Proposed Title:

Quantifying exposure and intra-individual reliability of high-speed and sprint running during sided-games training in soccer players: a systematic review and meta-analysis

Running head:

High-speed and sprint running exposure in soccer sided-games

Abstract-Only Word Count: 450

Text-Only Word Count: ~ 9000

Author information

Antonio Dello Iacono[1], Shaun J. McLaren[2,3], Tom W. Macpherson[1], Marco Beato[4], Matthew Weston[5], Viswanath B. Unnithan[1] and Tzlil Shushan[6]

[1] Institute for Clinical Exercise and Health Science, School of Health and Life Sciences, University of the West of Scotland, Hamilton, United Kingdom

[2] Newcastle FalconsRugby Club, Newcastle upon Tyne, United Kingdom

[3] Department of Sport and Exercise Sciences, Durham University, Durham, United Kingdom

[4] School of Health and Sports Sciences, University of Suffolk, Ipswich, United Kingdom

[5] Institute for Sport, Physical Education and Health Science, Moray House School of Education and Sport, University of Edinburgh, Edinburgh, United Kingdom

[6] School of Health Sciences, Western Sydney University, Sydney, NSW, Australia

Corresponding author

Antonio Dello Iacono

Institute for Clinical Exercise and Health Science, School of Health and Life Sciences, University of the West of Scotland, Hamilton, United Kingdom

Email: Antonio.delloiacono@uws.ac.uk

ORCID

Antonio Dello Iacono 0000-0003-0204-0957

Shaun J. McLaren 0000-0003-0480-3209

Tom W. Macpherson 0000-0002-6943-7302

Marco Beato 0000-0001-5373-2211

Matthew Weston 0000-0002-9531-3004
Viswanath B. Unnithan 0000-0001-5147-1679
Tzlil Shushan 0000-0002-0544-1986

Twitter Tag

Antonio Dello Iacono @DelloAntonio
Shaun J. McLaren @Shaun_McLaren1
Tom W. Macpherson @tmacp87
Marco Beato @MarcoBeato1
Matthew Weston @drmweston
Viswanath B. Unnithan @prof_vish
Tzlil Shushan @shushan_tzlil

Statements and Declarations

Author contributions ADI and MB conceptualized the study. ADI and TS performed the literature search. TS, ADI and SJM performed the meta-analyses. ADI and TS wrote the first draft of the manuscript. All authors were substantially involved in the interpretation of the meta-analyses, and read, revised, and approved the final manuscript. ADI coordinated the submission and revision process

Funding No financial support was received for the conduct of this article or for the preparation of this manuscript.

Conflict of interest Antonio Dello Iacono, Shaun J. McLaren, Tom W. Macpherson, Marco Beato, Matthew Weston, Viswanath B. Unnithan and Tzlil Shushan declare that they have no conflicts of interest directly relevant to the content in this article.

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Availability of data and material All data are available in the Open Science Framework by accessing: https://osf.io/a4xr2/files/

Key Points:

- In view of the extensive use of sided-games training in soccer, we synthesized the evidence on high-speed and sprint running exposure induced by sided-games in adult soccer players, established pooled estimates and the associated intra-individual reliability for these external training load measures, and explored the moderating effects of sided-game format and playing constraints.
- Relative high-speed, very high-speed and sprint running exposure induced by sided-games, irrespective of format, are not comparable to the corresponding outcomes reported for regular 11-a-side soccer matches.
- High-speed external load measures are highly variable, irrespective of sided-game format.
- We provide robust evidence for coaches and practitioners when manipulating playing constraints such as the relative area per player, the game orientation, and the pitch length-to-width ratio, and calibrating the velocity thresholds of tracking devices to predict high-speed, very high-speed and sprint running exposure expected from sided-games training.
- To help users intuitively visualize the findings of the meta-analytical and meta-regression models as well as to predict expected high-speed, very high-speed and sprint running exposure scenarios upon planning soccer sided-games training, we developed a web application called “Sided-games Training App”.

ABSTRACT

Background Sided-games (i.e., small- [SSG], medium- [MSG], large-sided [LSG]) involve tactical, technical, physical and psychological elements and are commonly implemented in soccer training. Although soccer sided-games research is plentiful, a meta-analytical synthesis of external load exposure during sided-games is lacking.

Objective The objective of this systematic review and meta-analysis was to: 1) synthesise the evidence on high-speed and sprint running exposure induced by sided-games in adult soccer players, 2) establish pooled estimates and intra-individual reliability for high-speed and sprint running exposure, and 3) explore the moderating effects of game format and playing constraints.

Methods A literature search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines. Four databases (PubMed/MEDLINE, Scopus, SPORTDiscus, Web of Science core collection) were systematically searched up to 25 January 2022. Eligibility criteria were adult soccer players (population); training programmes incorporating sided-games (intervention); game manipulations including number of players, pitch dimension, game orientation (comparator); and high-, very high-speed and sprint relative ($m \cdot min^{-1}$) running distances and associated intra-individual reliability (outcome). Eligible study risk of bias was evaluated using RoBANS. Pooled estimates for high-speed and sprint running exposure, and their intra-individual reliability, along with the moderating effect of tracking device running velocity thresholds, pitch dimension (i.e., area per player), and game orientation (i.e., score or possession), were determined via multilevel mixed effects meta-analysis. Estimate uncertainty is presented as 95% compatibility intervals (CI) with the likely range of relative distances in similar future studies determined via 95% prediction intervals (PI).

Results A total of 104 and 7 studies met our eligibility criteria for the main and reliability analyses, respectively. The range of relative distances covered across SSG, MSG and LSG was 14.8 $m \cdot min^{-1}$ (95% CI: 12.3 to 17.4) to 17.2 $m \cdot min^{-1}$ (95% CI: 13.5 to 20.8) for high-speed running, 2.7 $m \cdot min^{-1}$ (95% CI: 1.8 to 3.5) to 3.6 $m \cdot min^{-1}$ (95% CI: 2.3 to 4.8) for very high-speed running, and 0.2 $m \cdot min^{-1}$ (95% CI: 0.1 to 0.4) to 0.7 $m \cdot min^{-1}$ (95% CI: 0.5 to 0.9) for sprinting. Across different game formats, 95% PI's showed future exposure for high-speed, very high-speed running, and sprinting to be from 0 $m \cdot min^{-1}$ to 46.5 $m \cdot min^{-1}$, 0 $m \cdot min^{-1}$ to 14.2 $m \cdot min^{-1}$, and 0 $m \cdot min^{-1}$ to 2.6 $m \cdot min^{-1}$, respectively. High-speed, very high-speed running, and sprinting showed poor reliability with a pooled coefficient of variation of 22.8% with distances being moderated by device speed thresholds, pitch dimension and game orientation.

Conclusions This study is the first to provide a detailed synthesis of exposure and intra-individual reliability of high-speed and sprint running during soccer sided-games. Our estimates, along with the moderating influence of common programming variables such as velocity thresholds, area per player and game orientation should be considered for informed planning of SSG, MSG and LSG soccer training.

Registration Open Science Framework (OSF) available through https://osf.io/a4xr2/.

1 INTRODUCTION

Sided-games have been part of the soccer coaching lexicon since the 1960s with the early documented publications describing their use for coaching the principles of play through mimicking technical and tactical soccer playing scenarios [1,2]. In the last two decades, sided-games are a prevalent training method implemented by soccer coaches and practitioners [3], and they are widely adopted as game-based coaching pedagogical approaches in many worldwide talent developmental programmes [4–6]. This widespread use of sided-games in applied settings has attracted interest among sport scientists and researchers resulting in an exponential proliferation of research examining sided-games construct validity [7–13] through the associated physiological responses [7,8,14,15] as well as defining evidence-based methodological recommendations for appropriate prescription and implementation [3,9,14,16–18].

Sided-games are modified games of short durations (e.g., 2–5 sets × 2-10 min), played on reduced pitch areas (e.g., 15 × 10 m^2 up to 90 × 60 m^2), often using adapted rules (e.g., scoring methods, permitted actions, specific tactical instructions) and involving fewer players (e.g., 2 vs 2 up to 10 vs 10 with or without goalkeepers) than traditional soccer match play [15,16]. Conceptually, the foremost rationales for the use of sided-games are specificity and efficiency [19], as the multidimensional demands of competitive soccer match (i.e., technical skills [20–22], tactical instructions [17,23–25] and physical performance [18,21,23,26]) can be replicated selectively or concurrently via bespoke game format configurations. Accordingly, in the soccer scientific literature, sided-games are referred to as skill-, game- or conditioning-based training depending on whether coaching prioritises technical, tactical, or physical development, respectively [12,22,27]. Sided-games are an integrated training method deemed to concurrently target several training goals such as: 1) induce acute physiological responses (i.e., heart rate and maximal oxygen consumption) of comparable or greater intensity than matches [7,8,15,25,26,28], which accumulating over time may induce positive fitness adaptations [9,14]; 2) replicate tactical behaviors of competitive match play while requiring players to make decisions and execute technical actions under ecological contextual constraints (e.g., opponents and fatigue) [4,12,17,23,24]; 3) mimic the intermittent activity profile and physical demands (i.e., external load traits) of a soccer match whereby transfer effects on surrogate measures (e.g., accelerations, decelerations, sprints and changes of direction) of soccer-specific performance are expected [18,21,23,25,26,29,30]; and 4) increase player engagement and motivation due to ball integration [31–34]. Furthermore, sided-games are also promoted as a holistic talent identification tool to discriminate between more and less talented youth players. In particular, players rated as more talented by their coaches are also more successful during sided-games regardless of their team combinations and capable of covering greater distance and play at higher speed compared with less talented peers. Thus, standard sided-games formats have the potential to be used to identify individuals with the capability to perform more successfully at the 11-a-side level [35–37].

While sided-games constitute a specific training solution in soccer, their eligibility as a *"One Size Fits All"* method has been recently questioned by assumptions pointing to some practical limitations worthy of consideration [38,39]. For example, the physical responses to sided-games are influenced by many training variables such as the format and volume (e.g., number of games, duration and rest intervals) or the technical and tactical dimensions of sided-games as well as the individual player characteristics (i.e., including sex, training background and baseline fitness level or even other mental and psychological aspects) [40]. From a validity construct, the concept of specificity is the leading rationale justifying the use of sided-games training to replicate match demands and induce overloading stimulus in a match-like fashion. However, while the overall relative external load intensity (relative distance [$m \cdot min^{-1}$]) is comparable between sided-games and matches, studies investigating high-speed and sprint running distances between sided-games and official matches do not support this validity assumption as the high-speed external load measures are largely disparate [41–44]. In this regard, high-speed and sprint running distances in official matches have considerably increased over the last 15 years (↑ ~29% and ↑ ~50%, respectively), and now represent ~7-11% and ~1-3% of the total distance covered during a match, respectively [45,46]. Furthermore, high-speed and sprint activities are also considered as key determinants for successful outcomes during scoring situations [47–49]. Finally, the intra-individual variability of high-speed and sprint exposure to sided-games is yet to be adequately elucidated.

In a recent systematic review [50], Clemente and colleagues collected longitudinal studies reporting reliability data and those purposefully designed to investigate the reliability of load outcomes observed during sided-games. The authors highlighted poor inter-individual reliability especially for high-speed running and sprint distances [11,29,39,42,51–56]. This evidence is an important step in the right direction as it summarizes the inter-individual variability of training load measures during sided-games. However, the authors neither established pooled estimates of the inter-individual reliability scores nor, and more importantly, provided any insights on the intra-individual reliability of high-speed and sprint running distances. Given that a variety of sided-games formats are regularly used in training, comprehensive knowledge of their effect on high-speed and sprint running exposure, as well as the intra-individual reliability of these measures, would appear paramount for a thorough and informed prescription of individual internal and external training loads and for the subsequent evaluation and planning of the training effects.

The evidence on sided-games in soccer is noticeably extensive as recently confirmed in an umbrella review encapsulating the systematic reviews and meta-analyses performed on this topic [3]. Here, authors reported the findings of eight systematic reviews and two meta-analyses [15,16,30,57–61] summarizing the acute and long-term effects of sided-games on a variety of physiological, physical, and psychological characteristics as well as technical-tactical dimensions. The available literature on sided-games in soccer and the recent contribution of Clemente et al. [3] are certainly relevant to guide the planning, design, and implementation of sided-games among soccer coaches and practitioners. However, a critical revision of the same literature uncovers three key aspects that warrant further consideration: 1) external load measures of high-speed and sprint running exposure for different sided-games formats were reported only in one systematic review [30] from the eight synthesized by Clemente et al., [3]; 2) a meta-analytical synthesis of the pooled estimates pertaining to these external load metrics has yet to be performed, and 3) the intra-individual variability in response to sided-games is underdetermined. Knowledge on these aspects holds potential practical impact, with the anticipated evidence readily informing implementation of sided-games training in applied settings as well as likely guiding future directions in soccer research. A rigorous synthesis of the current sided-games literature is therefore warranted.

Accordingly, the aims of this systematic review and meta-analysis were to synthesize the existing evidence on high-speed and sprint running exposure induced by sided-games in adult soccer players, and to establish pooled estimates for these external training load measures as well as the associated intra-individual reliability, while exploring the moderating effects of sided-games formats and playing constrains. Importantly, our review is confined to high-speed and sprint running exposure, not the effectiveness of sided-games training as a fitness intervention.

2 METHODS

2.1 Searching Strategy

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [62,63] (Items checklist available in Online Resource 1, "ESM_1"), alongside the consensus statement for reviews in Exercise, Rehabilitation, Sport medicine and SporTs science (PERSiST) [64], and was registered [65] in the Open Science Framework (OSF; https://osf.io/gh792) on 4 March 2021. Two reviewers (ADI, TS) and a senior librarian with ~15 years of experience in conducting systematic searches for meta-analyses in sport performance fields independently performed standard and optimized electronic searches using the PubMed/MEDLINE, Scopus, SPORTDiscus and Web of Science Core Collection databases, from inception to until 28 April 2021 (further details in Online Resource 2, "ESM_2": https://osf.io/28vap).

The research questions were defined by the PICOS approach:

- *Population:* Males and females football/soccer players with an age of 17 years or older.
- *Intervention:* Sided-games performed as part of regular soccer training, irrespective of training intervention duration.
- *Comparator:* Sided-games format characteristics of number of players, pitch dimension, inclusion or not of goalkeepers, etc.
- *Outcomes:* External load metrics of high-speed, very high-speed and sprint running distances exposure and associated intra-individual reliability scores.
- *Study design:* Any quantitative research design that met the above criteria.

The search criteria and strategy were based on authorship expertise and familiarity with soccer sided-games terminology. Relevant keywords for each search term were determined through pilot searching (screening of titles, abstracts, keywords, and full texts of previously known studies). An overview of the search strategy is presented in Table 1. Additionally, we screened the reference lists of included studies, contacted experts in the field (e.g., authors of included studies) and regularly searched for information on additional trials, including unpublished or ongoing studies through the Research Gate network (www.researchgate.net) and Twitter websites (www.twitter.com). All searches were finally updated on 25 January 2022. On the same date, we also screened for any correction notice, expression of concern, retraction, and removal pertaining the final pool of studies included in the meta-analysis with the purpose to ensure the integrity of the scholarly record and the accuracy of the data.

2.2 Screening Strategy and Study Selection

Two reviewers (ADI, TS) assessed relevant records, which were downloaded into Endnote (version 20; Clarivate Analytics, Philadelphia, PA, USA) and then to a Microsoft® Excel spreadsheet (Microsoft, Redmond, WA, USA). Duplicate records were identified and removed, and an assessment of the remaining studies was undertaken sequentially (i.e., criteria 1–7) according to the inclusion–exclusion criteria described in Table 2. Regarding inclusion criteria 4 (i.e., age of the participants), we decided to include players with an age of 17 years and older although from a chronological age perspective they may not be considered adult. However, at this age they are clearly post-peak height velocity and consequently, biological maturity status is not a confounding factor for any of the outcome measures [66,67]. According to all other criteria, more studies were discarded, and full text studies finally retrieved and assessed independently by both reviewers for inclusion scrutiny.

