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Effects of pitch size on soccer players' physiological, physical, technical, and tactical responses during small-sided games: a meta-analytical comparison

AUTHORS: Filipe Manuel Clemente[1,2], Gibson Moreira Praça[3], Rodrigo Aquino[4], Daniel Castillo[5], Javier Raya-González[6], Markel Rico-González[7], José Afonso[8], Hugo Sarmento[9], Ana Filipa Silva[1,10], Rui Silva[1], Rodrigo Ramirez-Campillo[11,12]

[1] Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Rua Escola Industrial e Comercial de Nun'Álvares, 4900-347 Viana do Castelo, Portugal
[2] Instituto de Telecomunicações, Delegação da Covilhã, Lisboa 1049-001, Portugal
[3] Sports Department, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
[4] Department of Sports, Center of Physical Education and Sports, Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil
[5] Faculty of Education, Universidad de Valladolid, 42004, Soria, Spain
[6] Faculty of Health Sciences, Universidad Isabel I, Burgos, Spain
[7] Department of Physical Education and Sport, University of the Basque Country, UPV-EHU, Lasarte 71, 01007 Vitoria-Gasteiz, Spain
[8] Centre for Research, Education, Innovation and Intervention in Sport, Faculty of Sport of the University of Porto, Porto, Portugal
[9] University of Coimbra, Research Unit for Sport and Physical Activity. Faculty of Sport Sciences and Physical Education, Coimbra, Portugal
[10] The Research Centre in Sports Sciences, Health Sciences and Human Development (CIDESD), Vila Real 5001-801, Portugal
[11] Department of Physical Activity Sciences. Universidad de Los Lagos. Santiago, Chile
[12] Exercise and Rehabilitation Sciences Laboratory, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago 7591538, Chile

ABSTRACT: One of the most often-used task constraints in designing small-sided games (SSGs) is the manipulation of pitch size to promote increases or decreases in the relative area per player. Such adjustments cause changes in the acute responses during SSGs. This systematic review with meta-analysis aimed to compare the effects of smaller vs. larger pitch sizes on soccer players' physiological, physical, technical, and tactical responses during SSGs. Comparisons between smaller and larger pitches were not considered based on a specific size, but also between using at least two dimensions in the same comparative study, aiming to understand differences between using smaller and larger (independently of the specific dimensions). The data sources utilized were PubMed, PsycINFO, Scielo, Scopus, SPORTDiscus, and Web of Science. The database search initially yielded 249 titles. From those, 41 articles were eligible for the systematic review and meta-analysis. Results revealed that, compared to smaller pitches, SSGs played on larger pitches induced greater values for heart rate ($p < 0.001$; ES = 0.50), rate of perceived exertion ($p < 0.001$; ES = 0.70), total distance ($p < 0.001$; ES = 1.95), high-speed running ($p < 0.001$; ES = 1.20), stretch index ($p < 0.001$; ES = 1.02) and surface area ($p < 0.001$; ES = 1.54). No significant differences were found between pitch size regarding the numbers of accelerations ($p = 0.232$; ES = 0.45), decelerations ($p = 0.111$; ES = 0.85), passes ($p = 0.897$; ES = 0.02), dribbles ($p = 0.823$; ES = -0.05), or positional centroid ($p = 0.053$; ES = 0.56). Larger pitch sizes can be implemented as a meaningful task constraint to increase the internal and external load experienced by soccer players during SSGs, as well as to increase the dispersion of players while acting together. These results were found independent of format and age group.

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Corresponding author:
Rodrigo Ramirez-Campillo
Exercise and Rehabilitation Sciences Laboratory. School of Physical Therapy. Faculty of Rehabilitation Sciences. Universidad Andres Bello. Campus Casona. Fernandez Concha 700, Las Condes, Santiago, 7591538, Chile.
Phone: +56951399868.
E-mail: rodrigo.ramirez@unab.cl

ORCID:
Filipe Manuel Clemente
0000-0001-9813-2842

Gibson Moreira Praça
0000-0001-9971-7308

Rodrigo Aquino
0000-0002-4885-7316

Daniel Castillo
0000-0002-4159-6475

Javier Raya-González
0000-0002-3570-7159

Markel Rico-González
0000-0002-9849-0444

José Afonso
0000-0002-2038-393X

Hugo Sarmento
0000-0001-8681-0642

Ana Filipa Silva
0000-0002-1772-1272

Rui Silva
0000-0003-3380-864X

Rodrigo Ramirez-Campillo
0000-0003-2035-3279

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INTRODUCTION

Soccer is classified as an intermittent exercise [1] in which the effort exerted depends on the dynamic of the game [2]. Considering the complexity of soccer, performance is multidimensional—fitness status [3], technical skill [4], and tactical knowledge and execution [5] are just a few examples of parts that act concurrently to explain the ultimate outcome. Naturally, the aforementioned multidimensional factors also explain the physiological, physical, technical, and tactical responses of players training and matches [6].

The use of drill-based games such as small-sided games (SSGs), also known as small-sided conditioned games, have become popular since they reflect the multidimensional stimulus provided by matches while allowing the coach to alter players' specific responses by manipulating various task constraints [7–9]. SSGs can be thought of as adjusted versions of official games in which coaches adjust specific constraints (or conditions) to change the behaviors of the players [10]. Among the most common adjustments used by coaches is the pitch configuration, as implementing smaller vs. larger pitch sizes impacts players' behaviors [11].

Changing the pitch size (while keeping the same format of play) causes variations in relative area per player (calculated as the area of the pitch divided by the number of outfield players involved in the game) [12]. This manipulation is one of the main concerns while using SSGs since different relative areas per player for the same format change the players' responses [13, 14]. Decreasing or increasing the relative area per player can initiate changes in physiological responses, physical demands, technical execution, and tactical behavior (as well as collective dynamics) [15–17]. If the information is not systematized (e.g., using a meta-analysis), it is difficult to understand the true effects of changing the pitch size since different moderators may compromise the findings.

Most of the original studies testing the effects of different pitch sizes on players' responses have focused on specific measures within the main outcomes of physiological, physical, technical, and tactical responses [11]. In the case of physiological responses, the most often-used measures are heart rate, rate of perceived exertion (RPE), and blood lactate concentrations [14]. In the case of physical demands, microelectromechanical devices (e.g., Global Navigation Satellite System, Inertial Measurement Units) are usually used to assess the total distance covered, distances covered at different speed thresholds, and the number of accelerations/decelerations performed by players [18]. For technical execution, observational analysis is usually conducted to identify the number and accuracy of passes, receptions, dribbles, and shots during SSGs [15, 19]. Finally, in the case of tactical behavior also observational analysis is used to identify the accuracy of attacking and defensive behaviors or using bidimensional data to analyze measures related to the team's spread or dispersion in the pitch [20].

Since adjustments in pitch size for the same format of play (e.g., 4 vs. 4 played on a smaller pitch (50 m^2 per player) vs. a larger pitch (100 m^2 per player) induce changes in players' responses, it may be determinant to identify the impact of those changes. This allows coaches to understand the consequences of their adjustments on players' responses and identify the most appropriate pitch sizes for specific objectives. Although systematic reviews have been conducted on the topic of SSGs (particularly summarizing the evidence regarding the impact of pitch size manipulation on players' responses [7–9, 21, 22], no meta-analysis has been performed to identify the effects of smaller vs. larger pitch sizes on players' responses. A meta-analysis may provide consistent evidence about the magnitudes of changes occurring between smaller and larger pitch sizes. Therefore, the purpose of this systematic review with meta-analysis was to compare the effects of smaller vs. larger pith sizes on physiological, physical, technical, and tactical responses during small-sided soccer games.

MATERIALS AND METHODS

This systematic review and meta-analysis followed the Cochrane Collaboration [23], PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines [24] and guidelines for performing systematic review in sports sciences [25]. The PICOS approach (Population, Intervention, Comparator, Outcomes, Study design) was followed: (P) soccer players from any age-group, sex or skill, without injury, illness or other clinical condition; (I) smaller pitch sizes using any format of play (number of players involved) or other task condition; (C) larger pitch sizes using any format of play (number of players involved) or other task condition (keeping the same experimental conditions of smaller formats); (O) mean and standard deviation (SD) values in both pitch sizes for, at least, one of the following main outcomes: physiological responses, physical responses, technical actions and tactical behaviors; and (S) counterbalanced cross-over design. Important to highlight those comparisons between smaller and larger pitches were not considered based on a specific size, but also between using at least two dimensions in the same comparative study, aiming to understand differences between using smaller and larger (independently of the specific dimensions). The protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols with the number INPLASY202140016 and the DOI number 10.37766/inplasy2021.4.0016.

Eligibility criteria

Inclusion and exclusion criteria for this systematic review and meta-analysis can be found in table 1.

Duplicates were identified using a reference manager software (EndNote™ X9, Clarivate Analytics, Philadelphia, PA, USA). Two authors (FMC and HS) independently performed screening of the title, abstract and reference list of each study to locate potentially relevant studies. Additionally, they reviewed the full version of the papers in detail to identify articles that met the selection criteria and those that were excluded. A discussion was made in the cases of discrepancies regarding the selection process with the participation of a third author (AFS).

TABLE 1. Inclusion and exclusion criteria

Item	Inclusion criteria	Exclusion criteria
Population	Soccer players from any age-group, sex or skill, without injury, illness or other clinical condition.	Other sports than soccer (e.g., futsal or football indoor, beach soccer, American football, Australian football, basketball, handball, volleyball, hockey).
Intervention	Smaller pitch sizes using any format of play (number of players involved) or other task condition. The following conditions were ensured: • The same pitch size was repeated at least two times (two repetitions) for the same players; • The smaller pith size was extracted from the lowest relative pitch area (i.e., in case of studies comparing ≥ three pitch sizes for the same format or condition, only the smallest pitch size was extracted); • The same experimental conditions between smaller and larger pitch sizes were ensured (i.e., same teams, same players, same time duration, same task constraints).	• The same pitch size was applied in only one repetition; • Smaller and larger pitch sizes conditions were not applied with same contextual and experimental conditions.
Comparator	Larger pitch sizes using any format of play (number of players involved) or other task condition. The following conditions were ensured: • The same pitch size was repeated at least two times (two repetitions) for the same players; • The larger pith size was extracted from the greatest relative pitch area (i.e., in case of studies comparing ≥ three pitch sizes for the same format or condition, only the largest pitch size was extracted); • The same experimental conditions between smaller and larger pitch sizes were ensured (i.e., same teams, same players, same time duration, same task constraints).	• The same pitch size was applied in only one repetition; • Smaller and larger pitch sizes conditions were not applied with same contextual and experimental conditions.
Outcome	At least one measure of the following possibilities: • Physiological responses (e.g., heart rate, blood lactate concentrations or rated of perceived exertion); • Physical demands (e.g., total distance, distances covered at different speed thresholds, acceleration/ decelerations); • Technical execution (e.g., passes, receptions, shots); • Tactical behavior (e.g., attacking or defensive tactical principles, collective organization measures)	Other outcomes than those related to immediate physiological and physical, technical or tactical responses (e.g., fatigue tests, well-being tests).
Study design	A counterbalanced cross-over design.	Non-counterbalanced cross-over design studies.
Additional criteria	Peer reviewed, original, full-text studies written in English, Portuguese and/or Spanish.	Written in other language than those selected (English, Portuguese and/or Spanish). Reviews, letters to editors, trial registrations, proposals for protocols, editorials, book chapters, conference abstracts.

Information sources

Electronic databases (PubMed, PsycINFO, Scielo, Scopus, SPORTDiscus and Web of Science) were searched for relevant publications prior to the February 18, 2021. Keywords and synonyms were entered in various combinations in all fields: ("soccer" OR "football") AND ("small-sided games" OR "conditioned games" OR "SSG" OR "drill-based games" OR "small-sided conditioned games") AND ("pitch" OR "field"). Additionally, the reference lists of the included studies retrieved were manually searched to identify potentially eligible studies not captured by the electronic searches. Finally, an external expert in small-sided games with more than 10 publications in the last five years was contacted to verify the final list of references included in this systematic review and to indicate if there was any study that was not detected through our research.

Extraction of data

A data extraction sheet, adapted from the Cochrane Consumers and Communication Review Group's data extraction template [26], was used to assess inclusion requirements and subsequently tested on ten randomly selected studies (i.e., pilot testing). This process was conducted by two independent reviewers (FMC and HS). Any disagreement regarding study eligibility was resolved in a discussion between both reviewers and a third author (AFS). Full text articles excluded, with reasons, were recorded. The records were registered in a form created in Microsoft Excel (Microsoft Corporation, Readmon, WA, USA).

Data items

Aiming to establish consistency in data analyzing and reporting, only measures that were analyzed three or more times for different articles were included. For physiological responses the following list of measures were extracted, and following this order of priority: (i) heart rate responses (e.g., absolute or relative); (ii) blood lactate concentrations; and (iii) RPE. For physical demands, the following list of measures were extracted and following this order of priority: (i) total distance covered; (ii) distance covered at different speed thresholds; (iii) accelerations and decelerations (number at different intensity thresholds); and (iv) mechanical workload measures (derived from inertial measurement unit). For technical execution the following list of measures were extracted and following this order of priority: (i) individual passes (total number, relative number considering accuracy); (ii) individual receptions (total number, relative number considering accuracy); (iii) individual shots (total number, relative number considering accuracy); and (iv) individual dribbles (total number, relative number considering accuracy). For tactical behavior the following list of measures were extracted and following this order of priority: (i) individual attacking tactical behavior; (ii) individual defensive tactical behavior; (iii) collective measure of dispersion. Tests and instruments used for measuring the outcomes were also extracted. Mean and SD for each outcome extracted in smaller and larger pitch sizes were collected. Additionally, the following information was extracted from the included studies: (i) number of participants (n), age-group (years), competitive level (e.g., elite, professional, amateur) and sex; (ii) the SSGs format (e.g., 5 vs 5; 6 vs 6), pitch size and relative area per player; (iii) regimen of intervention (work duration, work intensity, modality, relief duration, relief intensity, repetitions and series, between-set recovery).

Assessment of methodological quality

The methodological index for non-randomized studies (MINORS) was used for assessing the methodological quality of the included studies [27]. This scale classifies twelve items of the original articles, in which a score of zero indicates the absence of a report, the score of one represents that report is inadequate and two points indicate that the report is adequate. Two of the authors (HS and MRG) independently assessed the methodological quality. Any disagreement in the rating was resolved through discussion and by a third author (FMC).

Summary measures, synthesis of results, and publication bias

Although two studies can be used in meta-analyses [28], considering reduced sample sizes are common in the sports science literature [29], particularly SSG studies [30], analysis and interpretation of results in this systematic review and meta-analysis were only conducted in the case of at least three study groups provided mean and standard-deviation for smaller and larger pith sizes for the same measure. Means and SD for dependent variables were used to calculate effect sizes (ES; Hedge's *g*) for each outcome in the smaller and larger pitch sizes. In case means and SDs were not available, they were obtained from 95% confidence intervals (CIs) or standard error of mean (SEM), using Cochrane's RevMan Calculator. Data were standardized using post-intervention SD values. The random-effects model was used to account for differences between studies that might impact the SSG-based effect [31, 32]. The ES values are presented with 95% CI. Calculated ES were interpreted using the following scale: < 0.2, trivial; 0.2–0.6, small; > 0.6–1.2, moderate; > 1.2–2.0, large; > 2.0–4.0, very large; > 4.0, extremely large [33]. Heterogeneity was assessed using the I^2 statistic, with values of < 25%, 25–75%, and > 75% considered to represent low, moderate, and high levels of heterogeneity, respectively [34]. The risk of bias was explored using the extended Egger's test [35]. To adjust for publication bias, a sensitivity analysis was conducted using the trim and fill method [36], with L0 as the default estimator for the number of missing studies [37]. All analyses were carried out using the Comprehensive Meta-Analysis software (version 2; Biostat, Englewood, NJ, USA). Statistical significance was set at $p \leq 0.05$.

Moderator analyses

Using a random-effects model and independent computed single factor analysis, potential sources of heterogeneity likely to influence the effects of SSGs were selected *a priori*. As the responses to SSGs may be affected by the format of play, sub-group analysis considered

the following the groups of formats of play [38]: (a) duels (1vs.1); (b) small formats (2vs.2, 3vs.3 and 4vs.4); (c) medium formats (5vs.5, 6vs.6, 7vs.7, 8vs.8); and (d) large formats (9vs.9, 10vs.10, 11vs.11). Additionally, information about age-group was also considered as moderator (young & youth < 23 years old since is the last category of youth in soccer; adults > 23 years old).

RESULTS

Study identification and selection

The searching of databases identified an initial 249 titles. Duplicates (160 references) were subsequently removed either automatically or manually. The remaining 89 articles were screened. After reading full texts, a further 47 studies were excluded owing to a number of reasons: studies not performed in soccer, studies that not compare two pitch size (or not with the same condition), and studies not reporting physical, physiological, technical, or tactical outcomes. Therefore, 42 articles were eligible for the systematic review and 41 for the meta-analysis (Figure 1). The included articles provided mean and SD for smaller and larger pitch sizes data for at least one main outcome.

Methodological quality

The assessment of the included studies can be found in Table 2.

