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Aerobic-oriented training and maximal oxygen uptake in soccer players: a systematic review with narrative synthesis of intervention studies

Vega Soniawan*), Ikhwanul Arifan
Coaching Department, Faculty of Sport Science, Universitas Negeri Padang, Padang, West Sumatra, Indonesia.

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ABSTRACT

Aerobic capacity is essential for repeated high-intensity actions, recovery between efforts, and running performance in soccer. This systematic review and narrative synthesis examined recent evidence on aerobic-oriented training interventions and maximal oxygen uptake (VO_2max) in soccer players. Following the PRISMA 2020 framework, a Boolean search of Scopus identified 778 records, with 224 records remaining after automated eligibility screening and deduplication. Eligible studies were English-language journal articles published between 2021 and 2025 involving prospective training interventions of at least four weeks with an explicit aerobic component and pre- and post-intervention VO_2max assessment. Twenty-three studies met the inclusion criteria. Participants ranged from 14 to 60 per study, predominantly male players aged 14–28 years, from academy to semi-professional levels. Methodological quality was assessed using the MMAT 2018, with all studies scoring ≥60% and 15 (65%) classified as high quality. Due to substantial heterogeneity in VO_2max assessment methods, comparators, and outcome reporting, a meta-analysis was not feasible. Interval-based training, particularly high-intensity interval training and small-sided games, accounted for approximately two-thirds of the evidence. All studies reported significant within-group improvements in VO_2max, although evidence of superiority between modalities was limited. Improvements were commonly observed following 4–12 weeks of training performed 2–3 times per week at near-maximal intensities. Overall, the findings support flexible selection of aerobic training modalities while emphasizing intensity as a key component of prescription. Future research should improve randomisation, blinding, and standardized effect-size reporting.

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Corresponding Author:

Vega Soniawan,
Coaching Department, Faculty of Sport Science, Universitas Negeri Padang,
Email: vegasoniawan@fik.unp.ac.id

Introduction

Soccer imposes an intermittent physiological demand profile. Across roughly ninety minutes, brief maximal actions are interspersed with incomplete recovery, and in the gaps between them the capacity to resynthesise phosphocreatine, clear metabolic by-products, and sustain running output is governed substantially by the oxidative system. Maximal oxygen uptake (VO_2max) therefore holds an unusual position in soccer science. It is not the outcome that wins matches. It is the physiological ceiling that determines how often a player can approach match-winning intensities and how completely they recover afterwards. Descriptive work across competitive levels has repeatedly linked higher aerobic capacity to greater accumulated and high-speed running

distance, superior repeated-sprint performance, and more favourable metabolic power profiles during play (Manzi et al., 2022; Michailidis, 2024a; Olsen et al., 2023). Position-specific and level-specific comparisons reinforce the point. Midfielders and wide players consistently record the highest VO_2max and anaerobic threshold values, while squads competing at higher standards tend to present higher aerobic benchmarks than lower-ranked opposition (Aksoy et al., 2022; Michailidis, 2024b; Xing et al., 2023). Aerobic capacity, in short, is a foundational rather than peripheral quality.

The applied problem is narrower than this general consensus suggests, and more stubborn as well. Coaches do not ask whether aerobic capacity matters. They ask which conditioning modality, at what dose, will raise it most efficiently, and they ask it within a week already saturated with technical and tactical work. That question has become harder, not easier, to answer. Over the last decade, competing prescriptions have proliferated: running-based high-intensity interval training, sprint interval training, small-sided games in varying formats and pitch dimensions, speed-endurance work, maximal-aerobic-speed running, and integrated multicomponent circuits. Each is supported by trials that differ in populations, durations, control conditions, and outcome instruments. Compounding matters, aerobic capacity is operationalised inconsistently across the literature. VO_2max is measured by respiratory gas analysis, estimated from Yo-Yo Intermittent Recovery test distance, or inferred from maximal aerobic speed, and the methods do not agree closely with one another (Buglione et al., 2025; Cheng et al., 2025; Thron et al., 2022). What results is a body of evidence large in volume but genuinely difficult to convert into a defensible training decision.

Existing research nonetheless establishes several reliable anchors. Aerobic capacity in soccer players is trainable, seasonally labile, and rapidly reversible. Longitudinal monitoring shows meaningful within-season fluctuation in cardiorespiratory fitness even in professional and elite female cohorts. Peaks typically follow preparatory periods, with regression during congested competitive phases (Papaevangelou et al., 2023). Enforced interruptions to organised training produce unambiguous decrements. Extended lockdown and off-season periods reduced maximal aerobic speed and aerobic capacity in youth and professional squads, and supervised remote or off-season programming attenuated but did not eliminate these losses (Alvurdu et al., 2022; Liu et al., 2024; Parpa & Michaelides, 2021; Silva et al., 2022). Training-load research adds a dose dimension. Graded relationships exist between accumulated internal load and endurance improvement during preseason, and load thresholds have been identified beyond which further accumulation yields diminishing aerobic returns (Kalapotharakos et al., 2021; Younesi et al., 2021). These strands converge on a clear implication: aerobic capacity responds to what is prescribed, so prescription detail matters.

Methodological and technological developments over the past five years have sharpened the questions rather than settling them. Small-sided games have been dissected into their constituent manipulations: pitch dimension, player number, floaters, ball-touch restriction. Evidence indicates that these variables alter internal and external load in ways that plausibly change the aerobic stimulus (Faga et al., 2023; Michailidis, 2024a; Wang et al., 2024). Interval prescription has been decomposed in similar fashion. Rest-interval distribution during short sprint interval training, running surface, time of day, and individualised versus group-based velocity anchoring have each been shown to modulate adaptation (Li & Xue, 2024; Yan & Li, 2025; Zhu et al., 2025). In parallel, wearable and field-based estimation of VO_2max has proliferated. This expands data availability while introducing measurement heterogeneity that complicates cross-study comparison (Ghouili et al., 2023). Each of these advances is individually valuable. Collectively, though, they fragment the literature into narrow comparisons that no single trial can integrate.

A first gap follows directly. Despite the volume of primary trials, no recent synthesis applies a single, explicit outcome criterion across the full range of aerobic-oriented modalities. That criterion is pre-to-post VO_2max in soccer players. Reviews and meta-analyses tend to be modality-bounded, examining small-sided games or high-intensity interval training in isolation. This reproduces the coach's comparison problem rather than resolving it. Studies that do compare modalities directly frequently find parity rather than superiority. Small-sided games against high-intensity interval training, and combined against single-modality programmes, often report similar aerobic gains despite markedly different training content (Daryanoosh et al., 2023; Nayıroğlu et al., 2022; Thomakos et al., 2023). Whether that parity reflects genuine physiological findings or an artefact of underpowered designs and insensitive field tests remains unresolved.

A second gap is theoretical and methodological rather than empirical. Much of the intervention literature rests on single-group pre-post designs or non-randomised allocation, with uneven reporting of randomisation procedures, assessor blinding, effect sizes, and confidence intervals. Where control groups exist, they frequently continue habitual soccer training, itself an aerobic stimulus. The estimated effect then represents the increment attributable to added conditioning, not the modality's isolated potency. Concurrent-training research adds a further wrinkle. Sequencing and composition of strength and endurance work modifies adaptation, so "aerobic training" in a soccer context is rarely delivered in isolation (Blechschmied et al., 2024; Thomakos et al., 2023).

Without transparent appraisal of these design features, the apparent uniformity of positive findings may reflect publication and design bias as much as physiological reality.

The case for synthesising this literature now is practical. Competitive calendars have compressed, preparatory windows have shortened, and the evidence base has expanded rapidly since 2021. Intervention trials now appear across a widening range of journals and player populations, including female, youth, amateur, and collegiate cohorts that were historically underrepresented (Kaewkamad et al., 2025; Yang et al., 2025; Zhou et al., 2025). Practitioners require an integrated account of which modalities have actually been tested against a VO_2max outcome, what doses were used, what magnitudes of change were reported, and how much confidence the underlying designs warrant. This systematic review provides that integrated, outcome-anchored account through a pre-specified search of the 2021–2025 Scopus corpus, MMAT-based quality appraisal, and narrative thematic synthesis.

To address these gaps, this study employs a systematic review design with pre-specified eligibility criteria, a reproducible database search, and explicit methodological appraisal the three procedural commitments that distinguish systematic from narrative review (Liberati et al., 2009; Tranfield et al., 2003). No experimental manipulation of participants was conducted; the design is therefore observational at the review level, prospective in its search protocol, and bounded by the available peer-reviewed intervention literature. The operationalising criterion is a reported VO_2max value measured directly by respiratory gas analysis or estimated from a validated field test at both a pre- and a post-intervention time point across soccer players. This single outcome criterion, applied uniformly across all aerobic-oriented modalities, resolves the modality-comparison problem identified above by placing heterogeneous conditioning strategies on a single comparable footing. It also renders the review's scope definitionally precise: studies that assessed aerobic fitness through alternative indices without a VO_2max estimate were excluded not arbitrarily but because the inclusion of such studies would undermine the common denominator that makes cross-modality comparison meaningful. With that framing, three research questions guide this review:

RQ1: Which aerobic-oriented training modalities have been used to improve aerobic capacity in soccer players, and how are they configured in terms of frequency, intensity, duration, and integration with regular soccer training?

RQ2: What effects do these interventions produce on VO_2max and related aerobic capacity indices, and to what extent does any modality demonstrate superiority over another?

RQ3: Which training characteristics and design features are associated with the largest and most trustworthy improvements in aerobic capacity?

The novelty of this review lies in its outcome-anchored rather than modality-anchored inclusion logic. By requiring a pre-to-post VO_2max outcome as the single common denominator and admitting every aerobic-oriented modality that meets it, the review places heterogeneous conditioning strategies on a comparable footing, quantifies the concentration of the evidence base across modalities and publication years, and appraises methodological quality with a design-sensitive instrument. The synthesis therefore contributes both an applied prescription map for practitioners and a methodological agenda for researchers.

Method

A systematic literature review design was the right fit here. The research questions center on the aggregation and critical appraisal of a defined body of primary intervention evidence, so generating new empirical data was never the goal. Systematic review methodology works well when a field has accumulated numerous small trials with heterogeneous designs, and when practitioner decisions hinge on an unbiased account of the entire evidence base rather than on individually persuasive studies (Tranfield et al., 2003). The review was also organized around the three procedural commitments that separate systematic review from narrative review: a pre-specified and reproducible search, eligibility criteria that were applied transparently and consistently, and explicit appraisal of the methodological quality of every retained study (Liberati et al., 2009).

For reproducibility, the following parameters are stated here in consolidated form. Database: Scopus (Elsevier) was the sole retrieval source, selected for its breadth of coverage in sport and exercise science, structured metadata export capability, and indexing of regional journals where a substantial proportion of the applied soccer-conditioning literature appears. Date limits: publication year 2021 to 2025, inclusive, applied via the Scopus 'pubyear' field limiter. The search was executed as a single session; the complete Boolean string with field codes and limiters is documented in Section 3.2. Screening: two review team members independently applied the inclusion and exclusion criteria (Table 2) to all 224 screened titles and abstracts. Disagreements were resolved by joint re-reading of the relevant criterion and the contested record, reaching consensus before

advancing the decision; no external arbitrator was involved. A formal inter-rater reliability coefficient (e.g., Cohen's kappa) was not computed, as the team employed a consensus-based arbitration protocol. The absence of a kappa statistic is acknowledged as a limitation in Section 5.7. Quality appraisal: the Mixed Methods Appraisal Tool (MMAT) Version 2018 (Hong et al., 2018) was applied independently to each of the 23 included studies, with an operational inclusion threshold of ≥60% (at least 3 of 5 design-specific criteria met affirmatively). Full appraisal results are presented in Table 3. The PRISMA 2020 flow diagram (Figure 1) documents the complete record flow from identification to inclusion.