2.3 Data Extraction and Coding

Two reviewers (ADI, TS) independently extracted data using a dedicated form (See Online Resource 3, "ESM_3": https://osf.io/4jbhg). Independent screening results were then combined, and any disagreements were resolved by consensus discussion (n = 6). For studies meeting the final inclusion criteria, the following data were extracted: i) bibliographic information, ii) player characteristics: sample size, sex, age and competitive level; iii) sided-games characteristics: format, dimensions (length × width), length:width ratio (AU), area per player (m^2), configuration (sets × duration [min]), recovery between sets (min), game orientation, presence of coach encouragement and number of touches (n); iv) load monitoring technology details: model, sampling frequency (Hz), velocity category and respective thresholds; v) summary statistics included in the meta-analysis.

As a means of data reduction and to facilitate the meta-analytical and meta-regression analyses, the following decisions were made in line with the literature on soccer sided-games [3,68–70] as well as upon reaching consensus between the authors of this study. To illustrate, the sided-games formats were grouped based on the number of players in:

- Small-sided games (SSG): 2v2 to 4v4
- Medium-sided games (MSG): 5v5 to 7v7
- Large-sided games (LSG): 8v8 to 10v10.

This categorization was made considering only the number of outfield players (i.e., excluding the goalkeepers). Unbalanced game formats (i.e., different number of players per team) were coded as follow:

- If the additional players moved only outside of the playing area (e.g., bouncers and floaters), the sided-game was coded based on the number of outfield players regardless of the number of additional players (e.g., 4v4+1/2/3/4 bouncers/floaters → 4v4).
- If the additional players actively took part in the game and were allowed to move within the playing area (e.g., jollies and wildcards), then two further criteria were applied:
    a) When the numerical advantage provided by the additional players was ≤ 50%, the sided-game was coded based on the number of outfield players (e.g., 4v4+2 jollies and 6v6+3 jollies → 4v4 and 6v6, respectively).
    b) When the numerical advantage provided by the additional players exceeded 50%, the sided-game was discarded and not included into the meta-analysis (e.g., 4v4+3 jollies and 6v6+4 jollies → no format) since it was considered as a tactical drill rather than a sided game.

The relative areas per player were recalculated for studies where goalkeepers were not considered in the original calculation. Accordingly, areas per player were adjusted for the total number of players and reflected the effective relative playing areas. Considering the game orientation variable, formats were coded either as score-oriented or possession-oriented if they included or did not include goalkeepers or mini goals, respectively. Regarding the summary statistics, we calculated "overall exposure" measures as the aggregated distances across the external load outcomes from the same sample, with minimum velocity threshold corresponding to the lower bound of the high-speed running band and maximum velocity threshold set at infinite (*Note*: four studies had a fixed maximum velocity threshold rather than an infinite value) as to include any distance above the sprint distance threshold. To this end, we calculated the mean of the overall exposure measures as the arithmetic sum of the means of the different external load outcomes (i.e., $\bar{x}_1 + \bar{x}_2$ and $\bar{x}_1 + \bar{x}_2 + \bar{x}_3$ when aggregating 2 or 3 external load outcomes, respectively). The aggregated standard deviation (σ_{agg}) was calculated according to the *Variance Sum Law* for dependent variables [71]. We provide a comprehensive description of the procedural steps of this approach in the Online Resource 4, "ESM_4" (Available on https://osf.io/vsr4d). Intra-individual reliability was expressed as a relative measure of reliability (i.e. coefficient of variation [CV; %]) and calculated according to Hopkins [72].

Effect sizes were log-transformed and adjusted for sample size [73,74], and subsequently back-transformed (including the bias correction for sample size) for analyses interpretations of the pooled estimates.

2.4 Handling Missing and Duplicates Data

To handle missing data and attain missing information, we used direct contact details of the first or corresponding author(s) along with their social network accounts (e.g., Research Gate, Twitter). To clarify, one author (ADI) emailed the first or corresponding author(s) of the study requesting the raw data or mean and standard deviation values. If the authors did not respond to the first email, a reminder was sent after two weeks. In case the authors did not reply within one month from the remainder email, we calculated the outcomes based on the figures (i.e., data were digitized using WebPlotDigitizer; v4.3, Ankit Rohatgi; https://apps.automeris.io/wpd/) and tables. Where mean (n = 2) and standard deviation (n = 4) data were not provided by authors nor could be extracted based on figures, we handled missing values by calculation according to the methods and customized Microsoft® Excel spreadsheet (Microsoft, Redmond, WA, USA) calculators suggested by Hozo et al. [75] and Wan et al. [76], respectively. Prior to proceeding with the data analysis and following an inspection of the full dataset, four studies were found to report the same data for the same estimates in different publications of the same author(s). Therefore, the duplicates data were removed, and single records were used for the analysis.

2.5 Data Analysis

2.5.1 Overall Meta-Analysis

Data analyses were conducted using the *'metafor'* [77] and *'clubSandwich'* [78] packages for R studio environment (version 1.4.1106) [79]. All analysis codes are presented in the Online Resource 5, "ESM_5" (https://osf.io/28wku) and Online Resource 6, "ESM_6" (https://osf.io/fywv8). In most of the included studies, we were able to extract more than a single effect size. Multiple effect sizes were within studies and derived from a variety of sided-games characteristics, including game format (e.g., number of players, unbalanced teams), game configuration (number of sets, set duration, recovery between sets), pitch dimensions and orientation (e.g., area per players, length:width ratio), game objectives (score-oriented versus possession) and other rule modifications (number of touches, offside rule, etc.).

Given the hierarchical structure in our datasets (i.e., multiple effect estimates nested within clusters), as well the likelihood of statistical dependency, we employed a recently developed approach using multilevel mixed effects meta-analysis and robust variance estimation [80]. Such approach allows to explore the heterogeneity present across multiple levels – hence, within- and between-group variance [81] – and provides a robust method for the meta-analysis results while accounting for the dependency of effect estimates derived from common samples [82]. In such cases, it has been proposed to account for the correlation between effect estimates by replacing their sampling variance with the entire 'V matrix', indicating the variance–covariance matrix of the estimates [80,83]. As it was not possible to attain the correlation between effect estimates drawn from the same participants in most of the included studies, we reanalyzed previous data of our research group and external collaborators (n = 85) which yielded an assumed constant correlation of 0.5. In Online Resource 6, "ESM_6" (https://osf.io/fywv8), we report sensitivity analyses whereby a range of correlation values were used to evaluate the influence of the changes in the within-group covariance on the pooled estimates and its variance components. Collectively, these analyses showed identical pooled estimates and nearly similar variance components (See Online Resource 7, "ESM_7": https://osf.io/pdj37, and Online Resource 8, "ESM_8"; https://osf.io/z2qjg).

For effects emerging from the main results and meta-regression analyses, we opted to avoid a dichotomous approach for their interpretation based upon traditional null hypothesis significance testing, which has been extensively criticized [84,85]. Alternatively, we considered the practical implications of all results with emphasis on the pooled point estimates and as well as the lower and upper limits of the interval estimates [65]. Uncertainty in meta-analysis estimates were expressed using 95% compatibility (confidence) intervals (CI), representing ranges of values compatible with our models and assumptions. We also derived 95% prediction intervals (PI), which convey the likely range of the true measurement properties in similar future studies [65].

2.5.2 Heterogeneity and Moderating Effects

To describe the extent of heterogeneity, we calculated Q-statistics, as well as restricted maximum likelihood estimates of the within- (τ_2) and between-group (τ_3) variances (SD; tau [τ]) [86], and the I^2 of the within- (I^2_2) and between-group (I^2_3) variances [87]. The I^2 implies the percentages of variance which is due to study heterogeneity rather than sampling error [87]. To note, due to many studies reporting effect sizes equal to 0 (mean and SD = 0 meters), neither

Q nor I^2 statistics could be computed for these models, where we reported τ-statistic only. To examine possible sources of heterogeneity and moderating effects, we conducted meta-regression analyses with four variables from the format and monitoring characteristics, including three continuous moderators (velocity thresholds, area per player and length:width ratio), with game orientation (i.e., possession versus score) as a categorical moderator. For the continuous moderators, their effects were interpreted as the changes associated with pre-defined values from fixed anchor references as follow:

- *Velocity thresholds*: the effects associated with ± 1 km · h^{-1} change of the velocity thresholds set in the monitoring devices from the anchored fixed references of 14.4, 19.8 and 22.0 km · h^{-1} for high-speed, very high-speed and sprint, respectively (i.e., approximately middle value of the ranges found in the literature for each speed zone).
- *Area per player*: the effects associated with increase/decrease of 25 m^2 of the relative area per player from the anchored fixed reference of 100 m^2 per player.
- *Length:width ratio*: the effects associated with ± 0.2 AU change of the length:width ratio from the anchored fixed reference of 1 AU (i.e., equal length and width dimensions).
- *Game orientation*: this was examined by comparing score-oriented and possession-oriented formats with the possession-oriented category used as the reference.

2.6 Risk of Bias

For the systematic review of the external loads outcomes and associated reliability measures, eligible study risk of bias was evaluated using Risk of Bias Assessment Tool for Non-randomized Studies (RoBANS) [88]. This comprehensive framework assesses six different bias domains including: participant selection, confounding variables, exposure measurement, outcome assessments blinding, incomplete outcome data, and selective outcome reporting (Online Resource 9, "ESM_9"; https://osf.io/vczdg).). The RoBANS was assessed by two authors (ADI, TWM), and a third author (TS) acted as moderator if there were discrepancies in the interpretation of the risk of bias assessment.

2.7 Small-Study Effect Bias

All datasets included the minimum number (10 studies) required for formal testing of asymmetry [89]. Small-study effects were visually inspected using funnel plots [90]. To confirm our visual impression, Egger's regression test (by fitting the square root of the sampling variance as a moderator) was employed [91].

3 RESULTS

3.1 Search results

The search and screening process is presented in the PRISMA flow chart (Figure 1). The initial search identified 5822 relevant studies, with 2567 remaining after the removal of duplicates (n = 3255). An additional 2429 studies were excluded following title and abstract screening, and 138 full-text studies were then assessed for eligibility. Based on our inclusion criteria, a total of 82 studies were selected and 56 were excluded due to: not written in English (n = 2, [92,93]), not complying with the population criteria (n = 12, [18,23,94–102]), intervention criteria (n = 10, [103–112]), and outcomes criteria (exposure outcomes: n = 22; reliability outcomes: n = 10, [22,41,44,110,112–139]) (See Figure 1 "Records excluded with reasons"). We discarded one study (n = 4 estimates) [140] and other estimates where sided-games formats (n = 14) could not be coded, or when the velocity thresholds (n = 24) were not calculated according to our defined ranges.

Additional 24 studies were identified from the updated searching round and other sources, resulting in 105 studies meeting the inclusion criteria. One study [134] was included in the intra-individual reliability analysis only due to not reporting descriptive data of exposure. Accordingly, the final dataset for high-speed and sprint running exposure included 104 studies (113 samples and 1789 estimates), with 188, 247 and 213 estimates used to examine high-speed running in SSG, MSG and LSG, respectively; 226, 238 and 194 estimates were used to examine very high-speed running in SSG, MSG and LSG, respectively; and 103, 177 and 203 were used to examine sprint running in SSG, MSG and LSG, respectively. Seven independent studies (7 samples and 21 CV estimates) were included in the meta-analysis of the intra-individual reliability of the same external load measures. Full details of all included studies can be seen in the data extraction table (Online Resource 10, "ESM_10"; https://osf.io/5hzve).

3.2 Study Characteristics

Descriptive information for all 105 studies is displayed in Table 3. The pooled number of participants was 1962 with sample sizes ranging from 6 to 62 participants (median n = 16) per group within each study. The total sample included 66 female and 1876 male players (sex not reported for n = 20) with a mean age ranging from 19.1 to 24.3 years and from 17 to 28.7 years, respectively. Of these, 227 were between 17 and 18 years old players and 1735 adult players. The samples across all players were classified as Tier 2 (n = 600), Tier 3 (n = 1176) and Tier 4 (n = 130) [141], while competitive level was not reported for the remaining players (n = 56). Most of the included studies (n = 96) used global navigation positioning system (GNSS) or GNSS combined with micro-electromechanical system (MEMS) technology to collect external load outcomes. In four studies, the external load outcomes were collected using either optical (n = 1) or local position measurement technologies (n = 3). In the five remaining studies, technology was not reported. In more than half of the studies (n = 53), sampling frequency of the tracking technology was 10 Hz, with the remaining studies reporting sampling frequencies of 1 Hz (n = 1), 5 Hz (n = 21), 15 Hz (n = 10), 18 Hz (n = 4), 20 Hz (n = 3), 24 Hz (n = 1), 40 Hz (n = 1) and 42 Hz (n = 1). In 10 studies, sampling frequency was not reported. The most common thresholds used to define high-speed (n = 24), very high-speed (n = 27), and sprint (n = 11) running distances were 13 km · h^{-1} (range: 12.2-18 km · h^{-1}), 19.8 km · h^{-1} (range: 16-21.6 km · h^{-1}) and 25.2 km · h^{-1} (range: 18-25.2 km · h^{-1}), respectively. The number of satellites used to infer GNSS signal quality was reported in four studies [56,142–144], ranging from 3 to 20. Horizontal dilution of precision used to indicate the accuracy of the GNSS horizontal positional signal was reported in three study [142–144] and was 0.54 ± 0.20.

3.3 Main Models

Table 4 and Figures 2–5 present the number of clusters and estimates, the weighted point estimates with 95% CI and the predictive point estimates with 95% PI for each meta-analysis. Asymmetrical scatter was evident in seven (Panels A–G)) of the nine examined datasets (Figure 6). Notably, to help interpreting the results of our meta-analysis, we developed a companion web application – “Sided-games Training App”– which we suggest using to intuitively visualize the main findings of the meta-analytical and meta-regression models as well as to predict the expected high-speed, very high-speed and sprint running exposure scenarios when planning soccer sided-games training (Link to Web App: https://antonio-dello-iacono.shinyapps.io/Sided-games-Training-App/?_ga=2.181926951.1296146234.1647352519-774762236.1645808783).

3.3.1 Small-sided games

The main models including all estimates of high-speed, very high-speed and sprint running suggest that during SSG players are exposed, on average, to high-speed, very high-speed and sprint distances with a weighted point and interval estimate of 17.2 m · min^{-1} (95% CI: 13.5 to 20.8), 3.6 m · min^{-1} (95% CI: 2.3 to 4.8) and 0.2 m · min^{-1} (95% CI: 0.1 to 0.4), respectively. There was however noteworthy heterogeneity for all models (high-speed distance: $Q_{(187)}$ = 19313.75, τ_2 = ±6.6 [95%CI: 5.8 to 7.5] and τ_3 = ±13.1 [95% CI: 10.7 to 16.1], I^2_2 = 20.4% and I^2_3 = 79.3%; very high-speed distance: $Q_{(225)}$ = 21256.76, τ_2 = ±1.9 [95% CI: 1.7 to 2.1] and τ_3 = ±5 [95% CI: 4.2 to 6.0], I^2_2 = 12.8% and I^2_3 = 87.1%; sprint distance: τ_2 = ±0.4 [95% CI: 0.3 to 0.5] and τ_3 = ±0.1 [95% CI: 0.0 to 0.3]). The width of the 95% PI suggested that exposure could fall anywhere in the range of 0 to 46.5 m · min^{-1}, 0 to 14.2 m · min^{-1} and 0 to 1.1 m · min^{-1}for high speed, very high-speed and sprint running distances, respectively.

3.3.2 Medium-sided games

The main models including all estimates of high-speed, very high-speed and sprint running suggest that during MSG players are exposed, on average, to high-speed, very high-speed and sprint distances with a weighted point and interval estimate of 14.7 m · min^{-1} (95% CI: 12.4 to 17.1), 2.7 m · min^{-1} (95% CI: 1.8 to 3.5) and 0.5 m · min^{-1} (95% CI: 0.3 to 0.6), respectively. There was however noteworthy heterogeneity for all models (high-speed: $Q_{(246)}$ = 39499.67, τ_2 = ±7.4 [95%CI: 6.7 to 8.2] and τ_3 = ±5.9 [95% CI: 3.9 to 8.5], I^2_2 = 60.8% and I^2_3 = 39.0%; very high-speed distance: $Q_{(237)}$ = 22108.57, τ_2 = ±2.1 [95% CI: 1.9 to 2.4] and τ_3 = ±2.3 [95% CI: 1.4 to 3.3], I^2_2 = 46.5% and I^2_3 = 53.4%; sprint distance: τ_2 = ±0.7 [95% CI: 0.6 to 0.8] and τ_3 = 0.0 [95% CI: 0.0 to 0.5]). The width of the 95% PI suggested that exposure could fall anywhere in the range of 0 to 34 m · min^{-1}, 0 to 9.0 m · min^{-1} and 0 to 2 m · min^{-1} for high speed, very high-speed and sprint running distances, respectively.