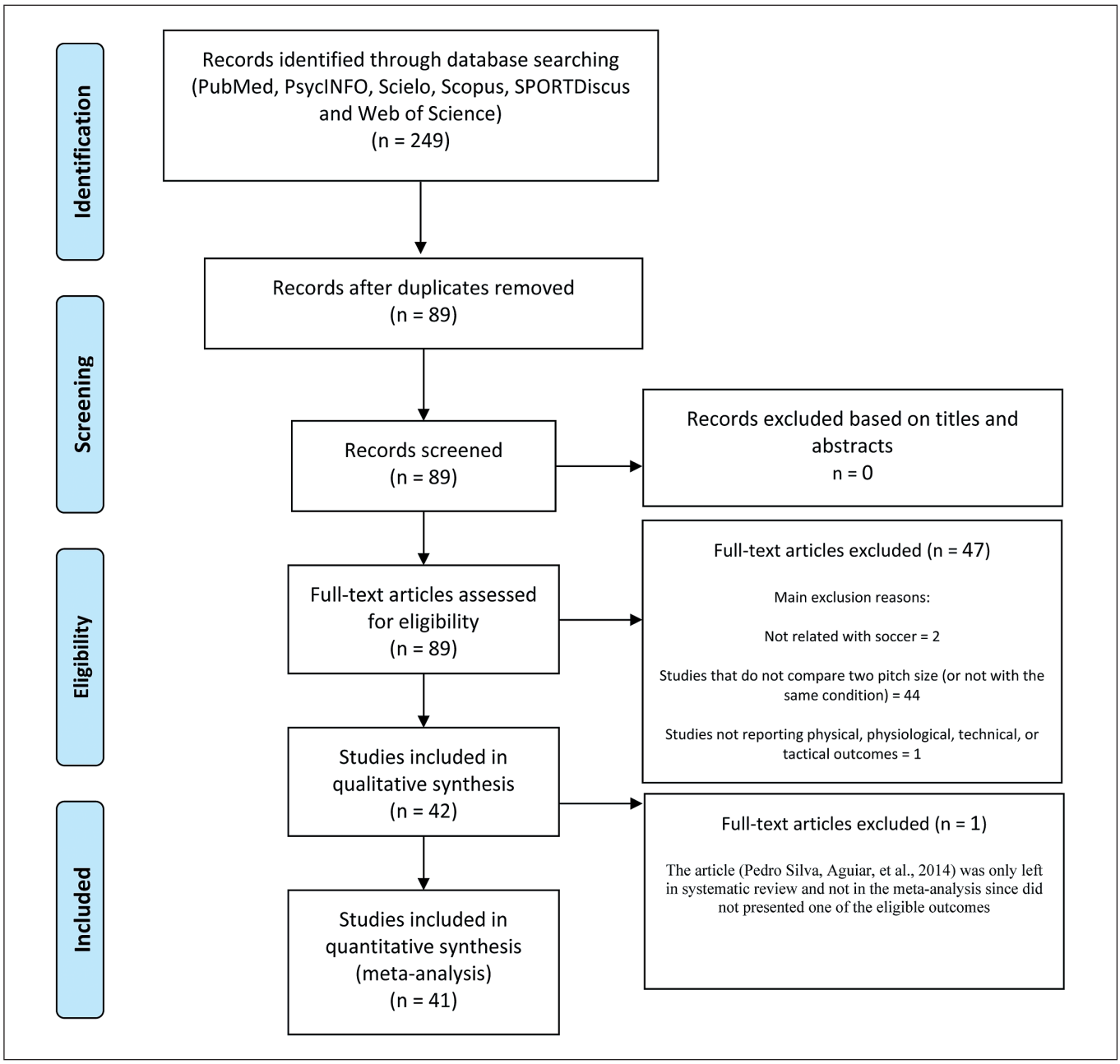

FIG. 1. PRISMA flow diagram highlighting the selection process for studies.

TABLE 2. Assessment of studies methodological quality using the MINORS scale

Study	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	Total** (%)
[71]	1	1	1	1	0	1	1	1	-	1	1	1	90
[72]	1	0	1	1	0	0	1	1	-	1	0	1	64
[73]	1	0	1	1	0	1	1	1	-	1	0	1	72
[74]	1	0	1	1	0	1	1	1	-	1	1	1	81
[40]	1	0	1	1	0	0	1	1	-	1	0	1	64
[18]	1	1	1	1	1	0	1	1	-	1	1	1	90
[75]	1	0	1	1	0	1	1	1	-	1	0	1	72
[76]	1	1	1	1	0	0	1	1	-	1	0	1	72
[77]	1	0	1	1	0	0	1	1	-	1	1	1	72
[14]	1	0	1	1	0	1	1	1	-	1	1	1	81
[13]	1	1	1	1	0	1	1	1	-	1	1	1	90
[78]	1	0	1	1	0	1	1	1	-	1	1	1	81
[79]	1	1	1	1	0	1	1	1	-	1	1	1	90
[80]	1	1	1	1	0	0	1	1	-	1	1	1	81
[68]	1	0	1	1	0	0	1	1	-	1	.0	1	64
[81]	1	0	1	1	0	0	1	1	-	1	0	1	64
[82]	1	0	1	1	0	1	1	1	-	1	1	1	81
[69]	1	0	1	1	0	0	1	1	-	1	0	1	64
[83]	1	1	1	1	0	1	1	1	-	1	1	1	90
[84]	1	0	1	1	0	0	1	1	-	1	1	1	72
[85]	1	0	1	1	0	1	1	1	-	1	1	1	81
[61]	1	1	1	1	0	0	1	1	-	1	1	1	81
[86]	1	0	1	1	0	1	1	1	-	1	0	1	72
[87]	1	0	1	1	0	1	1	1	-	1	1	1	81
[88]	1	0	1	1	0	1	1	1	-	1	1	1	81
[39]	1	0	1	1	1	1	1	1	-	1	1	1	91
[17]	1	0	1	1	0	0	1	1	-	1	0	1	64
[89]	1	0	1	1	0	1	1	1	-	1	1	1	81
[19]	1	1	1	1	0	1	1	1	-	1	1	1	90
[90]	1	1	1	1	0	0	1	0	-	1	1	1	73
[91]	1	1	1	1	0	1	1	1	-	1	1	1	91
[92]	1	0	1	1	0	0	1	1	-	1	0	1	64
[62]	1	0	1	1	0	0	1	1	-	1	1	1	72
[93]	1	1	1	1	0	0	1	1		1	1	1	81
[66]	1	1	1	1	0	0	1	1	-	1	1	1	81
[94]	1	1	1	1	0	0	1	1	-	1	0	1	72
[95]	1	0	1	1	0	1	1	1	-	1	0	1	72
[96]	1	0	1	1	0	0	1	1	-	1	0	1	64
[20]	1	0	1	1	0	0	1	1	-	1	1	1	72
[58]	1	0	1	1	0	0	1	1	-	1	1	1	72
[97]	1	0	1	1	0	1	1	1	-	1	0	1	72
[98]	1	0	1	1	0	0	1	1	-	1	0	1	64

*: MINORS scale items number; N..1: A clearly study aimed; N.. 2: Inclusion of consecutive patients; N.. 3: Prospective collection of data; N.. 4: Endpoints appropriate to the aim of the study; N.. 5: Unbiased assessment of the study endpoint; N.. 6: Follow-up period appropriate to the aim of the study; N.. 7: Loss to follow less than 5%; N.. 8: Prospective calculation of the study size; N.. 9: An adequate control group; N..10: Contemporary groups; N.. 11: Baseline equivalence of groups; N.. 12: Adequate statistical analyses; **: the total number of points from a ossible maximal of 24.

Study characteristics

The characteristics of the included studies in the meta-analysis can be found in Table 3. Additionally, the details of the SSGs-interventions can be found in Table 4.

Smaller vs. larger pitch sizes during SSG: effects on physiological responses

A summary of the included studies and results of physiological responses (HR and RPE) reported in smaller and larger SSGs are provided in Table 5.

TABLE 3. Characteristics of the included studies and outcomes extracted.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[71]	10 recreational players	31.7 ± 7.6	0.25–0.50	Male	Yes	Repeated measures	Mean HR; peak HR; RPE; HR zones; ball possession; dribbling; passes; tackles; shots. *Pitch effect:* ball possessions and unsuccessful passes were higher on a small pitch.	HR monitor; 15-point Borg scale; video cameras	Physiological responses; Technical actions
[72]	16 youth elite players	16.9 ± 0.3	-	Male	Yes	Repeated measures	Maximum velocity; mean velocity; distance covered at several velocities; accelerations. *Pitch effect:* more HI distance is covered in higher SSG.	GPS	Physical responses
[73]	9 professional soccer players	26.2 ± 3.7	5.5	Male	Yes	Repeated measures	Maximum velocity; distance/min; distance covered at several velocities; mean HR; peak HR; HR zones. *Pitch effect:* higher physical values in larger areas.	GPS; HR monitor	Physical responses; Physiological responses
[74]	20 amateur soccer players	21.0 ± 5.0	11	Male	No	Repeated measures	Peak HR; RPE; TD; maximum velocity; player load; accelerations/deceleration; change of directions. *Pitch effect:* increasing the pitch length had a greater effect compared to increasing the pitch width.	HR monitor; 10-point Borg scale; GPS	Physiological responses; Physical responses
[40]	10 male youth players	15.5 ± 0.5	7.5	Male	Yes	Repeated measures	Effective playing time; start of play; contact surface; successful actions. *Pitch effect:* increase frequency of motor actions when pitch is reduced.	Video camera	Technical actions
[18]	10 male youth players	15.5 ± 0.5	7.5	Male	Yes	Repeated measures	Effective playing time; Peak HR; HR zones; RPE; TD; distance/min; distance covered at several velocities; work-rest ratio; sprint frequency; several technical actions. *Pitch effect:* increasing the pitch size increase the effective playing time, the physical and physiological workload and the RPE, but reduce the frequency of motor actions.	HR monitor; 10-point Borg scale; GPS; video camera	Physiological responses; Physical responses; Technical actions
[75]	19 professional players	17.1 ± 0.3	-	Male	Yes	Repeated measures	TD; HI velocity; HI accelerations; HI decelerations; HI metabolic power; Lactate; Mean HR; Peak HR; RPE. *Pitch effect:* Lower SSG elicit lower external load values than higher SSGs	GPS; HR monitor; lactate portable analyser; 10-point Borg scale	Physical responses; Physiological responses

TABLE 3. Continue.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[76]	28 youth players	U13: 13.5 ± 0.3 U14: 14.3 ± 0.3	> 3	Male	Yes	Repeated measures	TD; distance covered at several velocities; player load; exertion index; work-rest ratio; Maximum velocity. *Pitch effect:* increasing pitch size elicit higher responses in both groups.	Accelerometer; GPS	Physical responses
[77]	24 youth elite players	13.3 ± 0.5	> 3	Male	Yes	Repeated measures	TD; distance covered at several velocities; player load; exertion index; work-rest ratio; Maximum velocity; Mean HR; Peak HR; RPE; HR zones. *Pitch effect:* higher pitch sizes are associated with increases in TD, work-rest ratio, player load, Peak HR and in the distance covered at 8 km/h.	GPS; HR monitor; 10-point Borg scale	Physical responses; Physiological responses
[14]	44 youth players	U12: 12.1 ± 0.4 U13: 13.3 ± 0.5	> 1	Male	No	Repeated measures	TD; distance covered at several velocities; player load; exertion index; work-rest ratio; Maximum velocity; Mean HR; Peak HR; RPE; HR zones. *Pitch effect:* higher pitch size is related with greater responses.	GPS; HR monitor; 10-point Borg scale	Physical responses; Physiological responses
[13]	28 youth players	U13: 13.5 ± 0.3 U14: 14.3 ± 0.3	> 3	Male	No	Repeated measures	Team length; width length; convex hull; stretch index; distance between centroids; length of both teams; width of both teams; convex hull of both teams; stretch index of both teams. *Pitch effect:* higher pitch size is related with greater tactical responses.	GPS	Tactical responses
[78]	24 youth players	11.8 ± 0.3	> 3	Male	Teams configuration	Repeated measures	TD; distance covered at several velocities; number of sprints; Maximum velocity; accelerations; decelerations; body impacts. *Pitch effect:* increasing pitch size elicit higher responses.	GPS	Physical responses
[79]	10 youth players	14.8 ± 0.6	> 3	Male	No	Repeated measures	TD; distance covered at several velocities; number of sprints; Maximum velocity; Mean HR; Peak HR. *Pitch effect:* increasing pitch size elicit higher responses.	GPS; HR monitor	Physical responses; Physiological responses
[80]	20 youth players	14.9 ± 0.6	> 3	Male	No	Repeated measures	TD; distance covered at several velocities; number of sprints; Maximum velocity; accelerations; decelerations; body impacts. *Pitch effect:* larger SSG demanded a higher external load in comparison with shorter SSG.	GPS	Physical responses

TABLE 3. Continue.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[68]	10 amateur players	23.4 ± 3.9	-	Male	No	Repeated measures	TD; distance covered at several velocities; number of sprints; spatial exploration index. *Pitch effect:* increasing pitch size elicit higher responses.	GPS	Physical responses; Tactical responses
[81]	10 amateur players	23.4 ± 3.9	-	Male	No	Repeated measures	Centroid; stretch index. *Pitch effect:* increasing pitch size elicit higher tactical responses.	GPS	Tactical responses
[82]	40 international players	25.3 ± 2.4	-	Male	Yes	Repeated measures	%HR reserve; Peak HR; RPE; lactate; TD, TD in sprinting; TD in HI; duels, passes, balls lost; ball possessions. *Pitch effect:* SSG elicit higher demands compared to friendly matches, except for lactate, successful passes and ball possessions.	HR monitor; GPS; semi-automatic multiple camera system; lactate portable analyser; 10-point Borg scale.	Physical responses; Physiological responses; Technical responses
[69]	10 amateur players	22.0 ± 3.0	-	Male	No	Repeated measures	Centroid; area; inter-team distance in longitudinal and lateral directions; distance of centroids. *Pitch effect:* increasing pitch size elicit greater area and distances.	LPS	Tactical responses
[83]	11 youth players	16.3 ± 0.6	> 6	Male	No	Repeated measured	Metabolic power; TD; HI demands. *Pitch effect:* increasing pitch size elicit higher responses.	GPS	Physical responses
[84]	8 amateur players	27.2 ± 3.1	12	Male	No	Repeated measured	Shots; passes; accurate passes; inaccurate passes; dribbles; interceptions; tackles. *Pitch effect:* no influence of pitch size on technical actions.	Digital cameras.	Technical responses
[85]	16 youth players	13.2 ± 0.6	> 3	Male	Yes	Repeated measures	HR; RPE: lactate. *Pitch effect:* higher physiological responses in larger pitch size.	HR monitor; lactate portable analyser; 10-point Borg scale.	Physiological responses
[61]	8 university-level players	20.0 ± 1.0	> 5	Male	Yes	Repeated measures	TD; HI distance; sprint distance; accelerations; decelerations; Peak HR; Maximum HR; pass; tackle; header; turn; interception; dribbling; shots. *Pitch effect:* increasing pitch size elicit higher responses.	GPS; HR monitor; video camera.	Physical responses; Physiological responses; Technical responses
[86]	29 junior players	18.1 ± 1.3	-	Male	No	Repeated measures	TD; Peak HR; HR zones; RPE. *Pitch effect:* increasing pitch size elicit higher physiological responses.	Video manual motion tracker; HR monitor; 10-point Borg scale	Physical responses; Physiological responses

TABLE 3. Continue.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[87]	3 youth goalkeepers	16.6 ± 0.9	7.3	Male	No	Repeated measures	Goalkeeper's actions: Goal kick; direct free kick; indirect free kick; pass by hand; pass by foot; length; direction; area; save; deflection; clear-out; Open palm; parry; fly; 1-on-1; screen; zone intervention. *Pitch effect:* decreasing pitch size elicit higher goalkeepers' technical responses.	Observational tool	Technical responses; Tactical responses
[88]	3 goalkeepers	24.5 ± 7.2	11	Male	No	Repeated measures	TD; spatial exploration index; predictive ellipse area; standard ellipse area; distance covered at different velocities; accelerations; decelerations. *Pitch effect:* increasing pitch size elicit lower goalkeepers' physical responses and higher tactical responses.	GPS	Physical responses; Tactical responses
[39]	149 young players	12.0 ± 0.4	-	Male	Yes	Repeated measures	Field players and goalkeepers actions: Ball touches; Passes; Shots; TD in play; TD out play Distance covered at different velocities. *Pitch effect:* pitch size influences on physical and technical responses of field players and goalkeepers.	Semi-automated multi-camera system	Physical responses; Technical responses
[17]	8 elite players	18.0 ± 1	-	Male	Yes	Repeated measures	Mean HR; pass; receive; turn; dribble; header; tackle; interception; shot; target pass. *Pitch effect:* While pitch size does not affect physiological responses, increasing pitch size elicit higher shots and tackles.	HR monitor; video camera	Physiological responses; Technical responses
[89]	16 youth players	14.2 ± 0.6	5.5	Male	Yes	Repeated measures	Mean HR; %HRmax; RPE. *Pitch effect:* Increasing pitch size elicit higher physiological responses.	HR monitor; 10-point Borg scale	Physiological responses
[19]	48 youth players	U13 U14	-	Male	Teams' composition	Repeated measures	TD; distance covered at different velocities; Peak HR; Mean HR. *Pitch effect:* no influence of pitch size on physical and physiological demands	GPS; HR monitor	Physiological responses; Physical responses
[90]	16 elite players	19.6 ± 2.0	5.8	Female	Yes	Repeated measures	TD; body loads, high-intensity distance. *Pitch effect:* Increasing pitch size elicit higher physical responses.	GPS	Physical responses
[91]	16 elite players	19.6 ± 2.0	5.8	Female	Yes	Repeated measures	Peak HR; Mean HR; %HRmean; HR zones; VAS scales. *Pitch effect:* Increasing pitch size elicit higher physiological responses at low intensities.	HR monitor; questionnaire	Physiological responses