For reporting, we followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The accompanying explanation and elaboration document helped us resolve ambiguities in item interpretation (Page, Moher, et al., 2021). We picked PRISMA 2020 over the 2009 statement because its revised flow architecture separates records removed by automated eligibility filters from records excluded through human screening. That distinction matters, since it affects how screening yield is interpreted in database exports of the type we used here. We decomposed the research questions using the PICO framework before building the search string. That way, each conceptual element produced its own keyword cluster.

Table 1. PICO Framework Underpinning the Search Strategy

Element	Specification for this review	Representative search terms
Population (P)	Soccer (association football) players of any sex, competitive standard, or age from adolescence upward	soccer, football, futsal, "soccer players", "football players"
Intervention / Interest (I)	Prospective training interventions containing an explicit aerobic-oriented conditioning component (interval running, sprint interval, small-sided games, continuous or extensive endurance, speed endurance, maximal-aerobic-speed running, integrated conditioning circuits)	train*, condition*, intervent*, "interval training", "small-sided game*", "endurance training"
Comparison (C)	A control group continuing habitual soccer training, an alternative training modality, or the participants' own pre-intervention values (within-group comparison)	Not searched as a separate cluster; applied at eligibility screening
Outcome (O)	Maximal oxygen uptake (directly measured or estimated from a validated field test) and directly derived aerobic capacity indices	VO2max, "maximal oxygen uptake", "aerobic capacity", "aerobic fitness", "aerobic power", "cardiorespiratory fitness", "maximal aerobic speed"

The Comparison element was deliberately excluded from the Boolean string. Comparator information is inconsistently indexed in titles, abstracts, and keywords, and including it as a mandatory cluster would have suppressed relevant records; comparator adequacy was therefore assessed at the eligibility stage rather than the retrieval stage. Boolean search string. The following string was executed in Scopus: TITLE-ABS-KEY ((("soccer player*" OR "football player*") AND ("aerobic training" OR "endurance training" OR "VO2max" OR "aerobic capacity") AND (training OR intervention OR program*)))

Truncation was used to capture morphological variants without inflating the string. Train* retrieves train, training, trained, and trainability, while condition* returns conditioning and conditioned. Intervent* works the same way, picking up intervention and interventional. The wildcard in "small-sided game*" handles something slightly different: it captures both the singular and plural of a term that appears inconsistently across the literature. Phrase searching was applied wherever a multi-word concept would otherwise fragment. This mattered most for maximal oxygen uptake and maximal aerobic speed. Without quotation marks, those searches would have returned records in which the constituent words appear in unrelated contexts.

Searching was restricted to the title, abstract, and keyword fields through the TITLE-ABS-KEY field code. Full-text searching was not used. It would have returned records where the search concepts show up only in the reference list or in incidental discussion, degrading precision substantially without meaningfully improving recall for intervention studies. Four limiters were applied, and each one had a specific rationale. The publication window of 2021, 2025 was imposed to capture the contemporary evidence base. The reasoning was that training prescription, monitoring technology, and outcome-assessment practice in soccer have changed enough over the preceding decade that older trials describe a different applied context. The document-type limiter narrowed retrieval to journal articles, excluding conference papers, book chapters, editorials, and notes. Those formats

typically lack the methodological detail needed for appraisal. The language limiter to English reflects the review team's working languages, and Section 5.5 acknowledges this as a limitation. Finally, the publication-stage limiter was set to final, excluding articles in press who's bibliographic and pagination data are unstable.

The string went through several rounds of refinement. An initial version omitted the intervention cluster entirely, and the corpus it returned was dominated by cross-sectional profiling and test-validation studies. Adding the third cluster improved precision without losing relevant intervention records in any material way. A second pilot version put athlet* into the population cluster. That brought in large numbers of mixed-sport and non-soccer records, so it was removed. Scopus served as the sole database. We selected it as the primary information source because of its breadth of coverage in sport and exercise science, its indexing of regional and emerging journals where a substantial portion of the applied soccer-conditioning literature appears, and its structured metadata export, which makes reproducible record management possible. The complete result set was exported as a comma-separated metadata file. Each record included author, title, year, source, volume, issue, article number, pagination, digital object identifier, abstract, keywords, document type, publication stage, and open-access status fields. The search ran as a single session, and the export used throughout this review is the one that session produced. Authors preparing this manuscript for submission should insert the exact execution date. That date is not recorded within the metadata export itself, so it has not been inferred. No supplementary databases were searched, and no citation-chasing or grey-literature searches were conducted either. The single-database approach is a deliberate constraint on recall, accepted in exchange for a fully reproducible retrieval path.

One further limitation of the source file needs to be stated explicitly, because it constrains what Section 5.2 can report. The metadata export contains no affiliation or country field. As a result, the geographic origin of included studies could not be extracted systematically, and no country-level distribution is reported. Where a study names its setting explicitly in the abstract, that information appears in Table 4. Otherwise, the field is recorded as not stated in the source record. We did not infer any country from author names, journal origin, or other indirect signals.

Eligibility criteria were fixed before screening began and applied unchanged throughout. The defining criterion is the outcome requirement. A study qualified only if it reported maximal oxygen uptake at both a pre-intervention and a post-intervention time point, whether measured directly by respiratory gas analysis or estimated from a validated field test. That criterion is deliberately restrictive. It rules out intervention studies that assessed aerobic-related performance solely through measures such as intermittent test distance without conversion to VO_2max, or through velocity-based indices reported without an oxygen-uptake estimate. The restriction exists to create a single comparable outcome metric across heterogeneous modalities, and that is the analytic premise of this review.

Table 2. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Population	Soccer (association football) players, any sex, any competitive standard, aged 13 years or older	Non-soccer athletes; Gaelic football, American football, and futsal-only cohorts; recreational participants without team affiliation; para-sport and clinical populations (amputee, cerebral palsy, spinal cord injury, visual impairment)
Intervention	Prospective training intervention of at least four weeks containing an explicit aerobic-oriented conditioning component, delivered alongside or in place of part of habitual soccer training	Interventions shorter than four weeks; acute or single-session studies; nutritional, supplementation, or pharmacological trials; strength, plyometric, resistance, or neuromuscular programmes without an aerobic component; rehabilitation-only protocols
Comparator	Control group continuing habitual training, an alternative training modality, or the participants' own pre-intervention values	No comparator of any kind; retrospective comparison against external normative data only
Outcome	VO_2max reported pre- and post-intervention, measured directly or estimated from a validated field test (Yo-Yo Intermittent Recovery, 20 m shuttle, Cooper, Åstrand, treadmill protocol)	No VO_2max outcome; aerobic performance reported only as raw test distance, velocity, or heart-rate response without an oxygen-uptake estimate; outcome reported at a single time point

Criterion	Inclusion	Exclusion
Study design	Randomised controlled trial, non-randomised controlled trial, matched-group or matched-pair trial, single-group pre–post-trial	Cross-sectional, correlational, and observational studies; longitudinal monitoring without a defined intervention; test validity and reliability studies; case reports; systematic reviews and meta-analyses
Language	English	All other languages
Document type	Journal article, final publication stage	Conference paper, book chapter, editorial, note, erratum, article in press
Publication period	2021–2025	Published before 2021
Accessibility	Record retrievable with sufficient methodological and outcome detail for appraisal	Record not retrievable; abstract-only availability
Sample independence	Independent participant sample	Companion publication reporting the same participants and overlapping outcomes as an already included report

Selection took place in four steps that aligned with the PRISMA 2020 methodology. First, the search identified 778 records. The database filter (document type, language, publication stage, and publication year) eliminated 540 records automatically. The search engine detected 14 duplicated records after they were matched based on the digital object identifier and, if no identifier was given, the authors' names, publication year, and title. In the screening stage, 224 abstracts were evaluated against the criteria in Table 2. Only those records were removed from the sample whose ineligibility was evident solely in the title or abstract; other uncertain papers were retained for further analysis. The conservative screening strategy was used only when ineligibility was obvious from the title and abstract; otherwise the manuscript was deemed eligible and recovered. Therefore, a total of 56 papers were potentially eligible, and out of them, 4 could not be traced enough for a reliable evaluation, ending up with 52 research reports for full consideration. Each of the 52 reports was subjected to criteria in Table 2 in the eligibility stage; the last outcome criterion was only used if necessary to reflect the main cause for exclusion. Twenty-nine articles weres excluded for various reasons and represented in Figure 1. Finally, twenty-three studies made it to the systematic review and meta-analysis step. Reviewers carried out screening and eligibility assessment, and they applied the inclusion/exclusion criteria one by one for each document rather than basing the assessment upon intuitive judgment. If reviewers disagree, the conflicting paper was discussed again and the criterion that caused the dispute was interpreted until a decision was made; it should be noted that no external party was involved in decision making.

Quality appraisal was done separately from the PICO-based search described in Section 3.2. The MMAT, the Mixed Methods Appraisal Tool Version 2018 (Hong et al., 2018), was used to evaluate each incorporated study. We chose the MMAT as our evaluation tool because the different types of evidence presented the different designs. The MMAT tool, on one hand, applies design-specific criteria to such heterogeneous designs and, on the other, it does not impose a standardized checklist. Each incorporated study was divided at first into Quantitative Randomised Controlled, Quantitative Non- Randomised, and Quantitative Descriptive design categories based on the authors' allocation and comparison procedures that they have described. After design classification, the corresponding MMAT checklist of five items were applied and the answer of each item would be a Yes, a Can't tell, or a No. If a particular paper's design did not fit in MMAT's categories, our default action was to have its corresponding Joanna Briggs Institute critical appraisal checklist as a substituent in such cases and to have written that substitution clearly down. We decided that even though we have not used any of these substitutions since they were actually not necessary because all our 23 included papers came under the category of Quantitative MMATs. Scoring scheme: On the scale of 1.0, 0.5, or 0.0, each of these items were rated as Yes, Can't tell (or partly fulfilled), or No, respectively. This means for a good quality study, a maximum score of 5.0 was possible. For a study to be included into the syntheses, it would only be if 60 or more percent of the items (3 or more out of 5) were answered in an affirmative manner. Those falling below this benchmark would not be automatically discarded; in fact, their lower methodological confidence level would be identified and their synthesis contributions would be down weighted correspondingly. We were also following the policy advice of MMAT developers not to consider the total scores as exclusion criteria. Naturally, appraisal is only based on what the research paper reports instead of what it's doing, which would explain why criteria that weren't addressed in a paper were scored as Can't tell rather than No. The research team carried out the appraisal using the written criteria of the MMAT; if there appeared to be a disagreement, we resolved it by jointly reading the relevant section of the article for which we had reached a misunderstanding at first reading and then reaching an agreement with our decision. It is not intended to measure agreement between different raters by any formal

coefficient calculation here. You can find a complete assessment of this section in Table 3. We placed this table here, so that it is possible to go back and forth between quality assessments and the characteristics of studies while reading the latter.

This paper presents a comprehensive review of training interventions for improving VO_2max through small-sided games. In order to ensure systematicity and precision, a template with fixed fields to record data was used for every selected article. It includes details such as author(s), year of publication; source journal; setting or cohort as clearly stated in the literature; sample size, number of groups or treatment conditions assigned; participant' gender, age, and competitive standard; training modality and programme design with respect to how and when work, recovery periods were done, session frequencies and overal length of the programme; Comparator condition; the aerobic capacity measure (VO_2max) and the instrumentation used; other secondary outcomes; also the trend (up or down), change magnitude, and statistical significance of the difference in VO_2max after the experimental period. It is important to emphasise that data extraction was strictly limited to the citation lists and abstracts of the documents. If a field was not given in the record, it was left as "not stated, " rather than being estimated, inferred, or even supplied from other sources. Tables 4 and 5 show the application of this rule which is why, for instance, some cells have "absent" entries rather than "approximate".

