, 95% CI = –0.21-0.53; I^2 = 32.0%), with a between-moderator category *p* value of 0.498. Of note, the studies from Koral et al. [73] and from Castillo et al. [74] were not included in the analyses as only 1 trial was available per each HIIT type.

The reduced number (i.e., <3) of available studies for a given sub-group precluded sub-group meta-analyses for the type of field test, and according to player's competitive level.

Results of the meta‐analysis: VO_2max

Results (Fig. 3) showed a non-significant small magnitude-based effect on VO2max, favoring the SSGs groups compared to the HIIT groups: ES = -0.20, 95% CI = 0.59–0.18, p = 0.303, I^2 = 12.9%, total participants n = 115. After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates (e.g., *p* value) was confirmed. The reduced number (i.e., <3) of available studies for a given sub-group precluded sub-group meta-analyses.

FIGURE 3

Results of the meta‐analysis: within-groups analyses

A posteriori, within-group (pre-post) meta-analyses were included for the main outcomes. Regarding interventions involving SSGs, results showed a significant improvement in field-based tests performance between the pre-intervention and the post-intervention period (Fig. 4): ES = 0.70, 95% CI = 0.43 – 1.10, $p < 0.001$, $I^2 = 87.2\%$, total participants $n = 172$, Egger test two-tailed < 0.001. Due to the significant value derived from the Egger test, the Duval and Tweedie's trim and fill method was applied, and the adjusted values remained as per the observed values. Of note, the study conducted by Arianto et al [69] was excluded from the analysis due to the lack of reported standard deviations. Additionally, the study of Safania [75] was removed due to an extremely large ES value (i.e., ≥3.0) [55]. After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates was confirmed (e.g., $p<0.05$).

FIGURE 4

Interventions involving SSGs also showed a significant improvement in *VO2max* between the pre-intervention and the post-intervention period (Fig. 5): ES = 0.50, 95% CI = 0.16 – 0.84, $p = 0.004$, $I^2 = 62.9\%$, total participants $n = 56$. After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates (e.g., *p* value) was confirmed.

FIGURE 5

Regarding interventions involving HIIT, results showed a significant improvement in field-based tests performance between the pre-intervention and the post-intervention period (Fig. 6): ES = 0.94, 95% CI = 0.53 – 1.35, $p < 0.001$, $I^2 = 87.6\%$, total participants $n = 165$, Egger test two-tailed = 0.035. Due to the significant value derived from the Egger test, the Duval and Tweedie's trim and fill method was applied, and the adjusted values remained as per the observed values. The study conducted by Arianto et al [69] was excluded from the analysis due to the lack of reported standard deviations. Additionally, two studies [75,76] were removed due to extreme large ES values (i.e., ≥3.0) [55]. After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates (e.g., *p* value) was confirmed.

FIGURE 6

Interventions involving HIIT did not showed a significant improvement in VO_2max between the pre-intervention and the post-intervention period (Fig. 7): ES = 0.34, 95% CI = -0.05 – 0.73, $p = 0.090$, $I^2 = 74.9\%$, total participants $n = 59$. After the sensitivity analyses (automated leave-one-out analysis), the robustness of the summary estimates (e.g., *p* value) was confirmed, except for the removal of one trial [30], producing an ES = 0.45, 95% CI = 0.02-0.89, p = 0.040, I^2 = 73.5%, total participants n = 48.

FIGURE 7

Certainty of evidence

The certainty of evidence was assessed using the GRADE scale, and the results are summarized in Table 10. It is important to note that the certainty of evidence for both endurance performance and VO_2max outcomes was determined to be very low. This is primarily due to the high risk of bias observed in the majority of the included studies, as well as the inconsistency in the reported effects on endurance performance. Additionally, the small sample sizes and the lack of clear direction of effects in the comparative analyses between SSGs and HIIT further contribute to the overall low certainty of evidence.

TABLE 10

Discussion

This systematic review aimed to compare the effects of SSG and running-based HIIT training interventions on the endurance performance of soccer players. Various methodological approaches were observed, including comparisons of smaller and larger formats of play and different types of running-based HIIT. Despite the methodological heterogeneity, it was possible to establish minimal criteria for conducting a meta-analysis to quantitatively examine the differences between the two types of interventions on the main outcomes of interest.

The meta-analysis focused on two main domains: endurance performance measured through various field-based tests and maximal oxygen uptake measured directly in laboratory settings. Regarding the impact on maximal oxygen uptake and endurance performance, the comparative studies did not find a significant difference or impact of the training methods on the observed variations after the intervention period. Moderators as total number of sessions, SSGs formats or HIIT types had no significant impact on the evidence found. However, it is important to acknowledge that the certainty of evidence in our analysis is very low. This is primarily due to methodological limitations in the included studies. Therefore, it is crucial to exercise caution when drawing definitive conclusions or making generalizations based on these findings. Future research should consider employing more robust methodological approaches to ensure a higher level of confidence in the results.

Methodological characteristics of training interventions: a comparative analysis of the effects of SSGs and running-based HIIT

Among the 20 studies deemed eligible for inclusion in the current systematic review, the majority adopted a two-arm parallel group design, with one study utilizing a two-arm crossover design [70] and another employing a four-arm parallel group design

[77]. In the realm of competitive sports research, the design of studies presents challenges due to the potential confounding effects of various factors such as concurrent training processes [78], recovery strategies [79], match demands, and phase of the season. Comparing two training interventions presents a considerable challenge in determining the true causal impact of the interventions, especially when factors outside the intervention itself may independently influence the observed changes. For instance, in the context of introducing a new SSGs-based training intervention, it is important to consider that coaches typically incorporate various formats of play and drill-based games as part of the regular training process [80]. This raises the question of to what extent the pre-existing formats of play used by the coach prior and during to the experimental intervention might play a role or contribute to explaining the observed adaptations.

Understanding the potential influence of pre-existing formats of play is crucial in accurately attributing the effects solely to the introduced intervention. It requires meticulous consideration and control of all training components involved, ensuring that the observed changes can be confidently attributed to the specific intervention being investigated. By isolating the effects of the new intervention from the existing training practices, researchers can establish a clearer understanding of the true impact of the intervention on the desired outcomes.

Of particular interest was the study employing the four-arm design [77], as it incorporated exclusive SSG and HIIT interventions, a combined SSG and HIIT intervention, and a control group not exposed to any intervention. This study showed significant within-group improvements in the Yo-Yo Intermittent Recovery Test Level 1 for all groups, including the control group [77]. Notably, the between-group analysis only revealed differences when comparing the combination of SSG and HIIT interventions against the control group. Conversely, in the Yo-Yo Intermittent Recovery Test Level 2, all intervention groups exhibited significant differences compared to the control group [77]. This study underscores the importance of methodological considerations when designing intervention studies, particularly regarding the necessity of including a control group that is not subjected to any intervention beyond regular training. Such an approach merits further emphasis in future research endeavors.

Among the studies included in this review, there was a notable bias towards investigating males, with only one study dedicated to examining the effects of SSGs vs. HIIT training on females [72]. It is important to highlight that nine out of the 20 articles did not provide information regarding the sex of the participants, which raises concerns regarding contextualization and replicability of the findings. This gender imbalance in research is reflective of a broader issue within sports sciences, as previously discussed in another study [81]. Achieving a more balanced approach in research is crucial, not only due to the inherent biological and contextual differences between sexes but also to acknowledge and support the growing trend of women's participation in soccer. Over recent years, female participation in soccer has been steadily increasing [82], and research should align with this trend by providing informed contributions to the training and development of female participants. Thus, efforts should be made to address the underrepresentation of female participants in research studies.

Moreover, another important limitation of the current literature is the underrepresentation of high-competitive level players. Among the 20 included studies, only three [72,83,84] were conducted with participants at tier 3 (highly trained/national level), and no studies were performed at the elite/international level (tier 4) or the world-class level (tier 5) [42]. This indicates that most of the research in this area has focused on youth players or those at the amateur/local-level representation, which highlights a significant gap in the literature. It is important to acknowledge the inherent challenges and complexities associated with conducting research at high-competitive levels. Factors such as limited access, logistical constraints, and ethical considerations may contribute to the scarcity of studies in elite and world-class teams. However, it is crucial to recognize that these competitive levels have distinct contexts that may influence the outcomes and generalizability of findings from research conducted at lower levels. Therefore, a greater investment and concerted effort should be made to include elite and world-class teams in studies comparing SSGs vs. HIIT training interventions.

The inclusion of studies conducted across different phases of the season provides valuable representativeness in terms of seasonality. Within the analyzed research, studies were identified that focused exclusively on the pre-season [72,73,77], first half of the competitive season [36,70,85,86], second half of the competitive season [74,87–89], and post-competitive season [37]. Additionally, some studies examined combined periods, such as pre-season and early competitive season [71,90]. Notably, one particular study [37] explored the effects of detraining after the conclusion of the season and investigated the use of SSGs and HIIT training as strategies to mitigate the detraining period. The inclusion of studies across various phases of the season is of practical importance. It recognizes that the trainability and physiological status of players can vary throughout the season, which in turn may influence their response and adaptation to a new training intervention. By encompassing different phases of the season, the research accounts for the dynamic nature of athlete preparation and allows for a more comprehensive understanding of the effects of SSGs and running-based HIIT interventions at different stages of the competitive calendar. Furthermore, studying interventions in specific season phases provides valuable insights into the practical application of these training methods. Coaches and practitioners can consider the timing and integration of SSGs and HIIT training based on the specific demands and objectives of each phase of the season. This information helps in optimizing training programs and enhancing performance outcomes across the entire competitive period.