TABLE 3. Continue.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[92]	10 youth players	13.0 ± 0.3	-	Male	No	Repeated measures	HR HI; passes; dribbles; possessions. *Pitch effect:* No influence in HR HI and increasing pitch size elicit higher lower possessions and higher ball touches.	HR monitor; Video camera	Physiological responses; Tecnhical responses
[62]	23 university players	22.3 ± 2.0	12.1	Male	Teams' composition	Repeated measures	TD; distance covered at different velocities; sprints; maximum sprint speed; ball contacts; maximum passing speed; RPE. *Pitch effect:* increasing pitch size elicit higher physical responses.	GPS; 10-point Borg scale; Play Soccer system	Physical responses; Physiological responses; Technical responses
[93]	52 youth players	U11: 10.0 ± 0.7 U15: 14.0 ± 1.3 U23: 21.0 ± 1.6	1.0 3.0 6.5	Male	-	Repeated measures	TD; distance covered at different velocities; sprints; maximum sprint speed; ball contacts; maximum passing speed; RPE. *Pitch effect:* increasing pitch size elicit higher physical responses and influence on technical actions.	GPS; 10-point Borg scale; Play Soccer system	Physical responses; Physiological responses; Technical responses
[66]	148 youth players	U12: 12.5 ± 0.5 U14: 14.4 ± 0.5 U16: 16.6 ± 3.2 U18: 17.9 ± 1.0	-	Male	Teams' composition	Repeated measures	TD; HI distance; sprints; inter-team distance, LPW-ratio, surface area, stretch indices, goalkeeper-defender distance; tactical variability. *Pitch effect:* increasing pitch size elicit higher physical responses and intra-team and inter-team distances and tactical variability.	LPS	Physical responses; Tactical responses
[94]	10 recreational players	20.1 ± 1.1	-	Male	-	Repeated measures	Mean HR; %HRmax; HR zones; TD; distance covered at different velocities; maximal speed; efforts; player load. *Pitch effect:* increasing pitch size elicit higher physiological and physical responses.	HR monitor; GPS	Physiological responses; Physical responses
[95]	20 amateur players	24.5 ± 4.1	15	Male	Yes	Repeated measures	Mean HR; Blood lactate; RPE. *Pitch effect:* increasing pitch size elicit higher physiological responses.	HR monitor; lactate portable analyser	Physiological responses
[96]	86 youth players	U10 U13	-	Male	Yes	Repeated measures	Mean HR; Peak HR; HR zones; TD; efforts; distance covered at different velocities; player load; number of technical actions; successful actions; success rate. *Pitch effect:* increasing pitch size elicit higher physical responses and lower technical involvement.	HR monitor; GPS; video camera	Physiological responses; Physical responses; Technical responses

TABLE 3. Continue.

Study	N	Mean + SD age (y)	Experience (y)	Sex	Randomization of SSGs order	Design	Variables assessed in the study and tendency	Tests or tools used	Outcome extracted
[20]	20 youth players	16.2 ± 0.6 [a] 15.6 ± 0.5	6.6 6.2	Male	No	Repeated measures	Spatial distribution variability; Shannon entropy; player-to-locus distance; coefficient of variation; sample entropy. *Pitch effect:* manipulating pitch size influence on movement variability.	GPS	Tactical responses. The outcomes were not obtained for meta-analysis since none was within the information extracted, thus keeping only in the systematic review
[58]	20 youth players	16.2 ± 0.6 15.6 ± 0.5	6.6 6.2	Male	No	Repeated measures	Team separateness; effective playing space; length-width ratio; average mutual information in longitudinal direction; average mutual information in lateral direction; sample entropy of distance to nearest opponent. *Pitch effect:* manipulating pitch size influence on tactical responses.	GPS	Tactical responses
[97]	24 youth players	14.5 ± 0.5	6.1	Male	Yes	Repeated measures	Effective relative space per player; radius of free movement; spatial distribution variability; numerical relations. *Pitch effect:* manipulating pitch size influence on spatial distributions and numerical relations.	GPS	Tactical responses
[98]	15 amateur players	21.9 ± 2.0	9.9	Male	Teams' composition	Repeated measures	Interpersonal distance attackers and defenders; distance to intercept a shot; distance to intercept a pass. *Pitch effect:* increasing pitch size elicit greater opportunities to maintain ball possessions.	Video camera	Tactical responses
[69]	10 amateur players	22.0 ± 3.0	-	Male	No	Repeated measures	Centroid; area; inter-team distance in longitudinal and lateral directions; distance of centroids. *Pitch effect:* increasing pitch size elicit greater area and distances.	LPS	Tactical responses

Notes. GPS: global position system; HI: high-intensity; HR: heart rate; LPS: local positioning system; RPE: rate of perceived exertion; SD: standard-deviation; SSG: small-sided games; TD: total distance; VAS: visual analogue scale.

TABLE 4. Characteristics of small-sided games (SSGs) in the included studies.

Study	SSG formats	Smaller pitch (length´ width)	Smaller pitch (area per player -m^2)	Larger pitch (length ˙ width)	Larger pitch (area per player -m^2)	Larger/ Smaller (m^2)	Task conditions	Sets	Reps	Work duration	Between reps duration	Type of recovery
[71]	5vs.5 + GK 7vs.7 + GK	44 × 23 m	5 players: 101.2 m^2 7 players: 72.3 m^2	57 × 30 m	5 players: 171.0 m^2 7 players: 122.1 m^2	5 players: 1.7x 7 players: 1.7x	No throw-ins; restart the game as quickly as possible.	1	1	40 min	-	-
[72]	4vs.4	Not reported (125 m^2)	15.6 m^2	Not reported (300 m^2)	37.5 m^2	2.4x	Verbal encouragement.	1	1	8 min	-	-
[73]	6vs.6 + 1 6vs. + 1 + GK	20 × 30 m	43 m^2	50 × 40 m	154 m^2	3.6x	Two touch per player; verbal encouragement; restart the game as quickly as Possible.	1	4	20 min	2 min	Passive
[74]	5vs.5 + GK	40 × 25 m	100 m^2	66 × 50 m	330 m^2	3.3x	No offside rule.	1	4	24 min	8 min	Passive
[40]	5vs.5 + GK	32 × 23 m	73.6 m^2	62 × 44 m	272.8 m^2	3.7x	No offside rule; verbal encouragement.	1	3	24 min	5 min	Passive
[18]	5vs.5 + GK	32 × 23 m	73.6 m^2	62 × 44 m	272.8 m^2	3.7x	No offside rule; verbal encouragement.	1	3	24 min	5 min	Passive
[75]	1vs.1	20 × 10 m	100 m^2	30 × 20 m	300 m^2	3.0x	Verbal encouragement; restart the game as quickly as possible; players free to score from any distance; no ball touches limit.	1	4	2 min	3 min	Active
[76]	7vs.7 + GK	30 × 40 m	100 m^2	60 × 40 m	200 m^2	2x	Restart the game as quickly as possible; offside rule.	1	4	28 min	4 min	Passive
[77]	7vs.7 + GK 9vs.9 + GK 11vs.11 + GK	45 × 27 m	100 m^2	100 × 60 m	300 m^2	3x	Verbal encouragement; restart the game as quickly as possible.	1	2	24 min	5 min	Passive
[14]	7vs.7 + GK 9vs.9 + GK 11vs.11 + GK	45 × 27 m	100 m^2	100 × 60 m	300 m^2	3x	Verbal encouragement; restart the game as quickly as possible.	1	2	24 min	5 min	Passive
[13]	7vs.7 + GK	30 × 40 m	100 m^2	60 × 40 m	200 m^2	2x	Restart the game as quickly as possible; offside rule.	1	4	28 min	4 min	Passive
[78]	6vs.6	22 × 13 m	25 m^2	39 × 23	75 m^2	3x	Restart the game as quickly as possible; verbal encouragement; offside rule in some configurations.	1	1	6 min	-	-
[79]	5vs.5 + GK	38 × 26 m	100 m^2	53 × 37 m	200 m^2	2x	Restart the game as quickly as possible; verbal encouragement.	1	6 4	4 min 6 min	2 min	Active
[80]	5vs.5 + GK	38 × 26 m	100 m^2	53 × 37 m	200 m^2	2x	Restart the game as quickly as possible; verbal encouragement; offside rule.	1	4	6 min	2 min	Active
[68]	11vs.11 + GK	54 × 68 m	167 m^2	108 × 68 m	334 m^2	2x	Official game rules	1	1	30 min	-	-
[81]	11vs.11 + GK	54 × 68 m	167 m^2	108 × 68 m	334 m^2	2x	Official game rules.	1	1	30 min	-	-
[82]	11vs.11 + GK	30 × 20 m	75 m^2	100 × 60 m	273 m^2	3.6x	Touch limitation (1, 2 or free).	1	4	16 min	3 min	Passive
[69]	4vs.4 + GK	24 × 16 m	38.4 m^2	30 × 20 m	60 m^2	1.6x	No offside rule; GK had 2-touch play; outfield players had to avoid long-range shots.	1	1	8 min	8 min	-
[83]	5vs.5 + GK	39 × 25 m	81 m^2	78 × 50 m	325 m^2	4x	No offside rule.	1	1	35 min	-	-

TABLE 4. Continue.

Study	SSG formats	Smaller pitch (length´ width)	Smaller pitch (area per player -m^2)	Larger pitch (length´ width)	Larger pitch (area per player -m^2)	Larger/ Smaller (m^2)	Task conditions	Sets	Reps	Work duration	Between reps duration	Type of recovery
[84]	4vs.4	34 × 26 m	111 m^2	40 × 30 m	150 m^2	1.4x	Miniature goals; Restart the game as quickly as possible; no offside rule.	1	3	18 min	5 min	-
[85]	4vs.4	10 × 15 m	19 m^2	20 × 25 m	62.5 m^2	3.3x	Restart the game as quickly as possible; verbal encouragement; free touches.	1	4	16 min	2 min	Passive
[61]	5vs.5 + GK	30 × 20 m	60 m^2	50 × 40 m	200 m^2	3.3x	Tournament scenario; restart the game as quickly as possible; verbal encouragement.	1	4	16 min	3 min	-
[86]	5vs.5 + GK 5vs.5	28 × 20 m	56 m^2	42 × 30 m	126 m^2	2.3x	Balls were disposed around the game areas.	1	3	12 min	3 min	Active
[87]	5vs.5 + GK	32 × 23 m	73.6 m^2	62 × 44 m	272.8 m^2	3.7x	Goalkeepers restart the game as quickly as possible.	1	3	24 min	5 min	Passive
[88]	5vs.5 + GK	32 × 23 m	73.6 m^2	62 × 44 m	272.8 m^2	3.7x	Goalkeepers restart the game as quickly as possible.	1	3	24 min	5 min	Passive
[39]	8vs.8 + GK	68 × 47 m	199.75 m^2	75 × 47 m	220.31 m^2	1.1x	Balls were disposed around the game areas; verbal encouragement.	1	1	30 min	-	-
[17]	5vs.5 + GK	30 × 20 m	60 m^2	50 × 40 m	200 m^2	3.3x	Balls were disposed around the game areas; verbal encouragement.	1	4	16 min	2 min	Active
[89]	3vs.3 + 4 4vs.4 + 4	20 × 15 m 20 × 20 m	50 m^2 50 m^2	30 × 20 m 32 × 25 m	100 m^2 100 m^2	2.0x	Balls were disposed around the game areas; verbal encouragement.	1 1	4 4	12 min 16 min	2 min 2 min	Passive
[19]	3vs.3 + GK + 1	36 × 27 m	138.9 m^2	40 × 29	165.7 m^2	1.2x	Offside rule; balls were disposed around the game areas; verbal encouragement; not technical and tactical instructions.	1	4	16 min	4 min	Passive
[90]	4vs.4	20 × 20 m	50 m^2	28.3 × 28.3 m	100 m^2	2x	Balls were disposed around the game areas; verbal encouragement.	1	3	4 min	10 min	Active
[91]	4vs.4	20 × 20 m	50 m^2	28.3 × 28.3 m	100 m^2	2x	Balls were disposed around the game areas; verbal encouragement.	1	3	4 min	10 min	Active
[92]	5vs.5	30 × 20 m	60 m^2	51 × 34 m	173.4 m^2	2.9x	Stop the ball with their foot backside to the limits of the pitch to score; balls were disposed around the game areas.	1	4	16 min	1 min	Passive

TABLE 4. Continue.

Study	SSG formats	Smaller pitch (length´width)	Smaller pitch (area per player -m²)	Larger pitch (length´width)	Larger pitch (area per player -m²)	Larger/ Smaller (m²)	Task conditions	Sets	Reps	Work duration	Between reps duration	Type of recovery
[62]	4vs.3 4vs.4 4vs.5	20 × 15 m	42.9 m² 37.5 m² 33.3 m²	30 × 25 m	107.1 m² 93.75 m² 83.3 m²	2.5x 2.5x 2.5x	Coach did not intervene; Balls were disposed around the game areas.	1	4	16 min	4 min	Active
[93]	4vs.4	20 × 15 m	37.5 m²	30 × 25 m	93.75 m²	2.5x	Coach did not intervene; Balls were disposed around the game areas.	1	4	16 min	4 min	Active
[66]	4vs.4 + GK	40 × 30 m	120 m²	68 × 47 m	320 m²	2.7x	Coach players similar to match; offside rule in large pitch; no offside rule in small pitch.	1	5	20 min	4 min	-
[94]	4vs.4 + GK	37 × 17 m	60 m²	40 × 20 m	80 m²	1.3x	No verbal encouragement; Balls were disposed around the game areas; one referee.	1	2	40 min	5 min	Passive
[95]	3vs.3 4vs.4 5vs.5 6vs.6	12 × 20 m 16 × 24 m 20 × 28 m 24 × 32 m	40 m² 48 m² 56 m² 64 m²	18 × 30 m 24 × 36 m 30 × 42 m 36 × 48 m	90 m² 108 m² 126 m² 144 m²	2.3x 2.3x 2.3x 2.3x	With and without coach encouragement.	1	3	12 min	3 min	Active
[96]	5vs.5 8vs.8	30 × 40 m	120 m²	105 × 68 m	325 m²	2.7x	Smaller goals or normal goals.	1	1	20 min	-	-
[20]	4vs.4 + GK	23.8 × 36.8 m	88 m²	37.4 × 57.8 m	216 m²	2.5x	Not allowed passing to the goalkeeper; coach did not intervene.	1	3	7 min	7 min	Active
[58]	4vs.4 + GK	36.8 × 23.8 m	87.6 m²	57.8 × 37.4 m	216.2 m²	2.5x	Not allowed passing to the goalkeeper.	1	3	7 min	7 min	Active
[97]	6vs.6	46.7 × 30.3 m	118 m²	52.9 × 34.4 m	152 m²	1.3x	Scoring zone; balls were disposed around the game areas; coach did not intervene.	1	3	18 min	4 min	Passive
[98]	5vs.5	28 × 14 m	39.2 m²	52 × 26 m	135.2 m²	3.4x	Small goals.	1	2	10 min	5 min	-
[69]	4vs.4 + GK	24 × 16 m	38.4 m²	30 × 20 m	60 m²	1.6x	No offside rule; GK had 2-touch play; outfield players had to avoid long-range shots.	1	1	8 min	8 min	-

Notes. GK: goalkeepers;