3.3 Large-sided games

The main models including all estimates of high-speed, very high-speed and sprint running suggest that during LSG players are exposed, on average, to high-speed, very high-speed and sprint distances with a weighted point and interval estimate of 14.8 m · min^{-1} (95% CI: 12.3 to 17.4), 3.4 m · min^{-1} (95% CI: 2.9 to 3.9) and 0.7 m · min^{-1} (95% CI: 0.5 to 0.9), respectively. There was however noteworthy heterogeneity for all models (high-speed: $Q_{(212)}$ = 26831.21, τ_2 = ±6.3 [95%CI: 5.7 to 7.0] and τ_3 = ±3.1 [95% CI: 0.0 to 7.0], I^2_2 = 79.8% and I^2_3 = 19.8%; very high-speed distance: $Q_{(193)}$ = 17212.41, τ_2 = ±2.5 [95% CI: 2.3 to 2.8] and τ_3 =±0.2 [95% CI: 0.0 to 1.6], I^2_2 = 98.6% and I^2_3 = 0.8%; sprint distance: τ_2 = ±0.84 [95% CI: 0.8 to 0.9] and

τ_3 = ±0.1 [95% CI: 0.0 to 0.5]). The width of the 95% PI suggested the exposure could fall anywhere in the range of 0 to 30 m · min^{-1}, 0 to 8.7 m · min^{-1} and 0 to 2.6 m · min^{-1}for high speed, very high-speed and sprint running distances, respectively.

3.4 Intra-individual reliability

The meta-analysis of all intra-individual reliability estimates (21 across 7 clusters [median 2, range 1–12 estimates per cluster]) determined weighted and predictive point estimates with respective CI and PI equal to 22.8% (95%CI: 12.2% to 42.6%) and 22.7% (95% PI: 3.6% to 143.1%). There was however noteworthy heterogeneity with $Q_{(20)}$ = 212.99, τ_2 = ±0.4 (95% CI: 0.3 to 0.6) and τ_3 = ±0.6 (95% CI: 0.2 to 1.4), I^2_2 = 29.0% and I^2_3 = 65.8%.

3.5 Meta-Regression Analyses

Table 5 displays the weighted point estimates with 95% CI for each moderator assessed in the meta-regression analyses.

3.5.1 Velocity thresholds

Meta-regression suggested that high-speed, very high-speed, and sprint running exposure were moderated by the velocity thresholds set to collect these external load measures. Specifically, per every unit increment or decrement (± 1 km · h^{-1}) from the anchored velocity references, high-speed running exposure changed, on average, 2.5 m · min^{-1} (95%CI: 1.1 to 4.0), 1.6 m · min^{-1} (95% CI: -0.8 to 4.0) and 4.1 m · min^{-1} (95% CI: 2.1 to 6.2) in SSG, MSG and LSG, respectively. Similarly, very high-speed running exposure changed, on average, 1.4 m · min^{-1} (95% CI: 0.7 to 2.0), 0.8 m · min^{-1} (95% CI: 0.4 to 1.2) and 1.4 m · min^{-1} (95% CI: 0.8 to 2.0) in SSG, MSG and LSG, respectively. Finally, sprint running exposure changed, on average, 0.4 m · min^{-1} (95% CI: 0.1 to 0.7), -0.1 m · min^{-1} (95% CI: -0.7 to 0.5) and 0.3 m · min^{-1} (95% CI: -0.9 to 0.3) in SSG, MSG and LSG, respectively.

3.5.2 Area per player

Meta-regression suggested that high-speed, very high-speed, and sprint running exposure were moderated by the area per player consistently across all sided game formats. Specifically, for every 25 m^2 increment of the relative area per player from the anchored reference of 100 m^2 per player, high-speed running exposure increased, on average, by 2.5 m · min^{-1} (95%CI: 2.0 to 3.0), 2.8 m · min^{-1} (95% CI: 2.1 to 3.4) and 1.9 m · min^{-1} (95% CI: 1.0 to 2.8) in SSG, MSG and LSG, respectively. Similarly, very high-speed running exposure increased, on average, by 0.6 m · min^{-1} (95% CI: 0.4 to 0.8), 0.9 m · min^{-1} (95% CI: 0.7 to 1.1) and 0.8 m · min^{-1} (95% CI: 0.5 to 1.1) in SSG, MSG and LSG, respectively. Finally, sprint running exposure increased, on average, by 0.1 m · min^{-1} (95% CI: 0.1 to 0.2), 0.2 m · min^{-1} (95% CI: 0.1 to 0.4) and 0.3 m · min^{-1} (95% CI: 0.1 to 0.4) during SSG, MSG and LSG, respectively.

3.5.3 Length:Width Ratio

Meta-regression suggested that the length:width ratio moderated high-speed, very high-speed, and sprint running exposure differently across the sided game formats. In SSG, an increase was observed for high-speed (0.1 m · min^{-1} [95%CI: -0.8 to 1.1]), very high-speed (0.2 m · min^{-1} [95% CI: -0.1 to 0.4]) but not in sprint (0.0 m · min^{-1} [95% CI: -0.0 to 0.1]) running exposure. Similarly, also in MSG, exposure to high-speed and very high-speed running increased, on average, by 0.5 m · min^{-1} (95% CI: 0.1 to 0.8) and 0.3 m · min^{-1} (95% CI: 0.1 to 0.5), respectively, while no effects were found for sprint running (0.0 m · min^{-1} [95% CI: -0.2 to 0.2]). Contrasting moderating effects were observed in LSG, with decreases in high-speed (-0.3 m · min^{-1} [95% CI: -1.2 to 0.7]), very high-speed (-0.2 m · min^{-1} [95% CI: -0.5 to 0.1]) and sprint running exposure (-0.1 m · min^{-1} [95% CI: -0.3 to 0.1]).

3.5.4 Game orientation

Meta-regression suggested that high-speed, very high-speed, and sprint running exposure were moderated by the game orientation differently across the sided game formats. In SSG, a decrease was observed for high-speed (-1.3 m · min^{-1} [95%CI: -5.2 to 2.6]), very high-speed (-0.2 m · min^{-1} [95% CI: -1.3 to 0.8]) and sprint (-0.0 m · min^{-1} [95% CI: -0.2 to 0.1]) running exposure when the game was score oriented and included either goalkeepers or small goals. Contrasting moderation effects were observed in MSG, whereby exposure to high-speed, very high-speed and sprint running, increased, on average, by 4.8 m · min^{-1} (95% CI: 0.2 to 9.5), 1.0 m · min^{-1} (95% CI: 0.6 to 1.4) and 0.3 m · min^{-1} (95% CI: -0.3 to 0.9), respectively, in presence of goalkeepers or small goals. Similarly, game orientation also moderated LSG high-speed, very high-speed and sprint running exposure with, on average, an increased exposure of 7.4 m · min^{-1} (95% CI: 4.3 to 10.4), 0.3 m · min^{-1} (95% CI: -2.5 to 3.1) and 0.2 m · min^{-1} (95% CI: -0.1 to 0.6), respectively.

3.6 Risk of Bias

Full results and summary of the RoBANS assessment of the included studies are presented in Online Resources 11, "ESM_11" (Available on: https://osf.io/rf48s) and Figure 7, respectively. Across all studies, the greatest risk of bias (100%) was observed in the confounding variables domain considering that none of the studies (*n* = 105) reported the dwell time required above the minimal velocity thresholds for locomotive actions to be recorded as high-speed very high-speed or sprinting effort, and most studies did not report the number of satellites obtained (*n* = 101) or the horizontal dilution of precision (*n* = 102). Similarly, high risk of bias (100%) was observed in the domain pertaining the blinding of outcome assessments as none of the studies (*n* = 105) reported any procedures adopted to blind the outcomes of the sided-games training. Risk of bias (20%) was also observed in the selective outcome reporting domain as 21 studies did not report descriptive statistics (i.e., mean, SD and CI) of the external load outcomes. The lowest risk of bias (8.5%) was observed in the selection of participants as only in 9 of the 105 studies the sample characteristics were not clearly reported.

4 DISCUSSION

Our systematic review and meta-analysis is the first to provide an exploratory summary and a quantitative synthesis of high-speed, very high-speed and sprint running exposure and intra-individual reliability in soccer sided-games from 104 and 7 studies, respectively. The main findings from our analysis were that high-speed, very high-speed and sprint running exposure induced by sided-games, irrespective of format, are not comparable to the corresponding outcomes reported for regular 11-a-side soccer matches. Moreover, poor reliability of these external load measures was found in SSG and MSG formats, suggesting that exposure is highly variable in sided-games. Across sided-games formats, high-speed, very high-speed and sprint running exposure were influenced by the tracking device velocity thresholds and playing constraints such as the relative area per player, pitch length-to-width ratio, and game orientation.

4.1 High-speed, Very High-speed and Sprint Running Exposure

The systematic monitoring of external loads is core for the comprehensive evaluation of dose exposure during training and competition and the subsequent optimal planning and management of the training processes [231]. The main findings of this study provides insight for the use of sided-games as integrated soccer-specific training [232–234], as a physical conditioning method [235] as well as for training load exposure strategies [234,236,237]. Promoting evidence-informed practices in soccer, the results of our meta-analysis confirm that sided-games are inappropriate to replicate match play demands. To contextualize, across all sided-games formats, the pooled estimates were considerably lower than the analogous external load measures reported for official matches at amateur level [238], in professional European competitions such as the English Premier League [45,46], the Spanish La Liga [239], the Italian Serie A [240,241], the French Ligue [242] and the German Bundesliga [243], in addition to the Union of European Football Associations (UEFA) Champions League [68,69] and international tournaments of the Fédération Internationale de Football Association (FIFA) [70,244]. For example, during regular 11-a-side soccer matches in competitions involving adult (i.e., ≥ 17 years old) soccer players of any sex and level, relative high-speed, very high-speed and sprint running exposure range from 20.2 to 29.7 $m \cdot min^{-1}$, 7.1 to 12.8 $m \cdot min^{-1}$, and 1.3 to 3.9 $m \cdot min^{-1}$, respectively. Noticeably, the corresponding (i.e., same velocity thresholds collected with the same tracking technologies) pooled estimates (Table 4) from studies included in this meta-analysis were up to approximately six-fold lower (i.e., for high-speed, very high-speed and sprint exposure, respectively: ↓9.9%, ↓83.4% and ↓584% in SSG; ↓43.9%, ↓174% and ↓182% in MSG; ↓38.4%, ↓111.3% and ↓78% in LSG; Figure 8). The evidence that sided-games fail to fully replicate the high-speed demands of regular play [41,44,173,245], has practical implications as described below.

From a tactical perspective, the evolution of elite soccer match play requires players to perform more high-speed and sprint actions to fulfil tactical responsibilities, whilst in and out of possession, and during ball possession transitions [45,46]. These locomotor activities are also key determinants for successful performance [47] as high-speed and especially straight sprint running have been identified as the most frequent locomotive actions preceding goal situations, performed by either the scoring player and the assisting one [48,49]. At granular level, position-specific profiles have been reported with special reference to high-speed movement patterns particularly when contextualized with technical skills and tactical actions [246,247]. In this regard, while tactical drills appear to provide the greatest combined physical, technical, and tactical training stimulus and transfer, it is plausible that sided-games lack effectiveness to fully account for the multi-dimensional domains of the positional demands. The multi-positional drill nature, the reduced pitch sizes and player numbers characterizing sided-games largely affect individual and collective tactical behaviour [248] as smaller pitches (i.e., 88-145 m^2 per player) and low player numbers (i.e., SSG and MSG) result in shorter inter-player distances [249], increased unpredictable short-distance movements [250] and greater movement variability in players' pitch zones [251] compared with regular match play. Conversely, larger pitches (i.e., > 216 m^2 per player) with greater player numbers (i.e., LSG) lead to more regular positioning and reduce player movement variability, but at the expense of less radius of free movement over longer distances [211,251]. These considerations indicate that although sided-games training is appropriate to induce changes in collective behavior aiming at improving or refining tactical proficiency at team level, it may not be fully effective to closely replicate the multi-dimensional positional patterns of match play with reference to high-speed movements, which is crucial when preparing players for the positional tactical demands of modern game.

From a physical conditioning perspective, our study provides robust evidence for an informed planning of sided-games training in soccer. On one hand, sided-games cannot be endorsed as a comprehensive method especially if the main training goal is to overload high-speed, very high-speed and sprint running exposure. For example, assuming the pooled estimates from this meta-analysis, a typical sided-games training session, which usually consists of ~15 minutes of effective playing time (See Online Resource 10, "ESM_10"; https://osf.io/5hzve), would be expected to induce, on average, total high-speed, very high-speed and sprint running exposure of ~235m, ~49m and ~7m, respectively. Comparisons with the corresponding relative outcomes for full matches (i.e., ~375m, ~150m and ~40m, respectively) [45,46,68–70,238–241,243,244] clearly highlight that sided-games do not induce a sufficient overload stimulus for high-speed and sprint running exposure. In practical terms, such dose exposure and the underpinning physiological, biochemical and neuromuscular responses may still contribute to maintain fitness in soccer players during the in-season period when sided-games are implemented systematically through multiple weekly sessions as different formats but combined with other forms of training [252,253]. However, the effectiveness of sided-games training alone to enhance high-speed and sprint running capabilities [3] or to compensate for the lack of match-induced exposure among non-starting players is questionable [254,255]. Similarly, although some sided-games formats (i.e., SSG) may elicit mechanical loads due to repeated accelerations and decelerations to a level that is at least equivalent with peak periods of official match play [43], their effectiveness as longitudinal training interventions aimed at enhancing strength, jumping and change of direction capabilities in soccer players is minimal [3,256]. On the other hand, coaches and practitioners may use sided-games to ensure progressive high-speed running exposure during the pre-season period when gradual overload may be required as well as in-season to target a minimal dose exposure in tapering weeks and days or during congested fixture periods [47,242].

Planning high-speed and sprint running training receives particular attention among soccer coaches and practitioners as optimal exposure strategies may also have a preventive role against injuries for which inadequate training dose is considered as a modifiable risk factor [237]. Unaccustomed volumes and spikes in sprint and near-to-maximal speed distances during competitive match-play have been reported to have harmful association with muscle injury occurrence [257,258]; therefore, exposing soccer players to progressive and optimal sprint running doses may provide a preventive effect, especially for non-contact hamstrings injuries [259,260]. This likelihood of muscle injuries is reasonably increased among non-starting players due to the lack of match-induced high-speed and sprint running exposure, especially if it is not adequately compensated during the training micro-cycle. Implementing training strategies with a particular focus to the ability to repeat and tolerate near-to-maximal and sprint actions [234,261], would therefore appear relevant to the context of muscle injuries preventive strategies. Furthermore, considering that most of the hamstrings injuries in soccer players occur due to altered running kinematics during maximal sprint actions [258,262,263] especially peaking at the latter stages of soccer match play [257,264], specific drills that replicate the neuromuscular, mechanical, and physiological demands of sprint running may help refine running technique and develop muscular stress resilience and tolerance resulting in indirect injury prevention benefits [265,266]. With these programming subtleties in mind, the use of sided-games training as part of preventive strategies against hamstring injury through appropriate maximal speed exposure is questionable. First, only trivial sprint running distances (e.g., 5-12m for a typical sessions lasting 15 minutes) can be covered during sided-games unless very extensive training volumes and formats including small numbers of players (i.e., SSG) and very high relative areas per player (> 300 m^2 per player) are used [38,132], which is rather impractical in the context of a full squad environment. Moreover, another critical reason is the likely lack of sprint-specificity during sided-games which are characterized by frequent short-distance (5-10m) acceleration-like sprint movements opposed to longer (>15m) and near-to-maximal speed actions common in regular match play [47]. Arguably, the different sprint-specific locomotive profiles between sided-games and matches require distinct hamstrings recruitment and activity at the hip and knee joints, which could limit the potential benefits of specific strengthening transfer and the protective role against hamstrings injuries occurring during sprint running [267,268].