Comparative analysis of the effects of SSGs and running-based HIIT on endurance performance measured by field-based tests

Endurance performance, as addressed in this article, encompasses a multifaceted capacity influenced by various physiological factors [91]. These factors include VO_2max, maximal heart rate, stroke volume, lactate threshold, movement economy, muscle fiber type and morphology, capillarization, aerobic enzyme activity, as well as factors associated with muscle mass and blood volume [91]. Field-based tests commonly used in soccer reflect this multi-dependency and serve as proxies for assessing overall endurance performance. By grouping these interrelated physiological factors together under the umbrella term of endurance performance, this article acknowledges the complex nature of the construct. The outcome of endurance performance in soccer is not solely determined by a single factor but represents a combination of physiological attributes and adaptations. It recognizes that improvements in one or more of these factors can contribute to enhanced endurance capacity and performance on the field.

Among the tests employed to assess endurance performance adaptations, the Yo-Yo Intermittent Recovery test level 1 emerged as the most frequently utilized, followed by the Yo-Yo Intermittent Recovery test level 2, the 30-15 Intermittent Fitness test, the University of Montreal Track Test, and the Vameval. These tests share a common characteristic of being progressive in nature, culminating in exhaustion. Additionally, several of these tests incorporate change-of-direction elements (e.g., Yo-Yo Intermittent Recovery tests, 30-15 Intermittent Fitness test), thereby introducing an additional challenge during the assessment. Preliminary analysis suggests that these tests capture different aspects associated with endurance performance. For instance, the Yo-Yo Intermittent Recovery test level 1 primarily places a high demand on aerobic capacity, whereas level 2 involves a combination of anaerobic and aerobic energy systems [92,93]. On the other hand, tests such as the 30-15 Intermittent Fitness test introduce change-of-direction components, making the final performance outcome reliant not solely on metabolic factors but also on factors such as movement economy and neuromuscular properties [94]. This aspect grants an advantage to individuals with superior change-of-direction abilities, particularly in the higher stages of the test [95].

The inherent heterogeneity of these endurance tests and their respective interpretations holds significance when considering the meta-analysis results comparing the effects of SSGs versus running-based HIIT on overall endurance performance. Our meta-analysis yielded compelling evidence suggesting that running-based HIIT interventions are associated with non-significant small beneficial effects compared to SSG-based training interventions. It is noteworthy that our findings align with a previous systematic review and meta-analysis that compared SSGs versus conventional endurance training, which encompassed a broader range of training methods beyond HIIT and considered various outcomes related to endurance [40]. In that review [40], no significant differences were found between the different training methods. Although no statistically significant differences were observed between running-based HIIT and SSGs in terms of their impact on endurance performance, there was a small beneficial effect of HIIT over SSGs, as evidenced by the sensitivity analyses. While the overall difference did not reach statistical significance, there was a trend indicating that running-based HIIT interventions may have a slightly greater impact on improving endurance performance compared to SSG interventions. However, it is important to note that both SSGs and HIIT interventions showed significant improvements in endurance performance according to the within-group analysis.

Several factors may help explain the observed trend of a slight non-significant superiority of HIIT over SSGs in our study. One such factor is the inherent within- and between-player variability associated with the training stimulus induced by SSGs. Previous research has shown that while heart rate variability remains relatively stable during SSGs (within-player variability), other variables such as locomotor demands at high speeds exhibit greater variability [96,97]. This variability is attributed to the dynamic nature of the game, which can significantly influence the level of neuromuscular stimulus experienced by players. Consequently, this variability may result in less pronounced improvements compared to the more standardized and individualized nature of running-based HIIT, where it is easier to control and regulate the imposed pace [98].

Furthermore, in medium to larger SSG formats (e.g., 5v5 or larger), the level of player participation can be influenced by tactical behaviors [34]. This variability in participation may lead to different training stimuli experienced by individual players within the same game [34]. In contrast, using standardized running protocols as in HIIT interventions helps mitigate such variability and ensures a more consistent and controlled training stimulus across participants.

Another possible explanation for the greater benefits (although not significant) associated with running-based HIIT compared to SSGs could be the specific types of SSGs employed. All of the included studies in our analysis utilized small formats of SSGs, ranging from 1v1 to 4v4, either exclusively or in combination with medium (5v5 to 8v8) and large formats (9v9 to 11v11). From a pure locomotor standpoint, these small SSG formats may not provide sufficient overload to elicit significant improvements in running loads during endurance-oriented training sessions [32,34]. This notion is supported by a previous study that compared different game formats and suggested that larger formats may be more effective in overloading running loads [32].

On the other hand, incorporating intermittent runs such as 15 seconds on and 15 seconds off may be beneficial in ensuring an appropriate complementary stimulus during SSGs. Combining medium SSG formats with intermittent runs could potentially provide a better balance in terms of ensuring adequate locomotor demands associated with endurance-oriented training [99]. Additionally, using small SSG formats (1v1 to 4v4) may primarily stimulate anaerobic and maximal aerobic power rather than endurance per se, as the metabolic response tends to be closer to maximal levels with higher mechanical work intensity [32]. This finding helps shed light on why our meta-analysis did not find statistically significant differences between SSG-based and running-based HIIT interventions in terms of VO_2max, despite a small non-significant favoring effect toward SSGs. In summary, the type of SSGs employed, specifically focusing on small formats, may limit the ability to effectively overload running loads during endurance-oriented training [33,34]. Incorporating intermittent runs and considering larger SSG formats could potentially enhance the benefits of SSG interventions for endurance performance.

Interestingly, the moderator analysis conducted to investigate the particularities of the studies revealed an intriguing finding. While the volume of training sessions (more or less) did not result in significant differences; it was observed that studies with more than 12 training sessions had a significant impact on reducing heterogeneity. Specifically, the studies with more than 12 training sessions exhibited a remarkably low heterogeneity value (I^2 = 5.7%) compared to those with 12 sessions or less, where heterogeneity was substantially higher (I^2 = 78.9%). This finding suggests that greater consistency in the results is achieved when the experimental interventions consist of more than 12 training sessions. It is important to note that this information enhances our understanding of the relationship between training volume and heterogeneity in the context of SSGs and running-based HIIT interventions. The moderator analysis conducted on the type of training interventions revealed interesting findings. First, comparisons between small formats (1v1 to 4v4) and mixed formats (small, medium, and large formats) did not result in significant differences. This could be attributed to the limited implementation of medium and large-sided games, leading to similar trends in terms of physiological and locomotor demands. This finding aligns with a previous study [32] that compared small and medium formats against larger ones.

Furthermore, comparisons between different types of running-based HIIT interventions also did not demonstrate significant differences. This aligns with a previous meta-analysis [7] indicating that running-based HIIT improves endurance performance in soccer players, regardless of the specific type of HIIT used. This is intriguing, considering that different HIIT types elicit distinct physiological and neuromuscular stimuli [15,100]. It suggests the need for further research to investigate the dose-response relationships between HIIT training and the subsequent adaptations, emphasizing the importance of more fundamental research in this area rather than solely applied studies.

Comparative analysis of the effects of SSGs and running-based HIIT on maximal oxygen uptake measured directly in laboratory-based tests

As mentioned earlier, VO_2max is an important component for assessing endurance performance, but it is not the sole determinant. Therefore, we conducted a separate analysis focusing on articles that directly measured VO_2max in a laboratory-based context, independent of field-based tests. The results of this meta-analysis provide robust evidence that SSG and running-based HIIT interventions do not significantly differ in their impact on the VO_2max of soccer players. The analysis included studies with a total of 115 participants, revealing a small level of heterogeneity (I^2 = 12.9%) and a small effect size. Importantly, no significant differences were found between the interventions (p = 0.303). Interestingly, the within-group analysis showed that SSG interventions led to a significant improvement in VO_2max (medium effect size; ES = 0.50) after the intervention. On the other hand, running-based HIIT interventions demonstrated a significant benefit with a small effect size (ES = 0.45), as confirmed by sensitivity analysis and robustness testing. These findings suggest that both SSG and running-based HIIT interventions have a positive impact on VO_2max in soccer players. Although SSG interventions showed a larger effect size, the difference between the two interventions was not statistically significant.

The use of SSGs, particularly with a greater emphasis on small formats (1v1 or 4v4), or in combination with these small formats, may explain the observed results. Despite not inducing high-intensity locomotor demands (due to limited space for running and achieving higher speeds) [101], these formats can promote a higher level of mechanical work, accelerations, and decelerations [32]. This results in a near-maximal physiological stimulus, often reflected in heart rate values near to or above 90% of maximal heart rate [22]. This enhanced maximal aerobic stimulus provided by SSGs, particularly those incorporating smaller formats, is important for improving VO_2max due to its ability to challenge the cardiovascular system and promote adaptations in oxygen uptake and utilization. There are several possible mechanisms through which SSGs or HIIT can contribute to improvements in VO2max. Firstly, the intensity achieved during SSGs can lead to increased stroke volume and cardiac output [102]. Secondly, SSGs and HIIT can improve skeletal muscle respiratory capacity [103]. The high-intensity intermittent nature of SSGs requires rapid and efficient oxygen utilization by the muscles, stimulating adaptations such as increased mitochondrial density and oxidative enzyme activity [104]. It is important to note that these potential mechanisms are not exclusive and may interact with each other to contribute to the improvements in VO_2max observed with SSG and HIIT interventions. However, further research is needed to fully understand the underlying physiological adaptations and mechanisms that occur in response to SSGs and HIIT training.

Overall, both SSG and running-based HIIT interventions provide valuable strategies for enhancing VO_2max in soccer players. Coaches and practitioners should carefully consider their specific training goals, available resources, and constraints when deciding which approach to incorporate. The choice between SSGs and running-based HIIT may also depend on factors such as the phase of the season, the number of players involved, and the team's context. Combining both SSGs and running-based HIIT can be an effective approach to provide a well-rounded training stimulus [99]. This combination allows for a variety of physiological and neuromuscular adaptations, as well as targeting different aspects of endurance performance. Specifically, SSGs mainly focus on game-specific skills, decision-making, and tactical aspects [24,25], while running-based HIIT can provide a more standardized and individualized training stimulus to improve players' endurance capacity.