TABLE 5. Summary of the included studies and results of physiological responses in smaller and larger pitch sizes.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[71]	5vs.5 + GK	Adults	10	HR	164.3 ± 11.9	167.0 ± 13.2	1.9	Increase in larger pitch size	Yes
[71]	7vs.7 + GK	Adults	10	HR	161.2 ± 12.9	163.5 ± 12.8	1.4	Increase in larger pitch size	Yes
[71]	5vs.5 + GK	Adults	10	RPE	12.4 ± 1.2	13.2 ± 1.9	6.5	Increase in larger pitch size	Yes
[71]	7vs.7 + GK	Adults	10	RPE	12.3 ± 0.9	12.8 ± 1.2	4.1	Increase in larger pitch size	Yes
[73]	6vs.6 + 1	Adults	9	HR	86.7 ± 7.7	89.1 ± 4.6	2.8	Increase in larger pitch size	Yes
[74]	5vs.5 + GK	Adults	20	HR	83.4 ± 5.1	86.5 ± 4.5	3.7	Increase in larger pitch size	Yes
[74]	5vs.5 + GK	Adults	20	RPE	3.8 ± 1.5	6.6 ± 1.2	84.8	Increase in larger pitch size	Yes
[18]	5vs.5 + GK	Youth [f]	10	HR	86.0 ± 5.8	88.9 ± 3.9	4.5	Increase in larger pitch size	Yes
[18]	5vs.5 + GK	Youth [f]	10	RPE	5.7 ± 1.0	6.7 ± 0.8	17.5	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	HR	157 ± 8	169 ± 6	7.6	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	RPE	5.1 ± 1.6	8 ± 1	56.9	Increase in larger pitch size	Yes
[77]	7vs.7 + GK	Youth [c]	24	HR	82 ± 3	88 ± 6	7.3	Increase in larger pitch size	Yes
[77]	7vs.7 + GK	Youth [c]	24	RPE	267.1 ± 47.5	299.9 ± 41.3	12.3	Increase in larger pitch size	Yes
[77]	9vs.9 + GK	Youth [c]	24	HR	83 ± 6	85 ± 6	2.4	Increase in larger pitch size	Yes
[77]	9vs.9 + GK	Youth [c]	24	RPE	233.4 ± 28.7	270.9 ± 25.8	16.1	Increase in larger pitch size	Yes
[77]	11vs.11 + GK	Youth [c]	24	HR	81 ± 4	88 ± 4	8.6	Increase in larger pitch size	Yes
[77]	11vs.11 + GK	Youth [c]	24	RPE	228.6 ± 49.3	306.1 ± 39.3	33.9	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [b]	22	HR	85.3 ± 7.1	88.3 ± 3.3	3.5	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [b]	22	RPE	283 ± 26	297 ± 25	4.9	Increase in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [b]	22	HR	84.7 ± 2.9	83.3 ± 4.5	-1.7	Decrease in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [b]	22	RPE	297 ± 35	310 ± 35	4.4	Increase in larger pitch size	Yes
[14]	11vs.11 + GK	Youth [b]	22	HR	80.0 ± 5.5	83.1 ± 5.0	3.9	Increase in larger pitch size	Yes
[14]	11vs.11 + GK	Youth [b]	22	RPE	257 ± 55	285 ± 41	10.9	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [c]	22	HR	81.8 ± 10.5	87.4 ± 4.4	3.5	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [c]	22	RPE	267 ± 47.5	300 ± 41	12.4	Increase in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [c]	22	HR	82.6 ± 4.7	84.7 ± 2.6	2.54	Increase in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [c]	22	RPE	297 ± 35	271 ± 26	-8.8	Decrease in larger pitch size	Yes

TABLE 5. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[14]	11vs.11 + GK	Youth [c]	22	HR	80.8 ± 2.8	87.6 ± 3.1	8.4	Increase in larger pitch size	Yes
[14]	11vs.11 + GK	Youth [c]	22	RPE	257 ± 55	306 ± 39	19.1	Increase in larger pitch size	Yes
[79]	5vs.5 + GK	Youth [e]	10	HR	180 ± 8	180 ± 8	0.0	No differences	Yes
[82]	11vs.11 + GK	Adults	40	HR	84.7 ± 2.7	83.2 ± 2.6	-1.8	Decrease in larger pitch size	Yes
[82]	11vs.11 + GK	Adults	40	RPE	7.3 ± 0.6	7.4 ± 0.5	1.4	Increase in larger pitch size	Yes
[85]	4vs.4 (SB)	Youth [d]	16	HR	166.9 ± 3.1	174.9 ± 3.2	4.8	Increase in larger pitch size	Yes
[85]	4vs.4 (SB)	Youth [d]	16	RPE	6.3 ± 0.9	7.1 ± 0.9	12.7	Increase in larger pitch size	Yes
[85]	4vs.4 (SG)	Youth [d]	16	HR	163.9 ± 3.2	170.9 ± 2.7	4.3	Increase in larger pitch size	Yes
[85]	4vs.4 (SG)	Youth [d]	16	RPE	5.8 ± 0.9	6.8 ± 0.8	17.2	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	HR	164 ± 14	168 ± 17	2.4	Increase in larger pitch size	Yes
[86]	5vs.5 + GK	Youth [h]	29	HR	169.3 ± 6.2	176.4 ± 7.5	4.2	Increase in larger pitch size	Yes
[86]	5vs.5 + GK	Youth [h]	29	RPE	4.9 ± 1.3	7.5 ± 1.8	53.1	Increase in larger pitch size	Yes
[86]	5vs.5	Youth [h]	29	HR	174.2 ± 6.5	177.1 ± 5.8	1.7	Increase in larger pitch size	Yes
[86]	5vs.5	Youth [h]	29	RPE	4.7 ± 1.1	7.1 ± 1.1	51.1	Increase in larger pitch size	Yes
[17]	5vs.5 + GK	Youth [h]	8	HR	175 ± 9	169 ± 6	-3.4	Decrease in larger pitch size	Yes
[89]	3vs.3 + 4	Youth [d]	16	HR	176.3 ± 2.5	184.2 ± 6.5	4.5	Increase in larger pitch size	Yes
[89]	4vs.4 + 4	Youth [d]	16	HR	175.0 ± 7.7	183.5 ± 8.4	4.9	Increase in larger pitch size	Yes
[19]	3vs.3 + GK + 1	Youth [c]	24	HR	168.0 ± 10.7	166.3 ± 11.9	-1.0	Increase in smaller pitch size	Yes
[19]	3vs.3 + GK + 1	Youth [d]	24	HR	164.1 ± 12.5	168.9 ± 11.2	2.9	Increase in larger pitch size	Yes
[91]	4vs.4	Youth [i]	16	HR	169.4 ± 12.1	169.3 ± 11.6	-0.1	Decrease in larger pitch size	Yes
[91]	4vs.4	Youth [i]	16	HR	163.7 ± 10.9	164.4 ± 9.7	0.4	Increase in larger pitch size	Yes
[91]	4vs.4	Youth [i]	16	HR	160.1 ± 8.8	165.5 ± 8.7	3.4	Increase in larger pitch size	Yes
[92]	5vs.5	Youth [c]	10	HR	85 ± 4	85 ± 5	0.0	No differences	Yes
[62]	4vs.3	Youth [i]	20	RPE	4.0 ± 0.5	3.8 ± 1.1	-5.0	Decrease in larger pitch size	Yes
[62]	4vs.4	Youth [i]	20	RPE	4.3 ± 0.8	4.0 ± 1.1	-7.0	No differences	Yes
[62]	4vs.5	Youth [i]	20	RPE	4.5 ± 0.8	5.0 ± 1.1	11.1	Increase in larger pitch size	Yes
[62]	4vs.2 + 1	Youth [i]	20	RPE	4.5 ± 0.8	5.3 ± 0.8	17.8	Increase in larger pitch size	Yes
[62]	4vs.2 + 2	Youth [i]	20	RPE	3.8 ± 0.8	5.3 ± 1.3	39.5	Increase in larger pitch size	Yes
[62]	4vs.2 + 3	Youth [i]	20	RPE	3.5 ± 1.1	3.3 ± 1.3	-5.7	No diferences	Yes

TABLE 5. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[93]	4vs.4	Youth [a]	16	RPE	3.9 ± 1.1	3.5 ± 1.0	-11.4	Decrease in larger pitch size	Yes
[93]	4vs.4	Youth [e]	18	RPE	4.3 ± 1.1	4.6 ± 1.0	7.0	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [i]	18	RPE	4.7 ± 0.9	4.9 ± 0.9	4.3	Increase in larger pitch size	Yes
[94]	4vs.4 + GK	Youth [i]	10	HR	160 ± 10	167 ± 9	4.4	Increase in larger pitch size	Yes
[95]	3vs.3	Adults	20	HR	89.5 ± 2.9	90.9 ± 2.0	1.4	Increase in larger pitch size	Yes
[95]	4vs.4	Adults	20	HR	88.7 ± 2.0	89.7 ± 1.8	1.0	Increase in larger pitch size	Yes
[95]	5vs.5	Adults	20	HR	87.8 ± 3.6	88.8 ± 2.3	1.0	Increase in larger pitch size	Yes
[95]	6vs.6	Adults	20	HR	86.4 ± 2.0	86.9 ± 2.4	0.5	Increase in larger pitch size	Yes
[95]	3vs.3	Adults	20	RPE	8.1 ± 0.6	8.5 ± 0.4	4.9	Increase in larger pitch size	Yes
[95]	4vs.4	Adults	20	RPE	7.6 ± 0.5	8.1 ± 0.-5	6.6	Increase in larger pitch size	Yes
[95]	5vs.5	Adults	20	RPE	7.2 ± 0.9	7.5 ± 0.6	4.2	Increase in larger pitch size	Yes
[95]	6vs.6	Adults	20	RPE	6.8 ± 0.6	7.2 ± 0.8	5.9	Increase in larger pitch size	Yes
[95]	3vs.3	Adults	20	HR	87.6 ± 1.7	89.1 ± 1.8	1.5	Increase in larger pitch size	Yes
[95]	4vs.4	Adults	20	HR	86.5 ± 3.4	87.2 ± 2.8	0.7	Increase in larger pitch size	Yes
[95]	5vs.5	Adults	20	HR	86.0 ± 4.0	86.9 ± 3.2	0.9	Increase in larger pitch size	Yes
[95]	6vs.6	Adults	20	HR	83.8 ± 5.0	85.0 ± 3.6	1.2	Increase in larger pitch size	Yes
[95]	3vs.3	Adults	20	RPE	6.6 ± 0.4	7.2 ± 0.7	0.6	Increase in larger pitch size	Yes
[95]	4vs.4	Adults	20	RPE	6.3 ± 0.5	6.8 ± 0.5	0.5	Increase in larger pitch size	Yes
[95]	5vs.5	Adults	20	RPE	5.9 ± 0.7	6.2 ± 0.6	0.3	Increase in larger pitch size	Yes
[95]	6vs.6	Adults	20	RPE	4.8 ± 0.9	5.9 ± 0.5	1.1	Increase in larger pitch size	Yes
[96]	5vs.5 8vs.8	Youth [a]	45	HR	174 ± 10	168 ± 12	-3.4	Decrease in larger pitch size	Yes
[96]	8vs.8 11vs.11	Youth [c]	41	HR	170 ± 10	171 ± 12	0.6	Increase in larger pitch size	Yes

SD: standard-deviation; HR: heart rate; RPE: rate of perceived exertion; SB: stop-ball; SG: small-goals; NR: data not reported; %: percentage of difference; a: Under-11 or below group; b: Under-12; group; c: Under-13 group; d: Under-14 group; e; under-15 group; f: under-16 group; g: under-17 group; h: under-18 group; i: under-23 group.

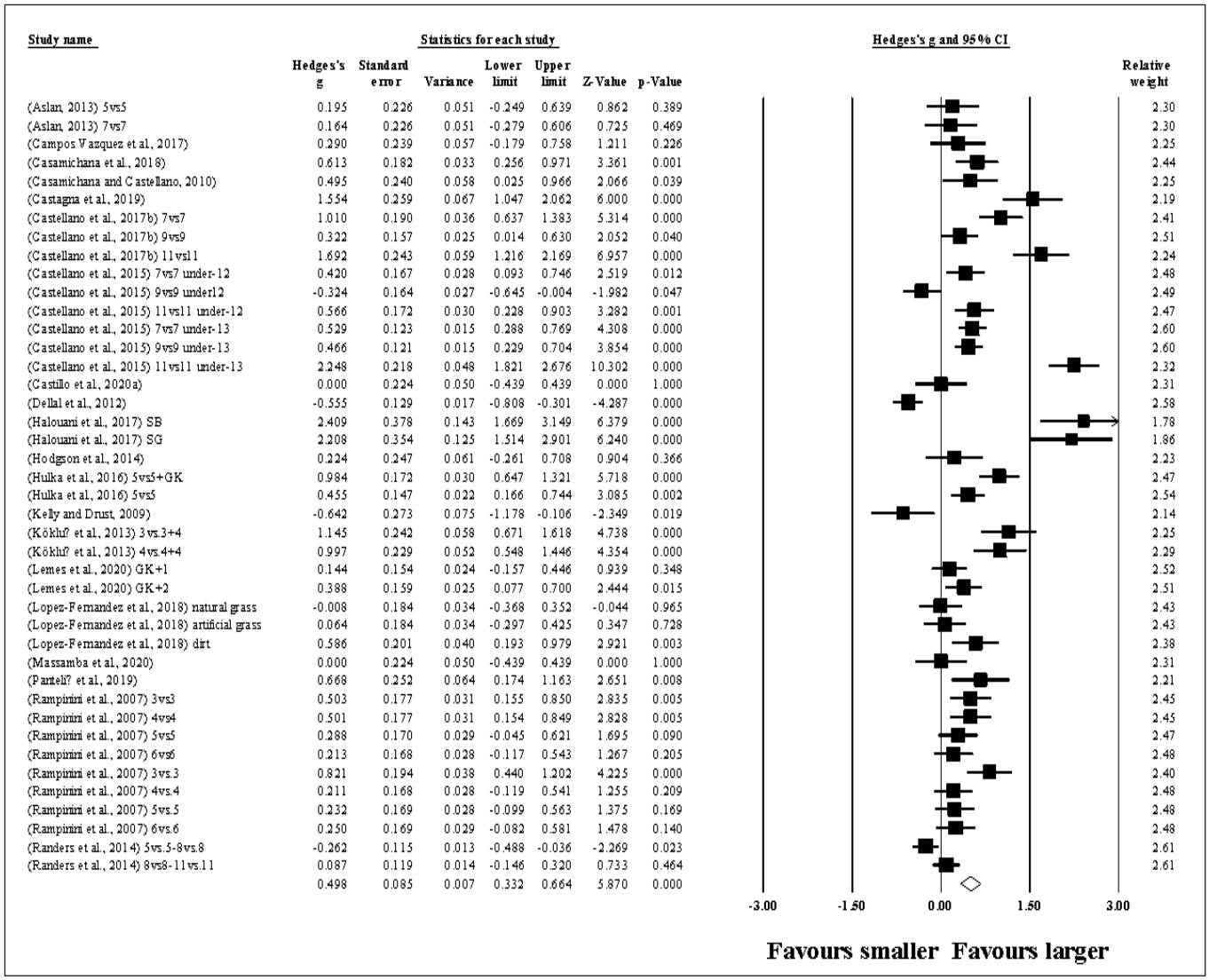

FIG. 2. Forest plot of changes in heart rate, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

Fourty-two study groups provided data for HR, involving 42 smaller and 42 larger pitch sizes being compared (pooled n = 898). Results (Figure 2) showed that SSGs played at larger pitches induced greater HR compared to smaller pitches (ES = 0.50, small; 95% CI = 0.33 to 0.66; $p < 0.001$; $I^2 = 89.1\%$; Egger's test $p < 0.001$, with a corrected value of ES = 0.67, 95% CI = 0.48 to 0.86; supplementary Figure 1).

Thirty-six study groups provided data for RPE, involving 32 smaller and 32 larger pitch sizes being compared (pooled n = 735). Results (Figure 3) showed that SSGs played at larger pitches induced greater RPE compared to smaller pitches (ES = 0.70, moderate; 95% CI = 0.52 to 0.89; $p < 0.001$; $I^2 = 88.6\%$; Egger's test $p < 0.001$, with a corrected value equal to the observed value; supplementary Figure 2).

Moderator analyses for HR and RPE

The HR was greater at larger compared to smaller pitches when SSGs were played with either small (14 study groups; ES = 0.55; $p < 0.001$; $I^2 = 84.9\%$), medium (19 study groups; ES = 0.30; $p = 0.001$; $I^2 = 79.2\%$) and large (8 study groups; ES = 0.69; $p = 0.048$; $I^2 = 96.1\%$) formats, although without significant sub-group difference between formats ($p = 0.056$).

The HR was greater at larger compared to smaller pitches when SSGs were played by young/youth (29 study groups; ES = 0.60; $p < 0.001$; $I^2 = 90.9\%$) and adult players (13 study groups; ES = 0.28; $p = 0.009$; $I^2 = 78.4\%$), with significant sub-group difference according to the age of the soccer players ($p = 0.037$).