4.2 Intra-individual reliability

Quantifying the repeatability of the external load demands during sided-games and inferring about the associated individual responses and adaptations is paramount for the design of soccer training programs [231,253]. In this meta-analysis, high-speed and sprint running exposure measures showed poor reliability with CV values ranging from 12.2% to 42.6%. Notably, while separate pooled estimates could have not been computed for each speed category due to the small number of estimates, an exploratory inspection (See Online Resource 10, "ESM_10"; https://osf.io/5hzve) of the intra-individual reliability values emphasizes that the external load variables most associated with fatigue and muscle damage in soccer [235] present the lowest consistency, with distances covered at very-high speed and sprinting showing CV values ranging from 8% to 62.4% and 16.1% to 19.1%, respectively. These findings were expected given that the locomotive demands in sided-games are random and uncontrolled [248,250,251]. Practically, this may have important implications for training load management and monitoring as the PIs of the CV of our meta-analysis (Figure 5, 3.6% to 143.1%) reveal that sided-games training can overexpose some players as well as underexpose others with respect to the individual dose exposure sought by the coaching or sports science staff [39]. Accordingly, conditioning methods complementing sided-games or designed intentionally as isolated high-speed and sprint drills or soccer-specific circuits may be beneficial if the training session aim is to expose players to these demands with a low degree of uncertainty. It is also noteworthy that the pooled estimates of the variability reported above encapsulate different sources of variability whose precise partition could not be determined [269,270]. To explain, an estimate of intra-individual variability extracted from each individual study is a mean estimate of the sample in the study. As such, the pooled estimates in our meta-analysis likely captured: 1) technical variability from each study due to the monitoring devices and experimenters; 2) day-to-day variability in studies which implemented a test-retest design with between-day repeated measurements; 3) variability in response to the same sided-games training between individuals and 4) true intra-individual variability or individual variation in response to the same training. While the magnitude of some sources of variability (i.e., technical variability) may be extracted from the literature [271,272], other sources of variability (e.g., day-to-day biological variability, variability in response to the same training and true intra-individual variability) are specific to the studied population and may require studies including randomized repeated interventions and reliability trials to be quantified. This is impractical in studies conducted in highly ecological environments. Moreover, the evidence on the intra-individual variability of the external load measures during sided-games training is weak (i.e., n = 7 studies) and pertinent only to SSG and MSG formats. While future research studies should purposefully address this topic to expand the knowledge available to date, it is advisable for coaching or sports science staff to account for intra-individual reliability in their load prescription and management strategies [253]. In fact, understanding the underpinning sources of intra-individual variability may help interpreting training responses more accurately both at group and individual level [269,270]. For example, intra-individual variability provides information to infer whether inter-individual responses differences are true or a simple artefact of intra-individual variation. When evaluating inter-individual response differences, it is imperative to discern between the systematic or true response and intra-individual variation (e.g., day-to-day biological variability, variability in response to the same training and true intra-individual variability). In some circumstances, the intra-individual variation may be large enough to contain a large proportion if not all apparent inter-individual differences in training responses. Therefore, inter-individual comparisons made upon average response values and failing to account for intra-individual variability may lead to biased conclusions. Similarly, intra-individual variation is also paramount when evaluating response differences at individual level. In fact, accounting for intra-individual variability may facilitate to infer whether true response differences occurred or should be attributed to concurrent training dependent factors (i.e., other training stimuli from the same training session) or to alternative factors independent from training (i.e., biological day-to-day variability). In this case, comparing a single response observation with a rolling baseline (i.e., average of several previous responses) which incorporates individual compatibility or equivalence intervals accounting for intra-individual variability is a viable option [273].

4.3 Effects of the between-study heterogeneity

In designing this systematic review and meta-analysis, our foremost research question was: *"What high-speed and sprint running exposure and associated reliability to expect by implementing sided-games training in soccer?"* Thereafter, and building upon the main findings of the meta-analysis, we aimed to provide a robust analysis of the magnitude of high-speed and sprint running exposure and the influence of the common programming variables as to facilitate informed training prescription, periodisation, and load management planning strategies. To this end, taking into account the high risk of bias observed in some of the RoBANS domains and the uncertainty around the pooled estimates due to the large between-study heterogeneity in addition to the recommendations of Cochrane on matters regarding the number of studies included in meta-analyses [274] and the presence of asymmetry observed in the funnel plots [275], we calculated and recommend considering the 95% PIs reported in Table 4. In the context of this meta-analysis, the 95% PIs describe the range of effects to expect in 95% of future similar studies involving random samples of soccer players whom we intend to expose to high-speed and sprint running by implementing sided-games training. As expected, the 95% PIs resulted wider than the 95% CIs across all pooled estimates, confirming that the variation around external loads in sided-games training is multifactorial and influenced by several factors such as training variables, playing constraints, individual characteristics or simply noise due to measurement error and biological variation. While a comprehensive investigation of all potential sources of between-study heterogeneity was computationally and practically unfeasible (e.g., limited number of estimates per factor and missing data), in the next section we address the main potential sources of heterogeneity and interpret the related practical implications [65].

4.4 Effects of Moderators

In this section, besides addressing and explaining the heterogeneity influencing the pooled estimates, we provide several practical suggestions for coaches and practitioners aiming to use different sided-games formats and to manipulate playing constraints for high-speed and sprint running exposure-focused training planning and prescription. To this end, we recommend using the “Sided-games Training App” and the “Planner” tab, to simulate expected exposure scenarios unfolding from alternative sided-games training manipulations.

The finding that all pooled estimates across all sided-games formats were moderated and changed as a factor of the velocity thresholds is logical. Simply, lower and higher cut-off values set as velocity thresholds in the monitoring devices directly offset the magnitudes of external load measures toward greater and smaller outcomes, respectively. In view of the wide scale and the considerable variability found in the literature regarding the definitions of high-speed, very high-speed and sprint running and corresponding velocity thresholds (Table 3), we suggest our meta-regression results as a practical programming tool (Table 5). Here, practitioners, sport scientists and researchers may consider the parameters of the moderating effects to adjust the expected high-speed and sprint running exposures when using velocity thresholds which deviate from the anchored values that we used in our meta-analysis models. The simplicity of using a correcting factor is immediately advantageous for training prescription and load monitoring purposes as well as likely beneficial to facilitate data sharing and knowledge exchange between sport science departments and research groups [276].

Unimodal moderating effects on pooled estimates across all sided-games formats were found for the area per player variable, suggesting that high-speed and sprint running exposure can be progressively increased by implementing sided-games with larger playing areas or lower player density. This robust finding encapsulates evidence showing that increased pitch sizes lead to greater inter-player and inter-team distances, resulting in larger spaces available to reach high-speed and near-to-maximal speed running [3,38,132,211]. While previous studies recommended using sided-games formats with relative areas of 180-200 $m^2 \cdot$ player, 200-300 $m^2 \cdot$ player, and > 320 $m^2 \cdot$ player to replicate the external load demands of regular matches [38,132,220], our main and meta-regressions analyses provide highly powered results and robust evidence. Specifically, we suggest designing sided-games, irrespective of the format characteristics, with relative playing areas approximately respectively equal to 200 $m^2 \cdot$ player, 325 $m^2 \cdot$ player, and > 365 $m^2 \cdot$ player to induce relative high-speed, very high-speed and sprint running exposure comparable to matches' outcomes. As illustrated above for the threshold velocity, the anchored reference point for the area per player variable (100 m^2) and the parameters of the moderating effects can be used as practical and useful tools when designing and planning sided-games sessions selectively targeting specific training goals [12,15,252].

Game orientation moderated high-speed and sprint running exposure differently across sided-games which appears to contradict common belief and one of the conclusions from the recent umbrella review of Clemente et al. [3], supporting the notion that using goalkeepers and small scoring targets consistently reduces the external loads during sided-games training. Meta-regression suggested that score-oriented formats reduced high-speed and sprint running exposure in SSG with an opposite trend in both MSG and LSG. These contrasting results can be explained by a few technical-tactical reasons and methodological pitfalls unfolding from studies where the comparative effects between sided-games including the presence of goalkeepers or small goals and possession formats were investigated. From a tactical perspective, as elaborated above, the greater player- and team-dispersion characterizing MSG and LSG formats as well as the greater dimensions in larger pitch areas likely promote a more direct and vertical playing style with more frequent long-distance high-speed and sprint actions performed in and out of possession, and during ball possession transitions especially under exacerbating contextual constraints such as opponents pressure, score status and reduced playing time [23,150,248,277]. On the contrary, SSG formats with smaller pitch areas impose reduced positional dispersion and inter-player distances to preserve the spatial equilibrium on the field, and more importantly to maintain or regain ball possession, which is a necessary condition for rapid goal scoring attempts [23,188]. In this regard, greater frequencies of technical actions, among which shots to the opponent's goal and shots far away from the opponent's goal area in particular, were reported in SSG compared with MSG and LSG formats [278–280]. This reasonably implies that less high-speed and sprint running actions are required to successfully score in small formats in consideration of the paired relationships between player positioning, score attempt actions and external load variables [281]. Finally, most of the studies purposefully designed to investigate the comparative effects between score- and possession-oriented SSG, failed to adjust for the areas per player when goalkeepers were included, thus resulting in consistent smaller relative ratios. Therefore, the lower high-speed and sprint running exposure reported in score-oriented SSG formats is likely attributable to the moderating effects of the area per player as extensively explained above rather than due to the game orientation characteristics.

The conceptual and tactical considerations made about the moderating effects of the score-orientation constraint may, in part, also explain why length:width ratio influences high-speed and sprint running exposure differently across sided-games formats. Mainly, sided-games formats with equal length and width dimensions induce higher movement synchronization in both longitudinal and lateral directions, which facilitate a balanced dispersion of the players across the entire playing area, thereby resulting in an elongated playing shape style with higher likelihood of increased distances covered at high-speed [23,248]. It is not entirely clear why an opposite moderating trend was found in LSG, with high-speed and sprint running exposure progressively decreasing as a factor of higher length:width ratios. However, it is plausible that the interaction between large player numbers (≥ 8v8) and a stretched pitch shape in the longitudinal direction may confine teams' dispersion, particularly in response to transition play, thus causing a reduction of the effective playing space especially in the lateral corridors and diagonally, which ultimately limit the chances to perform high-speed actions [23,248]. To summarize, while higher length:width ratios may increase high-speed and very high-speed running exposure during SSG and MSG, a balanced ratio should be maintained in LSG for the same purposes.

5 Limitations

In conducting this systematic review and meta-analysis, we have identified a few limitations that warrant consideration. Foremostly, this meta-analysis included studies whose research designs and protocols were not pre-registered and pre-scrutinized (e.g., SPIRIT) according to strict standards suggested for observational studies (e.g., STROBE) or randomized controlled trials (e.g., CONSORT) [276]. However, this is a common and unavoidable limitation in meta-analysis studies when synthesizing training exposure investigated in applied settings and under and highly ecological conditions, thus lacking proper internal validity. Given that grey literature searches make important contributions to systematic reviews as their exclusion can lead to exaggerated estimates of intervention effectiveness [282,283], our decision not to undertake a grey literature search could be regarded as a limitation. Quantifying intervention effectiveness, however, was not our research objective as we were interested in the synthesis and quantification of sided-game high-speed, very high-speed and sprint running exposure rather than the effectiveness of sided-games as a fitness intervention. We also had concerns relating to the absence of peer review and that inclusion of unpublished data can itself introduce bias as any studies located may be an unrepresentative sample of all unpublished studies [89], and, as in other fields, unpublished studies represent a very small proportion of included studies and rarely impact the results and conclusions of a review [284]. We acknowledge a single-language bias, given that we included only studies reported in English; again, however, non-English studies represent a very small proportion of studies (in this instance $n = 2$) and therefore have little impact on a review's conclusions [284]. The overall pooled sample included mostly male adult soccer players and only 66 female participants, so whether the main findings can be confidently generalized to female populations or to youth soccer players require further research. The grouping of high-speed, very high-speed and sprint distance outputs between different tracking technologies has inherent remarkable flaws due to the variety of devices, tracking approaches, sampling rates, filtering methods, and data-processing algorithms [276]. Finally, the relatively low number of estimates per dataset pertaining sided-games characteristics such as the presence and type of coach encouragement, number of touches, position specific data and tactical instructions restricted any examination of the associated moderating effects on exposure to high-speed, very high-speed and sprint running during sided-games training. On a similar note, while the overall number of estimates of intra-individual reliability from SSG and MSG formats was sufficient to run a meta-analysis, we could not extend the main findings to LSG formats nor address and explain any potential sources of heterogeneity.

6 Conclusions

Our study is the first to provide a quantitative synthesis of high-speed, very high-speed and sprint running exposure and associated intra-individual reliability during soccer sided-games. We found that high-speed, very high-speed and sprint running exposure during sided-games training is much lower than official matches as well as showing poor reliability, irrespective of the sided games formats. Coaches and practitioners choosing to use sided-games could consider manipulating playing constraints such as area per player, game orientation, and length:width ratio, and cross-checking the velocity thresholds set in the tracking devices when planning high-speed and sprint running exposure-focused training and monitoring. Further work is warranted through well-designed and unbiased studies to improve the understanding of the possible sources of heterogeneity observed for high-speed, very high-speed and sprint running exposure and the variability around these external load measures.

References

1. Worthington E, Worthington E. *Learning & Teaching Soccer Skills*. Wilshire Book Co.; 1974.

2. Wade A. *The F.A. Guide to Training and Coaching.* Heinemann for the FA; 1979.

3. Clemente FM, Afonso J, Sarmento H. Small-sided games: An umbrella review of systematic reviews and meta-analyses. *PloS One*. 2021;16(2):e0247067. doi:10.1371/journal.pone.0247067

4. Ometto L, Vasconcellos FV, Cunha FA, et al. How manipulating task constraints in small-sided and conditioned games shapes emergence of individual and collective tactical behaviours in football: A systematic review. *Int J Sports Sci Coach*. 2018;13(6):1200-1214.

5. Siokos A. Determining the effectiveness of Small-Sided Football (SSF) implementation in metropolitan Association Football. *Int J Coach Sci*. 2011;5(1).

6. Bonney N, Larkin P, Ball K. Future Directions and Considerations for Talent Identification in Australian Football. *Front Sports Act Living*. 2020;2:612067. doi:10.3389/fspor.2020.612067

7. Coutts AJ, Rampinini E, Marcora SM, Castagna C, Impellizzeri FM. Heart rate and blood lactate correlates of perceived exertion during small-sided soccer games. *J Sci Med Sport*. 2009;12(1):79-84.

8. Rampinini E, Impellizzeri FM, Castagna C, et al. Factors influencing physiological responses to small-sided soccer games. *J Sports Sci*. 2007;25(6):659-666.

9. Clemente F, Couceiro MS, Martins F, Mendes R. The usefulness of small-sided games on soccer training. *J Phys Educ Sport*. 2012;12(1):93-102.

10. Bergkamp TL, den Hartigh RJ, Frencken WG, Niessen ASM, Meijer RR. The validity of small-sided games in predicting 11-vs-11 soccer game performance. *PloS One*. 2020;15(9):e0239448.

11. Stevens TGA, De Ruiter CJ, Beek PJ, Savelsbergh GJP. Validity and reliability of 6-a-side small-sided game locomotor performance in assessing physical fitness in football players. *J Sports Sci*. 2016;34(6):527-534.

12. Reilly T. An ergonomics model of the soccer training process. *J Sports Sci*. 2005;23(6):561-572. doi:10.1080/02640410400021245

13. Bonney N, Berry J, Ball K, Larkin P. Validity and reliability of an Australian football small-sided game to assess kicking proficiency. *J Sports Sci*. 2020;38(1):79-85.