Limitations, gaps, and research directions in intervention studies comparing SSGs and running-based HIIT

The current systematic review is subject to some limitations that should be acknowledged. Firstly, the certainty of evidence supporting the findings is very low, indicating a need for further high-quality research to strengthen the conclusions. Secondly, the included randomized studies exhibited shortcomings, particularly in terms of insufficient information regarding randomization and allocation concealment, which raises concerns about potential bias. Additionally, the lack of blinding procedures for participants, evaluators, and researchers in most of the included studies is another limitation, compromising the objectivity and reliability of the findings. Future research should aim to address these limitations by providing clearer descriptions of the randomization process and implementing blinding techniques where feasible. This would help enhance the overall quality of the data and improve the reliability of the results obtained from the comparisons.

Furthermore, the meta-analysis conducted in this review faced challenges due to heterogeneity in study designs and methodological characteristics of the training interventions. Although efforts were made to mitigate this using moderators and sensitivity analyses, it is important to exercise caution when interpreting the final evidence obtained.

There are several challenges that need to be addressed in future research comparing SSGs and running-based HIIT. These include increasing the number of studies conducted in female participants, exploring the effects in higher competitive levels (elite, international, and world-class) in both genders, establishing dose-response relationships, and accounting for the influence of individual training sessions implemented by coaches. Three-arm designs with control groups and statistical models to isolate the effects of interventions are also valuable approaches.

Apart from the methodological concerns, future research should investigate the effects of different formats of play in interaction with the playing area, as it appears to significantly impact the locomotor demands and adaptations observed. Understanding the sealing effect based on the baseline fitness level and determining the minimum effective dose required for superior advantages are also important research paths. Additionally, studies examining the long-term effects of SSGs and running-based HIIT interventions, such as through crossover designs with extended timeframes, would provide valuable insights.

As practical implications, it is important to consider the limitations of the evidence available. However, based on the existing literature, both small-sided games (SSGs) and high-intensity interval training (HIIT) can be effective in improving endurance performance and maximal oxygen uptake.

Coaches may choose between SSGs and HIIT based on specific contextual factors and training objectives. If time efficiency and individualization are important considerations, HIIT may be a suitable strategy. HIIT allows for shorter training sessions and can be tailored to individual player needs. It can be utilized as a top-up strategy or in situations where training sessions involve a limited number of players.

On the other hand, if the coach aims to incorporate smaller formats of play and prioritize the development of endurance performance while maintaining a dynamic stimulus that involves tactical behaviors and technical actions more similar to match conditions, SSGs can be a suitable choice. SSGs provide an opportunity for players to work on their endurance within the context of the game, enhancing their ability to sustain effort over time.

It is essential for coaches to consider their specific training objectives, available resources, and the preferences and characteristics of their players when deciding between SSGs and HIIT. Ultimately, a tailored approach that aligns with the specific context and goals of the team or individual players is likely to yield the best results.

Conclusions

The current systematic review and meta-analysis suggests that both SSGs and running-based HIIT interventions have comparable effects on the endurance performance and maximal oxygen uptake of soccer players. However, it is important to note that the certainty of evidence supporting these findings is very low. Therefore, caution must be exercised when interpreting the results of this systematic review, and further high-quality research is needed to provide more robust and conclusive evidence. The within-group analysis also revealed significant improvements in both intervention groups, indicating their potential beneficial impact on players. The moderator analysis did not yield any significant differences between interventions with more or less than 12 training sessions. Similarly, no significant differences were found between using small formats of play versus mixed formats, or between different types of running-based HIIT. However, it is important to interpret these results with caution, as all the included studies focused on participants at trained/developmental levels or highly trained individuals, and none were conducted at elite/international or world-class levels. Additionally, only one study included female participants, limiting generalizability to this population. Therefore, while the findings of this systematic review provide valuable insights into the effects of SSGs and running-based HIIT interventions, it is important to consider the specific context and limitations of the included studies. Further research is needed, particularly in elite-level players and female participants, to enhance the generalizability and understanding of the effects of these interventions in different populations and competitive levels. Furthermore, future research should aim to establish a clearer dose-response relationship when investigating the effects of SSGs and running-based HIIT interventions. Optimizing research designs by varying the dosage of interventions, such as the frequency, duration, and intensity of training sessions, would provide valuable insights into the optimal training parameters for maximizing endurance performance and maximal oxygen uptake in soccer players.

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Figure Legends

[Fig. 1] PRISMA 2020 flow diagram [43].

[Fig. 2] Forest plot illustrating changes of the field-based tests performance after SSGs compared to HIIT. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

[Fig. 3] Forest plot illustrating VO_2max changes after HIIT compared to SSGs. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

[Fig. 4] Forest plot illustrating SSGs-related improvements of the field-based tests performance. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

[Fig. 5] Forest plot illustrating SSGs-related improvements of VO2max. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

[Fig. 6] Forest plot illustrating HIIT-related improvements of the field-based tests performance. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

[Fig. 7] Forest plot illustrating HIIT-induced changes of VO2max. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares:

individual studies. The size represents the relative weight. White rhomboid: summary value.

Table Legends

Table 1. Eligibility criteria in the systematic review.

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Table 8. Summary of included studies and endurance performance results from field-based tests before and after SSG-based and running-based HIIT interventions.

Table 9. Summary of the included studies and results of incremental exhaustive treadmill tests before and after SSG-based and running-based HIIT intervention.

Table 10. GRADE analysis.

Table 1. Eligibility criteria in the systematic review.

	Inclusion Criteria	Exclusion Criteria
Population	Healthy male or female soccer players who were integrated into team training routines and with a minimum competitive level of PCF tier 2 (trained/developmental) [42] and regardless of age.	Disabled, injured or unhealthy soccer players, as well as athletes from sports other than soccer (such as futsal, beach soccer, basketball, or handball).
Intervention	Chronic (i.e., ≥2 weeks) small-sided games (SSGs) interventions, with no restriction based on exposure duration (e.g., time, volume) or SSG configuration.	Studies that combined SSGs with another intervention (i.e., SSGs + resistance training).
Comparator	Exclusively running-based high-intensity interval training (HIIT) or a combination of SSGs and HIIT lasting ≥2 weeks.	Other interventions than running-based HIIT or SSGs + running based HIIT (e.g., strength training, game-based profile).
Outcomes	Pre- and post-intervention markers of endurance performance including (but not limited to) directly or indirectly measured maximal oxygen uptake (VO_2max), maximal aerobic speed, distance covered in an endurance field-based test, time to exhaustion in a test, ventilatory threshold.	Acute responses related with endurance performance (e.g., heart rate in session, oxygen uptake in the session). Chronic endurance performance outcomes that reported only post-intervention values.
Study design	Randomized or non-randomized with ≥2 arms.	Single-arm studies.

PCF: participant classification framework; The competitive level was classified based on the Participant Classification Framework [42]: Tier 0 and Tier 1: sedentary and recreationally active (not included, considering the context of this systematic review); Tier 2: trained/developmental; Tier 3: highly trained/national level; Tier 4: elite/international level; Tier 5: world class.

Table 2. Full search strategy for each database.

Database	Specificities of the databases	Search Strategy	Titles retrieved (n)
PubMed	None to report	((soccer[Title/Abstract] OR football*[Title/Abstract]) AND ("small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR SSGs OR SSG OR "drill-based game*" OR "conditioned-game*")) AND (aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness)	252
Scopus	Search for title and abstract also includes keywords	(TITLE-ABS-KEY (soccer OR football*) AND ALL ("small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR ssgs OR ssg OR "drill-based game*" OR "conditioned-game*") AND ALL (aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness))	2105
SPORTDiscus	Duplicate search, breaking down for titles and then for abstracts, regarding the first line	TI (soccer OR football*) AND TX ("small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR SSGs OR SSG OR "drill-based game*" OR "conditioned-game*") AND TX (aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness) AB (soccer OR football*) AND TX ("small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR SSGs OR SSG OR "drill-based game*" OR "conditioned-game*") AND TX (aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness)	2514
Web of Science	Search for title and abstract also includes keywords and its designated "topic"	soccer OR football* (Topic) and "small-sided" OR "medium-sided" OR "large-sided" OR "sided-game*" OR ssgs OR SSG OR "drill-based game*" OR "conditioned-game*" (All Fields) and aerobic* OR endurance* OR "cardiorespiratory" OR "maximal oxygen uptake" OR "maximal aerobic speed" OR "locomotor profile" OR "distance covered" OR "ventilatory threshold" OR "running performance" OR fitness (All Fields)	518

Table 3. Descriptive characteristics of study designs, participants, interventions, and outcomes of the included articles.