The RPE was greater at larger compared to smaller pitches when SSGs were played with either small (13 study groups; ES = 0.48;

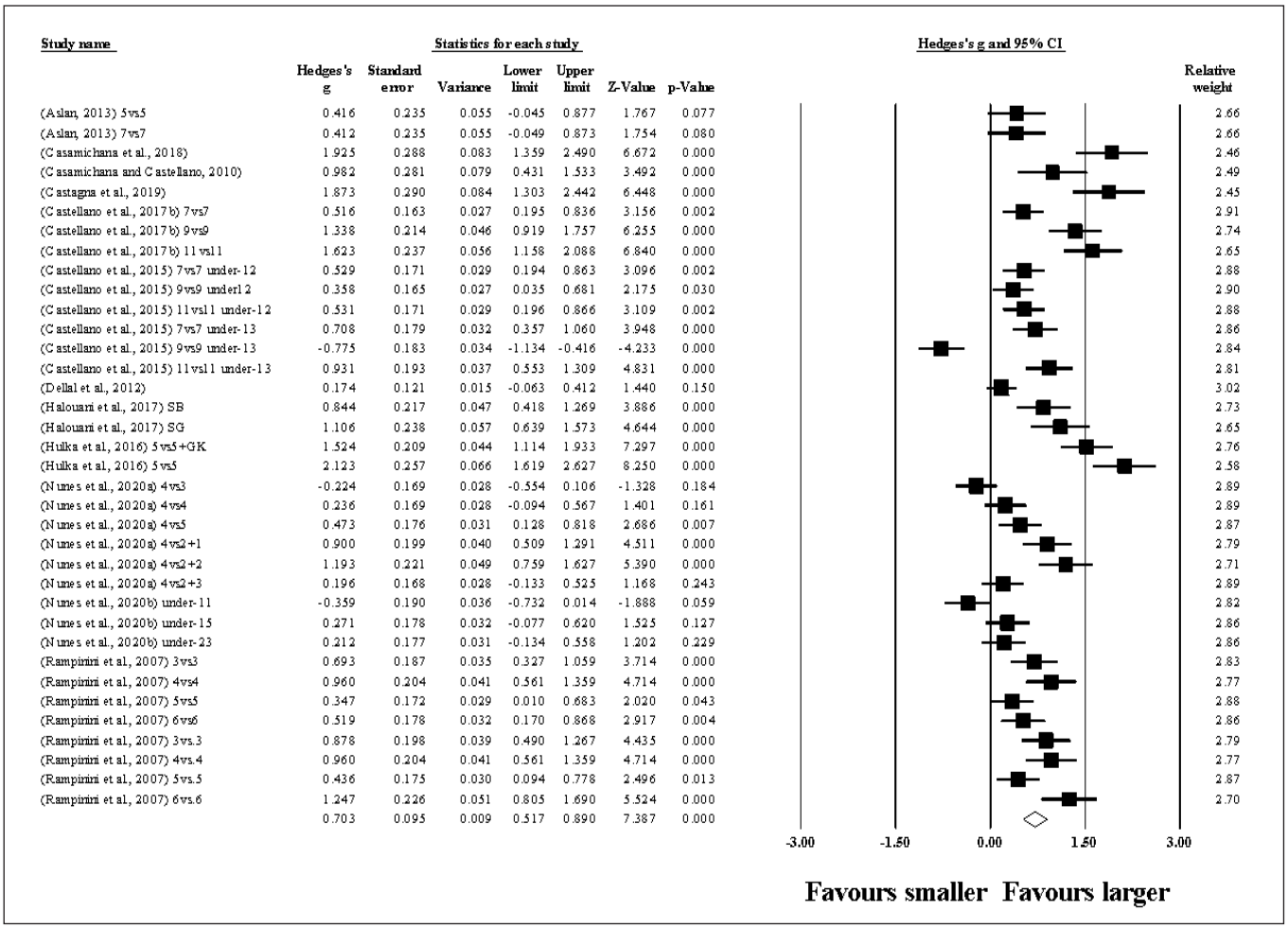

FIG. 3. Forest plot of changes in rating of perceived exertion, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

$p < 0.001$; $I^2 = 84.2\%$), medium (15 study groups; ES = 0.89; $p < 0.001$; $I^2 = 83.5\%$) and large (7 study groups; ES = 0.59; $p = 0.03$; $I^2 = 93.9\%$) formats, although without significant sub-group difference between formats ($p = 0.088$).

The RPE was greater at larger compared to smaller pitches when SSGs were played by young/youth (24 study groups; ES = 0.69; $p < 0.001$; $I^2 = 90.9\%$) and adult players (12 study groups; ES = 0.72; $p < 0.001$; $I^2 = 79.9\%$), without significant sub-group difference according to the age of the soccer players ($p = 0.895$).

Smaller vs. larger pitch sizes during SSG: effects on physical demands

A summary of the included studies and results of physical demands (TD, HSR, ACC and DEC) reported in smaller and larger SSGs are provided in Table 6.

Thirty-six study groups provided data for TD, involving 36 smaller and 36 larger pitch sizes being compared (pooled $n = 1.035$). Results (Figure 4) showed that SSGs played at larger pitches induced greater TD compared to smaller pitches (ES = 1.95, large; 95% CI = 1.62 to 2.29; $p < 0.001$; $I^2 = 95.9\%$; Egger's test $p < 0.001$, with a corrected value of ES = 2.49, 95% CI = 1.89 to 3.10; supplementary Figure 3).

Thirty-five study groups provided data for HSR, involving 35 smaller and 35 larger pitch sizes being compared (pooled $n = 920$). Results (Figure 5) showed that SSGs played at larger pitches induced greater HSR compared to smaller pitches (ES = 1.20, moderate; 95% CI = 0.93 to 1.47; $p < 0.001$; $I^2 = 94.4\%$; Egger's test $p < 0.001$, with a corrected value of ES = 1.32, 95% CI = 0.95 to 1.70; supplementary Figure 4).

Six study groups provided data for ACC, involving 6 smaller and 6 larger pitch sizes being compared (pooled $n = 86$). Results (Figure 6) showed that SSGs played at larger pitches induced similar ACC compared to smaller pitches (ES = 0.45, small; 95% CI = -0.29 to 1.18; $p = 0.232$; $I^2 = 93.5\%$; Egger's test $p = 0.040$,

TABLE 6. Summary of the included studies and results of physical demands in smaller and larger pitch sizes.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[72]	4vs.4	Youth [g]	16	TD	1000 ± 131	1095 ± 89	9.5	Increase in larger pitch size	Yes
[72]	4vs.4	Youth [g]	16	HSR	19.3 ± 14.9	64.9 ± 24.8	45.6	Increase in larger pitch size	Yes
[72]	4vs.4	Youth [g]	16	ACC	12.2 ± 5.5	10.5 ± 3.8	-13.9	Decrease in larger pitch size	Yes
[73]	6vs.6 + 1	Adults	9	TD	93.8 ± 11.6	103.4 ± 11.2	10.2	Increase in larger pitch size	Yes
[73]	6vs.6 + 1	Adults	9	HSR	46.9 ± 22.1	492.2 ± 181.3	949	Increase in larger pitch size	Yes
[74]	5vs.5 + GK	Adults	20	TD	101.2 ± 11.8	131.4 ± 14.4	29.8	Increase in larger pitch size	Yes
[74]	5vs.5 + GK	Adults	20	ACC	3.8 ± 3.3	2.3 ± 2.4	-39.5	Decrease in larger pitch size	Yes
[74]	5vs.5 + GK	Adults	20	DEC	4.5 ± 4.1	1.8 ± 2.0	-60	Decrease in larger pitch size	Yes
[18]	5vs.5 + GK	Youth [f]	10	TD	87.0 ± 4.6	125.0 ± 6.2	43.7	Increase in larger pitch size	Yes
[18]	5vs.5 + GK	Youth [f]	10	HSR	4.9 ± 5.5	74.2 ± 58.9	1414.3	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	TD	378 ± 46	601 ± 54	58.9	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	HSR	15 ± 9	146 ± 25	873.3	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	ACC	82 ± 16	145 ± 14	76.8	Increase in larger pitch size	Yes
[75]	1vs.1	Youth [g]	19	DEC	34 ± 6	69 ± 6	102.9	Increase in larger pitch size	Yes
[76]	7vs.7 + GK	Youth [c]	14	TD	663.9 ± 76.6	819.7 ± 106.5	23.5	Increase in larger pitch size	Yes
[76]	7vs.7 + GK	Youth [c]	14	HSR	7.7 ± 8.4	38.1 ± 38.2	394.8	Increase in larger pitch size	Yes
[76]	7vs.7 + GK	Youth [d]	14	TD	670.9 ± 67.9	871.0 ± 81.9	29.8	Increase in larger pitch size	Yes
[76]	7vs.7 + GK	Youth [d]	14	HSR	6.5 ± 8.1	59.9 ± 43.5	821.5	Increase in larger pitch size	Yes
[77]	7vs.7 + GK	Youth [d]	24	TD	1816 ± 155	2307 ± 212	27.1	Increase in larger pitch size	Yes
[77]	7vs.7 + GK	Youth [d]	24	HSR	48 ± 31	202 ± 78	320.8	Increase in larger pitch size	Yes
[77]	9vs.9 + GK	Youth [d]	24	TD	1845 ± 141	2250 ± 107	21.9	Increase in larger pitch size	Yes
[77]	9vs.9 + GK	Youth [d]	24	HSR	70 ± 32	164 ± 41	134.3	Increase in larger pitch size	Yes
[77]	11vs.11 + GK	Youth [d]	24	TD	1766 ± 181	2314 ± 134	31.1	Increase in larger pitch size	Yes
[77]	11vs.11 + GK	Youth [d]	24	HSR	62 ± 43	200 ± 105	222.6	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [b]	22	TD	1718 ± 150	2186 ± 90	27.2	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [b]	22	HSR	72 ±	199 ±	176.4	Increase in larger pitch size	No Reason: SD not reported
[14]	9vs.9 + GK	Youth [b]	22	TD	1867 ± 126	2159 ± 183	15.6	Increase in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [b]	22	HSR	89 ±	197 ±	121.3	Increase in larger pitch size	No Reason: no reported SD

TABLE 6. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[14]	11vs.11 + GK	Youth [b]	22	TD	1844 ± 254	2168 ± 127	17.6	Increase in larger pitch size	Yes
[14]	11vs.11 + GK	Youth [b]	22	HSR	109 ±	236 ±	116.5	Increase in larger pitch size	No Reason: no reported SD
[14]	7vs.7 + GK	Youth [c]	22	TD	1816 ± 155	2307 ± 212	34.3	Increase in larger pitch size	Yes
[14]	7vs.7 + GK	Youth [c]	22	HSR	55 ± NR	218 ± NR	296.4	Increase in larger pitch size	No Reason: SD not reported
[14]	9vs.9 + GK	Youth [c]	22	TD	1845 ± 141	2250 ± 107	20.5	Increase in larger pitch size	Yes
[14]	9vs.9 + GK	Youth [c]	22	HSR	91 ± NR	181 ± NR	98.9	Increase in larger pitch size	No Reason: no reported SD
[14]	11vs.11 + GK	Youth [c]	22	TD	1766 ± 181	2314 ± 134	25.5	Increase in larger pitch size	Yes
[14]	11vs.11 + GK	Youth [c]	22	HSR	72 ± NR	218 ± NR	202.8	Increase in larger pitch size	No Reason: no reported SD
[78]	6vs.6	Youth [b]	24	TD	466.1 ± 61.1	579.0 ± 90.1	24.2	Increase in larger pitch size	Yes
[78]	6vs.6	Youth [b]	24	HSR	3.4 ± 5.3	31.2 ± 26.1	817.6	Increase in larger pitch size	Yes
[79]	5vs.5 + GK	Youth [e]	10	TD	2254 ± 241	2603 ± 261	15.5	Increase in larger pitch size	Yes
[79]	5vs.5 + GK	Youth [e]	19	HSR	4 ± 9	23 ± 26	475	Increase in larger pitch size	Yes
[80]	5vs.5 + GK	Youth [e]	20	TD	2223 ± 248	2629 ± 227	18.3	Increase in larger pitch size	Yes
[80]	5vs.5 + GK	Youth [e]	20	HSR	3 ± 4	28 ± 21	984.3	Increase in larger pitch size	Yes
[80]	5vs.5 + GK	Youth [e]	20	ACC	409 ± 47	403 ± 57	-1.6	Decrease in larger pitch size	Yes
[80]	5vs.5 + GK	Youth [e]	20	DEC	353 ± 52	361 ± 53	2.3	Increase in larger pitch size	Yes
[68]	11vs.11 + GK	Adults	10	TD	2511.2 ± 279.7	3136.6 ± 323.8	24.9	Increase in larger pitch size	Yes
[68]	11vs.11 + GK	Adults	10	HSR	93.6 ± 43.5	256.2 ± 76.2	173.7	Increase in larger pitch size	Yes
[82]	11vs.11 + GK	Adults	40	TD	2664 ± 237	11173 ± 524	319.4	Increase in larger pitch size	Yes
[82]	11vs.11 + GK	Adults	40	HSR	353 ± 59.1	483 ± 71.2	36.8	Increase in larger pitch size	Yes
[83]	5vs.5 + GK	Youth [g]	11	TD	3067 ± 383	4068 ± 332	32.6	Increase in larger pitch size	Yes
[83]	5vs.5 + GK	Youth [g]	11	HSR	98 ± 47	538 ± 157	448.9	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	TD	1532 ± 145	1934 ± 133	26.2	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	HSR	0 ± 0	61 ± 47	6100	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	ACC	230 ± 111	327 ± 70	42.2	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	DEC	198 ± 89	298 ± 68	50.5	Increase in larger pitch size	Yes

TABLE 6. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[86]	5vs.5 + GK	Youth [h]	29	TD	372.4 ± 13.8	496.8 ± 26.1	33.4	Increase in larger pitch size	Yes
[86]	5vs.5	Youth [h]	29	TD	355.6 ± 17.0	488.7 ± 26.7	37.4	Increase in larger pitch size	Yes
[88]	5vs.5 + GK	Adults	3	TD	445.1 ± 44.3	255.2 ± 25.9	-42.7	Decrease in larger pitch size	Yes
[88]	5vs.5 + GK	Adults	3	HSR	0	1.6 ± 2.1	-	Increase in larger pitch size	Yes
[88]	5vs.5 + GK	Adults	3	ACC	5.5 ± 3.9	2.7 ± 1.9	-50.9	Decrease in larger pitch size	Yes
[88]	5vs.5 + GK	Adults	3	DEC	4.2 ± 2.9	2.5 ± 1.6	-40.5	Decrease in larger pitch size	Yes
[39]	8vs.8 + GK	Youth [b]	149	TD	2420.9 ± 215.7	2494.9 ± 203.3	3.1	Increase in larger pitch size	Yes
[39]	8vs.8 + GK	Youth [b]	149	HSR	1108.8 ± 492.8	924.0 ± 369.6	-16.7	Decrease in larger pitch size	Yes
[19]	3vs.3 + GK + 1	Youth [c]	48	TD	447.7 ± 45.3	457.8 ± 49.9	2.3	Increase in larger pitch size	Yes
[19]	3vs.3 + GK + 1	Youth [d]	48	HSR	13.5 ± 0.4	15.0 ± 0.5	11.1	Increase in larger pitch size	Yes
[90]	4vs.4	Youth [i]	16	TD	399.0 ± 33.4	458.6 ± 52.0	14.9	Increase in larger pitch size	Yes
[90]	4vs.4	Youth [i]	16	HSR	21.0 ± 11.3	55.1 ± 31.3	162.4	Increase in larger pitch size	Yes
[62]	4vs.3	Youth [i]	20	HSR	1.0 ± 1.1	5.8 ± 5.1	480	Increase in larger pitch size	Yes
[62]	4vs.4	Youth [i]	20	HSR	2.0 ± 2.1	9.3 ± 8.3	365	Increase in larger pitch size	Yes
[62]	4vs.5	Youth [i]	20	HSR	1.5 ± 1.3	10.8 ± 6.7	620	No differences	Yes
[62]	4vs.2 + 1	Youth [i]	20	HSR	2.3 ± 3.8	10.0 ± 6.7	335	Increase in larger pitch size	Yes
[62]	4vs.2 + 2	Youth [i]	20	HSR	1.5 ± 6	7.8 ± 5.9	420	Increase in larger pitch size	Yes
[62]	4vs.2 + 3	Youth [i]	20	HSR	3.5 ±	7.3 ± 4.3	109	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [a]	16	HSR	5.9 ± 6.0	30.9 ± 25.7	423.7	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [e]	18	HSR	3.9 ± 6.7	9.2 ± 10.4	135.9	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [i]	18	HSR	3.4 ± 4.3	5.7 ± 5.7	67.6	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [c]	36	TD	111.5 ± 10.9	128.7 ± 12.0	15.4	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [c]	36	HSR	4.6 ± 7.0	24.2 ± 20.4	426.1	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [e]	43	TD	121.3 ± 11.5	132.9 ± 13.8	9.6	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [e]	43	HSR	11.2 ± 11.7	43.8 ± 30.7	291.1	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [g]	28	TD	124.3 ± 9.6	134.4 ± 11.8	8.1	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [g]	28	HSR	12.8 ± 11.8	49.7 ± 28.6	288.3	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [i]	43	TD	128.3 ± 11.0	140.7 ± 12.0	9.7	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [i]	43	HSR	17.3 ± 14.4	50.3 ± 27.4	190.8	Increase in larger pitch size	Yes

TABLE 6. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[94]	4vs.4 + GK	Youth [i]	10	TD	3444 ± 293	3517 ± 152	2.1	Increase in larger pitch size	Yes
[94]	4vs.4 + GK	Youth [i]	10	HSR	31 ± 15	87 ± 51	180.6	Increase in larger pitch size	Yes
[96]	5vs.5 8vs.8	Youth [a]	86	TD	1754 ± 237	1771 ± 314	1.0	Increase in larger pitch size	Yes
[96]	5vs.5 8vs.8	Youth [a]	86	HSR	2 ± 6	6 ± 10	200.0	Increase in larger pitch size	Yes
[96]	8vs.8 11vs.11	Youth [c]	86	TD	1821 ± 325	2038 ± 328	11.9	Increase in larger pitch size	Yes
[96]	8vs.8 11vs.11	Youth [c]	86	HSR	2.5 ± NR	7.6 ± NR	204.0	Increase in larger pitch size	No Reason: no reported SD