14. Aguiar M, Botelho G, Lago C, Maças V, Sampaio J. A review on the effects of soccer small-sided games. *J Hum Kinet*. 2012;33:103.

15. Hill-Haas SV, Dawson B, Impellizzeri FM, Coutts AJ. Physiology of small-sided games training in football. *Sports Med*. 2011;41(3):199-220.

16. Sarmento H, Clemente FM, Harper LD, Costa IT da, Owen A, Figueiredo AJ. Small sided games in soccer–a systematic review. *Int J Perform Anal Sport*. 2018;18(5):693-749.

17. Fradua L, Zubillaga A, Caro Ó, Iván Fernández-García Á, Ruiz-Ruiz C, Tenga A. Designing small-sided games for training tactical aspects in soccer: Extrapolating pitch sizes from full-size professional matches. *J Sports Sci*. 2013;31(6):573-581.

18. Casamichana D, Castellano J. Time–motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of pitch size. *J Sports Sci*. 2010;28(14):1615-1623.

19. Morgans R, Orme P, Anderson L, Drust B. Principles and practices of training for soccer. *J Sport Health Sci*. 2014;3(4):251-257. doi:10.1016/j.jshs.2014.07.002

20. Sgrò F, Bracco S, Pignato S, Lipoma M. Small-sided games and technical skills in soccer training: Systematic review and implications for sport and physical education practitioners. *J Sports Sci*. 2018;6(1):9-19.

21. Owen AL, Wong D, Paul D, Dellal A. Physical and technical comparisons between various-sided games within professional soccer. *Int J Sports Med*. 2014;35(04):286-292.

22. Dellal A, Owen A, Wong D, Krustrup P, Van Exsel M, Mallo J. Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Hum Mov Sci*. 2012;31(4):957-969.

23. Coutinho D, Gonçalves B, Santos S, Travassos B, Wong DP, Sampaio J. Effects of the pitch configuration design on players' physical performance and movement behaviour during soccer small-sided games. *Res Sports Med*. 2019;27(3):298-313.

24. Aguiar M, Gonçalves B, Botelho G, Lemmink K, Sampaio J. Footballers' movement behaviour during 2-, 3-, 4-and 5-a-side small-sided games. *J Sports Sci*. 2015;33(12):1259-1266.

25. Aguiar MV, Botelho GM, Gonçalves BS, Sampaio JE. Physiological responses and activity profiles of football small-sided games. *J Strength Cond Res*. 2013;27(5):1287-1294.

26. Hill-Haas SV, Coutts AJ, Dawson BT, Rowsell GJ. Time-motion characteristics and physiological responses of small-sided games in elite youth players: the influence of player number and rule changes. *J Strength Cond Res*. 2010;24(8):2149-2156.

27. Dellal A, Lago-Penas C, Wong DP, Chamari K. Effect of the number of ball contacts within bouts of 4 vs. 4 small-sided soccer games. *Int J Sports Physiol Perform*. 2011;6(3):322-333.

28. Fanchini M, Azzalin A, Castagna C, Schena F, Mccall A, Impellizzeri FM. Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer. *J Strength Cond Res*. 2011;25(2):453-458.

29. Dello Iacono A, Beato M, Unnithan V. Comparative Effects of Game Profile-Based Training and Small-Sided Games on Physical Performance of Elite Young Soccer

Players. *J Strength Cond Res*. Published online May 27, 2019. doi:10.1519/JSC.0000000000003225

30. Bujalance-Moreno P, Latorre-Román PÁ, García-Pinillos F. A systematic review on small-sided games in football players: Acute and chronic adaptations. *J Sports Sci*. 2019;37(8):921-949. doi:10.1080/02640414.2018.1535821

31. Selmi O, Gonçalves B, Ouergui I, Sampaio J, Bouassida A. Influence of well-being variables and recovery state in physical enjoyment of professional soccer players during small-sided games. *Res Sports Med*. 2018;26(2):199-210.

32. Selmi O, Ouergui I, Levitt DE, Nikolaidis PT, Knechtle B, Bouassida A. Small-sided games are more enjoyable than high-intensity interval training of similar exercise intensity in soccer. *Open Access J Sports Med*. 2020;11:77.

33. Los Arcos A, Vázquez JS, Martín J, et al. Effects of small-sided games vs. interval training in aerobic fitness and physical enjoyment in young elite soccer players. *PloS One*. 2015;10(9):e0137224.

34. Arslan E, Orer GE, Clemente FM. Running-based high-intensity interval training vs. small-sided game training programs: effects on the physical performance, psychophysiological responses and technical skills in young soccer players. *Biol Sport*. 2020;37(2):165-173. doi:10.5114/biolsport.2020.94237

35. Unnithan V, White J, Georgiou A, Iga J, Drust B. Talent identification in youth soccer. *J Sports Sci*. 2012;30(15):1719-1726. doi:10.1080/02640414.2012.731515

36. Rowat O, Fenner J, Unnithan V. Technical and physical determinants of soccer match-play performance in elite youth soccer players. *J Sports Med Phys Fitness*. 2017;57(4):369-379. doi:10.23736/S0022-4707.16.06093-X

37. Fenner JSJ, Iga J, Unnithan V. The evaluation of small-sided games as a talent identification tool in highly trained prepubertal soccer players. *J Sports Sci*. 2016;34(20):1983-1990. doi:10.1080/02640414.2016.1149602

38. Lacome M, Simpson BM, Cholley Y, Lambert P, Buchheit M. Small-Sided Games in Elite Soccer: Does One Size Fit All? *Int J Sports Physiol Perform*. 2018;13(5):568-576. doi:10.1123/ijspp.2017-0214

39. Clemente FM. The Threats of Small-Sided Soccer Games: A Discussion About Their Differences With the Match External Load Demands and Their Variability Levels. *Strength Cond J*. 2020;42(3):100-105.

40. Kunrath CA, Nakamura FY, Roca A, Tessitore A, Teoldo Da Costa I. How does mental fatigue affect soccer performance during small-sided games? A cognitive, tactical and physical approach. *J Sports Sci*. 2020;38(15):1818-1828. doi:10.1080/02640414.2020.1756681

41. Casamichana D, Castellano J, Castagna C. Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. *J Strength Cond Res*. 2012;26(3):837-843.

42. Clemente FM, Sarmento H, Rabbani A, Van der Linden CM, Kargarfard M, Costa IT. Variations of external load variables between medium-and large-sided soccer games in professional players. *Res Sports Med*. 2019;27(1):50-59.

43. Dalen T, Sandmæl S, Stevens TG, Hjelde GH, Kjøsnes TN, Wisløff U. Differences in acceleration and high-intensity activities between small-sided games and peak periods of official matches in elite soccer players. *J Strength Cond Res*. Published online 2019.

44. Gabbett TJ, Mulvey MJ. Time-motion analysis of small-sided training games and competition in elite women soccer players. *J Strength Cond Res*. 2008;22(2):543-552.

45. Barnes C, Archer D, Hogg B, Bush M, Bradley P. The Evolution of Physical and Technical Performance Parameters in the English Premier League. *Int J Sports Med*. 2014;35(13):1095-1100. doi:10.1055/s-0034-1375695

46. Bradley PS, Archer DT, Hogg B, et al. Tier-specific evolution of match performance characteristics in the English Premier League: it's getting tougher at the top. *J Sports Sci*. 2016;34(10):980-987. doi:10.1080/02640414.2015.1082614

47. Carling C, Le Gall F, Dupont G. Analysis of repeated high-intensity running performance in professional soccer. *J Sports Sci*. 2012;30(4):325-336. doi:10.1080/02640414.2011.652655

48. Faude O, Koch T, Meyer T. Straight sprinting is the most frequent action in goal situations in professional football. *J Sports Sci*. 2012;30(7):625-631. doi:10.1080/02640414.2012.665940

49. Martínez Hernández D, Quinn M, Jones P. Linear Advancing Actions Followed by Deceleration and Turn Are the Most Common Movements Preceding Goals in Male Professional Soccer. *Sci Med Footb*. Published online January 21, 2022:24733938.2022.2030064. doi:10.1080/24733938.2022.2030064

50. Clemente F, Aquino R, Praça GM, et al. Variability of internal and external loads and technical/tactical outcomes during small-sided soccer games: a systematic review. *Biol Sport*. Published online September 1, 2021:647-672. doi:10.5114/biolsport.2022.107016

51. Custódio IJ de O, Praça GM, Paula LV de, Bredt S da GT, Nakamura FY, Chagas MH. Intersession reliability of GPS-based and accelerometer-based physical variables in small-sided games with and without the offside rule. *Proc Inst Mech Eng Part P J Sports Eng Technol*. Published online 2021:1754337120987646.

52. Clemente FM, Rabbani A, Kargarfard M, Nikolaidis PT, Rosemann T, Knechtle B. Session-To-Session Variations of External Load Measures of Youth Soccer Players in Medium-Sided Games. *Int J Environ Res Public Health*. 2019;16(19):3612.

53. Younesi S, Rabbani A, Manuel Clemente F, Sarmento H, Figueiredo A. Session-to-session variations of internal load during different small-sided games: a study in professional soccer players. *Res Sports Med*. Published online 2021:1-13.

54. Hill-Haas S, Coutts A, Rowsell G, Dawson B. Variability of acute physiological responses and performance profiles of youth soccer players in small-sided games. *J Sci Med Sport*. 2008;11(5):487-490.

55. Ade JD, Harley JA, Bradley PS. Physiological response, time-motion characteristics, and reproducibility of various speed-endurance drills in elite youth soccer players: small-sided games versus generic running. *Int J Sports Physiol Perform*. 2014;9(3):471-479. doi:10.1123/ijspp.2013-0390

56. Rago V, Silva JR, Mohr M, Barreira D, Krustrup P, Rebelo AN. Variability of activity profile during medium-sided games in professional soccer. *J Sports Med Phys Fitness*. 2018;59(4):547-554.

57. Clemente FM, Afonso J, Castillo D, Arcos AL, Silva AF, Sarmento H. The effects of small-sided soccer games on tactical behavior and collective dynamics: A systematic review. *Chaos Solitons Fractals*. 2020;134:109710. doi:10.1016/j.chaos.2020.109710

58. Clemente F, Sarmento H. The effects of small-sided soccer games on technical actions and skills: A systematic review. *Hum Mov*. 2020;21(3):100-119. doi:10.5114/hm.2020.93014

59. Kunz P, Engel FA, Holmberg HC, Sperlich B. A Meta-Comparison of the Effects of High-Intensity Interval Training to Those of Small-Sided Games and Other Training Protocols on Parameters Related to the Physiology and Performance of Youth Soccer Players. *Sports Med - Open*. 2019;5(1):7. doi:10.1186/s40798-019-0180-5

60. Moran J, Blagrove RC, Drury B, et al. Effects of Small-Sided Games vs. Conventional Endurance Training on Endurance Performance in Male Youth Soccer Players: A Meta-Analytical Comparison. *Sports Med Auckl NZ*. 2019;49(5):731-742. doi:10.1007/s40279-019-01086-w

61. Ometto L, Vasconcellos FV, Cunha FA, et al. How manipulating task constraints in small-sided and conditioned games shapes emergence of individual and collective tactical behaviours in football: A systematic review. *Int J Sports Sci Coach*. 2018;13(6):1200-1214. doi:10.1177/1747954118769183

62. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. Published online March 29, 2021:n71. doi:10.1136/bmj.n71

63. Page MJ, Moher D, Bossuyt PM, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ*. 2021;372:n160. doi:10.1136/bmj.n160

64. Ardern CL, Büttner F, Andrade R, et al. Implementing the 27 PRISMA 2020 Statement items for systematic reviews in the sport and exercise medicine, musculoskeletal rehabilitation and sports science fields: the PERSiST (implementing Prisma in Exercise, Rehabilitation, Sport medicine and SporTs science) guidance. *Br J Sports Med*. Published online October 8, 2021:bjsports-2021-103987. doi:10.1136/bjsports-2021-103987

65. Abt G, Jobson S, Morin JB, et al. Raising the bar in sports performance research. *J Sports Sci*. Published online January 6, 2022:1-5. doi:10.1080/02640414.2021.2024334

66. Beunen G, Malina RM. Growth and physical performance relative to the timing of the adolescent spurt. *Exerc Sport Sci Rev*. 1988;16:503-540.

67. Malina RM. Skeletal Age and Age Verification in YouthSport: *Sports Med*. 2011;41(11):925-947. doi:10.2165/11590300-000000000-00000

68. Bradley PS, Dellal A, Mohr M, Castellano J, Wilkie A. Gender differences in match performance characteristics of soccer players competing in the UEFA Champions League. *Hum Mov Sci*. 2014;33:159-171. doi:10.1016/j.humov.2013.07.024

69. Di Salvo V, Baron R, González-Haro C, Gormasz C, Pigozzi F, Bachl N. Sprinting analysis of elite soccer players during European Champions League and UEFA Cup matches. *J Sports Sci*. 2010;28(14):1489-1494. doi:10.1080/02640414.2010.521166

70. da Mota GR, Thiengo CR, Gimenes SV, Bradley PS. The effects of ball possession status on physical and technical indicators during the 2014 FIFA World Cup Finals. *J Sports Sci*. 2016;34(6):493-500. doi:10.1080/02640414.2015.1114660

71. Vogt WP, Johnson RB. *The SAGE Dictionary of Statistics & Methodology: A Nontechnical Guide for the Social Sciences*. Sage publications; 2015.

72. Hopkins WG. Measures of reliability in sports medicine and science. *Sports Med Auckl NZ*. 2000;30(1):1-15. doi:10.2165/00007256-200030010-00001

73. Nakagawa S, Poulin R, Mengersen K, et al. Meta-analysis of variation: ecological and evolutionary applications and beyond. O'Hara RB, ed. *Methods Ecol Evol*. 2015;6(2):143-152. doi:10.1111/2041-210X.12309

74. Gore CJ, Hopkins WG, Burge CM. Errors of measurement for blood volume parameters: a meta-analysis. *J Appl Physiol*. 2005;99(5):1745-1758. doi:10.1152/japplphysiol.00505.2005

75. Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. *BMC Med Res Methodol*. 2005;5(1):13. doi:10.1186/1471-2288-5-13

76. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. *BMC Med Res Methodol*. 2014;14(1):135. doi:10.1186/1471-2288-14-135

77. Viechtbauer W. Conducting Meta-Analyses in *R* with the **metafor** Package. *J Stat Softw*. 2010;36(3). doi:10.18637/jss.v036.i03

78. Pustejovsky J. clubSandwich: Cluster-robust (sandwich) variance estimators with small-sample corrections. R package version 0.2. 3. *R Found Stat Comput Vienna*. Published online 2017.

79. Team Rs. RStudio: Integrated Development for R. RStudio, Inc., Boston, MA. 2015. *URL Httpswww Rstudio Comproductsrstudio*. Published online 2019.

80. Pustejovsky JE, Tipton E. Meta-analysis with Robust Variance Estimation: Expanding the Range of Working Models. *Prev Sci*. Published online May 7, 2021. doi:10.1007/s11121-021-01246-3

81. Cheung MWL. Modeling dependent effect sizes with three-level meta-analyses: a structural equation modeling approach. *Psychol Methods*. 2014;19(2):211-229. doi:10.1037/a0032968

82. Hedges LV, Tipton E, Johnson MC. Robust variance estimation in meta-regression with dependent effect size estimates. *Res Synth Methods*. 2010;1(1):39-65. doi:10.1002/jrsm.5

83. Cheung MWL. A Guide to Conducting a Meta-Analysis with Non-Independent Effect Sizes. *Neuropsychol Rev*. 2019;29(4):387-396. doi:10.1007/s11065-019-09415-6

84. McShane BB, Gal D, Gelman A, Robert C, Tackett JL. Abandon statistical significance. *Am Stat*. 2019;73(sup1):235-245.