	Competitive level	**N**	**Age (M±SD)**	**Sex**	**Type of study**	**Randomization**	**Season period**	**Tests**	**Outcomes**
Akdoğan et al [77]	Tier 2	41	14.6±0.5	ND	Four-arm parallel group	ND	Pre-season	YYIRT-L1; YYIRT-L2	Distance covered (meters) at YYIRT-L1 and YYIRT-L2
Arianto et al [69]	Tier 2	24	15.5±0.8	ND	Two-arm parallel group	Yes	ND	YYIRT-L2	Estimated VO2max based on the distance covered (ml/kg/min) at YYIRT-L1
Arslan et al [36]	Tier 2	20	14.2±0.5	Male	Two-arm parallel group	ND	In-season (early season)	YYIRT-L1; 1000-m	Distance covered (meters) and estimated VO2max based on the distance covered (ml/kg/min) at YYIRT-L1; Time (s) at 1000-m.
Boraczynski et al [83]	Tier 3	25	19.4 to 34.0	Male	Two-arm parallel group	Yes	In-season (between 1st and 2nd halves of the season)	Incremental exhaustive treadmill test	Direct VO2max (ml/kg/min)
Castillo et al [74]	Tier 3	16	25.6±7.6	ND	Two-arm parallel group	Yes	In-season (second half of the season)	YYIRT-L1	Distance covered (meters) at YYIRT-L1
Clemente et al [37]	Tier 2	40	16.4±0.5	Male	Two-arm parallel group	Yes	End-season (after the last match)	30-15IFT; YYIRT-L1	Final velocity completed at 30-15IFT (km/h); Distance covered (meters) at YYIRT-L1
Dellal et al [105]	Tier 2	22	26.3±4.7	Male	Two-arm parallel group	Yes	In-season (second half of the season)	Vameval test; 30-15IFT	Final velocity completed at Vameval test (km/h); Final velocity completed at 30-15IFT (km/h)
Eniseler et al [90]	Tier 2	19	16.9±1.1	Male	Two-arm parallel group	Yes	Pre-season and in-season (early season)	YYIRT-L1	Distance covered (meters) at YYIRT-L1
Faude et al [70]	Tier 2	19	16.5±0.8	ND	Two-arm crossover design	Yes	In-season (first half)	Multistage endurance test at athletic track	Peak speed at multistage endurance test (km/h); individual anaerobic threshold (km/h)
Herazo-Sánchez et al [106]	Tier 2	16	19.5±1.7	Male	Two-arm parallel group	Yes	In-season	Maximal multistage 20-m shuttle run test	Estimated VO2max (ml/kg/min)
Hill-Haas et al [88]	Tier 2	19	14.6±0.9	ND	Two-arm parallel group	Yes	In-season (second half of the season)	Incremental exhaustive treadmill test; Maximal multistage 20-m shuttle run test; YYIRT-L1	Direct VO2max (ml/kg/min); Treadmill time to exhaustion (s); Distance covered (meters) at maximal multistage 20-m shuttle run test; Distance covered (meters) at YYIRT-L1

Impellizzeri et al [71]	Tier 2	29	17.2±0.8	ND	Two-arm parallel group	Yes	Pre-season and in-season (early season)	Incremental exhaustive treadmill test; Ekblom test	Direct VO2max (ml/kg/min); velocity at anaerobic threshold (km/h); time (s) at Ekblom test
Jastrzebski et al [85]	Tier 2	22	15.8	ND	Two-arm parallel group	No	In-season (first half)	Incremental exhaustive treadmill test	Direct VO2max (ml/kg/min); anaerobic threshold (%VO2max)
Koral et al [73]	Tier 2	73	19.2 to 19.5	ND	Three-arm parallel group	Yes	Pre-season	University of Montreal Track Test	Final velocity completed at University of Montreal Track Test (km/h)
Los Arcos et al [89]	Tier 2	17	15.5±0.6	Male	Two-arm parallel group	Yes	In-season (second half)	University of Montreal Track Test	Final velocity completed at University of Montreal Track Test (km/h)
Mohr et al [76]	Tier 2	18	19.0±1.0	Male	Two-arm parallel group	Yes	ND	YYIRT-L2	Distance covered (meters) at YYIRT-L2
Nayiroglu et al [72]	Tier 3	24	18.6±2.4	Female	Two-arm parallel group	Yes	Pre-season	30-15IFT	Final velocity completed at 30-15IFT (km/h)
Ouertatani et al [86]	Tier 2	24	16.7±0.9	Male	Two-arm parallel group	Yes	In-season (early season)	Vameval test	Final velocity completed at Vameval test (km/h)
Radmiminski et al [30]	Tier 2	20	15.0 to 15.1	Male	Two-arm parallel group	Yes	Pre-season	Incremental exhaustive treadmill test	Direct VO2max (ml/kg/min); anaerobic threshold (%VO2max)
Safania et al [75]	Tier 2	20	15.7±0.7	ND	Two-arm parallel group	Yes	ND	12-min running test	Estimated VO2max (ml/kg/min) based on the distance covered at 12-min running test

ND: Not described; VO2max; maximal oxygen uptake; YYIRT-L1: Yo-Yo intermittent recovery test level 1; YYIRT-L2: Yo-Yo intermittent recovery test level 2; 30-15IFT: 30-15 Intermittent Fitness Test

Table 4. Descriptive characteristics of SSGs-based interventions.

	Duration (w)	Weekly frequency (d/w)	Total sessions (n)	Adherence (%)	SSGs formats	SSG type*	SSGs dimensions (length × width)	SSGs are per player (m^2)	Sets	Reps	Work duration (min)	Work intensity	Relief between sets (min)	Relief intensity
Akdoğan et al [77]	6	2	12	ND	2v2 3v3 4v4	Small SSG	25 × 16m 30 × 20m 32 × 25m	100	4	-	2’ 4’ 4’	ND	3’	Rest
Arianto et al [69]	6	3	18	ND	4v4 5v5 7v7 11v11	Mixed SSG	30 × 20m 35 × 25m 60 × 40m 90 × 60m	75 88 171 245	8 6 3 1	-	3’ 4’ 8’ 24’	ND	1’ 2’ 3’ -	Rest
Arslan et al [36]	5	2	10	ND	2v2+GK 2v2	Small SSG	20 × 15m	75	2	2	2’30’’ to 4’30’’	ND	2’	Rest
Boraczynski et al [83]	6	2	15	88.2±6.4	2v2 4v4	Small SSG	35 × 25m 50 × 40m	219 250	4 5	-	4’ 3’	79.7±6.8% HRmax	3’	Active
Castillo et al [74]	6	4	24	ND	3v3 4v4 8v8	Mixed SSG	40 × 30m 25 × 20m 30x20 and 64 × 40m	200 63 38 and 160	3 3 3	-	3’ 5’ 5-6’	ND	3’ 2’ 2’	Rest
Clemente et al [37]	4	3	12	100	2v2+GK 2v2	Small SSG	20 × 18m 20 × 15m	72 75	2	2	2’30’’ to 4’	16.2 to 16.6 A.U.	2’	Rest
Dellal et al [105]	6	1 to 2	9	ND	1v1 2v2	Small SSG	15 × 10m 20 × 20m	150 100	5	-	1’30’’ 2’30’’	7.0 to 8.3 A.U.	1’30’’ 2’	Rest
Eniseler et al [90]	6	2	12	ND	3v3	Small SSG	30 × 18m	90	4	-	3’	89.5±5.5% HRmax	4’	Rest
Faude et al [70]	4	2	8	89	3v3 4v4	Small SSG	35 × 25m 40 × 30m	146 150	4	-	4’	72.7% HRmax	4’	Rest
Herazo-Sánchez et al [106]	6	2	12	ND	4v4+GK 4v4	Small SSG	32 × 25m 32 × 25m	89 100	3	-	6’	167.8 to 174.1 bpm	5’	Active
Hill-Haas et al [88]	7	2	14	ND	2v2 3v3 4v4 5v5 5v5+1 6v6 6v6+1 7v7	Mixed SSG	20 × 15m 30 × 15 and 30 × 20m 40 × 20m 45 × 35m 60 × 40m 45 × 30 and 50 × 40m	75 75 and 100 100 158 218 113 and 167 115	3 3-6 2 3 3 3 3 3	-	7’ 6-11’ 11’ 11’ 11’ 10-12’ 13’ 11-13’	7.5±1.2 A.U.	1’ 1-3’ 2’ 2’ 2’ 2’ 2’ 2’	Rest

							50 × 30m 35 × 25 and 55 × 40m	63 and 157						
Impellizzeri et al [71]	12	2	24	ND	3v3+GK 4v4+GK 4v4 5v5	Mixed SSG	35 × 25m 50 × 40m ND ND	125 222 ND ND	4	-	4’	ND	3’	Active
Jastrzebski et al [85]	8	2	16	ND	3v3	Small SSG	30 × 18m	90	7	-	3’	ND	1’30’’	Active
Koral et al [73]	3	2	6	ND	3v3 4v4 6v6	Mixed SSG	24 × 20m 34 × 30m 48 × 36m	80 128 144	5 5 4	-	5’ 4’ 4’	ND	3’ 3’ 3’	Rest
Los Arcos et al [89]	6	1-2	11	ND	3v3+1 4v4+GK 4v4+2 4v4+GK+2 4v4+2+1	Small SSG	ND ND ND ND ND	85 85 85 85 85	3	-	4’ 4’ 4’ 4’ 4’	ND	3’ 3’ 3’ 3’ 3’	Rest
Mohr et al [76]	4	2	8	ND	2v2+GK	Small SSG	20 × 20m	80	ND	-	45’’	ND	45’’	Rest
Nayiroglu et al [72]	8	3	24	93.6	2v2 3v3	Small SSG	24 × 12m 30 × 18m	72 90	2 2	6 6	90’’	8.5±0.3 A.U.	4’	Rest
Ouertatani et al [86]	6	2	12	ND	3v3+GK 4v4+GK 4v4 5v5	Mixed SSG	35 × 25m 50 × 40m ND ND	125 222 ND ND	4	-	4’	ND	3’	Rest
Radmiminski et al [30]	8	2	16	ND	3v3 3v3+1	Small SSG	30 × 18m 30 × 18m	90 77	5	-	4’	92.3±1.1% HRmax	3’	Active
Safania et al [75]	6	3	18	ND	ND	ND	ND	ND	4	-	4’	ND	3’	Rest

HRmax: maximal heart rate; A.U.: arbitrary units in rate of perceived effort scales; bpm; beats per minute; GK: goalkeeper; ND: not described; SSG: small-sided games; ‘: minutes; ‘’: seconds; *SSG type classified as proposed in Owen et al [62]: 1v1 o 4v4 (small SSG), 5v5 to 8v8 (medium SSG), 9v9 to 11v11 (large SSG); combining mixed SSG means that different types of SSGs were used.