A descriptive bibliometric analysis of the screened corpus was undertaken to understand the academic background leading to the inclusion of the studies. Firstly, keywords in the screened records were identified, converted into their standardized forms using the UMLS metathesaurus, etc, and then the keywords were listed in terms of how often each one was used and with how many others it was used. Orthographic and formatting variations of the same concept were grouped together. The most obvious were different forms of 'VO_2max' (e.g., V0$_2$max, VO2 max, etc) as well as singular/plural differences in 'small-sided game'. Additionally, in instances where 'football' and 'soccer' are referring to the same sport, they have been merged. The count of keywords is made per individual article, so a word that is repeated within the same article only counts once.

The co-occurrence is the number of articles that contain at least two normalised keywords. The resulting network is a weighted undirected graph: nodes are keywords and edges between nodes are the co-occurrences of keywords. The work described was performed directly on the metadata instead of using any bibliometric software like VOSviewer or Bibliometrix, because clustering, centrality, mapping, or any other visualising technique was not the focus of the analysis. The main objective is only to get a sense of what ideas are more prevalent in the retrieved literature, so that it would be evident to which degree the 23 experimental designs are representative of the general research context. Results are shown in Figure 4.

Data are often summarised together as the different categories are the main focus. Following the procedure used by Thomas and Harden (2008), this was a three-stage process. It is done by identifying words and phrases in the content extracts for each of the studies that relate to the same theme. Then, all of these 'lines-by-lines' are combined so that themes that describe the essence of a set of codes or a topic can easily be spotted. Finally, analytical themes are derived to answer the main questions posed within the review and usually reflect different levels in abstraction or complexity from descriptive themes. Codes were applied to parts containing descriptions of an intervention and outcomes reported but not the whole document or study text since it is not consistent with the document extraction convention in this study.

Themes describing the content of the research were generated through a top-down analysis approach, and after that, they were linked or mapped on the research questions in one-by-one fashion. It is very interesting to note that Section 5:2 is all about the classification and naming of the types of physical exercise. This is an interesting detail because what happened is that after this coding, we got the types or names of the physical exercises that are commonly used in this type of exercise and the physical stimulus is classified based on those. Therefore, instead of imposing the modality classification beforehand, it was allowed to emerge from the coding. Analytical themes were then developed by examining how similar and different findings across studies fell under the themes generated from coding both the physical activities and their delivery formats as mentioned above. The most interesting part about the theme development is the attention given to the studies which used the same intervention modality but the effect they observed was altogether different.

It is the methodological rather than the practical reason that a quantitative meta-analysis was not conducted. Since the review was about comparing different training or exercise forms on VO_2max performance the first problem with meta-analysis would be the different measurement techniques. There, at least, six different instruments were adopted among the included studies to evaluateVO_2max: direct respiratory gas analysis, treadmill protocols, cycle ergometry and several distinct field tests which provide estimation equations that are not interchangeable. A second problem arises from the variation in control conditions. The range of comparator conditions goes from no-training to habitual training to alternative active modalities thus pooling effect sizes together would not reflect different conceptual situations. In a significant proportion of the studies, no control

(or comparison) condition was employed (i.e., they were single-group studies). Moreover, the size of effects (effects sizes) and the dispersion statistics (e.g. standard deviation) were inconsistent across studies. Under these circumstances, to carry out a quantitative synthesis by aggregating studies, you could get a precise number (statistically) which reflects no real phenomenon i.e., a scientifically meaningless number because the set of data has so many different characteristics, e.g. different measurement techniques, different control conditions. Therefore, narrative and/or thematic synthesis along with structuring in tables was decided to be justifiable way of analysis.

The manuscript is reported along PRISMA 2020 checklist (Page et al., 2020) as required for a systematic literature review. In this regard, first, we referred to the 27-item checklist as a kind of outline for the writing of this work. Second, we have presented the PRISMA chart (Fig. 1) depicting the steps in the screening process identification, screening, eligibility, and inclusion in accordance with its visual representation in PRISMA 2020. The item-by-item rationale follows the PRSIMA 2020. In our work, we do not intend to follow up through PROSPECTORS, although, by all means, the review could have been registered at that place as in any alternative public registry for protocols such as PROSPECTORS. This issue is addressed directly and is one of the listed limitations in the discussion.

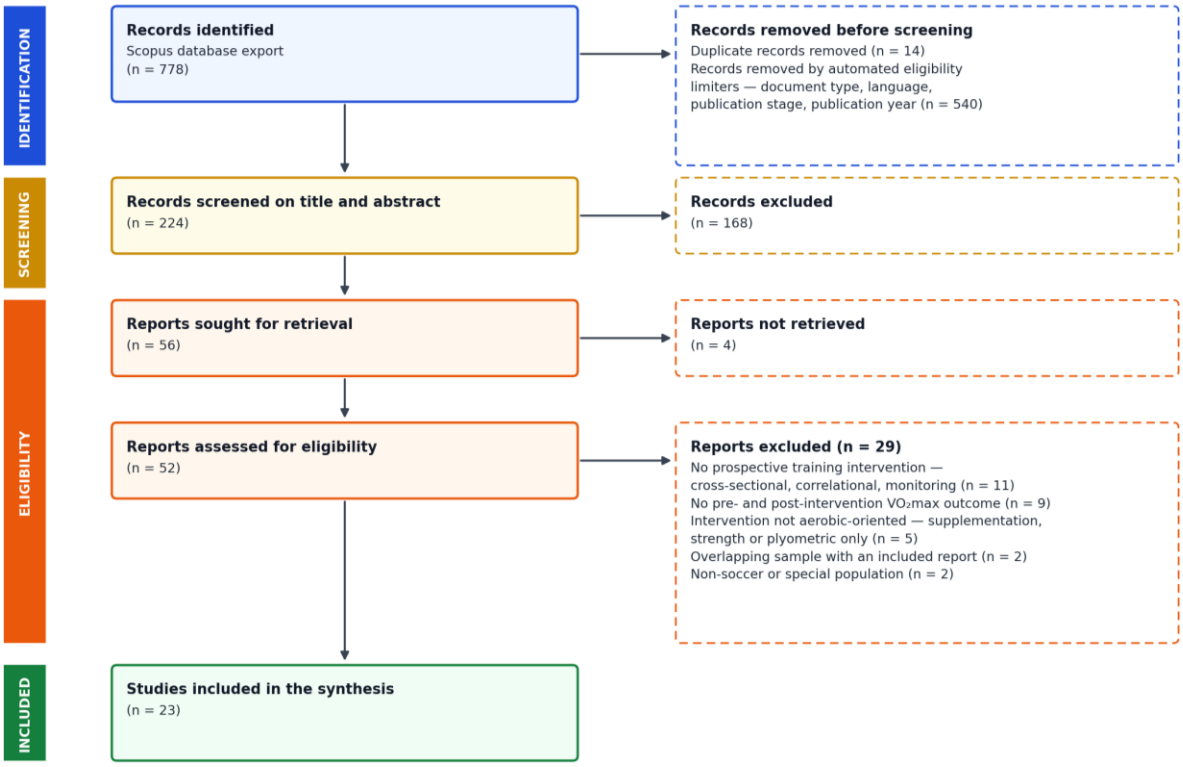

Figure 1. PRISMA 2020 Flow Diagram for the Selection of Studies on Aerobic-Oriented Training and VO_2max in Soccer Players

The flow of records through the review is presented in Figure 1. The diagram follows the four-phase PRISMA 2020 architecture - Identification, Screening, Eligibility, and Included - with exclusion reasons displayed in dashed-border boxes to the right of the main flow. The numerical content of the diagram is as follows. Identification: records identified from Scopus (n = 778); records removed before screening comprising duplicate records removed (n = 14) and records removed by automated eligibility limiters for document type, language, publication stage, and publication year (n = 540). Screening: records screened on title and abstract (n = 224); records excluded (n = 168). Eligibility: reports sought for retrieval (n = 56); reports not retrieved (n = 4); reports assessed for full eligibility (n = 52); reports excluded (n = 29) with reasons - no prospective training intervention, that is, cross-sectional, correlational, or monitoring design (n = 11); no pre- and post-intervention VO_2max outcome reported (n = 9); intervention not aerobic-oriented, that is, supplementation, strength, or plyometric only (n = 5); overlapping participant sample with an already included report (n = 2); non-soccer or special population (n = 2). Included: studies included in the final synthesis (n = 23). The diagram is drawn with Identification labelled in blue, Screening in yellow, Eligibility in orange, and Included in green, on a white background with a clean sans-serif typeface and directional arrows connecting every stage. The identification source is labelled as the Scopus database export.

Results and Discussions

The Scopus search itself turned up 778 records. From there, automated eligibility limiters inside the database interface kept only journal articles written in English, at their final publication stage, within the 2021, 2025 window. That step removed 540 records. A duplicate check then took out 14 more, matching on digital object identifier and, where no DOI existed, on the combination of first-author surname, year, and title. What remained was 224 unique records for screening, a figure that lines up exactly with the record count in the metadata export used for every subsequent stage of analysis. Screening titles and abstracts of those 224 records excluded 168 records. Design was the main reason. The retrieved corpus leans heavily toward cross-sectional profiling, positional comparison, seasonal monitoring, load-quantification, and test-validation studies, and none of those apply a prospective intervention. A secondary cluster consisted of intervention studies whose independent variable was nutritional, ergogenic, or purely neuromuscular. A third covered studies done in non-soccer or special populations. Fifty-six records moved forward as potentially eligible. Of those, 4 could not be retrieved with enough methodological and outcome detail to appraise properly, leaving 52 reports assessed for full eligibility. Of those 52, 29 were excluded. Eleven ultimately did not involve a prospective training intervention; they presented longitudinal or seasonal data with no defined programme contrast. Nine applied a qualifying intervention but did not report VO_2max at both time points. Instead, they reported intermittent test distance, velocity at exhaustion, or heart-rate response, with no estimate of oxygen uptake. That group includes several methodologically strong small-sided-games and sprint-interval trials, and their exclusion follows directly from the outcome criterion specified in Section 3.4, a consequence we acknowledge openly. Five more ran interventions with no aerobic-oriented component. Two were companion publications reporting the same participants and overlapping outcomes as a report already included. The final two were conducted in populations outside the eligibility definition. That left Twenty-three studies in the final synthesis. Every figure cited in this section matches its counterpart in Figure 1 and in the Abstract exactly.

Appraisal classified 9 studies as quantitative randomised controlled trials, 8 as quantitative non-randomised trials, and 6 as quantitative descriptive studies using single-group pre–post designs. Total MMAT scores ranged from 3.0 to 5.0 out of 5.0. Fifteen studies (65%) met the criteria for high methodological confidence (≥4.0, equivalent to ≥80%), and eight (35%) fell in the medium band (3.0–3.5, equivalent to 60–70%). No study scored below the 60% threshold, so no study required the lower-confidence weighting described in Section 3.6, and a sensitivity analysis excluding low-quality studies was consequently not required.