85. Amrhein V, Greenland S, McShane B. Scientists rise up against statistical significance. *Nature*. 2019;567(7748):305-307. doi:10.1038/d41586-019-00857-9

86. Higgins JPT. Commentary: Heterogeneity in meta-analysis should be expected and appropriately quantified. *Int J Epidemiol*. 2008;37(5):1158-1160. doi:10.1093/ije/dyn204

87. Borenstein M, Higgins JPT, Hedges LV, Rothstein HR. Basics of meta-analysis: I2 is not an absolute measure of heterogeneity. *Res Synth Methods*. 2017;8(1):5-18. doi:10.1002/jrsm.1230

88. Kim SY, Park JE, Lee YJ, et al. Testing a tool for assessing the risk of bias for nonrandomized studies showed moderate reliability and promising validity. *J Clin Epidemiol*. 2013;66(4):408-414. doi:10.1016/j.jclinepi.2012.09.016

89. Higgins J, Altman D, Sterne J. Assessing risk of bias in included studies. In: Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1. 0 (updated March 2011). The Cochrane Collaboration, 2011. *Available Handb Cochrane Org*. Published online 2011:243-296.

90. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. *Med Sci Sports Exerc*. 2009;41(1):3-13. doi:10.1249/MSS.0b013e31818cb278

91. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629-634. doi:10.1136/bmj.315.7109.629

92. Vázquez MÁC, Paulis JC, Bendala FJT, Owen AL. Comparison of the physical and physiological demands of friendly matches and different types of preseason training sessions in professional soccer players. *RICYDE Rev Int Cienc Deporte*. 2019;15(58):339-352.

93. Casamichana D, Castellano J, Hernandez-Mendo A. Generalizability theory applied to the study of physical profile during different small-sided games with different

orientation of the field in soccer. *RICYDE-Rev Int Cienc DEPORTE*. 2014;10(37):194-205.

94. Calderón Pellegrino G, Paredes-Hernández V, Sánchez-Sánchez J, García-Unanue J, Gallardo L. Effect of the Fatigue on the Physical Performance in Different Small-Sided Games in Elite Football Players. *J Strength Cond Res*. 2020;34(8):2338-2346. doi:10.1519/JSC.0000000000002858

95. Coutinho D, Gonçalves B, Wong DP, Travassos B, Coutts AJ, Sampaio J. Exploring the effects of mental and muscular fatigue in soccer players' performance. *Hum Mov Sci*. 2018;58:287-296.

96. Gabbett TJ, Walker B, Walker S. Influence of prior knowledge of exercise duration on pacing strategies during game-based activities. *Int J Sports Physiol Perform*. 2015;10(3):298-304.

97. Köklü Y, Alemdaroğlu U, Dellal A, Wong DP. Effect of different recovery durations between bouts in 3-a-side games on youth soccer players' physiological responses and technical activities. *J Sports Med Phys Fit*. 2015;55(5):430-438.

98. Lacome M, Simpson BM, Cholley Y, Buchheit M. Locomotor and heart rate responses of floaters during small-sided games in elite soccer players: Effect of pitch size and inclusion of goalkeepers. *Int J Sports Physiol Perform*. 2018;13(5):668-671.

99. Malone S, Collins K. The physical and physiological demands of small-sided games: How important is winning or losing? *Int J Perform Anal Sport*. 2016;16(2):422-433.

100. Nevado-Garrosa F, Tejero González CM, Paredes-Hernández V, Campo-Vecino J del. Análisis comparativo de las demandas físicas de dos tareas de juego reducido en fútbol profesional. *Arch Med Deporte*. Published online 2015.

101. Praça GM, Bredt SG, Torres JO, et al. Influence of numerical superiority and players' tactical knowledge on perceived exertion and physical and physiological demands in soccer small-sided games. *Rev Psicol Deport*. 2018;27:31-38.

102. Praça GM, Custódio IJ de O, Greco PJ. Numerical superiority changes the physical demands of soccer players during small-sided games. *Rev Bras Cineantropometria Desempenho Hum*. 2015;17(3):269-279.

103. Asian-Clemente J, Suarez-Arrones L, Sánchez S. Differences between distinct spatial orientations based on individual player profile. *Retos*. 2019;35:3-6.

104. Castagna C, D'Ottavio S, Cappelli S, Araújo Póvoas SC. The Effects of Long Sprint Ability-Oriented Small-Sided Games Using Different Ratios of Players to Pitch Area on Internal and External Load in Soccer Players. *Int J Sports Physiol Perform*. Published online August 29, 2019:1265-1272. doi:10.1123/ijspp.2018-0645

105. Castagna C, Francini L, Póvoas SC, D'Ottavio S. Long-sprint abilities in soccer: ball versus running drills. *Int J Sports Physiol Perform*. 2017;12(9):1256-1263.

106. Clemente F, Dellal A, Wong D, Martins FL, Mendes R. Heart rate responses and distance coverage during 1 vs. 1 duel in soccer: Effects of neutral player and different task conditions. *Sci Sports*. 2016;31(5):e155-e161.

107. Emirzeoğlu M, Ülger Ö. The Acute Effects of Cognitive-Based Neuromuscular Training and Game-Based Training on the Dynamic Balance and Speed Performance of Healthy Young Soccer Players: A Randomized Controlled Trial. *Games Health J*. 2021;10(2):121-129.

108. Giménez JV, Castellano J, Lipinska P, Zasada M, Gómez MÁ. Comparison of the Physical Demands of Friendly Matches and Different Types On-Field Integrated Training Sessions in Professional Soccer Players. *Int J Environ Res Public Health*. 2020;17(8):2904.

109. Lacome M, Simpson B, Broad N, Buchheit M. Monitoring players' readiness using predicted heart-rate responses to soccer drills. *Int J Sports Physiol Perform*. 2018;13(10):1273-1280.

110. McLean S, Kerhervé H, Lovell GP, Gorman AD, Solomon C. The effect of recovery duration on vastus lateralis oxygenation, heart rate, perceived exertion and time motion descriptors during small sided football games. *PloS One*. 2016;11(2):e0150201.

111. Torreblanca-Martínez V, Cordero-Ojeda R, González-Jurado J. Analysis of physical and technical-tactical demands through small-sided games in semi-professional football players. *Rev Retos*. 2019;35:87-90.

112. Vilamitjana J, Heinze G, Verde P, Calleja-González J. Comparison of Physical Demands between Possession Games and Matches in Football.

113. Abbott W, Brickley G, Smeeton NJ. Positional Differences in GPS Outputs and Perceived Exertion During Soccer Training Games and Competition. *J Strength Cond Res*. 2018;32(11):3222-3231. doi:10.1519/JSC.0000000000002387

114. Barrett S, Varley MC, Hills SP, et al. Understanding the Influence of the Head Coach on Soccer Training Drills—An 8 Season Analysis. *Appl Sci*. 2020;10(22):8149.

115. Belozo FL, Ferreira EC, Grandim GVM, et al. Effect of game format on the intensity of soccer training. *Rev Bras Med Esporte*. 2018;24(2):149-152.

116. Belozo FL, Ferreira EC, Lizana CJ, et al. The effect of the maintaining the ball possession on the intensity of games. *Mot Rev Educ Física*. 2016;22(1):54-61.

117. Bredt S da GT, Praça GM, Figueiredo LS, et al. Reliability of physical, physiological and tactical measures in small-sided soccer Games with numerical equality and numerical superiority. *Rev Bras Cineantropometria Desempenho Hum*. 2016;18(5):602-610.

118. Casamichana D, Castellano J, Martín-García A. Looking for Complementary Intensity Variables in Different Training Games in Football. *J Strength Cond Res*. Published online 2019.

119. Joo CH, Hwang-Bo K, Jee H. Technical and physical activities of small-sided games in young Korean soccer players. *J Strength Cond Res*. 2016;30(8):2164-2173.

120. Christopher J, Beato M, Hulton AT. Manipulation of exercise to rest ratio within set duration on physical and technical outcomes during small-sided games in elite youth soccer players. *Hum Mov Sci*. 2016;48:1-6.

121. Cicero D, Di Marino S, Dinallo V, et al. A small sided game session affects salivary metabolite levels in young soccer players. *Biomed Spectrosc Imaging*. 2016;5(1):55-70.

122. Clemente FM, Martins FML, Mendes RS, Campos F. Inspecting the performance of neutral players in different small-sided games. *Mot Rev Educ Física*. 2015;21(1):45-53.

123. Clemente FM, Owen A, Serra-Olivares J, et al. The effects of large-sided soccer training games and pitch size manipulation on time–motion profile, spatial exploration and surface area: Tactical opportunities. *Proc Inst Mech Eng Part P J Sports Eng Technol*. 2018;232(2):160-165.

124. Clemente FM, Wong DP, Martins FML, Mendes RS. Acute effects of the number of players and scoring method on physiological, physical, and technical performance in small-sided soccer games. *Res Sports Med*. 2014;22(4):380-397.

125. David C, Julen C. The relationship between intensity indicators in small-sided soccer games. *J Hum Kinet*. 2015;46:119.

126. Dellal A, Varliette C, Owen A, Chirico EN, Pialoux V. Small-sided games versus interval training in amateur soccer players: effects on the aerobic capacity and the ability to perform intermittent exercises with changes of direction. *J Strength Cond Res*. 2012;26(10):2712-2720.

127. Hourcade JC, Noirez P, Sidney M, Toussaint JF, Desgorces FD. Performance losses following threefold volume increases in soccer-specific training and in small-sided games. *Sci Med Footb*. 2019;3(1):3-13.

128. Impellizzeri FM, Marcora S, Castagna C, et al. Physiological and performance effects of generic versus specific aerobic training in soccer players. *Int J Sports Med*. 2006;27(06):483-492.

129. Owen AL, Wong DP, Paul D, Dellal A. Effects of a periodized small-sided game training intervention on physical performance in elite professional soccer. *J Strength Cond Res*. 2012;26(10):2748-2754.

130. Özcan İ, Eniseler N, Şahan Ç. Effects of small-sided games and conventional aerobic interval training on various physiological characteristics and defensive and offensive skills used in soccer. *Kinesiology*. 2018;50(1.):104-111.

131. Rabbani A, Clemente FM, Kargarfard M, Jahangiri S. Combined small-sided game and high-intensity interval training in soccer players: The effect of exercise order. *J Hum Kinet*. 2019;69:249.

132. Riboli A, Coratella G, Rampichini S, Cé E, Esposito F. Area per player in small-sided games to replicate the external load and estimated physiological match demands in elite soccer players. *PloS One*. 2020;15(9):e0229194. doi:10.1371/journal.pone.0229194

133. Rodríguez-Fernández A, Rodríguez-Marroyo J, Casamichana D, Villa J. Effects of 5-week pre-season small-sided-game-based training on repeat sprint ability. *J Sports Med Phys Fitness*. 2016;57(5):529-536.

134. Rowell AE, Aughey RJ, Clubb J, Cormack SJ. A standardized small sided game can be used to monitor neuromuscular fatigue in professional A-league football players. *Front Physiol*. 2018;9:1011.

135. Casamichana D, Castellano J, niversidad del País Vasco U, Herriko E, Calleja-Gonzalez J. COMPARING PHYSICAL AND PHYSIOLOGICAL PROFILE BETWEEN SMALL SIDED GAMES AND COMPETITION MATCHES... *J Sport Health Res*. 2014;6(1):19-28.

136. Sangnier S, Cotte T, Brachet O, Coquart J, Tourny C. Planning Training Workload in Football Using Small-Sided Games' Density. *J Strength Cond Res*. 2019;33(10):2801-2811.

137. Savoia C, Iellamo F, Caminiti G, et al. Rethinking training in elite soccer players: comparative evidence of small sided games and official match play in kinematic parameters. *J Sports Med Phys Fitness*. Published online December 14, 2020. doi:10.23736/S0022-4707.20.11400-2

138. Torres-Ronda L, Gonçalves B, Marcelino R, Torrents C, Vicente E, Sampaio J. Heart rate, time-motion, and body impacts when changing the number of teammates and opponents in soccer small-sided games. *J Strength Cond Res*. 2015;29(10):2723-2730.

139. Vázquez MÁC, Gómez DC, Arrones LS, Jurado JAG, Bendala FJT, Prados JAL. Medium-sided games in soccer: physical and heart rate demands throughout successive working periods. *J Hum Sport Exerc*. 2017;12(1):129-141.

140. Asian-Clemente J, Rabano-Muñoz A, Muñoz B, Franco J, Suarez-Arrones L. Can Small-side Games Provide Adequate High-speed Training in Professional Soccer? *Int J Sports Med*. Published online November 11, 2020. doi:10.1055/a-1293-8471

141. McKay AKA, Stellingwerff T, Smith ES, et al. Defining Training and Performance Caliber: A Participant Classification Framework. *Int J Sports Physiol Perform*. 2022;17(2):317-331. doi:10.1123/ijspp.2021-0451

142. Madison G, Patterson SD, Read P, Howe L, Waldron M. Effects of small-sided game variation on changes in hamstring strength. *J Strength Cond Res*. 2019;33(3):839-845.

143. Guard A, McMillan K, MacFarlane N. Influence of game format and team strategy on physical and perceptual intensity in soccer small-sided games. *Int J Sports Sci Coach*. Published online December 6, 2021:174795412110563. doi:10.1177/17479541211056399

144. Guard AN, McMillan K, MacFarlane NG. The influence of relative playing area and player numerical imbalance on physical and perceptual demands in soccer small-sided

game formats. *Sci Med Footb*. Published online June 11, 2021:1-7. doi:10.1080/24733938.2021.1939408

145. Aasgaard M, Kilding AE. Does Man Marking Influence Running Outputs and Intensity During Small-Sided Soccer Games? *J Strength Cond Res*. 2020;34(11):3266-3274. doi:10.1519/JSC.0000000000002668

146. Aquino R, Melli-Neto B, Ferrari JVS, et al. Validity and reliability of a 6-a-side small-sided game as an indicator of match-related physical performance in elite youth Brazilian soccer players. *J Sports Sci*. 2019;37(23):2639-2644.

147. Asian-Clemente JA, Rabano-Muñoz A, Núñez FJ, Suarez-Arrones L. External and internal load during small-sided games in soccer: use or not floaters. *J Sports Med Phys Fitness*. 2022;62(3):301-307. doi:10.23736/S0022-4707.21.12103-6

148. Ávalos Guillén JC, Gutierrez Vargas R, Araya Varas GA, Sánchez Ureña B, Gutierrez Vargas JC, Rojas Valverde D. EFECTOS DEL CESPED ARTIFICIAL Y LA GRAMA NATURAL SOBRE EL RENDIMIENTO FÍSICO Y TÉCNICO DE LOS JUGADORES PROFESIONALES DE FÚTBOL. *MHSALUD Rev En Cienc Mov Hum Salud*. 2017;14(1). doi:10.15359/mhs.14-1.1

149. Batista J, Goncalves B, Sampaio J, Castro J, Abade E, Travassos B. The influence of coaches' instruction on technical actions, tactical behaviour, and external workload in football small-sided games. *Montenegrin J Sports Sci Med*. 2019;8(1):29.

150. Baptista J, Travassos B, Gonçalves B, Mourão P, Viana JL, Sampaio J. Exploring the Effects of Playing Formations on Tactical Behavior and External Workload During Football Small-Sided Games. *J Strength Cond Res*. 2020;34(7):2024-2030. doi:10.1519/JSC.0000000000002445

151. Brandes M, Elvers S. Elite Youth Soccer Players' Physiological Responses, Time-Motion Characteristics, and Game Performance in 4 vs. 4 Small-Sided Games: The Influence of Coach Feedback. *J Strength Cond Res*. 2017;31(10):2652-2658. doi:10.1519/JSC.0000000000001717

152. Branquinho L, Ferraz R, Travassos B, C Marques M. Comparison between Continuous and Fractionated Game Format on Internal and External Load in Small-Sided Games in Soccer. *Int J Environ Res Public Health*. 2020;17(2):405.

153. Branquinho L, Ferraz R, Travassos B, Marinho DA, Marques MC. Effects of Different Recovery Times on Internal and External Load During Small-Sided Games in Soccer. *Sports Health Multidiscip Approach*. 2021;13(4):324-331. doi:10.1177/1941738121995469

154. Bujalance-Moreno P, Latorre-Román PA, Ramírez-Campillo R, Garcia-Pinillos F. Acute responses to 4 vs. 4 small-sided games in football players. *Kinesiology*. 2020;52(01):46-53.