Table 5. Descriptive characteristics of HIIT-based interventions.

	Duration (w)	Weekly frequency (d/w)	Total sessions (n)	Adherence (%)	HIIT type*	Sets	Reps	Work duration	Work intensity	Recovery between sets (time)	Recovery between reps (time)	Type of recovery (intensity)
Akdoğan et al [77]	6	2	12	ND	RST	7-9	-	20-40’’	All-out sprint	100’’-200’’	-	Rest
Arianto et al [69]	6	3	18	ND	Long intervals	4-5	-	ND	60-90%	120’’	-	Rest
Arslan et al [36]	5	2	10	ND	Short intervals	2	12-20	15’’	90-95% V_{IFT}	120’’	15’’	Rest
Boraczynski et al [83]	6	2	15	86.4±5.3	SIT	1-2	10	30-45’’	83.9±8.1% HRmax	180’’	30-60’’	Active
Castillo et al [74]	6	4	24	ND	RST and SIT**	2-3	1-4	4 reps sprint to 8’ min running (50-m maximal intensity interspaced by 50-m active running)	All-out	180’’	30’’	Active and rest
Clemente et al [37]	4	3	12	100	Short intervals	2	12-18	15’’	90-95% V_{IFT}	120’’	15’’	Rest
Dellal et al [105]	6	1 to 2	9	ND	Short intervals	2	7-10	10-30’’	95-100 V_{IFT}	300-360’’	10-30’’	Rest
Eniseler et al [90]	6	2	12	ND	RST	3	6	40-m	All-out sprint	240’’	20’’	Rest
Faude et al [70]	4	2	8	87.5	Short intervals	2	12-15	15’’	73.0% HRmax	600’’	15’’	Rest
Herazo-Sánchez et al [106]	6	2	12	ND	Long intervals	5	-	180’’	80-90% HRmax	180’’	-	50-60%HRmax
Hill-Haas et al [88]	7	2	14	ND	Short intervals	1-3	3-10	10’’-90’’	90% HRmax to all-out	ND	10-90’’	ND
Impellizzeri et al [71]	12	2	24	ND	Long intervals	4	-	240’’	90-95% HRmax	180’’	-	60-70% HRmax
Jastrzebski et al [85]	8	2	16	ND	Short intervals	7	6	15’’	85-90% HRmax	90’’	15’’	Active (jogging)
Koral et al [73]	3	2	6	ND	SIT	4-7	-	30’’	All-out sprint	240’’	-	Rest
Los Arcos et al [89]	6	1-2	11	ND	Long intervals	3	-	180’’	90-95% HRmax	240’’	-	50-60% HRmax
Mohr et al [76]	4	2	8	ND	RST	8-10	-	30’’	All-out	150’’	-	Rest
Nayiroglu et al [72]	8	3	24	91.7	Short intervals	2-3	6	15’’	90-95% V_{IFT}	240’’	15’’	Rest
Ouertatani et al [86]	6	2	12	ND	Short intervals	4	8	15’’	110% MAS	180’’	15’’	Rest

Radmiminski et al [30]	8	2	16	ND	Long intervals	5	-	240''	90% HRmax	180''	-	Active
Safania et al [75]	6	3	18	ND	Long intervals	4	-	240''	70-95% HRmax	180''	-	Rest

RST: repeated sprint training; SIT: sprint interval training; MAS: maximal aerobic speed; V_{IFT}: final velocity at 30-15 Intermittent Fitness Test; HRmax: maximal heart rate; ND: not described; ': minutes; '': seconds; *HIIT type classified as proposed by Buchheit and Laursen [15]; **the HIIT formats were combined with SSGs

Table 6. Assessment of risk of bias for the randomized trials using the Cochrane risk-of-bias tool for randomized trials (RoB 2).

Study	D1	D2	D3	D4	D5	Overall
Endurance performance						
Arianto et al [69]	-	+	+	-	!	-
Boraczynski et al [83]	-	+	+	!	!	-
Castillo et al [74]	-	+	+	!	!	-
Clemente et al [37]	-	+	+	!	!	-
Dellal et al [105]	-	+	+	!	!	-
Eniseler et al [90]	-	+	+	!	!	-
Faude et al [70]	!	+	-	!	!	-
Herazo-Sánchez et al [106]	-	+	+	!	!	-
Hill-Haas et al [88]	!	+	+	!	!	!
Impellizzeri et al [71]	-	+	+	!	!	-
Koral et al [73]	-	+	+	!	!	-
Los Arcos et al [89]	-	+	+	!	!	-
Mohr et al [76]	-	+	+	!	!	-
Nayiroglu et al [72]	-	+	+	!	!	-
Ouertatani et al [86]	-	+	+	!	!	-
Radmiminski et al [30]	-	+	+	!	!	-
Safania et al [75]	-	+	+	!	!	-
VO2max						
Boraczynski et al [83]	-	!	+	!	!	-
Hill-Haas et al [88]	!	-	+	!	!	-
Impellizzeri et al [71]	-	!	+	!	!	-
Radmiminski et al [30]	-	+	+	!	!	-

D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result

Table 7. Assessment of risk of bias of non-randomized studies using the Non-Randomized Studies of Interventions (ROBINS-I).

	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in selection of the reported result	Overall Bias
Akdoğan et al [77]	Moderate	Low	Serious	Low	Low	Moderate	Low	Serious
Arslan et al [36]	Moderate	Low	Serious	Low	Low	Moderate	Low	Serious
Jastrzebski et al [85]	Moderate	Low	Serious	Low	Serious	Moderate	Low	Serious

Table 8. Summary of included studies and endurance performance results from field-based tests before and after SSG-based and running-based HIIT interventions.

Study	Intervention	Sub-group	Total sessions	Competitive level	Randomized	N	Outcome	Before Mean ± SD	After Mean ± SD	Before-After (Δ%)
Akdoğan et al [77]	SSG	Small SSG	≤12	Tier 2	No	11	Distance (m) at YYIRT-L1	1450±411	1712±373	18.1
Arslan et al [36]	SSG	Small SSG	≤12	Tier 2	No	10	Distance (m) at YYIRT-L1	1284±152	1472±99	14.6
Castillo et al [74]	SSG	Mixed SSG	>12	Tier 3	Yes	8	Distance (m) at YYIRT-L1	2331±445	2373±464	1.8
Clemente et al [37]	SSG	Small SSG	≤12	Tier 2	Yes	20	Distance (m) at YYIRT-L1	1331±202	1568±213	17.8
Eniseler et al [90]	SSG	Small SSG	≤12	Tier 2	Yes	10	Distance (m) at YYIRT-L1	2320±388	2432±336	4.6
Hill-Haas et al [88]	SSG	Mixed SSG	>12	Tier 2	Yes	10	Distance (m) at YYIRT-L1	1488±345	1742±362	17.1
Akdoğan et al [77]	HIIT	RST	≤12	Tier 2	No	10	Distance (m) at YYIRT-L1	1416±427	1748±504	23.4
Arslan et al [36]	HIIT	Short intervals	≤12	Tier 2	No	10	Distance (m) at YYIRT-L1	1240±75	1484±74	19.7
Castillo et al [74]	HIIT	RST and SIT	>12	Tier 3	Yes	8	Distance (m) at YYIRT-L1	2063±554	2070±562	0.3
Clemente et al [37]	HIIT	Short intervals	≤12	Tier 2	Yes	20	Distance (m) at YYIRT-L1	1334±199	1700±247	27.4
Eniseler et al [90]	HIIT	RST	≤12	Tier 2	Yes	9	Distance (m) at YYIRT-L1	2307±252	2480±159	7.5
Hill-Haas et al [88]	HIIT	Short intervals	>12	Tier 2	Yes	9	Distance (m) at YYIRT-L1	1764±256	2151±261	21.9
Akdoğan et al [77]	SSG	Small SSG	≤12	Tier 2	No	11	Distance (m) at YYIRT-L2	520±144	756±193	45.4
Arianto et al [69]	SSG	Mixed SSG	>12	Tier 2	Yes	12	Distance (m) at YYIRT-L2	50.8±SD not reported	53.8±SD not reported	5.9
Mohr et al [76]	SSG	Small SSG	≤12	Tier 2	Yes	9	Distance (m) at YYIRT-L2	693±52	858±48	23.8
Akdoğan et al [77]	HIIT	Small SSG	≤12	Tier 2	No	10	Distance (m) at YYIRT-L2	530±93	780±95	47.2
Arianto et al [69]	HIIT	Long intervals	>12	Tier 2	Yes	12	Distance (m) at YYIRT-L2	50.7±SD not reported	54.6±SD not reported	7.7
Mohr et al [76]	HIIT	RST	≤12	Tier 2	Yes	9	Distance (m) at YYIRT-L2	680±68	978±57	43.8
Clemente et al [37]	SSG	Small SSG	≤12	Tier 2	Yes	20	Final velocity (km/h) at 30-15IFT	16.0±0.5	18.2±0.6	13.8
Dellal et al [105]	SSG	Small SSG	≤12	Tier 2	Yes	8	Final velocity (km/h) at 30-15IFT	19.6±0.9	20.7±1.3	5.6
Nayiroglu et al [72]	SSG	Small SSG	>12	Tier 2	Yes	12	Final velocity (km/h) at 30-15IFT	15.2±1.6	16.5±1.5	8.6
Clemente et al [37]	HIIT	Short intervals	≤12	Tier 2	Yes	20	Final velocity (km/h) at 30-15IFT	16.0±1.2	18.8±1.5	17.5
Dellal et al [105]	HIIT	Short intervals	≤12	Tier 2	Yes	8	Final velocity (km/h) at 30-15IFT	19.4±0.6	20.8±1.3	7.2
Nayiroglu et al [72]	HIIT	Short intervals	>12	Tier 2	Yes	12	Final velocity (km/h) at 30-15IFT	14.9±1.4	16.5±1.3	10.7
Dellal et al [105]	SSG	Small SSG	≤12	Tier 2	Yes	8	Final velocity (km/h) at VAMEVAL	16.1±0.5	16.9±0.9	5.0
Ouertatani et al [86]	SSG	Mixed SSG	≤12	Tier 2	Yes	12	Final velocity (km/h) at VAMEVAL	16.8±0.7	17.4±0.5	3.6
Dellal et al [105]	HIIT	Short intervals	≤12	Tier 2	Yes	8	Final velocity (km/h) at VAMEVAL	15.8±0.7	16.9±0.7	7.0
Ouertatani et al [86]	HIIT	Short intervals	≤12	Tier 2	Yes	12	Final velocity (km/h) at VAMEVAL	17.1±0.6	17.6±0.4	2.9
Arslan et al [36]	SSG	Small SSG	≤12	Tier 2	No	10	Time (s) at 1000-m	236±17	230±15	–2.5
Arslan et al [36]	HIIT	Short intervals	≤12	Tier 2	No	10	Time (s) at 1000-m	243±17	229±14	–5.8
Faude et al [70]	SSG	Small SSG	≤12	Tier 2	Yes	9	Peak speed (km/h) at multistage endurance test at athletic track	17.5±1.0	17.8±0.7	1.7