Table 3. Methodological Quality Appraisal (MMAT Version 2018)

Author(s), Year	MMAT design category	Q1	Q2	Q3	Q4	Q5	Total	Quality category
Koç et al., 2025	Quantitative randomised controlled	1.0	1.0	1.0	0.0	1.0	4.0	High
Gnanasigamani et al., 2025	Quantitative randomised controlled	1.0	0.5	0.5	0.0	1.0	3.0	Medium
Salazar-Martínez et al., 2023	Quantitative randomised controlled	1.0	1.0	1.0	0.0	1.0	4.0	High
Samavati Sharif et al., 2024	Quantitative randomised controlled	0.5	1.0	1.0	0.0	1.0	3.5	Medium
Selmi et al., 2023	Quantitative randomised controlled	1.0	1.0	1.0	0.5	1.0	4.5	High
Mara & Çobaj, 2025	Quantitative randomised controlled	1.0	1.0	1.0	0.0	0.5	3.5	Medium
Diker et al., 2023	Quantitative randomised controlled	1.0	1.0	1.0	0.0	1.0	4.0	High
Kaewkamad et al., 2025	Quantitative randomised controlled	1.0	0.5	1.0	0.0	1.0	3.5	Medium
Deep et al., 2025	Quantitative randomised controlled	1.0	1.0	1.0	0.0	1.0	4.0	High
Radhouane et al., 2023	Quantitative non-randomised	0.5	1.0	1.0	0.5	1.0	4.0	High
Zaharia et al., 2023	Quantitative non-randomised	1.0	1.0	1.0	0.5	1.0	4.5	High
Ahmad et al., 2024	Quantitative non-randomised	1.0	1.0	1.0	0.5	1.0	4.5	High
Kumar et al., 2025	Quantitative non-randomised	1.0	1.0	1.0	1.0	1.0	5.0	High
Norrahmah et al., 2025	Quantitative non-randomised	1.0	1.0	1.0	0.5	1.0	4.5	High
Bahtra et al., 2024	Quantitative non-randomised	0.5	1.0	1.0	0.5	1.0	4.0	High
Arslanoglu et al., 2024	Quantitative non-randomised	1.0	1.0	1.0	0.5	1.0	4.5	High
Pierros & Spyrou, 2023	Quantitative non-randomised	0.5	1.0	1.0	0.5	1.0	4.0	High
Kabdwal et al., 2023	Quantitative descriptive	0.5	0.5	1.0	1.0	0.5	3.5	Medium

Author(s), Year	MMAT design category	Q1	Q2	Q3	Q4	Q5	Total	Quality category
Ndlomo et al., 2023	Quantitative descriptive	0.5	0.5	1.0	1.0	1.0	4.0	High
Bici & Kasa, 2025	Quantitative descriptive	0.5	0.5	1.0	0.5	0.5	3.0	Medium
Saharullah et al., 2024	Quantitative descriptive	0.5	0.5	1.0	1.0	0.5	3.5	Medium
Arifan et al., 2024	Quantitative descriptive	0.5	0.5	1.0	1.0	0.5	3.5	Medium
Saha et al., 2025	Quantitative descriptive	0.5	0.5	1.0	1.0	1.0	4.0	High

Note. For randomised controlled trials, Q1–Q5 correspond to appropriateness of randomisation, baseline comparability, completeness of outcome data, blinding of outcome assessors, and adherence to the assigned intervention. For non-randomised studies, they correspond to representativeness of participants, appropriateness of measurements, completeness of outcome data, accounting for confounders, and fidelity of intervention delivery. For descriptive studies, they correspond to relevance of sampling strategy, sample representativeness, appropriateness of measurements, risk of non-response bias, and appropriateness of statistical analysis. Scores reflect what each record reported; criteria not addressed in the available reporting were scored 0.5 (Can't tell).

Two patterns in Table 3 warrant emphasis because they condition the interpretation of every finding that follows. First, blinding of outcome assessors was scored zero in eight of the nine randomised trials. This is partly an inherent feature of exercise interventions, in which participants cannot be blinded to the training they perform, but it also reflects a reporting practice in which the blinding status of testers is simply not stated. Because most included outcomes are effort-dependent field or laboratory tests, non-blinded assessment is a plausible source of inflated post-intervention values. Second, the six single-group descriptive studies necessarily score poorly on sampling representativeness while scoring well on analytic appropriateness, producing medium overall ratings that understate their internal analytic rigour and overstate their capacity to attribute change to the intervention.

Altogether, 23 studies made it into the review, and they all appeared between 2023 and 2025. Not a single study from 2021 or 2022 cleared the eligibility bar, even though those two years contributed 67 records to the screening pool. That gap is worth treating as a real finding, not a quirk of the search, and we come back to it in Section 5.6. Broken down by year, the split is 8 studies in 2023, 6 in 2024, and 9 in 2025. Figure 2 lays that out graphically. Sample sizes sat between 14 and 60 participants, with the median landing right around 30. Sixteen studies drew only male participants, while a single study recruited women exclusively. The rest simply did not say whether the cohort was male, female, or mixed, at least in the source record. The competitive level ranged all over the map, from school and academy youth to university and collegiate squads, amateur-league players, semi-professional outfits, and elite youth sides. Interventions lasted anywhere from 4 to 12 weeks, though one study stretched across an entire competitive season. Session frequency, meanwhile, came in at 2 to 5 times per week.

Table 4. Characteristics of the 23 Included Studies

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
Effects of 4-week velocity-based HIIT on athletic performance in youth soccer players	Koç et al., 2025	PeerJ	Not stated in record; youth male players	Randomised controlled; n = 14 (EG 7, CG 7), age 18.9 yr	Velocity-based HIIT at 85–90% intensity, 2 sessions/wk for 4 wk, added to regular soccer training	VO_2max; 30-15 Intermittent Fitness Test	Significant group-by-time interactions favouring the experimental group across all parameters; change-of-direction time and 30-15 IFT improved significantly in the experimental group only.
Effect of periodized interval training in combination with explosive strength and speed in game-like situation on	Kabdwal et al., 2023	Physical Education Theory and Methodology	Not stated in record; male youth players	Single-group pre–post; n = 23, age 16.7 ± 2.1 yr	Periodised interval training combined with explosive strength, speed, and game-like situations, 8 wk	VO_2max estimated from Yo-Yo IR1 distance	VO_2max increased from 55.26 to 60.07 $mL \cdot kg^{-1} \cdot min^{-1}$ and Yo-Yo IR1 performance improved; agility time also improved significantly.

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
agility and high intensity aerobic capacity of youth soccer players							
Development of some aerobic and anaerobic indicators in under-21 footballers using hypoxic training mask during the physical preparation period	Radhouane et al., 2023	Sport TK	Tiaret youth team, second professional division	Non-randomised controlled; n = 20 U21 (EG 10, CG 10)	Identical training programme in both groups; experimental group wore a hypoxic training mask for 8 wk during physical preparation	Maximal aerobic velocity and VO_2max from intermittent Yo-Yo test	Significant pre-to-post differences in aerobic and anaerobic indicators favouring the hypoxic-mask group; repeated-sprint efficiency and explosive power also improved.
Multidomain connectivity as a marker of HIIT-induced adaptation in elite youth soccer players: A correlational mapping approach	Gnanasigamani et al., 2025	Applied Sciences	Not stated in record; elite youth players	Randomised controlled; sample size not stated in record	High-intensity interval training, 4 wk	Laboratory VO_2max with lactate and biochemical markers	Significant improvements in aerobic capacity, buffering efficiency, and perceptual-cognitive function; cross-domain correlations between metabolic, cognitive, and neuromuscular indices emerged only in the HIIT group.
The effects of 8 aerobic endurance training weeks of 4vs.4+GK small-sided games versus traditional training on physical fitness and skills among U18 football players	Zaharia et al., 2023	Applied Sciences	Not stated in record; U18 club players	Non-randomised controlled; n = 40 (EG 20, CG 20), age 17.5 yr	4v4 small-sided games with goalkeepers, 2 sessions/wk for 8 wk, versus specific aerobic endurance training	VO_2max; sprint and agility with and without ball	Both groups improved VO_2max; between-group differences favoured the small-sided-games group on all parameters except the 10 m sprint. Session total distance rose 7.78% and high-speed running distance 30.90%.
The effects of small-sided games on fitness components and technical abilities among youth soccer players	Ahmad et al., 2024	Central European Journal of Sport Sciences and Medicine	Not stated in record; youth players	Non-randomised controlled; n = 60 (IG 30, CG 30), age 19.98 yr	Small-sided games training programme, 6 wk	Cardiovascular endurance expressed as VO_2max	Significant within-group improvements in speed, passing, dribbling, and VO_2max in the intervention group; between-group differences favoured the intervention

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
							group for speed, dribbling, and VO_2max.
The influence of small-sided games and floaters intervention on physical components of soccer players	Kumar et al., 2025	Physical Education Theory and Methodology	Not stated in record; players aged 14–16 yr	Non-randomised controlled with ANCOVA; n = 52 (SSG + floaters 26, CG 26)	Small-sided games with floaters, 5 days/wk for 12 wk, 90 min sessions	VO_2max from Yo-Yo IR1	Significant improvement in maximal aerobic endurance, leg explosive strength, and agility in the intervention group; speed was unchanged and the control group showed no comparable gains.
The effects of high-intensity training on aerobic capacity of football players	Ndlomo et al., 2023	Journal of Physical Education and Sport	Not stated in record; sub-elite male players	Single-group pre–post; n = 18, age 21 ± 1.8 yr	Field-based HIIT prescribed above vVO_2max with progressive overload of work-to-rest ratio, repetitions, and high-speed distance; 8 sessions across the first 4 preseason weeks	Treadmill VO_2max (modified Heck protocol) to volitional fatigue	VO_2max rose from 43.9 to 50.5 $mL \cdot kg^{-1} \cdot min^{-1}$, vVO_2max from 13.8 to 16.3 $km \cdot h^{-1}$, and velocity at the second ventilatory threshold from 9.2 to 11.6 $km \cdot h^{-1}$, all $p < 0.0001$.
Comparative impact of small-sided games and high-intensity interval training on physical performance in youth soccer players	Salazar-Martínez et al., 2023	Journal of Physical Education and Sport	Not stated in record; youth players, mid-competitive season	Randomised parallel groups; n = 24 (12 per group)	Small-sided games from 2v2 to 6v6, 20–40 min per session, 9 wk, versus HIIT matched for duration and frequency	Laboratory ergospirometry; Course Navette	No significant between-group difference in VO_2max ($p = 0.44$); the small-sided-games group improved 6% and the HIIT group 12%, with a moderate effect size. The small-sided-games group improved significantly on all repeated-sprint variables.
A comparative study of intense continuous and intermittent aerobic training on physiological factors in football players	Samavati Sharif et al., 2024	International Journal of Sport Studies for Health	Hamadan; young football players	Randomised three-group; n = 45 (15 per group)	Intense continuous aerobic training at 90–95% HRmax, 3 sessions/wk, versus high-intensity interval training, 3 sessions/wk, versus	VO_2max with heart rate and blood pressure	Both training groups improved significantly relative to control; VO_2max gains and reductions in resting heart rate and blood pressure were larger in the continuous training group.

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
					control; 6 wk		
Effects of aerobic and speed training versus active control on repeated sprint ability and measures of self-confidence and anxiety in highly trained male soccer players	Selmi et al., 2023	Sports Medicine - Open	Not stated in record; highly trained male athletes	Randomised controlled; n = 38 (COMB 20, CON 18), age 18.9 yr	Intermittent aerobic exercise at 110–120% of final Yo-Yo IL1 velocity plus maximal 15–20 m sprints, 20 min per session replacing part of soccer-specific training; active control performed soccer-specific training only	VO_2max derived from Yo-Yo Intermittent Fitness Test Level 1	Significant group-by-time interactions for VO_2max, final velocity, total distance, and all repeated-sprint measures, favouring the combined group; self-confidence rose and somatic and cognitive anxiety fell.
Quantitative analysis of athletic performance enhancement: The effects of aerobic training on VO2 max in young soccer's	Mara & Çobaj, 2025	Edelweiss Applied Science and Technology	Sports University of Tirana laboratory; players aged 18–19 yr	Randomised controlled; n = 44 (EG 22, CG 22)	Aerobic exercises combined with acrobatic movements, 3 sessions/wk across a full competitive season	Laboratory VO_2max	Groups did not differ at baseline; the experimental group showed a significantly greater post-intervention VO_2max increase, with a large training-by-time interaction, $F(1, 42) = 1176.58$, $p < .001$.
Using small-sided games or their combination with speed endurance training: Which is more effective for improving aerobic capacity in young amateur league soccer players?	Norrahmah et al., 2025	Physical Education Theory and Methodology	Not stated in record; young amateur-league players	Matched-group non-randomised; n = 36, age 20.1 yr	Small-sided games versus small-sided games combined with speed endurance training; 12 sessions over 4 wk, 3 sessions/wk	Yo-Yo IR1 total distance and derived VO_2max	Both methods improved aerobic capacity; the combined small-sided games plus speed endurance group achieved significantly greater increases in total distance and VO_2max than small-sided games alone.
Effects of 8-week HIIT short interval training with extensive intensity and change of direction (COD) on aerobic and anaerobic capacity of	Bici & Kasa, 2025	Journal of Physical Education and Sport	Football school; players aged 16 yr	Single-group pre–post; n = 18 enrolled, 14 analysed	30 s intervals at 105–120% vVO_2max with 30 s active recovery at 50% vVO_2max on a 115–130 m circuit	Åstrand 6 min cycle ergometer VO_2max; 12 min Cooper test	VO_2max increased by 8.96 units (18.89%) and Cooper distance by 215 m (7.9%), both $p < 0.001$ with very large effect sizes; RAST fatigue index