SD: standard-deviation; TD: total distance; HSR: high speed running; ACC: accelerations; DEC: decelerations; %: percentage of difference; a: Under-11 group or below; b: Under-12; group; c: Under-13 group; d: Under-14 group; e; under-15 group; f: under-16 group; g: under-17 group; h: under-18 group; i: under-23 group; NR: non-reported

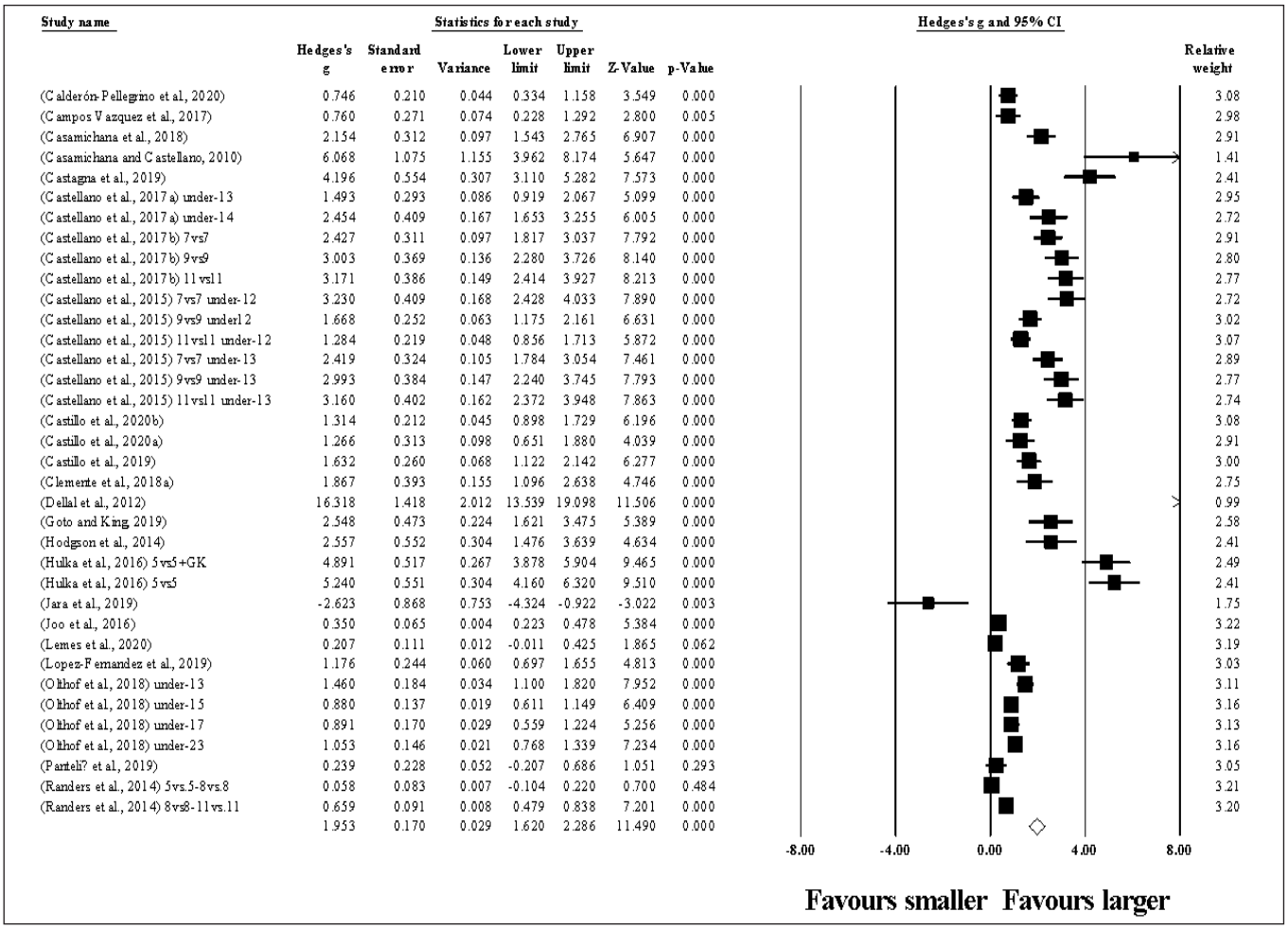

FIG. 4. Forest plot of changes in total distance, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

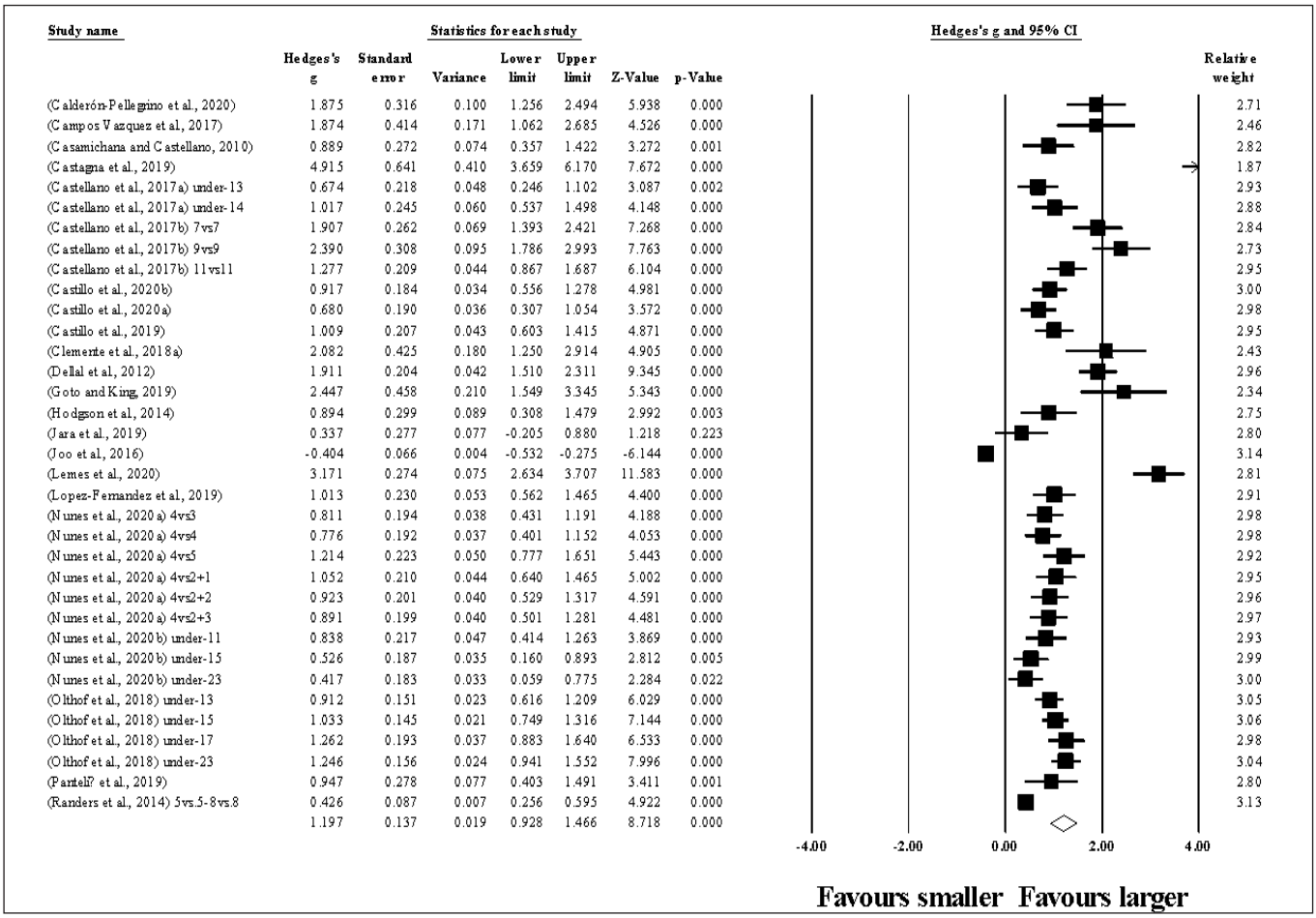

FIG. 5. Forest plot of changes in high speed running distance, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

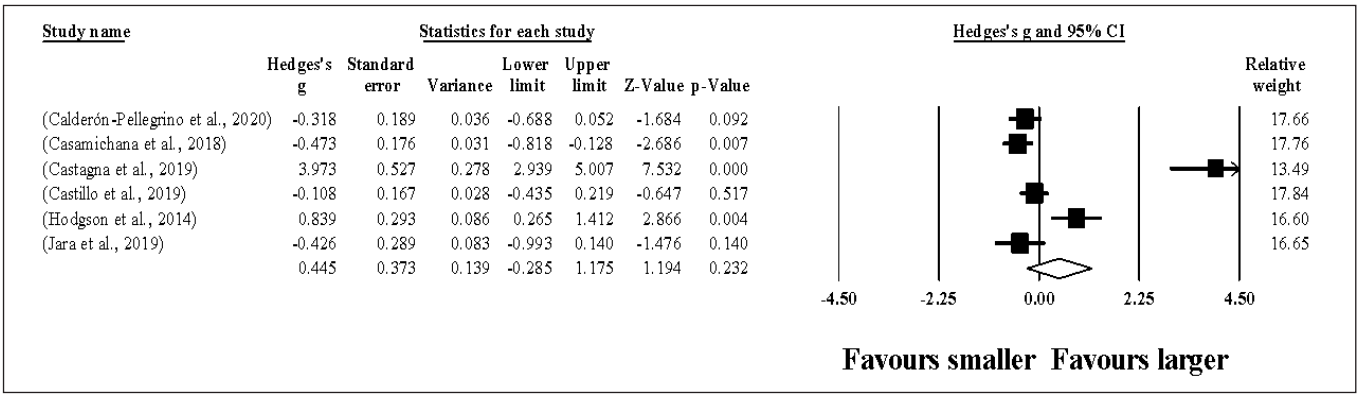

FIG. 6. Forest plot of changes in acceleration actions, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

with a corrected value of ES = 0.69, 95% CI = -0.17 to 1.55; supplementary Figure 5).

Five study groups provided data for DEC, involving 5 smaller and 5 larger pitch sizes being compared (pooled n = 70). Results (Figure 7) showed that SSGs played at larger pitches induced similar DEC compared to smaller pitches (ES = 0.85, moderate; 95% CI = -0.20 to 1.90; p = 0.111; I^2 = 95.3%; Egger's test p = 0.049, with a corrected value of ES = 1.40, 95% CI = -0.17 to 2.97; supplementary Figure 6).

Moderator analyses for TD, and HSR

The TD was greater at larger compared to smaller pitches when SSGs were played with either small (8 study groups; ES = 0.83; p < 0.001; I^2 = 86.7%), medium (18 study groups; ES = 2.04; p < 0.001; I^2 = 96.3%) and large (9 study groups; ES = 3.11; p < 0.001; I^2 = 96.8%) formats, with significant sub-group difference between formats (p < 0.001).

The TD was greater at larger compared to smaller pitches when SSGs were played by young/youth (31 study groups; ES = 1.90; p < 0.001; I^2 = 95.6%) and adult players (5 study groups; ES = 3.21; p = 0.007; I^2 = 97.2%), without significant sub-group difference according to the age of the soccer players (p = 0.272).

The HSR was greater at larger compared to smaller pitches when SSGs were played with either small (17 study groups; ES = 1.09; p < 0.001; I^2 = 83.4%), medium (13 study groups; ES = 0.93; p < 0.001; I^2 = 94.9%) and large (4 study groups; ES = 1.87;

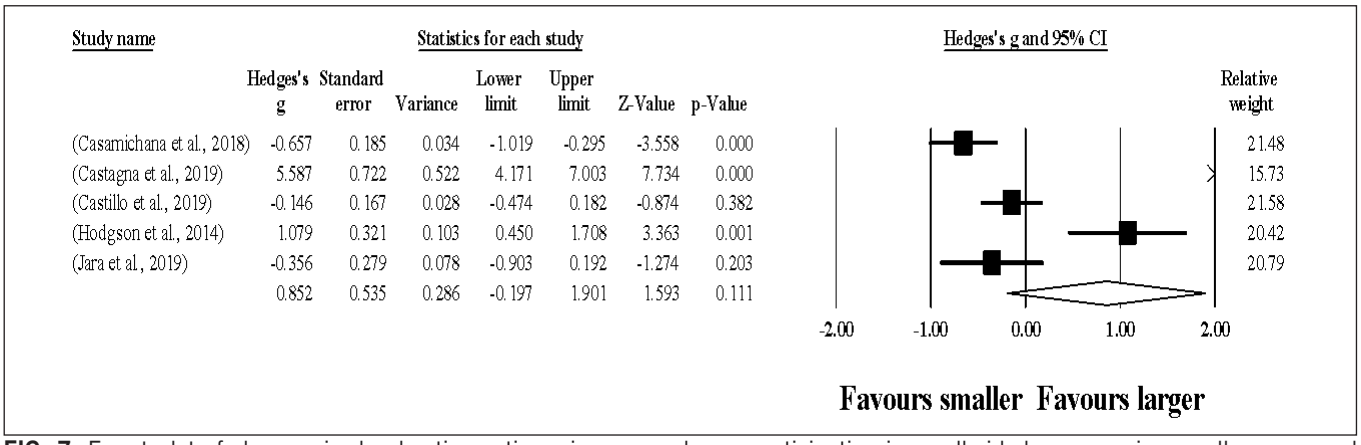

FIG. 7. Forest plot of changes in deceleration actions, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

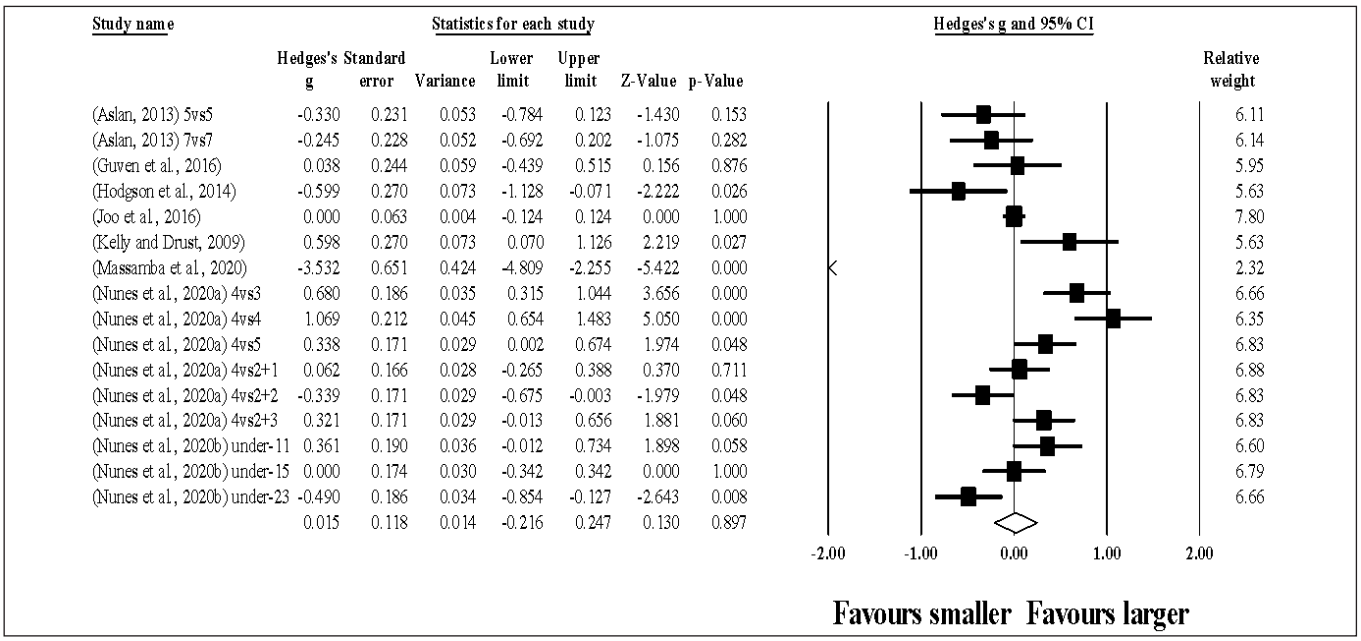

FIG. 8. Forest plot of changes in passes, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