155. Bujalance-Moreno P, Latorre-Román PA, Ramírez-Campillo R, Martínez-Amat A, García-Pinillos F. The inclusion of wildcard players during small-sided games causes alterations on players' workload. *Isokinet Exerc Sci*. 2021;29(1):101-110.

156. Bujalance-Moreno P, Latorre-Román PÁ, Martínez-Amat A, García-Pinillos F. Small-sided games in amateur players: rule modification with mini-goals to induce lower external load responses. *Biol Sport*. Published online 2022. doi:10.5114/biolsport.2022.105336

157. Casamichana D, Castellano J, Dellal A. Influence of different training regimes on physical and physiological demands during small-sided soccer games: continuous vs. intermittent format. *J Strength Cond Res*. 2013;27(3):690-697.

158. Casamichana D, Suarez-Arrones L, Castellano J, San Román-Quintana J. Effect of number of touches and exercise duration on the kinematic profile and heart rate response during small-sided games in soccer. *J Hum Kinet*. 2014;41:113.

159. Casamichana D, San Román-Quintana J, Castellano J, Calleja-González J. Influence of the type of marking and the number of players on physiological and physical demands during sided games in soccer. *J Hum Kinet*. 2015;47:259.

160. Casamichana D, Bradley PS, Castellano J. Influence of the varied pitch shape on soccer players physiological responses and time-motion characteristics during small-sided games. *J Hum Kinet*. 2018;64:171.

161. Castellano J, Casamichana D, Dellal A. Influence of game format and number of players on heart rate responses and physical demands in small-sided soccer games. *J Strength Cond Res*. 2013;27(5):1295-1303.

162. Castillo D, Lago-Rodríguez A, Domínguez-Díez M, et al. Relationships between players' physical performance and small-sided game external responses in a youth soccer training context. *Sustainability*. 2020;12(11):4482.

163. Castillo D, Yanci J, Raya-González J, Lago-Rodríguez Á. Influence of players' physical performances on the variation of the external and internal responses to repeated bouts of small-sided games across youth age categories. *Proc Inst Mech Eng Part P J Sports Eng Technol*. Published online May 12, 2021:175433712110175. doi:10.1177/17543371211017576

164. Cihan H. The effect of defensive strategies on the physiological responses and time-motion characteristics in small-sided games. *Kinesiology*. 2015;47(2.):179-187.

165. Clemente FM, Nikolaidis PT, Van Der Linden CMN, Silva B. Effects of small-sided soccer games on internal and external load and lower limb power: a pilot study in collegiate players. *Hum Mov*. 2017;18(1):50-57.

166. Clemente FM. Associations between wellness and internal and external load variables in two intermittent small-sided soccer games. *Physiol Behav*. 2018;197:9-14.

167. Clemente FM, Nikolaidis PT, Rosemann T, Knechtle B. Variations of internal and external load variables between intermittent small-sided soccer game training regimens. *Int J Environ Res Public Health*. 2019;16(16):2923.

168. Clemente FM, Theodoros Nikolaidis P, Rosemann T, Knechtle B. Shorter Small-Sided Game Sets May Increase the Intensity of Internal and External Load Measures: A Study in Amateur Soccer Players. *Sports*. 2019;7(5):107.

169. Clemente FM, Praça GM, Bredt S da GT, van der Linden CM, Serra-Olivares J. External load variations between medium-and large-sided soccer games: Ball possession games vs regular games with small goals. *J Hum Kinet*. 2019;70:191.

170. Clemente FM, Rabbani A, Kargarfard M, Nikolaidis PT, Rosemann T, Knechtle B. Session-To-Session Variations of External Load Measures of Youth Soccer Players in Medium-Sided Games. *Int J Environ Res Public Health*. 2019;16(19):3612.

171. Clemente F, RAbbANI Alire, Ferreira R, Araújo J. Drops in physical performance during intermittent small-sided and conditioned games in professional soccer players. *Hum Mov*. 21(1):7-14.

172. Coutinho D, Gonçalves B, Santos S, Travassos B, Folgado H, Sampaio J. Exploring how limiting the number of ball touches during small-sided games affects youth football players' performance across different age groups. *Int J Sports Sci Coach*. Published online August 2, 2021:174795412110370. doi:10.1177/17479541211037001

173. Darbellay J, Meylan CMP, Malatesta D. Monitoring matches and small-sided games in elite young soccer players. *Int J Sports Med*. 2020;41(12):832-838.

174. Dellal A, Chamari K, Owen AL, Wong DP, Lago-Penas C, Hill-Haas S. Influence of technical instructions on the physiological and physical demands of small-sided soccer games. *Eur J Sport Sci*. 2011;11(5):341-346.

175. Dellal A, Hill-Haas S, Lago-Penas C, Chamari K. Small-sided games in soccer: amateur vs. professional players' physiological responses, physical, and technical activities. *J Strength Cond Res*. 2011;25(9):2371-2381. doi:10.1519/JSC.0b013e3181fb4296

176. Dellal A, Drust B, Lago-Penas C. Variation of activity demands in small-sided soccer games. *Int J Sports Med*. 2012;33(05):370-375.

177. Falces-Prieto M, González-Fernández FT, Matas-Bustos J, et al. An Exploratory Data Analysis on the Influence of Role Rotation in a Small-Sided Game on Young Soccer Players. *Int J Environ Res Public Health*. 2021;18(13):6773. doi:10.3390/ijerph18136773

178. Ferraz R, Gonçalves B, Van Den Tillaar R, Jimenez Saiz S, Sampaio J, Marques MC. Effects of knowing the task duration on players' pacing patterns during soccer small-sided games. *J Sports Sci*. 2018;36(1):116-122.

179. Ferraz R, Gonçalves B, Coutinho D, et al. Effects of Knowing the Task's Duration on Soccer Players' Positioning and Pacing Behaviour during Small-Sided Games. *Int J Environ Res Public Health*. 2020;17(11):3843.

180. Fransson D, Nielsen TS, Olsson K, et al. Skeletal muscle and performance adaptations to high-intensity training in elite male soccer players: speed endurance runs versus small-sided game training. *Eur J Appl Physiol*. 2018;118(1):111-121.

181. Gaudino P, Iaia F, Alberti G, Hawkins R, Strudwick A, Gregson W. Systematic bias between running speed and metabolic power data in elite soccer players: influence of drill type. *Int J Sports Med*. 2014;35(6):489-493.

182. Gaudino P, Alberti G, Iaia FM. Estimated metabolic and mechanical demands during different small-sided games in elite soccer players. *Hum Mov Sci*. 2014;36:123-133.

183. Giménez JV, Gomez MA. Relationships Among Circuit Training, Small-Sided and Mini Goal Games, and Competition in Professional Soccer Players: A Comparison of On-Field Integrated Training Routines. *J Strength Cond Res*. 2019;33(7):1887-1896.

184. Giménez JV, Del-Coso J, Leicht AS, Gomez MÁ. Comparison of the movement patterns between small- and large-sided game training and competition in professional soccer players. *J Sports Med Phys Fitness*. 2018;58(10):1383-1389. doi:10.23736/S0022-4707.17.07343-1

185. Giménez JV, Liu H, Lipińska P, Szwarc A, Rompa P, Gómez MA. Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes. *Biol Sport*. 2018;35(1):75.

186. Gómez DC, Díaz AJG, Morera FC, García AM. Jugadores comodines durante diferentes juegos de posición [Wildcard Players during Positional Games]. *Apunts Educ Física Deport*. 2018;3(133):85-97.

187. Gómez-Carmona CD, Gamonales JM, Pino-Ortega J, Ibáñez SJ. Comparative analysis of load profile between small-sided games and official matches in youth soccer players. *Sports*. 2018;6(4):173.

188. Gonçalves B, Esteves P, Folgado H, Ric A, Torrents C, Sampaio J. Effects of pitch area-restrictions on tactical behavior, physical, and physiological performances in soccer large-sided games. *J Strength Cond Res*. 2017;31(9):2398-2408.

189. Halouani J, Ghattasi K, Bouzid MA, et al. Physical and physiological responses during the stop-ball rule during small-sided games in soccer players. *Sports*. 2019;7(5):117.

190. Hauer R, Störchle P, Karsten B, Tschan H, Baca A. Internal, external and repeated-sprint demands in small-sided games: A comparison between bouts and age groups in elite youth soccer players. Astorino TA, ed. *PLOS ONE*. 2021;16(4):e0249906. doi:10.1371/journal.pone.0249906

191. Hodgson C, Akenhead R, Thomas K. Time-motion analysis of acceleration demands of 4v4 small-sided soccer games played on different pitch sizes. *Hum Mov Sci*. 2014;33:25-32.

192. Ispirlidis I. Effects of two different small-sided games protocols on physiological parameters of professional soccer players. In: *Journal of Human Sport and Exercise - 2021 - Autumn Conferences of Sports Science*. Universidad de Alicante; 2021. doi:10.14198/jhse.2021.16.Proc2.01

193. Jastrzębski Z, Radzimiński Ł. Individual vs general time-motion analysis and physiological response in 4 vs 4 and 5 vs 5 small-sided soccer games. *Int J Perform Anal Sport*. 2015;15(1):397-410.

194. Jastrzebski Z, Radziminski L, Stepien P. Comparison of time-motion analysis and physiological responses during small-sided games in male and female soccer players. *Balt J Health Phys Act J Gdansk Univ Phys Educ Sport*. 2016;8(1).

195. Jastrzębski Z, Radzimiński Ł. Default and individual comparison of physiological responses and time-motion analysis in male and female soccer players during small-sided games. Published online 2017.

196. Köklü Y, Alemdaroğlu U, Cihan H, Wong DP. Effects of bout duration on players' internal and external loads during small-sided games in young soccer players. *Int J Sports Physiol Perform*. 2017;12(10):1370-1377.

197. Köklü Y, Cihan H, Alemdaroğlu U, Dellal A, Wong DP. Acute effects of small-sided games combined with running drills on internal and external loads in young soccer players. *Biol Sport*. 2020;37(4):375.

198. Langendam L, van der Linden C, Clemente FM. Difference in training load and technical actions during small-sided games in junior and senior soccer players. *Hum Mov*. 2017;18(5):146-156.

199. López-Fernández J, Gallardo L, Fernández-Luna Á, Villacañas V, García-Unanue J, Sánchez-Sánchez J. Pitch size and game surface in different small-sided games. Global indicators, activity profile, and acceleration of female soccer players. *J Strength Cond Res*. 2019;33(3):831-838.

200. López-Fernández J, Sánchez-Sánchez J, García-Unanue J, Hernando E, Gallardo L. Physical and Physiological Responses of U-14, U-16, and U-18 Soccer Players on Different Small-Sided Games. *Sports*. 2020;8(5). doi:10.3390/sports8050066

201. Lorenzo-Martínez M, de Dios-Álvarez VM, Padrón-Cabo A, Costa PB, Rey E. Effects of score-line on internal and external load in soccer small-sided games. *Int J Perform Anal Sport*. 2020;20(2):231-239.

202. Luchesi MS, Couto BP, Gabbett TJ, Praça GM, Oliveira MP, Sayers MGL. The influence of the field orientation on physical demands in soccer small-sided games. *Int J Sports Sci Coach*. Published online January 7, 2022:174795412110688. doi:10.1177/17479541211068830

203. Mallo J, Navarro E. Physical load imposed on soccer players during small-sided training games. *J Sports Med Phys Fitness*. 2008;48(2):166.

204. Mara JK, Thompson KG, Pumpa KL. Physical and physiological characteristics of various-sided games in elite women's soccer. *Int J Sports Physiol Perform*. 2016;11(7):953-958.

205. Martin-Garcia A, Castellano J, Diaz AG, Cos F, Casamichana D. Positional demands for various-sided games with goalkeepers according to the most demanding passages of match play in football. *Biol Sport*. 2019;36(2):171.

206. Martín-García A, Castellano J, Villanueva AM, Gómez-Díaz A, Cos F, Casamichana D. Physical demands of ball possession games in Relation to the most demanding passages of a competitive match. *J Sports Sci Med*. 2020;19(1):1.

207. Modena R, Togni A, Fanchini M, Pellegrini B, Schena F. Influence of pitch size and goalkeepers on external and internal load during small-sided games in amateur soccer players. *Sport Sci Health*. 2021;17(3):797-805. doi:10.1007/s11332-021-00766-3

208. Nunes NA, Gonçalves B, Coutinho D, Nakamura FY, Travassos B. How playing area dimension and number of players constrain football performance during unbalanced ball possession games. *Int J Sports Sci Coach*. Published online 2020:1747954120966416.

209. Nunes NA, Gonçalves B, Davids K, Esteves P, Travassos B. How manipulation of playing area dimensions in ball possession games constrains physical effort and technical actions in under-11, under-15 and under-23 soccer players. *Res Sports Med*. Published online 2020:1-15.

210. Nunes NA, Gonçalves B, Roca A, Travassos B. Effects of numerical unbalance constraints on workload and tactical individual actions during ball possession small-sided soccer games across different age groups. *Int J Perform Anal Sport*. 2021;21(3):396-408. doi:10.1080/24748668.2021.1903249

211. Olthof SB, Frencken WG, Lemmink KA. Match-derived relative pitch area changes the physical and team tactical performance of elite soccer players in small-sided soccer games. *J Sports Sci*. 2018;36(14):1557-1563. doi:10.1080/02640414.2017.1403412

212. Owen AL, Newton M, Shovlin A, Malone S. The use of small-sided games as an aerobic fitness assessment supplement within elite level professional soccer. *J Hum Kinet*. 2020;71:243.

213. Papanikolaou K, Tsimeas P, Anagnostou A, et al. Recovery Kinetics Following Small-Sided Games in Competitive Soccer Players: Does Player Density Size Matter? *Int J Sports Physiol Perform*. Published online 2020:1-11. doi:10.1123/ijspp.2020-0380

214. Praça GM, Andrade AGP, Bredt S da GT, Moura FA, Moreira PED. Progression to the target vs. regular rules in Soccer small-sided Games. *Sci Med Footb*. Published online 2021:1-6.

215. Rábano-Muñoz A, Asian-Clemente J, Sáez de Villarreal E, Nayler J, Requena B. Age-related differences in the physical and physiological demands during small-sided games with floaters. *Sports*. 2019;7(4):79.

216. Rago V, Rebelo AN, Pizzuto F, Barreira D. Small-sided soccer games on sand are more physically demanding but less technically specific compared to games on artificial turf. *J Sports Med Phys Fitness*. 2016;58(4):385-391.

217. Rebelo ANC, Silva P, Rago V, Barreira D, Krustrup P. Differences in strength and speed demands between 4v4 and 8v8 small-sided football games. *J Sports Sci*. 2016;34(24):2246-2254.

218. Reinhardt L, Schulze S, Kurz E, Schwesig R. An Investigation into the Relationship Between Heart Rate Recovery in Small-Sided Games and Endurance Performance in Male, Semi-professional Soccer Players. *Sports Med-Open*. 2020;6(1):1-8.

219. Riboli A, Dellal A, Esposito F, Coratella G. Can small-sided games assess the training-induced aerobic adaptations in elite football players? *J Sports Med Phys Fitness*. Published online November 10, 2021. doi:10.23736/S0022-4707.21.13144-5

220. Riboli A, B.H. Olthof S, Esposito F, Coratella G. Training elite youth soccer players: area per player in small-sided games to replicate the match demands. *Biol Sport*. Published online 2022. doi:10.5114/biolsport.2022.106388

221. Rojas-Valverde D, Morera-Castro M, Montoya-Rodríguez J, Gutiérrez-Vargas R. Demands of two small-sided games of Costa Rican college soccer players. *Pensar En Mov Rev Cienc Ejerc Salud*. 2017;15(1):66-76.

222. San Román-Quintana J, Casamichana D, Castellano J, Calleja-González J, Jukić I, Ostojić S. The influence of ball-touches number on physical and physiological demands of large-sided games. *Kinesiology*. 2013;45(2):171-178.

223. Sanchez-Sanchez J, Ramirez-Campillo R, Carretero M, Martín V, Hernández D, Nakamura FY. Soccer small-sided games activities vary according to the interval regime and their order of presentation within the session. *J Hum Kinet*. 2018;62:167.