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
youth soccer players					incorporating 45° and 90° direction changes; 8 wk		improved in 12 of 14 players.
Enhancing VO2Max: Contrasting effects of fartlek training and small-sided games	Bahtra et al., 2024	Journal of Physical Education and Sport	Not stated in record; players aged 15–17 yr	Quasi-experimental matched pairs; n = 20	Fartlek training versus small-sided games training; duration not stated in record	VO_2max derived from Yo-Yo Intermittent Recovery test	Both modalities raised VO_2max, but fartlek was significantly more effective, increasing mean VO_2max by 1.33 units versus 0.52 for small-sided games.
Recovery time variation during sprint interval training impacts amateur soccer players adaptations - a pilot study	Diker et al., 2023	Biology of Sport	Not stated in record; amateur players, off-season	Randomised three-group; n = 23 (SIT150 8, SIT30 7, CG 8), age 21.4 yr	Running-based sprint interval training, 30 s all-out, 6–10 repetitions, 2 days/wk for 6 wk, with either 150 s or 30 s recovery intervals, plus routine training and one match weekly	Treadmill VO_2max; Yo-Yo IRT1 and IRT2	VO_2max and Yo-Yo performance improved significantly in both sprint interval groups; the 150 s recovery protocol produced superior Yo-Yo IRT1 and IRT2 adaptations than the 30 s protocol.
The effects of speed endurance training on aerobic and anaerobic performance of young female soccer players	Kaewkamad et al., 2025	Retos	Not stated in record; female players aged 14–18 yr	Randomised controlled; n = 30 (EG and CG)	Speed endurance training twice weekly for 6 wk in addition to regular soccer training; control continued regular training only	Yo-Yo IR1 distance and derived VO_2max	Yo-Yo IR1 distance rose 68.8% and VO_2max 10.2% in the experimental group, with resting heart rate reduced; anaerobic capacity improved 35.6% and anaerobic power 38.3%, while controls showed minimal change.
An effective method of aerobic capacity development : Combined training with maximal aerobic speed and small-sided games for amateur football players	Arslanoglu et al., 2024	Applied Sciences	Not stated in record; amateur players aged 23–25 yr	Non-randomised three-group; n = 60 (combined 20, MAS 20, normal training 20)	Maximal aerobic speed training with small-sided games (combined) or maximal aerobic speed training alone, twice weekly for 12 wk, in addition to regular football	Yo-Yo IR1 training load, running distance, and derived VO_2max	Both the combined and maximal-aerobic-speed groups improved significantly relative to normal training on training load, running distance, and VO_2max ($p = 0.001$); the normal training group showed

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
					training; control continued routine training		no significant change.
Application of combination of physical training methods to improve the aerobic capacity of football players	Saharullah et al., 2024	Sport TK	South Sulawesi; players preparing for the 2024 National Sports Week	Single-group pre–post; n = 20	Structured combination of aerobic, anaerobic, and strength training, 3 sessions/wk across 16 sessions	VO_2max test	VO_2max increased significantly following the combined programme ($p < 0.05$), indicating that integrated multicomponent conditioning can raise aerobic capacity in match-preparation contexts.
Effects of high-intensity interval training versus sprint interval training during the second wave of COVID-19 lockdown on soccer players	Pierros & Spyrou, 2023	Apunts Sports Medicine	Not stated in record; semi-professional players during lockdown	Non-randomised two-group; n = 29 (HIIT 16, SIT 13)	HIIT with progressive intensity plus resistance training versus sprint interval training plus bodyweight circuit training; sessions capped at 60 min; 4 wk	Yo-Yo IR1 with derived VO_2max and vVO_2max; countermovement jump	VO_2max, vVO_2max, and jump height increased and maximal heart rate decreased in the HIIT group; the sprint interval group showed no change, and post-intervention VO_2max was significantly higher in the HIIT group.
Increase in maximum oxygen volume (VO2Max) based on the small side game method	Arifan et al., 2024	International Journal of Human Movement and Sports Sciences	Student Training Education Centre (PPLP), West Sumatra; players aged 14–17 yr	Single-group pre–post; n = 40, approximately 9 yr training experience	Small-sided games training method; total duration not stated in record	VO_2max field test	VO_2max increased significantly from pre- to post-test ($t = -26.645$, $p < 0.01$), with normalised gain scores between 0.4 and 0.9 placing the intervention in the effective category.
The impact of targeted soccer training interventions on YO-YO intermittent recovery test performance in university-level soccer players	Saha et al., 2025	Physical Education Theory and Methodology	Visva-Bharati University; male players aged 17–25 yr	Quasi-experimental single-group pre–post; n = 32	Targeted soccer training programme, 12 wk	Yo-Yo IR1 accumulated distance, cumulative time, and derived VO_2max	Accumulated distance rose 312.5 m ($d = 1.70$), cumulative time 2.54 min ($d = 1.80$), and VO_2max 2.62 $mL \cdot kg^{-1} \cdot min^{-1}$ ($d = 1.72$), all $p < 0.001$ with large effect sizes.
Eight-week intervention of small-sided games	Deep et al., 2025	International Journal of Kinesiology	Not stated in record; collegiate male	Randomised controlled parallel	Small-sided games combined with HIIT	Yo-Yo IR1 with derived VO_2max; RAST; agility,	Agility, sprint speed, explosive power, and

Title	Author(s), Year	Journal	Setting / cohort as reported	Design and sample	Intervention and dose	Aerobic capacity instrument	Key findings
with high-intensity interval training versus traditional HIIT on the physical fitness of soccer players		and Sports Science	players aged 18–24 yr	groups; n = 22	versus traditional HIIT, 2 supervised sessions/wk for 8 wk in addition to regular soccer practice	sprint, and jump tests	perceived exertion improved significantly more with combined small-sided games plus HIIT; VO_2max and anaerobic power improved more in that group but between-group differences were not statistically significant.

Table 5. Classification of Included Studies by Modality, Theme, Comparator, and Aerobic Outcome

Author(s), Year	Research design	Modality category	Thematic focus	Comparator	Duration / frequency	Aerobic outcome direction
Koç et al., 2025	Randomised controlled	HIIT (interval running)	Velocity-anchored interval prescription	Habitual training control	4 wk / 2 per wk	Significant increase, superior to control
Gnanasigamani et al., 2025	Randomised controlled	HIIT (interval running)	Multidomain physiological adaptation	Habitual training control	4 wk / not stated	Significant increase, superior to control
Ndlomo et al., 2023	Single-group pre–post	HIIT (interval running)	Preseason time efficiency	Within-group baseline	4 wk / 2 per wk	Significant increase
Bici & Kasa, 2025	Single-group pre–post	HIIT (interval running)	Supramaximal intensity with direction change	Within-group baseline	8 wk / not stated	Significant increase
Pierros & Spyrou, 2023	Non-randomised controlled	HIIT (interval running)	Modality contrast under training restriction	Sprint interval training	4 wk / not stated	Significant increase, superior to comparator
Samavati Sharif et al., 2024	Randomised controlled	Continuous versus interval contrast	Intensity-distribution contrast	HIIT and passive control	6 wk / 3 per wk	Significant increase, continuous superior
Zaharia et al., 2023	Non-randomised controlled	Small-sided games (single modality)	Game-based aerobic conditioning	Traditional aerobic endurance training	8 wk / 2 per wk	Significant increase, superior to comparator
Ahmad et al., 2024	Non-randomised controlled	Small-sided games (single modality)	Concurrent fitness and technical development	Habitual training control	6 wk / not stated	Significant increase, superior to control
Kumar et al., 2025	Non-randomised controlled	Small-sided games (single modality)	Numerical superiority manipulation	Habitual training control	12 wk / 5 per wk	Significant increase, superior to control
Arifan et al., 2024	Single-group pre–post	Small-sided games (single modality)	Applied academy conditioning	Within-group baseline	Not stated	Significant increase
Salazar-Martínez et al., 2023	Randomised controlled	Small-sided games (comparative)	Game-based versus running-based stimulus	HIIT	9 wk / matched	Significant within-group increase, no between-group difference

Author(s), Year	Research design	Modality category	Thematic focus	Comparator	Duration / frequency	Aerobic outcome direction
Norrahmah et al., 2025	Matched-group controlled	Small-sided games (combined)	Additive effect of speed endurance	Small-sided games alone	4 wk / 3 per wk	Significant increase, combined superior
Bahtra et al., 2024	Matched-pairs quasi-experimental	Small-sided games (comparative)	Game-based versus varied-pace running	Fartlek training	Not stated	Significant increase, fartlek superior
Arslanoglu et al., 2024	Non-randomised controlled	Small-sided games (combined)	Velocity anchoring plus game-based work	Maximal aerobic speed alone; routine training	12 wk / 2 per wk	Significant increase, both experimental groups superior to routine training
Deep et al., 2025	Randomised controlled	Small-sided games (combined)	Sport-specific versus generic interval work	Traditional HIIT	8 wk / 2 per wk	Significant increase, no significant between-group difference
Diker et al., 2023	Randomised controlled	Sprint and speed-endurance training	Recovery-interval manipulation	Alternative recovery ratio; habitual control	6 wk / 2 per wk	Significant increase in both interval conditions
Kaewkamad et al., 2025	Randomised controlled	Sprint and speed-endurance training	Female youth adaptation	Habitual training control	6 wk / 2 per wk	Significant increase, superior to control
Selmi et al., 2023	Randomised controlled	Sprint and speed-endurance training	Combined physical and psychological adaptation	Soccer-specific training only	Not stated	Significant increase, superior to control
Kabdwal et al., 2023	Single-group pre–post	Multicomponent integrated conditioning	Periodised concurrent development	Within-group baseline	8 wk / not stated	Significant increase
Mara & Çobaj, 2025	Randomised controlled	Multicomponent integrated conditioning	Aerobic work with coordinative loading	Standard soccer training	Full season / 3 per wk	Significant increase, superior to control
Saharullah et al., 2024	Single-group pre–post	Multicomponent integrated conditioning	Competition-preparation programming	Within-group baseline	16 sessions / 3 per wk	Significant increase
Saha et al., 2025	Single-group pre–post	Multicomponent integrated conditioning	University-level endurance development	Within-group baseline	12 wk / not stated	Significant increase
Radhouane et al., 2023	Non-randomised controlled	Environmental or equipment adjunct	Hypoxic overlay on standard training	Identical training without mask	8 wk / not stated	Significant increase, superior to control

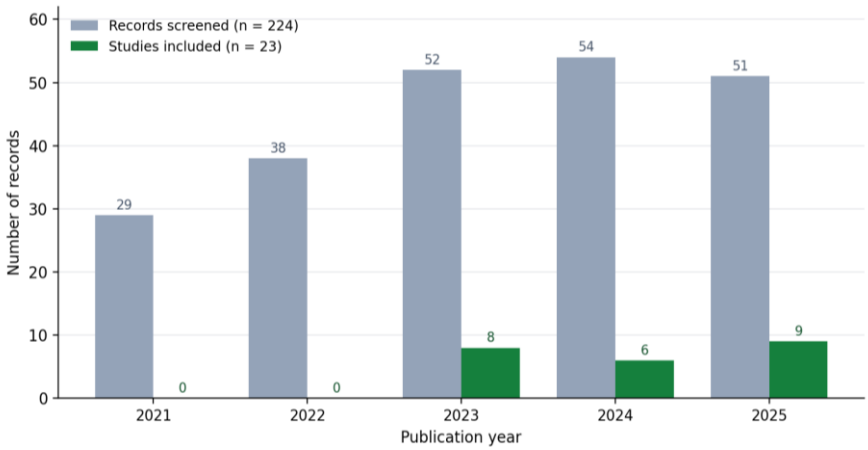

Figure 2. Distribution of Included Studies by Publication Year (2021–2025)

Figure 2 presents the annual distribution of the 23 included studies against the annual distribution of the 224 screened records. The contrast is the informative element: the screened corpus is distributed relatively evenly across the five-year window, whereas the included studies cluster entirely in the final three years.