TABLE 7. Summary of the included studies and results of technical execution in smaller and larger pitch sizes.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)*	Tendency of change	Included in the meta-analysis
[71]	5vs.5 + GK	Adults	10	Dribbles	13.9 ± 7.9	15.6 ± 6.8	12.2	Increase in larger pitch size	Yes
[71]	7vs.7 + GK	Adults	10	Dribbles	12.1 ± 6.5	11.3 ± 6.6	-6.6	Decrease in larger pitch size	Yes
[71]	5vs.5 + GK	Adults	10	Passes	32.8 ± 12.6	28.6 ± 9.0	-12.8	Decrease in larger pitch size	Yes
[71]	7vs.7 + GK	Adults	10	Passes	29.5 ± 9.6	26.9 ± 9.8	-8.8	Decrease in larger pitch size	Yes
[40]	5vs.5 + GK	Youth [f]	10	Dribbles	5.2 ± 1.7	1.7 ± 0.8	-67.3	Decrease in larger pitch size	Yes
[40]	5vs.5 + GK	Youth [f]	10	Passes	14.5 ± 6.6	18.7 ± 4.3	29.1	Increase in larger pitch size	No. Reason: results are the same as presented in the [40]
[18]	5vs.5 + GK	Youth [f]	10	Dribbles	5.2 ± 1.7	1.7 ± 0.8	-67.3	Decrease in larger pitch size	No. Reason: results are the same as presented in the [40]
[18]	5vs.5 + GK	Youth [f]	10	Passes	14.5 ± 6.6	18.7 ± 4.3	29.1	Increase in larger pitch size	No. Reason: results are the same as presented in the [40]
[84]	4vs.4	Adults	8	Dribbles	11.3 ± 8.5	12.8 ± 10.2	13.3	Increase in larger pitch size	Yes
[84]	4vs.4	Adults	8	Passes	74.6 ± 27.2	76.0 ± 35.3	1.9	Increase in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	Dribbles	7.1 ± 2.6	6.9 ± 2.9	-2.8	Decrease in larger pitch size	Yes
[61]	5vs.5 + GK	Youth [i]	8	Passes	23.1 ± 4.8	20.1 ± 3.0	-12.9	Decrease in larger pitch size	Yes
[87]	5vs.5 + GK	Youth [g]	3	Passes	14 ± NR	8 ± NR	-42.9	Decrease in larger pitch size	No. Reason: no reported SD
[39]	8vs.8 + GK	Youth [b]	149	Passes	13.8 ± 5.2	13.8 ± 6.4	0.0	No differences	Yes
[17]	5vs.5 + GK	Youth [h]	8	Passes	71.5 ± 10.2	79.9 ± 13.5	11.7	Increase in larger pitch size	Yes
[17]	5vs.5 + GK	Youth [h]	8	Dribbles	53.0 ± 10.1	62.2 ± 9.3	17.4	Increase in larger pitch size	Yes
[92]	5vs.5	Youth [c]	10	Passes	18.6 ± 1.9	11.7 ± 1.6	-37.1	Decrease in larger pitch size	Yes
[92]	5vs.5	Youth [c]	10	Dribbles	3.4 ± 0.8	3.6 ± 1.0	5.9	Increase in larger pitch size	Yes
[62]	4vs.3	Youth [i]	20	Passes	9.3 ± 3.5	12.8 ± 5.4	37.6	Increase in larger pitch size	Yes
[62]	4vs.4	Youth [i]	20	Passes	6.3 ± 3.2	10 ± 3.5	58.7	Increase in larger pitch size	Yes
[62]	4vs.5	Youth [i]	20	Passes	7.3 ± 3.8	8.8 ± 4.6	20.5	Increase in larger pitch size	Yes
[62]	4vs.2 + 1	Youth [i]	20	Passes	9.0 ± 4.0	9.3 ± 3.8	3.3	Increase in larger pitch size	Yes
[62]	4vs.2 + 2	Youth [i]	20	Passes	8.0 ± 3.2	9.3 ± 3.8	16.3	Decrease in larger pitch size	Yes
[62]	4vs.2 + 3	Youth [i]	20	Passes	9.0 ± 4.0	10.3 ± 3.2	14.4	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [a]	16	Passes	8.7 ± 4.9	11.3 ± 7.4	29.9	Increase in larger pitch size	Yes
[93]	4vs.4	Youth [e]	18	Passes	7.1 ± 3.1	7.1 ± 2.7	0.0	No differences	Yes
[93]	4vs.4	Youth [i]	18	Passes	8.0 ± 3.6	6.0 ± 4.1	-25.0	Decrease in larger pitch size	Yes

SD: standard-deviation; %: percentage of difference; a: Under-11 group; b: Under-12; group; c: Under-13 group; d: Under-14 group; e; under-15 group; f: under-16 group; g: under-17 group; h: under-18 group; i: under-23 group; NR: non-reported

$p < 0.001$; $I^2 = 71.8\%$) formats, with significant sub-group difference between formats ($p = 0.009$).

The HSR was greater at larger compared to smaller pitches when SSGs were played by young/youth (31 study groups; ES = 1.16; $p < 0.001$; $I^2 = 94.6\%$) and adult players (4 study groups; ES = 1.53; p = 0.001; $I^2 = 87.7\%$), without significant sub-group difference according to the age of the soccer players ($p = 0.423$).

Due to the limited number of study groups available for each moderator category, robust moderator analyses were precluded for ACC and DEC.

Smaller0 vs. larger pitch sizes during SSG: effects on technical execution

A summary of the included studies and results of technical execution (passes and dribbles) reported in smaller and larger SSGs are provided in Table 7.

Six-teen study groups provided data for passes, involving 16 smaller and 16 larger pitch sizes being compared (pooled $n = 375$). Results (Figure 8) showed that SSGs played at larger pitches induced similar passes compared to smaller pitches (ES = 0.02, trivial; 95% CI = -0.22 to 0.25; $p = 0.897$; $I^2 = 85.2\%$; Egger's test $p = 0.640$, with a corrected value equal to the observed vaue; supplementary Figure 7). Seven study groups provided data for dribbling, involving 7 smaller and 7 larger pitch sizes being compared (pooled $n = 64$). Results (Figure 9) showed that SSGs played at larger pitches induced similar dribbles compared to smaller pitches (ES = -0.05, trivial; 95% CI = -0.50 to 0.40; $p = 0.823$; $I^2 = 82.0\%$; Egger's test $p = 0.159$, with a corrected value of ES = -0.29, 95% CI = -0.76 to 0.18; supplementary Figure 8).

Moderator analyses

The passes were similar at larger compared to smaller pitches when SSGs were played with either small (10 study groups; ES = 0.20; p = 0.153; $I^2 = 82.5\%$) and medium (6 study groups; ES = -0.42; p = 0.102; $I^2 = 87.9\%$) formats, with significant sub-group difference between formats ($p = 0.034$).

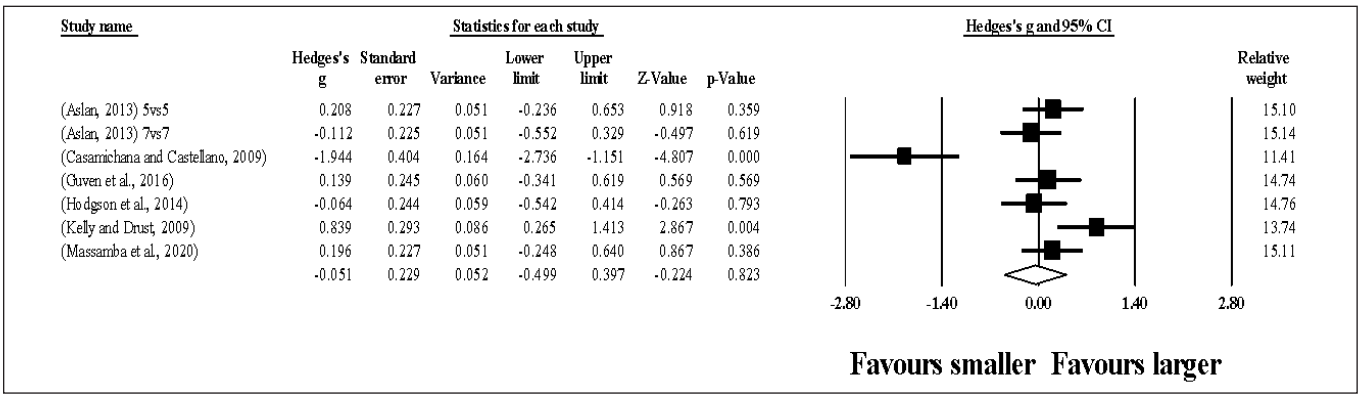

FIG. 9. Forest plot of changes in dribbles, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

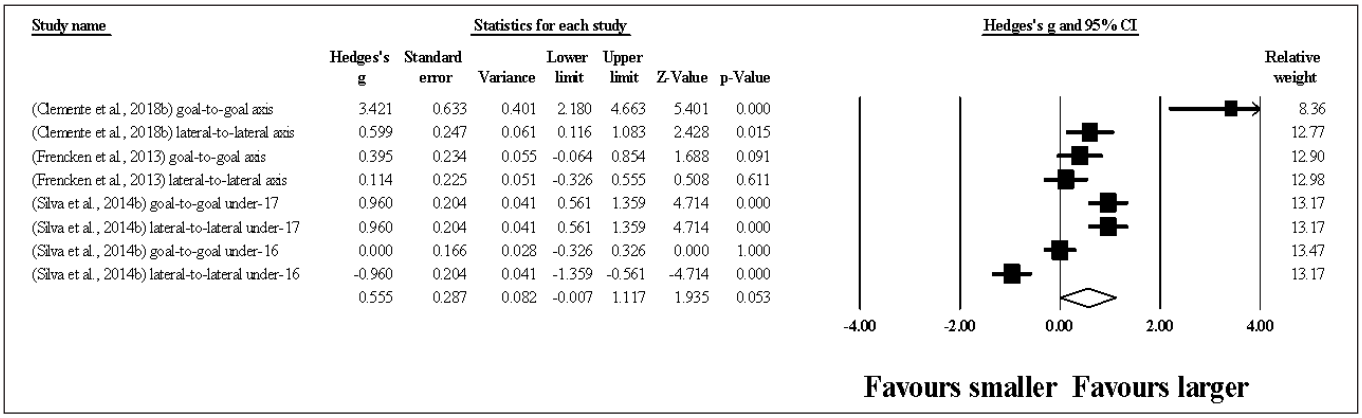

FIG. 10. Forest plot of changes in centroid, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

TABLE 8. Summary of the included studies and results of tactical behavior in smaller and larger pitch sizes.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[13]	7vs.7 + GK	Youth [c]	14	Stretch index	8.6 ± 1.7	11.5 ± 2.3	33.7	Increase in larger pitch size	Yes
[13]	7vs.7 + GK	Youth [d]	14	Stretch index	8.6 ± 2.5	10.1 ± 2.0	17.4	Increase in larger pitch size	Yes
[68]	11vs.11 + GK	Adults	10	Spatial exploration index	85.1 ± 1.6	68.6 ± 9.2	-19.4	Decrease in larger pitch size	No Reason: less than 3 studies reported the outcome
[81]	11vs.11 + GK	Adults	10	Stretch index	35.5 ± 9.5	45.8 ± 7.8	29.01	Increase in larger pitch size	Yes
[81]	11vs.11 + GK	Adults	10	Centroid (g)	24.5 ± 8.4	58.6 ± 9.6	139.2	Increase in larger pitch size	Yes
[81]	11vs.11 + GK	Adults	10	Centroid (l)	33.1 ± 6.1	36.8 ± 3.9	11.2	Increase in larger pitch size	Yes
[69]	4vs.4 + GK	Adults	10	Surface area	38 ± 31	34 ± 29	-10.5	Decrease in larger pitch size	Yes
[69]	4vs.4 + GK	Adults	10	Centroid (g)	1.5 ± 1.1	2.0 ± 1.2	33.3	Increase in larger pitch size	Yes
[69]	4vs.4 + GK	Adults	10	Centroid (l)	1.0 ± 0.8	1.1 ± 0.8	10.0	Increase in larger pitch size	Yes
[88]	5vs.5 + GK	Adults	3	Spatial exploration index	2.2 ± 0.3	3.2 ± 0.4	45.5	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[88]	5vs.5 + GK	Adults	3	Predictive Ellipse Area	67.6 ± 18.8	129.1 ± 46.5	91.0	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[88]	5vs.5 + GK	Adults	3	Standard Ellipse Area	11.3 ± 3.1	21.4 ± 7.8	89.4	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[66]	4vs.4 + GK	Youth [c]	36	Surface area	84.5 ± 8.7	143.2 ± 23.9	69.5	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [c]	36	Stretch index	4.6 ± 0.4	5.9 ± 1.8	28.3	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [c]	36	Width per length ratio	1.0 ± 0.2	1.1 ± 0.3	10.0	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[66]	4vs.4 + GK	Youth [e]	43	Surface area	94.8 ± 11.1	158.3 ± 34.2	67.0	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [e]	43	Stretch index	5.1 ± 0.4	6.2 ± 0.8	21.6	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [e]	43	Width per length ratio	0.9 ± 0.2	1.1 ± 0.3	22.2	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[66]	4vs.4 + GK	Youth [g]	28	Surface area	115.5 ± 30.9	146.4 ± 22.3	26.8	Increase in larger pitch size	Yes

TABLE 8. Continue.

Study	Format	Age category	N	Variable	Smaller Mean ± SD	Larger Mean ± SD	Larger-Smaller (%)	Tendency of change	Included in the meta-analysis
[66]	4vs.4 + GK	Youth [g]	28	Stretch index	5.3 ± 0.7	6.0 ± 0.6	13.2	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [g]	28	Width per length ratio	1.0 ± 0.1	1.1 ± 0.1	10.0	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[66]	4vs.4 + GK	Youth [i]	43	Surface area	101.2 ± 18.2	140.9 ± 27.0	39.2	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [i]	43	Stretch index	5.2 ± 0.6	5.9 ± 0.6	13.5	Increase in larger pitch size	Yes
[66]	4vs.4 + GK	Youth [i]	43	Width per length ratio	0.9 ± 0.2	1.0 ± 0.2	11.1	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[58]	4vs.4 + GK	Youth [g]	20	Width per length ratio	1.1 ± 0.1	1.1 ± 0.2	0.0	No differences	No Reason: less than 3 studies reported the outcome
[58]	4vs.4 + GK	Youth [g]	20	Surface area	119.5 ± 13.5	247.7 ± 44.6	107.3	Increase in larger pitch size	Yes
[58]	4vs.4 + GK	Youth [g]	20	Centroid (g)	0.5 ± 0.1	0.6 ± 0.1	20.0	Increase in larger pitch size	Yes
[58]	4vs.4 + GK	Youth [g]	20	Centroid (l)	0.4 ± 0.1	0.5 ± 0.1	25.0	Increase in larger pitch size	Yes
[58]	4vs.4 + GK	Youth [f]	20	Width per length ratio	1.0 ± 0.5	1.5 ± 0.2	50.0	Increase in larger pitch size	No Reason: less than 3 studies reported the outcome
[58]	4vs.4 + GK	Youth [f]	20	Surface area	121.2 ± 24.6	251.2 ± 46.3	107.3	Increase in larger pitch size	Yes
[58]	4vs.4 + GK	Youth [f]	20	Centroid (g)	0.5 ± 0.1	0.5 ± 0.1	0.0	No differences	Yes
[58]	4vs.4 + GK	Youth [f]	20	Centroid (l)	0.5 ± 0.1	0.4 ± 0.1	-20.0	Decrease in larger pitch size	Yes
[97]	6vs.6	Youth [e]	24	Surface area	23.9 ± 7.0	28.8 ± 9.1	20.5	Increase in larger pitch size	Yes

SD: standard-deviation; g: goal-to-goal; l: lateral-to-lateral; %: percentage of difference; a: Under-11 group; b: Under-12; group; c: Under-13 group; d: Under-14 group; e; under-15 group; f: under-16 group; g: under-17 group; h: under-18 group; i: under-23 group

Due to the limited number of study groups available for each age category, robust moderator analyses were precluded for passes and dribbles, and the same for format of play in dribbles.

Smaller vs. larger pitch sizes during SSG: effects on tactical behavior

A summary of the included studies and results of tactical behavior (centroid, stretch index and surface area) reported in smaller and larger SSGs are provided in Table 8.

Eight study groups provided data for centroid, involving 8 smaller and 8 larger pitch sizes being compared (pooled n = 120). Results (Figure 10) showed that SSGs played at larger pitches induced similar centroid compared to smaller pitches (ES = 0.56, small; 95% CI = -0.01 to 1.12; p = 0.053; I^2 = 92.2%; Egger's test p = 0.151, with a corrected value of ES = 0.81, 95% CI = 0.11 to 1.51; supplementary Figure 9).

Seven study groups provided data for stretch index, involving 7 smaller and 7 larger pitch sizes being compared (pooled n = 188).