Faude et al [70]	HIIT	Short intervals	≤12	Tier 2	Yes	10	Peak speed (km/h) at multistage endurance test at athletic track	17.8±1.0	17.3±1.0	–2.8
Faude et al [70]	SSG	Small SSG	≤12	Tier 2	Yes	9	Individual anaerobic threshold (km/h) at multistage endurance test at athletic track	14.3±0.8	14.5±0.7	1.4
Faude et al [70]	HIIT	Short intervals	≤12	Tier 2	Yes	10	Individual anaerobic threshold (km/h) at multistage endurance test at athletic track	14.3±0.9	14.5±0.7	1.4
Herazo-Sánchez et al [106]	SSG	Small SSG	≤12	Tier 2	Yes	8	Estimated VO2max (ml/kg/min) at maximal multistage 20-m shuttle run test	49.4±3.2	50.5±2.1	2.2
Hill-Haas et al [88]	SSG	Mixed SSG	>12	Tier 2	Yes	10	Distance (m) at maximal multistage 20-m shuttle run test	2222±240	2206±221	–0.7
Herazo-Sánchez et al [106]	HIIT	Long intervals	≤12	Tier 2	Yes	8	Estimated VO2max (ml/kg/min) at maximal multistage 20-m shuttle run test	49.4±3.1	50.1±3.2	1.4
Hill-Haas et al [88]	HIIT	Short intervals	>12	Tier 2	Yes	9	Distance (m) at maximal multistage 20-m shuttle run test	2258±131	2327±174	3.1
Impellizzeri et al [71]	SSG	Mixed SSG	>12	Tier 2	Yes	14	Time (s) at Ekblom test	723±47	609±33	–15.8
Impellizzeri et al [71]	HIIT	Long intervals	>12	Tier 2	Yes	15	Time (s) at Ekblom test	704±42	603±17	–14.3
Koral et al [73]	SSG	Mixed SSG	≤12	Tier 2	Yes	24	Final velocity (km/h) at University of Montreal Track Test	14.4±1.1	13.8±1.1	–4.2
Los Arcos et al [89]	SSG	Small SSG	≤12	Tier 2	Yes	7	Final velocity (km/h) at University of Montreal Track Test	17.0±0.8	16.9±0.8	–0.6
Koral et al [73]	HIIT	SIT	≤12	Tier 2	Yes	26	Final velocity (km/h) at University of Montreal Track Test	14.6±1.1	16.4±1.1	12.3
Los Arcos et al [89]	HIIT	Long intervals	≤12	Tier 2	Yes	8	Final velocity (km/h) at University of Montreal Track Test	16.8±0.9	17.1±1.0	1.8
Safania et al [75]	SSG	ND	>12	Tier 2	Yes	10	Estimated VO2max (ml/kg/min) at 12-min running test	34.2±1.6	42.9±1.4	25.4
Safania et al [75]	HIIT	Long intervals	>12	Tier 2	Yes	10	Estimated VO2max (ml/kg/min) at 12-min running test	34.0±1.4	43.5±1.4	27.9

SSG: small-sided games (as generic term); small SSG: formats between 1v1 and 4v4; mixed SSGs: formats between 1v1 to 10v10; RST: repeated sprint training; SIT: sprint interval training; HIIT: high-intensity interval training; ND: not described; VO2max: maximum oxygen uptake; 30-15IFT: 30-15 intermittent fitness test; YYIRTL1: Yo-Yo Intermittent recovery test level 1; YYIRTL2: Yo-Yo Intermittent recovery test level 2; Tier 2: trained/developmental; Tier 3: highly trained/national level

Table 9. Summary of the included studies and results of incremental exhaustive treadmill tests before and after SSG-based and running-based HIIT intervention.

Study	Intervention	Sub-group	Total sessions	Competitive level	Randomized	N	Outcome	Before Mean ± SD	After Mean ± SD	Before-After (Δ %)
Boraczynski et al [83]	SSG	Small SSG	>12	Tier 3	Yes	12	Direct VO2max (ml/kg/min)	56.3±5.6	59.2±7.6	5.2
Hill-Haas et al [88]	SSG	Mixed SSG	>12	Tier 2	Yes	10	Direct VO2max (ml/kg/min)	59.3±4.5	58.9±5.5	–0.7
Impellizzeri et al [71]	SSG	Mixed SSG	>12	Tier 2	Yes	14	Direct VO2max (ml/kg/min)	57.7±4.2	61.8±4.5	7.1
Jastrzebski et al [85]	SSG	Small SSG	>12	Tier 2	No	11	Direct VO2max (ml/kg/min)	52.5±5.2	57.0±5.4	8.6
Radmiminski et al [30]	SSG	Small SSG	>12	Tier 2	Yes	9	Direct VO2max (ml/kg/min)	58.6±6.9	63.3±8.0	8.0
Boraczynski et al [83]	HIIT	SIT	>12	Tier 3	Yes	13	Direct VO2max (ml/kg/min)	54.5±5.0	55.9±6.0	2.6
Hill-Haas et al [88]	HIIT	Short intervals	>12	Tier 2	Yes	9	Direct VO2max (ml/kg/min)	60.2±4.6	61.4±3.5	2.0
Impellizzeri et al [71]	HIIT	Long intervals	>12	Tier 2	Yes	15	Direct VO2max (ml/kg/min)	55.6±3.4	60.2±3.9	8.3
Jastrzebski et al [85]	HIIT	Short intervals	>12	Tier 2	No	11	Direct VO2max (ml/kg/min)	55.7±5.2	56.9±5.6	2.2
Radmiminski et al [30]	HIIT	Long intervals	>12	Tier 2	Yes	11	Direct VO2max (ml/kg/min)	56.2±8.7	55.3±6.1	–1.6

SSG: small-sided games (as generic term); small SSG: formats between 1v1 and 4v4; mixed SSGs: formats between 1v1 to 10v10; RST: repeated sprint training; SIT: sprint interval training; HIIT: high-intensity interval training; VO2max: maximum oxygen uptake; Tier 2: trained/developmental; Tier 3: highly trained/national level

Table 10. GRADE analysis.

Outcomes (SSG vs HIIT)	Studies and PSS	Risk of bias in studies	Risk of publication bias	Inconsistency	Imprecision	Certainty of evidence
Endurance performance	16, n = 337-347	Downgrade by two levels (high-risk of bias)	No downgrading	Downgrade by one level (I^2=70.6-71.6%)	Downgrade by two levels: (i) <800 participants; (ii) no clear direction of effect.	⊕, Very low
VO2max	5, n = 115	Downgrade by two levels (high-risk of bias)	Not applicable	No downgrading (I^2=12.9%)	Downgrade by two level: (i) <800 participants; (ii) no clear direction of effect.	⊕, Very low

i) *Risk of bias in studies*: downgraded by one level if some concerns and two levels if high-risk of bias; **ii)** *Indirectness*: considered low due to eligibility criteria; **iii)** *Risk of publication bias*: not assessed, as all comparison had <10 studies available; downgrade one level if Egger's test < 0.05;; **iv)** *Inconsistency*: downgraded by one level when the impact of statistical heterogeneity (I^2) was moderate (>25%) and by two levels when high (>75%); **v)** *Imprecision*: downgraded by one level when <800 participants were available for a comparison or if there was no clear direction of the effects; accumulation of both resulted in downgrading by two levels.
GRADE: Grading of Recommendations Assessment, Development and Evaluation; **SSG:** small-sided games; **HIIT:** high-intensity interval training; **PSS**: pooled sample size.