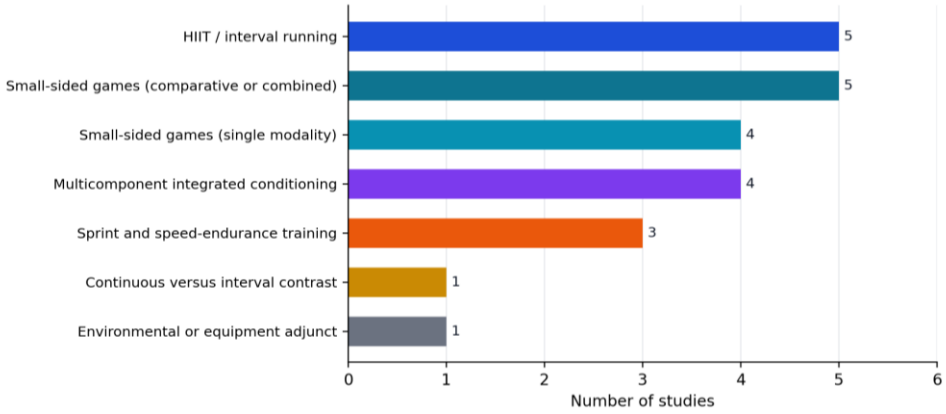

Figure 3. Distribution of Included Studies by Training Modality Category

Figure 3 displays the seven modality categories derived inductively during coding, with the number of studies in each: HIIT or interval running (5), small-sided games as a single modality (4), small-sided games in comparative or combined designs (5), sprint and speed-endurance training (3), multicomponent integrated conditioning (4), continuous versus interval contrast (1), and environmental or equipment adjunct (1). Small-sided games in any configuration account for 9 of 23 studies and interval-based running for 6, so that interval-type stimuli in some form underpin roughly two-thirds of the evidence base.

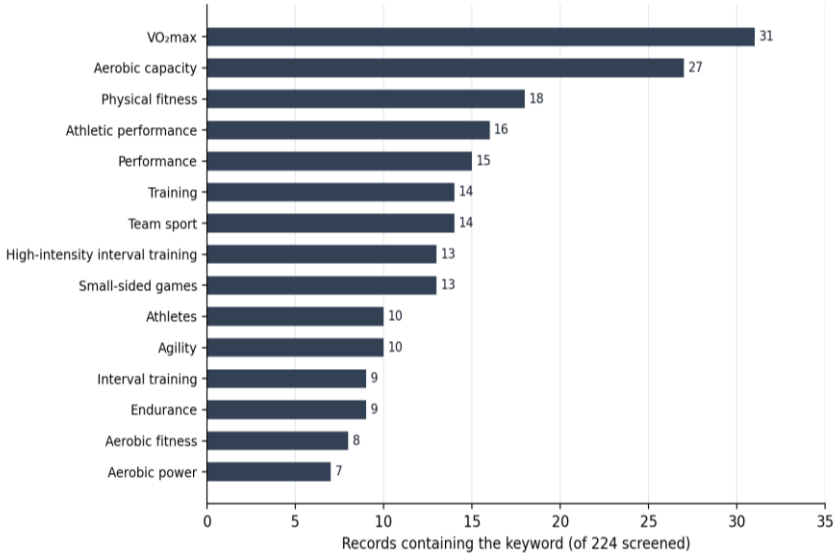

Figure 4. Author Keyword Frequency and Co-occurrence in the Screened Corpus

Figure 4 summarises the bibliometric analysis described in Section 3.8, showing the fifteen most frequent normalised author keywords across the 224 screened records together with the strongest co-occurrence pairs. After merging typographic variants, *VO_2max* appears in 31 records and *aerobic capacity* in 27, placing outcome concepts immediately behind the population term *soccer* (112 records) and ahead of every modality term. Among modalities, *high-intensity interval training* and *small-sided games* appear in 13 records each, with *interval training* in a further 9. The strongest co-occurrence pairs link the population term to *physical fitness* (16 records), *athletic performance* (11), *aerobic capacity* (10), *small-sided games* (9), and *high-intensity interval training* (9). The corpus is therefore thematically concentrated on exactly the intersection this review addresses, which supports the representativeness of the included sample.

Thematic Synthesis

Findings for RQ1 - Modalities Used and How They Are Configured

What the field has actually tested is the first analytical theme. The intervention descriptions from all 23 included studies were coded, and seven modality categories came out of that coding. Yet underneath them sits a simpler structural finding: with one exception, every intervention delivers its aerobic stimulus through repeated bouts of near-maximal or supramaximal effort, with incomplete recovery in between. Running-based high-intensity interval training is a standalone modality in five studies (Bici & Kasa, 2025; Gnanasigamani et al., 2025; Koç et al., 2025; Ndlomo et al., 2023; Pierros & Spyrou, 2023) and a comparator in three more (Deep et al., 2025; Salazar-Martínez et al., 2023; Samavati Sharif et al., 2024). Small-sided games show up in nine studies, four of them using this format as the sole intervention (Ahmad et al., 2024; Arifan et al., 2024; Kumar et al., 2025; Zaharia et al., 2023) and five using it in comparative or combined configurations (Arslanoglu et al., 2024; Bahtra et al., 2024; Deep et al., 2025; Norrahmah et al., 2025; Salazar-Martínez et al., 2023). Sprint and speed-endurance work accounts for three studies (Diker et al., 2023; Kaewkamad et al., 2025; Selmi et al., 2023). A further four studies delivered aerobic work inside integrated multicomponent programmes, where endurance, strength, speed, and coordinative elements were periodised together rather than isolated: periodised interval work with explosive strength, speed, and game-like situations (Kabdwal et al., 2023); aerobic exercise paired with acrobatic movement across a full season (Mara & Çobaj, 2025); a structured combination of aerobic, anaerobic, and strength elements during competition preparation (Saharullah et al., 2024); and a targeted university training programme (Saha et al., 2025). Only one study examined a genuinely continuous aerobic stimulus, and even that was done as a comparator against intervals rather than as the main intervention (Samavati Sharif et al., 2024). So intermittent prescription dominates almost totally, which mirrors the concentration of modality keywords in the wider screened corpus (Figure 4).

These interventions are more consistent in configuration than their labels suggest. Three parameters recur across the categories. First, an explicit intensity anchor is tied to an individual physiological or performance reference: percentages of velocity at VO_2max (Bici & Kasa, 2025; Ndlomo et al., 2023), of final velocity in an intermittent field test (Selmi et al., 2023), of maximum heart rate (Samavati Sharif et al., 2024), of maximal aerobic speed (Arslanoglu et al., 2024), or of a velocity-based ceiling (Koç et al., 2025). Second, session frequency sits at two or three exposures per week in twelve of the fifteen studies that report it. Only one goes further, delivering small-sided games five days weekly within 90-minute sessions (Kumar et al., 2025). Third, the conditioning is built as an addition to habitual soccer training, or as a partial substitution inside it, rather than as an isolated block. This last feature matters analytically. The contrast in most studies is not "training versus no training" but "conditioning increment versus habitual soccer stimulus", and habitual soccer training is itself aerobically demanding, as research on internal load during regular sessions and games has shown (Michailidis, 2024a; Younesi et al., 2021).

Programme duration clusters tightly and narrowly. Five studies ran four weeks, four ran six weeks, five ran eight weeks, and three ran twelve weeks. One extended across a competitive season, and the remaining studies never state duration in the source record. The four-week cluster is worth noting because those studies all operated under specific temporal constraints: a compressed preseason window (Ndlomo et al., 2023), a lockdown period (Pierros & Spyrou, 2023), an in-season addition (Koç et al., 2025; Norrahmah et al., 2025). That points to feasibility, not physiology, as the reason these shortest programmes were chosen. Apart from the one season-long study, no intervention runs longer than twelve weeks. The literature therefore says nothing about how durable aerobic gains are, or when adaptation plateaus. That is a genuine gap, especially since aerobic capacity regresses substantially within comparable timeframes once organised training ceases (Alvurdu et al., 2022; Liu et al., 2024; Silva et al., 2022).

The final configuration theme concerns the deliberate manipulation of secondary variables inside a modality. Instead of testing modality A against modality B, several included studies keep the modality constant and vary one parameter: recovery interval duration within sprint interval training (Diker et al., 2023), floaters added to create numerical superiority within small-sided games (Kumar et al., 2025), change-of-direction demands added

to interval running (Bici & Kasa, 2025), speed-endurance work added to small-sided games (Norrahmah et al., 2025), and a hypoxic mask added to an otherwise identical programme (Radhouane et al., 2023). This parameter-level focus is methodologically more mature than comparing whole modalities, and it mirrors a similar refinement in the wider literature, where rest distribution, pitch dimension, playing format, and individualised velocity anchoring have each been isolated as manipulable variables (Faga et al., 2023; Li & Xue, 2024; Wang et al., 2024; Zhu et al., 2025). The answer to RQ1 is therefore not just a list of modalities. It is a description of a field that has largely converged on intermittent, intensity-anchored, twice-to-thrice-weekly conditioning appended to normal soccer training, and that is now examining what happens when individual parameters within that template are altered.

Findings for RQ2 - Effects on VO_2max and Evidence of Modality Superiority

The most immediate finding is also the least discriminating one. Every one of the 23 included studies reported a statistically significant improvement in VO_2max or a directly derived aerobic capacity index in at least one intervention arm. Not one returned a null within-group result. That sort of uniformity almost certainly does not mirror physiological reality, and we treat it as a probable publication and design artefact in Section 5.6. Still, taken at face value, it indicates that aerobic-oriented conditioning, in virtually any intermittent configuration, applied twice or three times weekly for four to twelve weeks, reliably raises measured or estimated VO_2max in soccer populations.

Reported magnitudes vary by more than an order of magnitude, and the variation tracks measurement method more closely than it tracks modality. The biggest relative changes come from field-test-derived estimates. A 68.8% increase in Yo-Yo IR1 distance, for example, appeared alongside a 10.2% VO_2max rise in female youth players (Kaewkamad et al., 2025). Cycle-ergometer estimation following supramaximal interval work produced an 18.89% VO_2max increase (Bici & Kasa, 2025), and eight HIIT sessions raised directly measured VO_2max by 15%, from 43.9 to 50.5 $mL \cdot kg^{-1} \cdot min^{-1}$ (Ndlomo et al., 2023). At the other end, studies reporting VO_2max in absolute units from established field protocols describe changes of 1.33 and 0.52 $mL \cdot kg^{-1} \cdot min^{-1}$ between two modalities (Bahtra et al., 2024) and 2.62 $mL \cdot kg^{-1} \cdot min^{-1}$ over twelve weeks (Saha et al., 2025). Both patterns can be internally valid. The disparity arises because the relationship between Yo-Yo distance and VO_2max is non-linear, so a large percentage change in test distance corresponds to a much smaller change in estimated oxygen-uptake value. Dedicated measurement work comparing estimated with directly measured VO_2max has documented exactly that discrepancy (Buglione et al., 2025; Cheng et al., 2025; Thron et al., 2022). Any reader comparing effect magnitudes across this literature without attending to the instrument will systematically misjudge which interventions are potent.