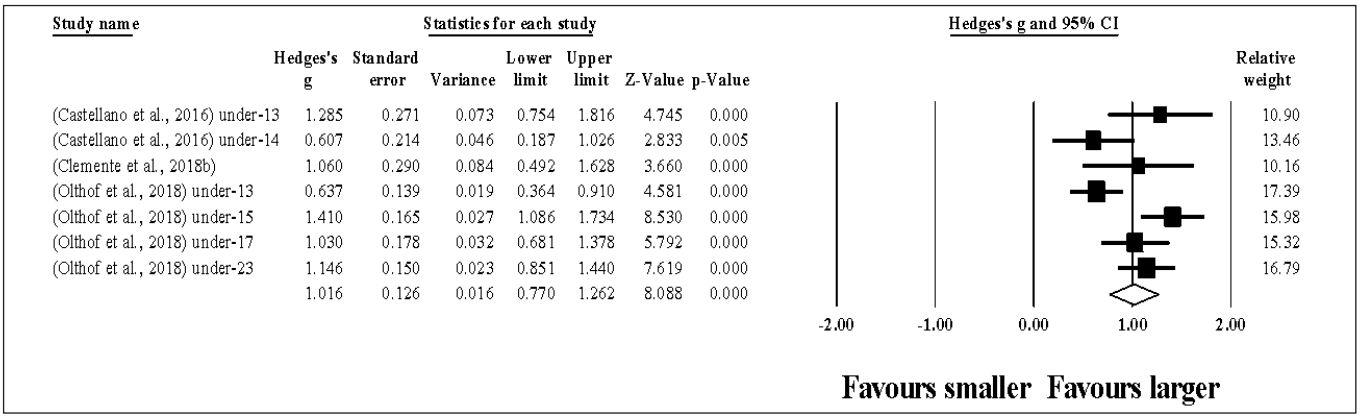

FIG. 11. Forest plot of changes in stretch index, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

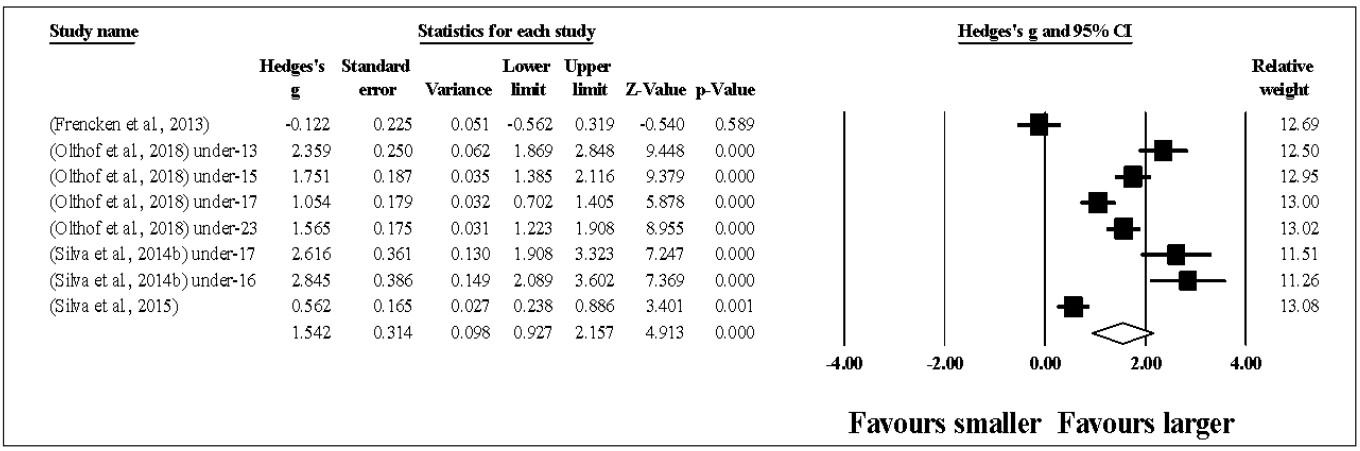

FIG. 12. Forest plot of changes in surface area, in soccer players participating in small-sided games using smaller compared to larger pitch sizes. Values shown are effect sizes (Hedges's g) with 95% confidence intervals (CI). The size of the plotted squares reflects the statistical relative weight of the study. The withe diamond reflects the overall result.

Results (Figure 11) showed that SSGs played at larger pitches induced greater stretch index compared to smaller pitches (ES = 1.02, moderate; 95% CI = 0.77 to 1.26; $p < 0.001$; $I^2 = 67.5\%$; Egger's test $p = 0.701$, with a corrected value of ES = 0.89, 95% CI = 0.63 to 1.15; supplementary Figure 10).

Eight study groups provided data for surface area, involving 8 smaller and 8 larger pitch sizes being compared (pooled $n = 224$). Results (Figure 12) showed that SSGs played at larger pitches induced greater surface area compared to smaller pitches (ES = 1.54, large; 95% CI = 0.93 to 2.16; $p < 0.001$; $I^2 = 94.0\%$; Egger's test $p = 0.164$, with a corrected value of ES = 1.38, 95% CI = 0.78 to 1.97; supplementary Figure 11).

Moderator analyses

Due to the limited number of study groups available for each moderator category, robust moderator analyses were precluded for centroid, stretch index and surface area.

DISCUSSION

The current findings of this systematic review and meta-analysis revealed a meaningful effect of changing the pitch size in the physiological, physical, and tactical responses of soccer players during SSGs. Such an effect was not verified in technical responses.

Smaller vs. larger pitch sizes during SSGs: Effects on physiological responses

The current systematic review and meta-analysis revealed that larger pitches meaningfully intensified exercise, reflected by the HR responses and RPE values of players. Additionally, a sub-group analysis revealed that this evidence was also significant in small, medium, and large formats of play, as well as in youth and adult players. Despite the high heterogeneity levels of meta-analysis and the experimental differences considering the pitch sizes, it was clear that larger pitch sizes generated greater HR (38 out of 42 study groups included) and RPE levels (33 out of 36 study groups included).

Larger pitches were between 1.1x [39] and 3.7x [40] bigger than the smaller pitches, and all formats of play were covered.

It is reasonable to expect that greater physiological responses would occur in larger pitches since there more space to cover, albeit with less spatial exploration variability. However, larger pitches may make the game more structured [20] even though the space available allows each player to cover greater distances at a faster pace. This fact was confirmed in the current meta-analysis, as significantly greater distances were covered and greater dispersion between teammates was found on larger pitches. HR and RPE reflect external load demands [41], which could explain the meaningful physiological intensification occurring on larger pitches. Additionally, the fact that RPE is conditioned both by HR and external load demands (in particular, total distance) [42] further explains the association between larger pitches and higher HR and RPE scores.

Comparisons between larger and smaller pitch sizes were also executed while considering the format of play as moderators (formats of play were classified as small – 2 vs. 2 to 4 vs. 4; medium – 5 vs. 5 to 8 vs. 8; and large – 9 vs. 9 to 11 vs. 11). Interestingly, increasing the pitch size had similar effects in all formats (i.e., HR and RPE were significantly increased). Similarly, youth and adult players alike presented significantly greater values of HR and RPE on larger pitch sizes. Therefore, it can be argued that larger pitches foster more intense exercise than smaller pitches independent of the format of play or age group.

Smaller vs. larger pitch sizes during SSGs: Effects on physical demands

The representative learning design and manipulation of task constraints are important pedagogical principles that coaches and practitioners should consider while planning training sessions [43]. Smaller and/or larger pitch sizes during SSGs can be utilized to achieve the main goal of the session. It is also known that the size of the pitch can be managed to simulate more or less the demands of the match. As an example, in a recent study [44], it was found that larger pitch sizes 156 to 182 m^2 were the most similar to replicate match demands regarding the total distance, high-speed running, very high speed running, and sprinting.

For example, the results of our meta-analysis showed that SSGs played at larger pitches (range length: 30–108 m; range width: 20–68 m; range area per player: 37.5–334 m^2) induced greater TD and HSR values than smaller configurations (range length: 10–68 m; range width: 13–68 m; range area per player: 15.6–199.75 m^2), independent of the format of play and age. In addition, similar ACC and DEC values were observed during SSGs played on larger and smaller pitches.

A moderator analysis of the current study showed that high values of area per player (e.g., 300 m^2) and reduced number of players (e.g., 7 vs. 7) increased the physical demands imposed on players during SSGs [14]. These findings should be considered by coaches during training planning, especially in youth academies and on training days before matches. A previous study demonstrated that simultaneously reducing absolute and relative area per player induced a higher frequency of offensive unity and increased the level of interaction between teammates [45]. Therefore, the increase in tactical performance and reduced physical demands (TD and HSR) during SSGs played with a low relative area per player suggest that this configuration can be beneficial in training sessions designed for youth and adult players of a low skill level, as the levels of task difficulty and complexity are easier to adjust [46]. On the other hand, according to the development of physical fitness and tactical skills, coaches and practitioners can increase the pitch size and formats. In addition, previous studies found that coaches periodized training contents to attain the highest weekly training load in the middle of the week (e.g., three days before a match) [47, 48]. Therefore, especially regarding starters (e.g., players who participate for at least 75 min in official matches), SSGs played on larger pitches are recommended in the middle of the week.

In youth and professional players, high-intensity activities (e.g., HSR and sprinting) are important physical variables in official matches [49–51]. In fact, using meta-analytical procedures, the current study provided robust conclusions about the advantages of larger SSGs in increasing TD and HSR compared to smaller SSGs. However, previous studies have provided a critical discussion about the specificity and representativeness of SSGs to stimulate the physical demands of official matches, which is worthy of further discussion [52]. Players tend to perform fewer high-intensity activities (e.g., > 19.8 $km \cdot h^{-1}$ or > 25.2 $km \cdot h^{-1}$) in SSGs than in official matches [53]. In contrast, accelerometry-based variables increase during SSGs [54] and achieve similar values to the peak periods of official matches [55]. Therefore, regarding physical demands, SSGs are not the same as official matches. External load monitoring and complementary exercise approaches (e.g., generic high-intensity running exercises) could be useful to ensure that distance- and accelerometry-based outcomes are achieved throughout the season [56]. Naturally, interactions of pitch sizes with other task constraints as rule modifications may produce different results for coaches. As an example, a recent study revealed that including mini-goals vs. using a ball possession match lead to lower values in physical demands [57].

Smaller vs. larger pitch sizes during SSGs: Effects on technical execution

Analyzing the differences in the technical actions performed by players under different SSG rules may help coaches improve the propensity of the task to the main goal of the session. Knowledge on the impact of pitch size alterations on players' technical execution is useful for better pedagogical planning. The results of the current systematic review and meta-analysis showed that the frequency of technical actions is not influenced by changing the pitch size.

Differences in tactical [58], physiological [59], and physical [60] responses were observed when the pitch size was changed. Also, smaller pitches seem to induce players to reduce the interpersonal

distances between them. Together, these two factors could lead to differences in technical execution when the pitch size is manipulated, which contrasts the current results. The heterogeneity of the data and the type of variable measured are two main factors that might contribute to this effect.

Regarding the heterogeneity of the data, some studies indicated that the numbers of passes [61] and dribbles [40] are higher for SSGs played on smaller pitches, while others showed that these values are higher on larger pitches [17, 62]. We argue that other rules might have biased the results, leading to high heterogeneity. Specifically, the presence of a goalkeeper, the adoption of the offside rule, and the presence of floaters are examples of rules that were not homogeneously adopted across studies. For example, a previous study showed that numerically balanced SSGs required players to dribble more frequently than in formats with floaters [63]. Even though the smaller pitches brought players closer together (thus facilitating the execution of passes), the numerically balanced condition might have encouraged players to dribble instead of pass. Therefore, these contradictory effects, when expanded to other possible manipulations, might explain the high heterogeneity among results and the failure of some studies to detect an influence of changing the pitch size on technical execution.

Moreover, technical execution was primarily measured by accounting for the frequency of the events. Although this approach allows coaches to understand the propensity of each SSG to stimulate the main outcome of the session, it neglects the quality of the technical executions observed. Thus, coaches must also consider players' skill levels [64] and task complexity [65] when deciding which formats to choose. Specifically, the same frequencies of technical actions could be observed even if differences in the quality of the execution are hidden. For example, since the players are closer to each other on smaller pitches [66], a higher percentage of successful passes could be expected, although dribbling could become more difficult because there is less available space. These results are not measurable by the current methodology, as most of the studies accounted only for the frequency and not the quality of technical actions. Therefore, adopting a contextual analysis of technical execution that includes performance indicators for each variable and accounts for skill efficacy and efficiency remains a challenge for future researchers in this topic.

Smaller vs. larger pitch sizes during SSGs: Effects on tactical behavior

The selected studies on tactical behavior considered positional variables, collected by tracking techniques using devices such as GPS and LPM systems [58, 66]. All tactical variables were continuously measured during the SSGs and represent both with- and without-the-ball behaviors. These results revealed no differences in the centroid position when changing the pitch size. While, larger pitches induced higher values of the stretch index and surface area.

A previous study on this topic has shown that when a specific axis of the field (e.g., depth) is increased, the players tend to increase their exploration towards that axis [67], even if the relative area per player remains the same. This means that increases in the pitch size as a whole (not just on one axis) are expected to increase the spatial exploration along both axes—this explains the observed increase in the stretch index and the surface area in larger pitches. The larger the pitch, the further the players are expected to be from each other to cover larger distances to create scoring opportunities when attacking and prevent them when defending. On the other hand, no differences in the centroid position were observed when the pitch size was altered. In the current study, goal-to-goal and lateral-to-lateral axes were analyzed together due to the small sample, which might explain the absence of differences. Specifically, the goal-to-goal centroid difference seems to be more strongly affected by changing the pitch size than the lateral axis distance [58, 68, 69]. In the future, when more studies on each variable are available, a new investigation on this topic is recommended to test this hypothesis.

The positional differences resulting from changing the pitch size should be considered by coaches when designing training tasks using SSGs. Specifically, increasing the pitch size seems to increase the difficulty that players face when attempting to adequately occupy the most relevant spaces on the pitch. At this point, adjusting the tactical complexity to players' current level is recommended [65]. For this reason, the increase in pitch size could be understood as a task constraint that should be progressively applied as the players get used to one specific format. In other words, when teaching young groups or introducing new tactical content to experienced groups, it could be beneficial to facilitate the tactical occupation by adopting smaller pitches—the pitch size can later be enlarged according to the development of players' tactical skills on small pitches. Supporting this assumption, a previous study showed that enlarging the pitch size reduces the number of interactions that occur during SSGs [45]. This is a strong indicator of difficulty to adopt more complex offensive strategies when the pitch size is increased.

Limitations, future research, and practical applications

Besides its contribution to the training process in soccer, the current review has limitations that must be considered. First, the high heterogeneity of the studies might be considered, as comparing studies methodologically different can increase the risk of bias. Therefore, a more in-depth investigation of SSGs is recommended to include studies with more similar experimental designs, thus reducing this bias. Also, none of the studies achieved a two-point score in the methodological quality assessment. This indicates that studies on SSGs should improve their methodology quality to adequately investigate the phenomenon. This issue is a challenge when conducting studies with high ecological validity, although recent advances in players' monitoring allow better control of intervening variables when the SSGs are prescribed alongside regular training. Still, better descriptions of experimental protocols will increase the reproducibility of studies and, hence, improve the methodological quality of future research by allowing the replication of designs under different task

conditions. It seems also important to emphasize the development of studies on the technical and tactical dimensions, as the small number of studies did not allow us to conduct a moderator analysis in the current systematic review. Finally, it seems important to consider the natural human variation occurring in SSGs which may play an important bias in case of no repeating measures in the experiments or in case of a high noise which may induce different results based on player's participation [70].

In practical settings, SSGs with larger pitch sizes (e.g., > 250 m^2 per player) can increase the physical demands imposed on players, especially TD and HSR. Considering that coaches periodize training contents in such a way that training load is increased until three days before the next match, larger pitches can be better during the middle of the week. In contrast, smaller pitches with optimal accelerometry loads can be a good option at the beginning of the week and/or until two days before the next match. In addition, SSGs with reduced load demands (e.g., smaller pitches associated with other task constraints) can facilitate the engagement of low-level young groups during training sessions.

Practical implications can be proposed concerning tactical and technical dimensions. Specifically, increasing the pitch size is not intended to impact the frequency of technical actions, although it significantly increases players' area of occupation on the pitch. For this reason, smaller pitches should be preferably adopted in young groups, which will characterize a facilitated task condition and allow players to explore tactical solutions for emerging problems. On the other hand, larger pitches will create a challenging environment in which the spatial occupation will be more difficult, which can emphasize the development of collective tactical principles related to concentration and space creation.

CONCLUSIONS

This systematic review revealed a clear effect of larger pitch sizes for increasing the intensification of internal load responses (HR and RPE), distances covered (total and HSR), and promoting the dispersion of players at a collective level (stretch index and surface area). These results were confirmed independently of the format of play and age group in terms of internal load and external load. Despite the heterogeneity of the pool of included articles, the individual results of each study provided clear support for these findings. On the other hand, meaningful differences were not evident between pitch sizes in terms of the numbers of accelerations, decelerations, passes, or dribbles performed. Based on the available evidence, larger pitch sizes can be recommended to increase the physiological and physical intensities of SSGs and promote collective dynamics occupying greater space to distance players.

Conflicts of interest/Competing interests

The authors declare that they have no conflicts of interest relevant to the content of this review.

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Authorship Contributions

FMC lead the project, wrote and revised the original manuscript. RRC analyzed and interpreted the data, wrote the statistical report and revised the original manuscript. FMC, HS and MRG run the data search, performed the methodological assessment, conducted the data extraction, wrote and revised the original manuscript. GMP, RA, DC, JRG, RS and AFS wrote and revised the original manuscript.

Conflict of interest

The authors declared no conflict of interest.

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