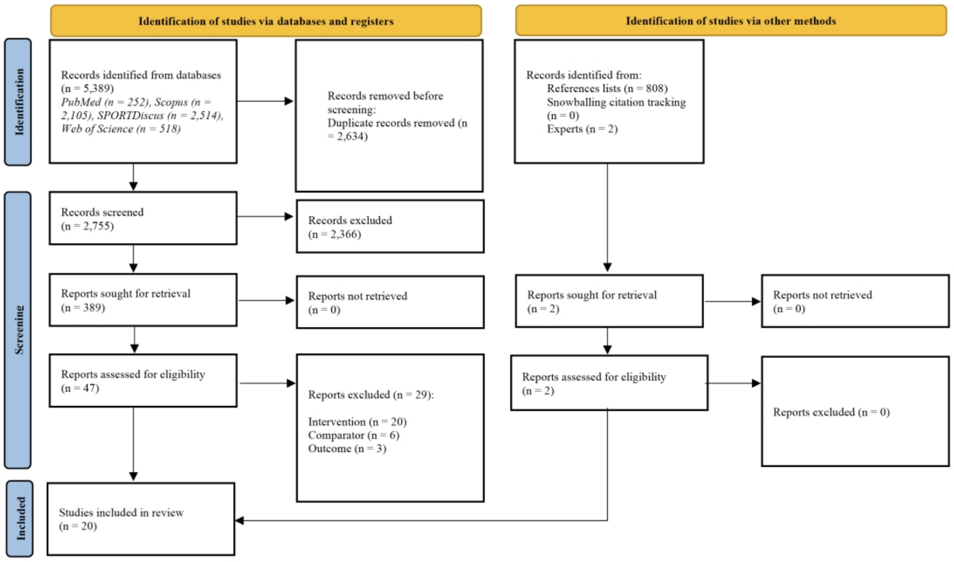

Figure 1. PRISMA 2020 flow [43]

228x132mm (300 x 300 DPI)

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
	Statistics for each study						
Akdogan et al	0.153	0.420	0.176	-0.671	0.976	0.364	0.716
Arslan et al	0.614	0.439	0.193	-0.247	1.474	1.397	0.162
Castillo et al	-0.064	0.473	0.224	-0.991	0.863	-0.136	0.892
Clemente et al	0.548	0.316	0.100	-0.071	1.167	1.735	0.083
Eniseler et al	0.218	0.440	0.194	-0.645	1.081	0.494	0.621
Hill-Haas et al	0.399	0.444	0.197	-0.471	1.268	0.899	0.369
Mohr et al	2.404	0.602	0.362	1.225	3.583	3.995	0.000
Dellal et al	0.218	0.474	0.225	-0.711	1.148	0.460	0.646
Nayiroglu et al	0.206	0.395	0.156	-0.568	0.981	0.522	0.602
Ouertatani et al	-0.213	0.395	0.156	-0.988	0.562	-0.539	0.590
Faude et al	-0.877	0.461	0.213	-1.781	0.028	-1.900	0.057
Herazo-Sánchez et al	-0.140	0.473	0.224	-1.068	0.788	-0.295	0.768
Impellizzeri et al	-0.487	0.367	0.135	-1.206	0.232	-1.327	0.185
Koral et al	2.148	0.352	0.124	1.458	2.837	6.105	0.000
Los Arcos et al	0.412	0.493	0.243	-0.554	1.378	0.836	0.403
Safania et al	0.547	0.437	0.191	-0.309	1.404	1.252	0.210
	0.366	0.205	0.042	-0.036	0.768	1.787	0.074

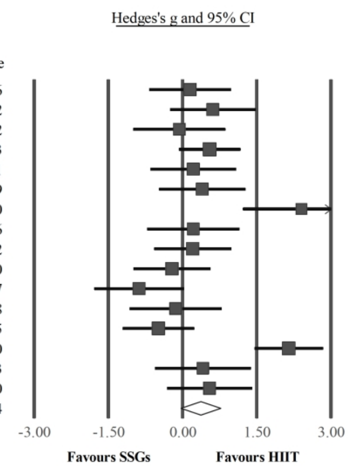

Figure 2. Forest plot illustrating changes of the field-based tests performance after SSGs compared to HIIT. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

279x134mm (300 x 300 DPI)

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Boraczynski et al	-0.213	0.388	0.151	-0.974	0.548	-0.548	0.583
Hill-Haas et al	0.327	0.442	0.195	-0.539	1.194	0.741	0.459
Impellizzeri et al	0.116	0.362	0.131	-0.593	0.824	0.320	0.749
Jastrzebski et al	-0.577	0.419	0.176	-1.399	0.245	-1.376	0.169
Radmiminski et al	-0.765	0.447	0.200	-1.642	0.111	-1.711	0.087
	-0.202	0.196	0.038	-0.585	0.182	-1.030	0.303

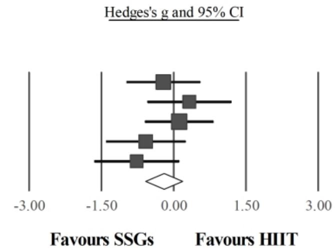

Figure 3. Forest plot illustrating VO2max changes after HIIT compared to SSGs. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

277x79mm (300 x 300 DPI)

Study name	Statistics for each study						
	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Akdogan et al	0.613	0.238	0.057	0.146	1.080	2.573	0.010
Arslan et al	1.224	0.308	0.095	0.619	1.828	3.969	0.000
Castillo et al	0.082	0.244	0.060	-0.396	0.560	0.336	0.737
Clemente et al	1.094	0.214	0.046	0.676	1.513	5.124	0.000
Eniseler et al	0.279	0.229	0.052	-0.170	0.728	1.217	0.224
Hill-Haas et al	0.656	0.251	0.063	0.164	1.148	2.612	0.009
Mohr et al	2.967	0.590	0.348	1.811	4.123	5.031	0.000
Dellal et al	0.816	0.290	0.084	0.247	1.385	2.811	0.005
Nayiroglu et al	0.778	0.242	0.058	0.304	1.252	3.219	0.001
Ouertatani et al	0.865	0.249	0.062	0.377	1.353	3.474	0.001
Faude et al	0.294	0.239	0.057	-0.175	0.763	1.228	0.219
Herazo-Sánchez et al	0.331	0.252	0.063	-0.163	0.824	1.314	0.189
Impellizzeri et al	2.476	0.412	0.169	1.670	3.283	6.017	0.000
Koral et al	-0.527	0.164	0.027	-0.849	-0.206	-3.219	0.001
Los Arcos et al	-0.109	0.256	0.065	-0.610	0.392	-0.425	0.671
	0.704	0.184	0.034	0.344	1.064	3.829	0.000

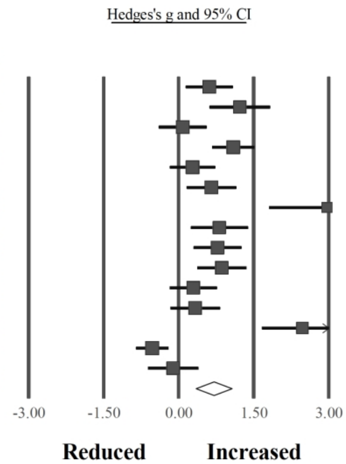

Figure 4. Forest plot illustrating SSGs-related improvements of the field-based tests performance. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

245x120mm (300 x 300 DPI)

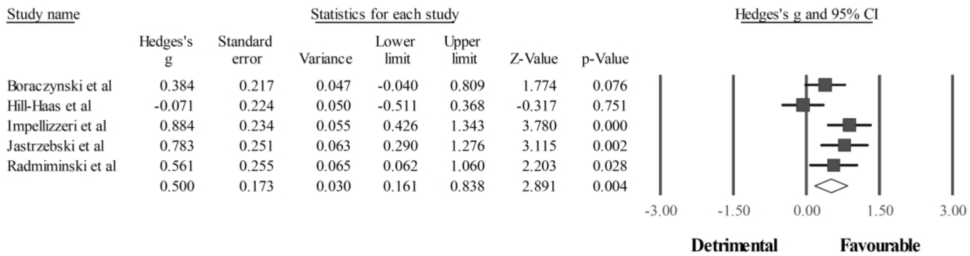

Figure 5. Forest plot illustrating SSGs-related improvements of VO2max. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

329x95mm (300 x 300 DPI)

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Akdogan et al	0.640	0.250	0.062	0.150	1.130	2.561	0.010
Arslan et al	2.994	0.565	0.319	1.887	4.101	5.300	0.000
Castillo et al	0.011	0.243	0.059	-0.466	0.488	0.046	0.963
Clemente et al	1.526	0.250	0.063	1.036	2.017	6.101	0.000
Eniseler et al	0.669	0.263	0.069	0.153	1.185	2.543	0.011
Hill-Haas et al	1.352	0.340	0.115	0.686	2.017	3.981	0.000
Dellal et al	0.985	0.309	0.096	0.379	1.591	3.185	0.001
Nayiroglu et al	1.098	0.271	0.073	0.567	1.629	4.053	0.000
Ouertatani et al	0.840	0.247	0.061	0.356	1.324	3.403	0.001
Faude et al	-0.457	0.238	0.056	-0.923	0.008	-1.925	0.054
Herazo-Sánchez et al	0.197	0.246	0.061	-0.286	0.680	0.801	0.423
Impellizzeri et al	2.279	0.374	0.140	1.547	3.011	6.099	0.000
Koral et al	1.587	0.225	0.051	1.145	2.028	7.044	0.000
Los Arcos et al	0.279	0.249	0.062	-0.210	0.767	1.117	0.264
	0.941	0.208	0.043	0.533	1.348	4.524	0.000

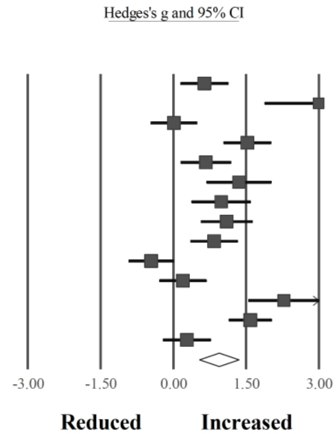

Figure 6. Forest plot illustrating HIIT-related improvements of the field-based tests performance. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

276x131mm (300 x 300 DPI)

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Boraczynski et al	0.233	0.204	0.042	-0.167	0.633	1.141	0.254
Hill-Haas et al	0.255	0.238	0.057	-0.211	0.721	1.071	0.284
Impellizzeri et al	1.176	0.252	0.063	0.682	1.670	4.670	0.000
Jastrzebski et al	0.204	0.218	0.048	-0.223	0.632	0.936	0.349
Radmiminski et al	-0.104	0.216	0.047	-0.527	0.320	-0.479	0.632
	0.340	0.200	0.040	-0.053	0.733	1.697	0.090

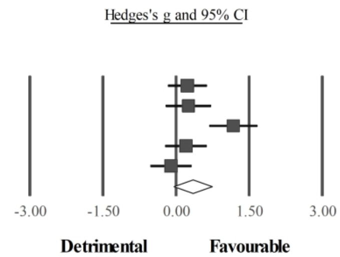

Figure 7. Forest plot illustrating HIIT-induced changes of VO2max. Forest plot values are shown as effect sizes (ES [Hedges' g]) with 95% confidence intervals (CI). Black squares: individual studies. The size represents the relative weight. White rhomboid: summary value.