Evidence of genuine modality superiority is far weaker than the volume of positive findings implies. When two active modalities were compared under matched conditions, the modal result was parity. Small-sided games and high-intensity interval training, for instance, produced no significant between-group VO_2max difference across nine weeks despite a nominal 6% versus 12% split (Salazar-Martínez et al., 2023). Likewise, small-sided games combined with HIIT produced no significant VO_2max advantage over traditional HIIT across eight weeks, even while showing clear superiority on agility, sprint speed, explosive power, and perceived exertion (Deep et al., 2025). Four contrasts did establish superiority, and every one of them involved either an inactive or a substantially weaker comparator: small-sided games with goalkeepers over traditional aerobic endurance training (Zaharia et al., 2023), HIIT over sprint interval training under lockdown constraints (Pierros & Spyrou, 2023), continuous high-intensity aerobic work over interval work (Samavati Sharif et al., 2024), and fartlek over small-sided games (Bahtra et al., 2024). The last two are notable because they run against the field's prevailing assumption that intermittent, game-based work is aerobically superior. Both, however, rest on modest samples, and they stand against a broader literature in which such contrasts more often resolve to parity (Daryanoosh et al., 2023; Nayıroğlu et al., 2022).

Additive configurations produce the most consistent superiority signal. Where a second stimulus was layered onto a base modality, the combined condition outperformed the base in three of four cases: small-sided games plus speed endurance over small-sided games alone (Norrahmah et al., 2025), maximal aerobic speed work with or without small-sided games over routine training (Arslanoglu et al., 2024), and a hypoxic mask over identical unmasked training (Radhouane et al., 2023). The exception is the combination of small-sided games with HIIT, which improved aerobic outcomes numerically but not significantly relative to HIIT alone (Deep et al., 2025). That pattern fits a dose interpretation. Adding a second high-intensity stimulus increases total time near VO_2max, and it is that accumulated exposure, rather than the modality label, that drives adaptation. This interpretation aligns with dose, response work showing graded relationships between accumulated high-intensity load and endurance improvement, together with evidence of thresholds beyond which additional load ceases to help (Kalapotharakos et al., 2021; Younesi et al., 2021).

Table 6. Summary of Reported Aerobic Capacity Effects by Modality Category

Modality category	k	Typical dose reported	Within-group VO_2max effect	Between-group superiority established
HIIT / interval running	5	4–8 wk, 2 sessions/wk, 100–120% vVO_2max	Significant increase in 5 of 5	Superior to sprint interval training in 1 of 2 active comparisons; no advantage over small-sided games
Small-sided games (single modality)	4	6–12 wk, 2–5 sessions/wk, 2v2 to 4v4+GK	Significant increase in 4 of 4	Superior to traditional aerobic endurance training in 1 of 1 active comparison
Small-sided games (comparative or combined)	5	4–12 wk, 2–3 sessions/wk	Significant increase in 5 of 5	Parity with HIIT in 2 of 2 matched contrasts; combined conditions superior to single-modality base in 2 of 3
Sprint and speed-endurance training	3	6 wk, 2 sessions/wk, 30 s maximal efforts or 15–20 m sprints	Significant increase in 3 of 3	Superior to habitual training control in 2 of 2; recovery-interval length modified magnitude
Multicomponent integrated conditioning	4	8 wk to full season, 3 sessions/wk	Significant increase in 4 of 4	Superior to standard training in the single controlled study; remaining three uncontrolled
Continuous versus interval contrast	1	6 wk, 3 sessions/wk, 90–95% HRmax	Significant increase in both arms	Continuous superior to interval in this trial
Environmental or equipment adjunct	1	8 wk, hypoxic mask overlay	Significant increase	Superior to identical unmasked training

The answer to RQ2 is therefore two-part and asymmetric. The effect of aerobic-oriented conditioning on VO_2max is consistently positive and, in several trials, large. The effect of choosing one intermittent modality over another is small, frequently non-significant, and not established in either direction by the available evidence.

Findings for RQ3 - Training Characteristics Associated with the Largest Effects

Three characteristics distinguish the studies reporting the largest and most credible aerobic gains, and none of the The first is an individualised intensity anchor. Where studies reported the largest directly measured changes, work was prescribed against each player's own velocity at VO_2max or final test velocity. It was not pegged to a group-level pace or a rating of perceived exertion (Bici & Kasa, 2025; Ndlomo et al., 2023; Selmi et al., 2023). Take Ndlomo et al. (2023). In just eight sessions they raised laboratory-measured VO_2max by 15%, progressively increasing the prescribed percentage of vVO_2max while also manipulating work-to-rest ratio, repetitions, and high-speed distance. It stands as an unusually explicit account of progressive overload inside an interval framework. The mechanism is straightforward. Individual anchoring means every player accumulates time in the intensity domain that drives central and peripheral oxidative adaptation. Group-level prescription, by contrast, systematically overloads the least fit and underloads the fittest. The wider literature backs this up: individualised locomotor profiling shifts HIIT adaptation relative to non-individualised prescription (Zhu et al., 2025).

The second characteristic concerns recovery structure, not work structure. Diker et al. (2023) kept the sprint interval work itself constant and changed only recovery duration. Their finding: 150-second recovery beat 30-second recovery on both Yo-Yo IRT1 and IRT2 adaptation, though VO_2max improved either way. Why would that be? Longer recovery allows higher-quality repeated efforts, which means more cumulative time at a high fractional oxygen uptake. Very short recovery, by contrast, degrades effort quality inside the session itself. Independent work on rest-interval distribution in short sprint interval training points the same direction, treating recovery configuration as decisive rather than incidental (Li & Xue, 2024). Coaches informally tweak recovery duration more than any other parameter, so it matters practically that this particular lever has evidence behind it.

Third comes stimulus layering. Section 5.4.2 documents the pattern: pairing a base modality with a second high-intensity stimulus beat the base alone in three of four tests (Arslanoglu et al., 2024; Norrahmah et al., 2025; Radhouane et al., 2023). The telling detail is that the successful combinations added quality , not volume. They layered in speed-endurance repetitions, maximal-aerobic-speed running, or an inspiratory-resistance overlay. Extra low-intensity minutes were not the driver. Programmes that boosted exposure mainly through frequency and duration tell a different story. The twelve-week, five-day small-sided-games programme (Kumar et al., 2025)

produced significant gains, but nothing disproportionate, which fits a plateau in the volume, adaptation relationship.

Two characteristics conspicuously did not predict effect magnitude. Programme duration had no monotonic relationship with reported change. Some of the largest values came from four-week interventions (Ndlomo et al., 2023; Pierros & Spyrou, 2023), while some of the smallest came from twelve-week ones (Saha et al., 2025). Baseline training status and instrument choice explain that pattern far better than any dose, time link does. Sample size behaved the same way. It showed no relationship with effect magnitude, and the classic small-study bias is plainly visible in the included set: the largest effects appear in the smallest samples. The two biggest relative changes came from samples of 14 and 30 participants, after all. So the answer to RQ3 is this. Intensity anchoring, recovery configuration, and quality-based stimulus layering are what track with the largest gains. Duration and modality are not.

Comparative and Critical Analysis of Methods

Across the 23 studies, methodological approaches fall into a clear hierarchy, though one that maps imperfectly onto the strength of their claims. Nine studies used randomised allocation; eight used non-randomised group allocation with a comparator; six used single-group pre, post designs. The six single-group studies supply four of the multicomponent-conditioning entries and two of the interval-running entries. In other words, the category practitioners are most likely to adopt wholesale, integrated multicomponent programmes, rests disproportionately on the weakest design in the set. Habitual soccer training by itself already produces measurable aerobic change across a preseason or competitive phase (Kalapotharakos et al., 2021; Papaevangelou et al., 2023). So a single-group pre, post design in this field simply cannot separate the intervention effect from the effect of the training year itself.

Comparator selection is the most consequential methodological variable and also the least consistently handled. Three comparator types appear: passive or habitual-training controls, active alternative modalities, and within-group baselines. Superiority claims are almost entirely confined to the first type. When the comparator was an active, dose-matched alternative, the result was parity in both instances (Deep et al., 2025; Salazar-Martínez et al., 2023). That is the single most important pattern in the methodological analysis, because it tells us that much of the apparent modality differentiation in this literature is an artefact. Interventions keep being judged against a weaker or absent stimulus rather than against a credible alternative.

Outcome instrumentation is heterogeneous to a degree that constrains synthesis. Across the included studies, VO_2max was obtained through direct respiratory gas analysis, treadmill protocols to volitional exhaustion, cycle ergometry, the Yo-Yo Intermittent Recovery Test Level 1 with a regression-based conversion, the Yo-Yo Intermittent Fitness Test, the 20 m shuttle, and the Cooper test. These instruments are not interchangeable, and their disagreement is well documented: field-test estimation systematically diverges from directly measured values, and different field protocols yield different maximal aerobic speed estimates in the same players (Buglione et al., 2025; Thron et al., 2022). Studies that reported both a field-test distance and a converted VO_2max value, such as Kaewkamad et al. (2025) and Saha et al. (2025), effectively report a single measurement expressed twice. That can create an impression of convergent evidence where none exists.

Statistical reporting has improved but remains uneven. Roughly half the included studies reported effect sizes, and several provided partial eta-squared or Cohen's d alongside significance tests (Bici & Kasa, 2025; Koç et al., 2025; Saha et al., 2025; Salazar-Martínez et al., 2023; Selmi et al., 2023). Confidence intervals were reported far less often. At least one study reported partial eta-squared values exceeding 1.0, which is outside the possible range for that statistic. That points to a computational or transcription error that peer review did not catch. Several studies reported extremely large t-statistics from modest samples without accompanying dispersion data. These are not incidental blemishes. They constrain how much weight any synthesis can place on reported magnitudes and reinforce the decision not to pool effects quantitatively.

Still, an evolution is visible across the three publication years. The 2023 studies mostly pit a modality against a control or against another modality. The 2024 and 2025 studies are more likely to isolate a single parameter within a modality, adopt multi-domain outcome batteries, and analyse covariance with baseline values as covariates instead of relying on simple change-score comparison (Deep et al., 2025; Kumar et al., 2025; Norrahmah et al., 2025). That is an encouraging move, and it mirrors the wider contemporary literature on interval and game-based prescription (Li & Xue, 2024; Yan & Li, 2025; Zhu et al., 2025). What has not improved across any of the three years is the missing assessor blinding and the fact that no protocol was registered.

Interpretation of findings

The central claim of this review is that aerobic adaptation in soccer players comes from accumulated exposure to a high fractional oxygen uptake, not from the format that delivers it. Every included modality produced significant gains: running intervals, small-sided games, sprint and speed-endurance repetitions, integrated

circuits, and even a continuous protocol held at 90, 95% of maximum heart rate. When two formats were compared under matched conditions, they did not reliably differ. What separated larger effects from smaller ones were the variables that decide whether players actually reach and stay in the target intensity domain. Individual velocity anchoring mattered. So did recovery duration that was long enough to preserve effort quality, and the layering of an additional high-quality stimulus. Format, on this reading, is a delivery mechanism. Its principal value is contextual rather than physiological.

Theoretical implications

This finding extends the existing frameworks rather than overturning them. The idea that time spent near VO_2max is the proximate determinant of aerobic adaptation is hardly new, but the present synthesis offers an unusually clean test of it. The outcome criterion admits every modality that reports VO_2max, which removes the modality-bounded framing that has characterised most previous reviews. It also complicates the specificity principle as team sports usually apply it. Specificity predicts that game-based conditioning should outperform generic running because it replicates the movement, decision, and load patterns of competition. For the aerobic outcome specifically, the evidence assembled here does not support that prediction. It supports it clearly for neuromuscular and technical outcomes, though. The combined small-sided games plus HIIT condition improved agility, sprint speed, and explosive power without any aerobic advantage (Deep et al., 2025). The theoretical resolution is that specificity operates on the qualities that depend on movement pattern, whereas central oxidative adaptation responds to intensity and duration largely irrespective of pattern. A second theoretical implication concerns the ceiling effect. VO_2max trainability appears to be strongly conditioned by baseline status and maturation, an interaction this literature acknowledges but rarely models. Independent work on maturation-stratified adaptation to combined game and interval training has begun to address it (Zhou et al., 2025).