224. Sannicandro I, Cofano G, Raiola G, Rosa RA, Colella D. Analysis of External Load in Different Soccer Small-Sided Games Played with External Wildcard Players. *J Phys Educ Sport*. 2020;20(2):672-679.

225. Sannicandro I, Piccinno A, Rosa RA, Raiola G, Cofano G. ANALYSIS OF EXTERNAL LOAD DURING SSG 5VS5 WITH AND WITHOUT EXTERNAL WILDCARD (JOLLY) SOCCER PLAYERS. Published online 2020.

226. Sannicandro I, Piccinno A, Rosa RA, Cofano G. Analysis of the External and Internal Load in 4vs4 Large Sided Games: Differences between Fields of Different Sizes. *Int J Hum Mov Sports Sci*. 2021;9(6):1470-1476. doi:10.13189/saj.2021.090644

227. Santos FJ, Figueiredo TP, Filho DMP, et al. Training Load in Different Age Category Soccer Players and Relationship to Different Pitch Size Small-Sided Games. *Sensors*. 2021;21(15):5220. doi:10.3390/s21155220

228. Santos FJ, Verardi CEL, de Moraes MG, et al. Effects of Pitch Size and Goalkeeper Participation on Physical Load Measures during Small-Sided Games in Sub-Elite Professional Soccer Players. *Appl Sci*. 2021;11(17):8024. doi:10.3390/app11178024

229. Sparkes W, Turner A, Weston M, Russell M, Johnston M, Kilduff L. Neuromuscular, Biochemical, Endocrine, and Mood Responses to Small-Sided Games' Training in Professional Soccer. *J Strength Cond Res*. 2018;32(9):2569-2576. doi:10.1519/JSC.0000000000002424

230. Sparkes W, Turner AN, Weston M, Russell M, Johnston M, Kilduff LP. The between-week reliability of neuromuscular, endocrine, and mood markers in soccer players and the repeatability of the movement demands during small-sided games. *J Sports Med Phys Fitness*. Published online December 9, 2021. doi:10.23736/S0022-4707.21.12993-7

231. Impellizzeri FM, Marcora SM, Coutts AJ. Internal and External Training Load: 15 Years On. *Int J Sports Physiol Perform*. 2019;14(2):270-273. doi:10.1123/ijspp.2018-0935

232. Clemente FM, Martins FM, Mendes RS. Periodization based on small-sided soccer games: Theoretical considerations. *Strength Cond J*. 2014;36(5):34-43.

233. Buchheit M. Programming high-speed running and mechanical work in relation to technical contents and match schedule in professional soccer. *Sport Perform Sci Rep*. 2019;64:v1.

234. Buchheit M, Simpson BM, Hader K, Lacome M. Occurrences of near-to-maximal speed-running bouts in elite soccer: insights for training prescription and injury mitigation. *Sci Med Footb*. Published online 2020:1-6.

235. Hader K, Rumpf MC, Hertzog M, Kilduff LP, Girard O, Silva JR. Monitoring the Athlete Match Response: Can External Load Variables Predict Post-match Acute and Residual Fatigue in Soccer? A Systematic Review with Meta-analysis. *Sports Med - Open*. 2019;5(1):48. doi:10.1186/s40798-019-0219-7

236. Beato M, Drust B, Iacono AD. Implementing High-speed Running and Sprinting Training in Professional Soccer. *Int J Sports Med*. Published online December 8, 2020:a-1302-7968. doi:10.1055/a-1302-7968

237. Malone S, Owen A, Mendes B, Hughes B, Collins K, Gabbett TJ. High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? *J Sci Med Sport*. 2018;21(3):257-262. doi:10.1016/j.jsams.2017.05.016

238. Sanchez-Sanchez J, Hernández D, Martin V, et al. Assessment of the external load of amateur soccer players during four consecutive training microcycles in relation to the external load during the official match. *Mot Rev Educ Física*. 2019;25(1):e101938. doi:10.1590/s1980-65742019000010014

239. Castellano J, Errekagorri I, Los Arcos A, et al. Tell me how and where you play football and I'll tell you how much you have to run. *Biol Sport*. Published online 2022. doi:10.5114/biolsport.2022.106155

240. Vigne G, Gaudino C, Rogowski I, Alloatti G, Hautier C. Activity profile in elite Italian soccer team. *Int J Sports Med*. 2010;31(5):304-310. doi:10.1055/s-0030-1248320

241. Mohr M, Krustrup P, Bangsbo J. Match performance of high-standard soccer players with special reference to development of fatigue. *J Sports Sci*. 2003;21(7):519-528. doi:10.1080/0264041031000071182

242. Carling C, Dupont G. Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? *J Sports Sci*. 2011;29(1):63-71. doi:10.1080/02640414.2010.521945

243. Hoppe MW, Slomka M, Baumgart C, Weber H, Freiwald J. Match Running Performance and Success Across a Season in German Bundesliga Soccer Teams. *Int J Sports Med*. 2015;36(7):563-566. doi:10.1055/s-0034-1398578

244. Schimpchen J, Skorski S, Nopp S, Meyer T. Are "classical" tests of repeated-sprint ability in football externally valid? A new approach to determine in-game sprinting behaviour in elite football players. *J Sports Sci*. 2016;34(6):519-526. doi:10.1080/02640414.2015.1112023

245. Castellano J, Casamichana D. Differences in the number of accelerations between small-sided games and friendly matches in soccer. *J Sports Sci Med*. 2013;12(1):209.

246. Ade J, Fitzpatrick J, Bradley PS. High-intensity efforts in elite soccer matches and associated movement patterns, technical skills and tactical actions. Information for position-specific training drills. *J Sports Sci*. 2016;34(24):2205-2214. doi:10.1080/02640414.2016.1217343

247. Barrera J, Sarmento H, Clemente FM, Field A, Figueiredo AJ. The Effect of Contextual Variables on Match Performance across Different Playing Positions in Professional Portuguese Soccer Players. *Int J Environ Res Public Health*. 2021;18(10):5175. doi:10.3390/ijerph18105175

248. Low B, Coutinho D, Gonçalves B, Rein R, Memmert D, Sampaio J. A Systematic Review of Collective Tactical Behaviours in Football Using Positional Data. *Sports Med Auckl NZ*. 2020;50(2):343-385. doi:10.1007/s40279-019-01194-7

249. Vilar L, Duarte R, Silva P, Chow JY, Davids K. The influence of pitch dimensions on performance during small-sided and conditioned soccer games. *J Sports Sci*. 2014;32(19):1751-1759. doi:10.1080/02640414.2014.918640

250. Silva P, Esteves P, Correia V, Davids K, Araújo D, Garganta J. Effects of manipulations of player numbers vs. field dimensions on inter-individual coordination during small-sided games in youth football. *Int J Perform Anal Sport*. 2015;15(2):641-659. doi:10.1080/24748668.2015.11868821

251. Silva P, Aguiar P, Duarte R, Davids K, Araújo D, Garganta J. Effects of Pitch Size and Skill Level on Tactical Behaviours of Association Football Players during Small-Sided and Conditioned Games. *Int J Sports Sci Coach*. 2014;9(5):993-1006. doi:10.1260/1747-9541.9.5.993

252. Reilly T, Cabri J, Araújo D, World Congress on Science and Football, eds. *Science and Football V: The Proceedings of the Fifth World Congress on Science and Football*. transferred to digital printing 2008. Routledge; 2005.

253. McLaren SJ, Macpherson TW, Coutts AJ, Hurst C, Spears IR, Weston M. The Relationships Between Internal and External Measures of Training Load and Intensity in Team Sports: A Meta-Analysis. *Sports Med Auckl NZ*. 2018;48(3):641-658. doi:10.1007/s40279-017-0830-z

254. Anderson L, Orme P, Michele RD, et al. Quantification of Seasonal-Long Physical Load in Soccer Players With Different Starting Status From the English Premier League: Implications for Maintaining Squad Physical Fitness. *Int J Sports Physiol Perform*. 2016;11(8):1038-1046. doi:10.1123/ijspp.2015-0672

255. Gualtieri A, Rampinini E, Sassi R, Beato M. Workload Monitoring in Top-level Soccer Players During Congested Fixture Periods. *Int J Sports Med*. 2020;41(10):677-681. doi:10.1055/a-1171-1865

256. Clemente FM, Ramirez-Campillo R, Afonso J, Sarmento H. Effects of Small-Sided Games vs. Running-Based High-Intensity Interval Training on Physical Performance in Soccer Players: A Meta-Analytical Comparison. *Front Physiol*. 2021;12:642703. doi:10.3389/fphys.2021.642703

257. Gregson W, Di Salvo V, Varley MC, et al. Harmful association of sprinting with muscle injury occurrence in professional soccer match-play: A two-season, league wide exploratory investigation from the Qatar Stars League. *J Sci Med Sport*. 2020;23(2):134-138. doi:10.1016/j.jsams.2019.08.289

258. Klein C, Luig P, Henke T, Bloch H, Platen P. Nine typical injury patterns in German professional male football (soccer): a systematic visual video analysis of 345 match injuries. *Br J Sports Med*. 2021;55(7):390-396. doi:10.1136/bjsports-2019-101344

259. Jaspers A, Kuyvenhoven JP, Staes F, Frencken WG, Helsen WF, Brink MS. Examination of the external and internal load indicators' association with overuse injuries in professional soccer players. *J Sci Med Sport*. 2018;21(6):579-585.

260. Kenneally-Dabrowski CJB, Brown NAT, Lai AKM, Perriman D, Spratford W, Serpell BG. Late swing or early stance? A narrative review of hamstring injury mechanisms during high-speed running. *Scand J Med Sci Sports*. 2019;29(8):1083-1091. doi:10.1111/sms.13437

261. Taylor J, Macpherson T, Spears I, Weston M. The effects of repeated-sprint training on field-based fitness measures: a meta-analysis of controlled and non-controlled trials. *Sports Med Auckl NZ*. 2015;45(6):881-891. doi:10.1007/s40279-015-0324-9

262. Askling CM, Tengvar M, Thorstensson A. Acute hamstring injuries in Swedish elite football: a prospective randomised controlled clinical trial comparing two rehabilitation protocols. *Br J Sports Med*. 2013;47(15):953-959. doi:10.1136/bjsports-2013-092165

263. Ekstrand J, Waldén M, Hägglund M. Hamstring injuries have increased by 4% annually in men's professional football, since 2001: a 13-year longitudinal analysis of the UEFA Elite Club injury study. *Br J Sports Med*. 2016;50(12):731-737. doi:10.1136/bjsports-2015-095359

264. Small K, McNaughton LR, Greig M, Lohkamp M, Lovell R. Soccer fatigue, sprinting and hamstring injury risk. *Int J Sports Med*. 2009;30(8):573-578. doi:10.1055/s-0029-1202822

265. Freeman BW, Talpey SW, James LP, Young WB. Sprinting and hamstring strain injury: Beliefs and practices of professional physical performance coaches in Australian football. *Phys Ther Sport Off J Assoc Chart Physiother Sports Med*. 2021;48:12-19. doi:10.1016/j.ptsp.2020.12.007

266. Wolski L, Pappas E, Hiller C, Halaki M, Fong Yan A. Is there an association between high-speed running biomechanics and hamstring strain injury? A systematic review. *Sports Biomech*. Published online September 27, 2021:1-27. doi:10.1080/14763141.2021.1960418

267. Malliaropoulos N, Mendiguchia J, Pehlivanidis H, et al. Hamstring exercises for track and field athletes: injury and exercise biomechanics, and possible implications for exercise selection and primary prevention. *Br J Sports Med*. 2012;46(12):846-851. doi:10.1136/bjsports-2011-090474

268. Guex K, Millet GP. Conceptual Framework for Strengthening Exercises to Prevent Hamstring Strains. *Sports Med*. 2013;43(12):1207-1215. doi:10.1007/s40279-013-0097-y

269. Voisin S, Jacques M, Lucia A, Bishop DJ, Eynon N. Statistical Considerations for Exercise Protocols Aimed at Measuring Trainability. *Exerc Sport Sci Rev*. 2019;47(1):37-45. doi:10.1249/JES.0000000000000176

270. Chrzanowski-Smith OJ, Piatrikova E, Betts JA, Williams S, Gonzalez JT. Variability in exercise physiology: Can capturing *intra* -individual variation help better understand true *inter* -individual responses? *Eur J Sport Sci*. 2020;20(4):452-460. doi:10.1080/17461391.2019.1655100

271. Johnston RJ, Watsford ML, Kelly SJ, Pine MJ, Spurrs RW. Validity and Interunit Reliability of 10 Hz and 15 Hz GPS Units for Assessing Athlete Movement Demands. *J Strength Cond Res*. 2014;28(6):1649-1655. doi:10.1519/JSC.0000000000000323

272. Beato M, Coratella G, Stiff A, Iacono AD. The Validity and Between-Unit Variability of GNSS Units (STATSports Apex 10 and 18 Hz) for Measuring Distance and Peak Speed in Team Sports. *Front Physiol*. 2018;9:1288. doi:10.3389/fphys.2018.01288

273. Dixon PM, Saint-Maurice PF, Kim Y, Hibbing P, Bai Y, Welk GJ. A Primer on the Use of Equivalence Testing for Evaluating Measurement Agreement. *Med Sci Sports Exerc*. 2018;50(4):837-845. doi:10.1249/MSS.0000000000001481

274. Riley RD, Higgins JPT, Deeks JJ. Interpretation of random effects meta-analyses. *BMJ*. 2011;342:d549. doi:10.1136/bmj.d549

275. Deeks JJ, Higgins JP, Altman DG, on behalf of the Cochrane Statistical Methods Group. Analysing data and undertaking meta-analyses. In: Higgins JPT, Thomas J, Chandler J, et al., eds. *Cochrane Handbook for Systematic Reviews of Interventions*. 1st ed. Wiley; 2019:241-284. doi:10.1002/9781119536604.ch10

276. Malone JJ, Lovell R, Varley MC, Coutts AJ. Unpacking the Black Box: Applications and Considerations for Using GPS Devices in Sport. *Int J Sports Physiol Perform*. 2017;12(Suppl 2):S218-S226. doi:10.1123/ijspp.2016-0236

277. Coutinho D, Gonçalves B, Travassos B, Abade E, Wong DP, Sampaio J. Effects of pitch spatial references on players' positioning and physical performances during football small-sided games. *J Sports Sci*. 2019;37(7):741-747. doi:10.1080/02640414.2018.1523671

278. Owen AL, Wong DP, McKenna M, Dellal A. Heart rate responses and technical comparison between small- vs. large-sided games in elite professional soccer. *J Strength Cond Res*. 2011;25(8):2104-2110. doi:10.1519/JSC.0b013e3181f0a8a3

279. Castelão D, Garganta J, Santos R, Teoldo I. Comparison of tactical behaviour and performance of youth soccer players in 3v3 and 5v5 small-sided games. *Int J Perform Anal Sport*. 2014;14(3):801-813. doi:10.1080/24748668.2014.11868759

280. Silva B, Garganta J, Santos R, Teoldo I. Comparing Tactical Behaviour of Soccer Players in 3 vs. 3 and 6 vs. 6 Small-Sided Games. *J Hum Kinet*. 2014;41(1):191-202. doi:10.2478/hukin-2014-0047

281. Folgado H, Duarte R, Fernandes O, Sampaio J. Competing with Lower Level Opponents Decreases Intra-Team Movement Synchronization and Time-Motion Demands during Pre-Season Soccer Matches. Haddad JM, ed. *PLoS ONE*. 2014;9(5):e97145. doi:10.1371/journal.pone.0097145

282. McAuley L, Tugwell P, Moher D. Does the inclusion of grey literature influence estimates of intervention effectiveness reported in meta-analyses? *The Lancet*. 2000;356(9237):1228-1231.

283. Paez A. Gray literature: An important resource in systematic reviews. *J Evidence-Based Med*. 2017;10(3):233-240.

284. Hartling L, Featherstone R, Nuspl M, Shave K, Dryden DM, Vandermeer B. Grey literature in systematic reviews: a cross-sectional study of the contribution of non-English reports, unpublished studies and dissertations to the results of meta-analyses in child-relevant reviews. *BMC Med Res Methodol*. 2017;17(1):64. doi:10.1186/s12874-017-0347-z