334x97mm (300 x 300 DPI)

Supplementary material 1. list of included and excluded articles during full-text analysis

ARTICLES	Population	Intervention	Comparator	Outcomes	Study design	FINAL DECISION
Physiological and performance effects of generic versus specific aerobic training in soccer players	YES	YES	YES	YES	YES	INCLUDE
Generic versus small-sided game training in soccer	YES	YES	YES	YES	YES	INCLUDE
Effects of small-sided games on physical conditioning and performance in young soccer players	YES	YES	NO	YES	YES	EXCLUDE
Small-sided games versus interval training in amateur soccer players: Effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction	YES	YES	YES	YES	YES	INCLUDE
Generic versus specific sprint training in young soccer players	YES	NO	YES	YES	YES	EXCLUDE
A comparison of the physiological and technical effects of high-intensity running and small-sided games in young soccer players	YES	YES	YES	YES	YES	INCLUDE
ALTERACIONES INDUCIDAS POR DOS DIFERENTES TIPOS DE ENTRENAMIENTO DE FÚTBOL EN NIVELES SÉRICOS DE CK, CORTISOL Y TESTOSTERONA. / ALTERATIONS INDUCED BY TWO DIFFERENT SOCCER WORKOUTS IN CK, CORTISOL AND TESTOSTERONE SERUM LEVELS	YES	NO	NO	NO	NO	EXCLUDE
The effect of short-term interval training during the competitive season on physical fitness and signs of fatigue: A crossover trial in high-level youth football players	YES	YES	YES	YES	YES	INCLUDE
Effect of in-season generic and soccer-specific high-intensity interval training in young soccer players	YES	YES	YES	YES	YES	INCLUDE
Effects of small-sided games vs. interval training in aerobic fitness and physical enjoyment in young elite soccer players	YES	YES	YES	YES	YES	INCLUDE
Comparison between two types of anaerobic speed endurance training in competitive soccer players	YES	YES	YES	YES	YES	INCLUDE
Contrasting effects of a mixed-methods high-intensity interval training intervention in girl football players	YES	NO	YES	YES	YES	EXCLUDE
High-Intensity Small-Sided Games versus Repeated Sprint Training in Junior Soccer Players	YES	YES	YES	YES	YES	INCLUDE
Fitness effects of 10-month frequent low-volume ball game training or interval running for 8-10-year-old school children	NO	YES	YES	YES	YES	EXCLUDE
High Intensity Interval Training Does Not Improve Cardiorespiratory Parameters in Trained Young occer Players	YES	NO	NO	YES	YES	EXCLUDE
INTERVAL VERSUS CONTINUOUS SMALL-SIDED SOCCER GAMES WITH SAME PITCH SIZE AND NUMBER OF PLAYERS. / INTERVALNE NASPRAM KONTINUIRANIH IGARA NA UMANJENIM TERENIMA ISTIH DIMENZIJA I BROJA IGRAČA	YES	NO	NO	NO	NO	EXCLUDE
SMALL SIDED GAMES EFFECTS ON MAXIMUM OXYGEN UPTAKE IN AMATEUR SOCCER PLAYERS	YES	YES	YES	YES	YES	INCLUDE
The effect of a concentrated period of soccer-specific fitness training with small-sided games on physical fitness in youth players	YES	NO	YES	YES	YES	EXCLUDE
Combined small-sided game and high-intensity interval training in soccer players: The effect of exercise order	YES	NO	YES	YES	YES	EXCLUDE

SMALL-SIDED GAMES VERSUS INTERVAL TRAINING IN ADOLESCENT SOCCER PLAYERS: EFFECTS ON SPEED, CHANGE OF DIRECTION SPEED AND JUMPING PERFORMANCE	YES	YES	YES	NO	YES	EXCLUDE
Short-term training based on small-sided games improved physical and match performance in young football players	YES	NO	NO	YES	NO	EXCLUDE
Running-based high-intensity interval training vs. small-sided game training programs: Effects on the physical performance, psychophysiological responses and technical skills in young soccer players	YES	YES	YES	YES	YES	INCLUDE
Effect of skill-based training vs. small-sided games on physical performance improvement in young soccer players	YES	YES	NO	YES	YES	EXCLUDE
Effectiveness of a Generic vs. Specific Program Training to Prevent the Short-Term Detraining on Repeated-Sprint Ability of Youth Soccer Players	YES	NO	YES	NO	YES	EXCLUDE
The effect of isolated or combined small-sided games and speed endurance training on physical performance parameters in young soccer players	YES	YES	YES	YES	YES	INCLUDE
The effects of exercise order on the psychophysiological responses, physical and technical performances of young soccer players: Combined small-sided games and high-intensity interval training	YES	NO	YES	YES	YES	EXCLUDE
Short-term effects of on-field combined core strength and small-sided games training on physical performance in young soccer players	YES	YES	NO	YES	YES	EXCLUDE
Effects of including endurance and speed sessions within small-sided soccer games periodization on physical fitness	YES	YES	YES	YES	YES	INCLUDE
Comparative Effects of Game Profile-Based Training and Small-Sided Games on Physical Performance of Elite Young Soccer Players	YES	YES	NO	YES	YES	EXCLUDE
Effects of non-sport-specific versus sport-specific training on physical performance and perceptual response in young football players	YES	NO	NO	YES	YES	EXCLUDE
Fitness improvements of young soccer players after high volume or small sided games interventions	YES	YES	NO	YES	YES	EXCLUDE
Effects of Three Preseason Training Programs on Speed, Change-of-Direction, and Endurance in Recreationally Trained Soccer Players	YES	YES	YES	YES	YES	INCLUDE
Small-sided games are not as effective as intermittent running to stimulate aerobic metabolism in prepubertal soccer players	YES	NO	NO	YES	NO	EXCLUDE
Can high-intensity interval training and small-sided games be effective for improving physical fitness after detraining? A parallel study design in youth male soccer players	YES	YES	YES	YES	YES	INCLUDE
Small-sided Games Vs Small-sided Games And Repeated Sprint In Young Soccer Players Effects On Fitness	YES	YES	YES	YES	YES	EXCLUDE
Effects of small-sided games and running-based high-intensity interval training on body composition and physical fitness in under-19 female soccer players	YES	YES	YES	YES	YES	INCLUDE
Comparing the physical effects of combining small-sided games with short high-intensity interval training or repeated sprint training in youth soccer players: A parallel-study design	YES	NO	YES	YES	YES	EXCLUDE
Comparison of the Physical, Physiological, and Psychological Responses of the High-Intensity Interval (HIIT) and Small-Sided Games (SSG) Training Programs in Young Elite Soccer Players	YES	YES	YES	YES	YES	INCLUDE
THE EFFECTS OF HIGH-INTENSITY INTERVAL TRAINING AND GAME-BASED TRAINING ON JUNIOR HIGH SCHOOL SOCCER PLAYER	YES	NO	YES	YES	YES	EXCLUDE
Effects of a small-sided games training program in youth male soccer players: variations of the locomotor profile while interacting with baseline level and with the accumulated load	YES	NO	YES	YES	YES	EXCLUDE

Do conditioning focused various-sided training games prepare elite youth male soccer players for the demands of competition?	YES	NO	NO	NO	NO	EXCLUDE
COMPARISON OF THE EFFECTS OF 4*4 NARROW GAME AND MAS (MAXIMAL AEROBIC SPEED) TRAINING IN FOOTBALL: A RESEARCH ON U19 FOOTBALL TEAM PLAYERS	NO	NO	NO	NO	NO	EXCLUDE
Effects of Different Concurrent Training Methods on Aerobic and Anaerobic Capacity in U 21 soccer players	YES	NO	NO	YES	YES	EXCLUDE
Effects of two low-volume high-intensity interval training protocols in professional soccer: sprint interval training versus small-sided games	YES	YES	YES	YES	YES	INCLUDE
Effect of interval and continuous small-sided games training on the bio-motor abilities of young soccer players: a comparative study	YES	YES	NO	YES	YES	EXCLUDE
Can Running Speed and Aerobic Endurance Be Affected after 4 weeks of In-season Running-based HIIT of Different Modes?	YES	NO	YES	YES	YES	EXCLUDE
Effects of Concurrent High-Intensity and Strength Training on Muscle Power and Aerobic Performance in Young Soccer Players during the Pre-Season	YES	NO	YES	YES	YES	EXCLUDE
Effect of small sided games and interval training on aerobic endurance of U-17 soccer players	YES	YES	YES	YES	YES	INCLUDE
A Comparison of Small-Side Games and Interval Training on Same Selected Physical Fitness Factors in Amateur Soccer Players	YES	YES	YES	YES	YES	INCLUDE