Practical implications

Four implications follow for practitioners. First, modality choice can legitimately be made on grounds other than aerobic efficacy. Technical development, player engagement, injury-risk profile, and pitch and staffing constraints all become valid reasons, because the aerobic return is broadly comparable. Small-sided games are defensible not because they are aerobically superior but because they deliver technical, tactical, and psychological benefits at no aerobic cost (Ahmad et al., 2024; Zaharia et al., 2023). Second, whatever modality is chosen should be anchored to an individually determined intensity reference. The practical cost is one field test per player per phase, and the evidence suggests this single decision differentiates effective from ineffective prescription more than any modality choice does. Third, two to three sessions per week for four to eight weeks is sufficient to produce meaningful change. That places aerobic development within reach even in congested calendars, and the four-week studies conducted under acute constraint are the strongest evidence here (Koç et al., 2025; Ndlomo et al., 2023; Pierros & Spyrou, 2023). Fourth, recovery duration within interval work should be treated as a deliberate prescription variable rather than a default. Longer recoveries are favoured when the goal is maintaining effort quality across repetitions (Diker et al., 2023; Li & Xue, 2024).

Comparison with prior reviews

Positioning this review against prior quantitative syntheses reveals both convergence and a distinctive contribution. Three meta-analyses in soccer aerobic conditioning are directly comparable. Clemente et al. (2021), pooling effect sizes across 27 small-sided-game intervention studies, reported a large weighted mean effect on aerobic capacity indices (SMD = 1.12, 95% CI: 0.84–1.41), though their outcome criterion admitted Yo-Yo distance and velocity-based indices alongside VO_2max, which inflates apparent effect sizes relative to oxygen-uptake-specific outcomes. Jiménez-Rubio et al. (2020), examining HIIT in soccer with 18 eligible studies, reported a moderate mean VO_2max improvement of approximately 4.2 $mL \cdot kg^{-1} \cdot min^{-1}$, with substantial heterogeneity ($I^2 > 70\%$) that they attributed to variation in training intensity and duration. Dello Iacono et al. (2019), comparing small-sided games and HIIT in a direct meta-analytic contrast across 22 studies, found no significant between-modality difference in VO_2max ($p = 0.41$), a finding that directly corroborates the narrative equivalence result we report here. By contrast, the present review's 23-study corpus was assembled under a stricter outcome criterion VO_2max at two time points, directly measured or estimated via conversion that excluded nine otherwise eligible trials. The effect of this criterion is to reduce apparent effect magnitude while increasing comparability across modalities. The within-group VO_2max changes we report (approximately 1 to 9 $mL \cdot kg^{-1} \cdot min^{-1}$, or 6% to 19% relative improvement across modalities) are smaller in absolute terms than the pooled estimates in modality-bounded meta-analyses, which is the expected consequence of a more restrictive outcome definition. This pattern documents a critical outcome-reporting heterogeneity problem in the field: studies that report only raw Yo-Yo distance or velocity-based indices cannot be directly compared to those reporting VO_2max, yet they are often pooled together in reviews that treat aerobic fitness as a single construct. The VO_2max-only criterion also carries an external validity implication that must be stated explicitly for field-based practitioners. The nine excluded trials, several of them methodologically strong small-sided-games and

sprint-interval studies, used outcome reporting conventions that are more practical in the field shuttle-test accumulated distance, maximal aerobic speed rather than the oxygen-uptake estimate that requires a regression conversion. Practitioners who rely on such proxies may find our review's recommendations applicable in principle but not immediately translatable to their assessment toolkit. We address this directly in Section 5.5 (Limitations) and in the Future Research Agenda (Section 5.8), where adoption of a minimum reporting standard that includes both the raw test result and the VO_2max conversion equation is recommended as a priority.

Contradictions in the literature

Three genuine contradictions emerged. The first concerns continuous versus intermittent work. Samavati Sharif et al. (2024) reported that continuous high-intensity aerobic training was superior to interval training for VO_2max, and Bahtra et al. (2024) found fartlek superior to small-sided games. Both findings run against the field's dominant assumption. Modest samples in the two trials could explain part of it, and it is also possible that the interval protocols did not accumulate enough time at high intensity. Baseline training status is an untested contributor too. The second contradiction concerns sprint interval training. One included trial improved VO_2max substantially (Diker et al., 2023), while another produced no change at all (Pierros & Spyrou, 2023). Context offers the best explanation, since the null result emerged during lockdown with sessions capped at 60 minutes and combined with bodyweight circuits, conditions that plausibly compromised the intended stimulus. The third concerns small-sided games. They outperformed traditional endurance training in one trial (Zaharia et al., 2023), were outperformed by fartlek in another (Bahtra et al., 2024), and matched HIIT in two more (Deep et al., 2025; Salazar-Martínez et al., 2023). The most parsimonious reading is that small-sided games can deliver an adequate aerobic stimulus but with greater variability, because intensity depends on player behaviour, format, pitch dimension, and rule constraints rather than on an imposed pace. That variability has been documented repeatedly in dedicated load-characterisation work (Faga et al., 2023; Michailidis, 2024a; Wang et al., 2024).

Research gaps

At least five gaps are identifiable, and three of them are substantive. Temporal coverage comes first. No included study ran beyond twelve weeks except a single season-long trial, so the literature is silent on adaptation plateaus, maintenance dosing, and the durability of gains. That silence is made more consequential by clear evidence of rapid reversibility once training is interrupted (Alvurdu et al., 2022; Parpa & Michaelides, 2021; Silva et al., 2022). Population coverage is the second gap. Only one included study examined female players (Kaewkamad et al., 2025), despite an expanding body of descriptive and interventional work in women's soccer that establishes both the relevance and the feasibility of such trials (Papaevangelou et al., 2023; Xing et al., 2023; Yang et al., 2025). Third, comparator adequacy: only two included studies compared dose-matched active modalities, so the field's central applied question remains effectively untested. Fourth is individual response. Apart from one multidomain analysis as a partial exception (Gnanasigamani et al., 2025), studies report group means without characterising responders and non-responders, even though heterogeneity of response is precisely what individualised prescription is meant to address. Fifth, integration with concurrent strength work. None of the included studies manipulated the sequencing of aerobic and resistance training within the week, despite evidence that sequencing modifies adaptation (Blechschmied et al., 2024; Thomakos et al., 2023).

Limitations of this review

Six limitations warrant explicit statement. First, single-database retrieval: relying on Scopus alone secures reproducibility at the cost of recall, and relevant trials indexed only in PubMed, Web of Science, SPORTDiscus, or regional databases will have been missed. Second, the English-language limiter excludes work published in other languages, a material constraint in a field with strong non-anglophone research traditions. Third, extraction was based on bibliographic and abstract content rather than full texts. Intervention details, dispersion statistics, and dropout information not reported in abstracts were recorded as not stated. This convention protects against fabrication but reduces extraction depth, which is why several cells in Tables 4 and 5 are incomplete. Fourth, no formal inter-rater agreement coefficient was computed for screening or appraisal, so the reliability of those judgements is asserted rather than quantified. Fifth, the review protocol was not prospectively registered, leaving the specification of criteria unverifiable by third parties. Sixth, the strict VO_2max outcome criterion, while analytically necessary, excluded methodologically strong trials whose outcome reporting conventions differ. The review's conclusions therefore apply to the VO_2max-reporting subset of this literature rather than to all aerobic-training research in soccer.

Future research agenda

Five concrete recommendations follow. First, conduct dose-matched active-comparator trials in which two modalities are equated for total time above a defined intensity threshold rather than for session duration or frequency. Only this design can establish whether format matters once exposure is controlled. Second, extend intervention periods to at least sixteen weeks and include a subsequent detraining or maintenance phase,

reporting both the adaptation trajectory and the decay curve. Practitioners could then plan maintenance dosing rather than development blocks only. Third, adopt a minimum reporting standard that comprises the intensity anchor and how it was determined, work and recovery durations, session frequency, total sessions completed, dropout, the exact VO_2max instrument and any conversion equation used, and effect sizes with confidence intervals. The measurement heterogeneity documented in Section 5.5 is otherwise unresolvable. Fourth, replicate the parameter-isolation designs that have proved most informative, namely recovery duration, individualised versus group anchoring, and numerical superiority manipulation, in female, youth, and amateur populations, where the evidence base is thinnest. Fifth, report individual response distributions alongside group means, identifying responder proportions and baseline predictors of response, so that the individualisation logic underpinning modern prescription can be empirically evaluated rather than assumed.

RQ1 asked what the aerobic-oriented modalities look like. Between 2023 and 2025, the studies in soccer players leaned almost entirely on intermittent formats. Running-based high-intensity interval training showed up often. So did small-sided games, whether used alone, compared against something else, or combined with other work. Sprint and speed-endurance training appeared, as did integrated multicomponent circuits. One protocol was continuous, and one involved an environmental adjunct. The typical setup across all of these was fairly uniform. Two or three sessions per week, lasting anywhere from four to twelve weeks, anchored to an individual intensity reference and layered on top of the players' usual soccer training. RQ2 concerned outcomes. Every single included study reported a significant improvement in VO_2max or some derived index. The reported gains spanned roughly 1 to 9 $mL \cdot kg^{-1} \cdot min^{-1}$, or 6% to 19%, though the numbers depended heavily on which measurement instrument was used. As for modality superiority, genuine advantages emerged only against inactive or weaker comparators. When active interventions were matched for dose and compared directly, the results consistently came out equal. RQ3 asked which characteristics actually mattered. The largest and most credible gains clustered around three features. An individualised intensity anchor came first, usually expressed relative to velocity at VO_2max or the final test velocity. After that, a recovery structure long enough to preserve effort quality across repetitions. The third piece was an additional high-quality stimulus layered onto a base modality. Programme duration had no association with effect magnitude. Neither did session volume or the modality label.

Conclusions

The consistency across the 23 included intervention studies is striking: every study reported a statistically significant improvement in maximal oxygen uptake following aerobic-oriented conditioning. The gains were produced through high-intensity interval running, small-sided games, sprint and speed-endurance work, integrated multicomponent conditioning, or a continuous high-intensity protocol, and were typically achieved through delivery of two to three sessions per week for four to twelve weeks. The central claim of this review that intermittent modalities produce equivalent aerobic adaptations when compared under dose-matched conditions rests on a qualitative inference from narrative synthesis rather than meta-analytic quantification. This distinction is important and must be stated explicitly. Only two of the 23 included studies compared dose-matched active modalities (Salazar-Martínez et al., 2023; Deep et al., 2025), and neither returned a statistically significant between-group VO_2max difference. Across the broader set, superiority claims were confined to comparisons against inactive or substantially weaker controls. The pattern is consistent with equivalence, but it cannot be established as equivalence in the formal statistical sense without pooled effect estimates and heterogeneity statistics from a meta-analysis with standardised outcome instrumentation. Confirmatory meta-analysis using directly measured or instrumentation-standardised VO_2max, with dose-matched active comparators, remains an essential next step. The association between larger aerobic gains and three training characteristics individualised intensity anchoring, recovery structures that preserve effort quality, and quality-focused stimulus layering emerges from this synthesis as the most actionable finding for practitioners. Format choice, by contrast, does not appear to be a consequential decision for aerobic outcomes and can therefore be made on non-aerobic grounds. This review carries methodological limitations that bound its conclusions. Retrieval was restricted to a single database (Scopus) with an English-language filter applied. Data extraction operated at the bibliographic and abstract level, meaning that intervention details not reported in abstracts were recorded as not stated. Dual screening was conducted with consensus arbitration, but a formal inter-rater reliability coefficient was not computed, which is acknowledged as a reproducibility constraint. The protocol was not prospectively registered. The strict VO_2max outcome criterion, while analytically necessary, excluded nine methodologically strong trials, limiting the review's coverage of the small-sided-games and sprint-interval literature. Future research should prioritise dose-matched controlled trials, registered protocols, and a minimum outcome-reporting standard that enables cross-study instrumentation comparability.

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