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Effects of small-sided games on technical-tactical actions and physical performance in handball: a systematic review

review paper
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ABSTRACT

Purpose. This systematic review aimed to investigate the acute and chronic effects of the task constraints of small-sided games on technical-tactical, physical, and physiological indicators in handball players.

Methods. A systematic literature search was performed between 2000 and 2020 in SciELO, ISI Web of Science, SPORTDiscus by EBSCOhost, Medline, Redalyc, and Scopus. Studies in female and male youth and adult handball players which involved acute and chronic effects of small-sided games on technical-tactical, physical, and physiological indicators were considered. Methodological quality was determined for the included studies.

Results. Altogether, 20 studies were included; 91% were published since 2014. The studies presented a mean of 80% in terms of methodological quality. Seven articles (35%) had a mean of 75% or less, and 13 articles (65%) had a mean above 75%. Decreasing on pitch area increased the total distance covered, while the smaller player format promoted increasing the total distance covered and time in sprints. Additionally, the time above 90% of the relative heart rate increased concomitantly with the player format increase.

Conclusions. The greater individual playing area (i.e., the pitch area divided by the number of players) resulted in higher values of total distance covered. The results identified gaps in the knowledge on the effects of task constraints on collective dynamic and tactical behaviour in handball players to be analysed in further studies.

Key words: task constraints, team sport, constraint-led approach, time-motion analysis, sports sciences

Introduction

Small-sided games (SSGs) are modified games, played in a different pitch area or player format [1]. This kind of practice is widely used by coaches of team sports (e.g., handball) in different competitive spheres with the purpose to simulate specific match situations by implementing constraint-led approaches, such as changing the number of players, the pitch area, and the playing time [2].

Initially, SSGs were employed with the purpose of technical-tactical development, as they favour a greater frequency of technical actions and stimulate decision making through their intrinsic characteristics [1]. Subsequently, in view of the scientific evidence and demonstrated practices, researchers and coaches gradually incorporated this training strategy to improve the physical (e.g., capacity for repeated sprints) and physiological indicators (e.g., aerobic power, maximal oxygen uptake), with the premise that the greatest training benefits occur when the stimuli influence specific motor action patterns and physiological demands of the sport [3–6].

Advances in technologies (e.g., local positioning system, heart rate monitors, video cameras) contributed, simultaneously, to better control of internal and external loads, as well as technical-tactical demands during SSGs and other training [7]. Previous review

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articles revisited and organized research on SSGs mainly in soccer [8, 9] and some team sports [10, 11]. These studies analysed the most commonly searched topics, characterized the methodologies, and systematized the evolution of research trends related to these topics. In addition, the studies demonstrated that the number of players involved, the playing area, the encouragement of the coach, the establishment of rules, the presence or absence of goalkeepers, and the size and number of targets were task constraints that provided valuable information about the complex interaction of technical-tactical, physical, and physiological aspects, and on how the manipulation of these types of constraints could influence the training process. However, to the best of our knowledge, no previous systematic review investigated the effect of task constraints in SSGs on technical-tactical, physical, and physiological indicators in handball players.

Therefore, the aim of this study was to analyse, through a systematic review, the available literature on the effects of different task constraints applied during SSG sessions on technical-tactical, physical, and physiological indicators in handball players. In addition, the study summarized the comparisons of training programs based on SSGs and traditional high-intensity training (e.g., running and sprinting without game context).

Material and methods

Search strategy

This study was structured and carried out in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [12].

Two researchers (RA, CJD) conducted the literature search during the month of April 2021. In any case of disagreement, a researcher with extensive experience in the topic (RPM) determined whether the article should be included. Agreement between evaluators was assessed with Cohen's kappa coefficient ($\kappa = 0.90$). Seven databases were consulted: SciELO (Scientific Electronic Library Online), Web of Science, SPORTDiscus via EBSCOhost, Medline, Redalyc, and Scopus. The search was performed in 3 languages (English, Portuguese, and Spanish) by using the following descriptors: «handball and small-sided game», «balonmano and juegos reducidos», and «handebol and jogos reduzidos».

Eligibility criteria

This systematic review followed the PRISMA guidelines [13]. The PICOS approach (Population, Intervention, Comparator, Outcomes, Study design) was applied: (P) handball 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); (C) larger pitch sizes using any format of play (number of players involved); (O) mean and standard deviation values in both pitch sizes for at least 1 of the following main outcomes: physiological responses, physical responses, technical actions, and tactical behaviours; and (S) experimental or cross-over studies.

To be eligible in this systematic review, articles were required to (i) be empirical in nature; (ii) be written in Portuguese, English, or Spanish; (iii) have the terms 'handball' and 'small-sided games' in the title or abstract; (iv) be published between 2000 and 2020; (v) involve handball players; (vi) not include any insertion of rules that de-characterize the formal game (e.g., the insertion of targets); and (vii) not review studies. Congress abstracts, dissertations, theses, narratives, systematic reviews, meta-analyses, and articles published in journals without peer reviews were excluded from the sample. A flowchart of the literature search and selection is presented in Figure 1. Information about the participants, journal, year of publication, objectives, methods, and main conclusions were obtained for each article.

Methodological quality assessment

The methodological evaluation of each study reviewed was carried out in accordance with previous studies [14, 15], by applying an adapted version of the scoring system (Table 1). Six questions (Q1–Q6) were answered with a 3-point scale ('yes' = 2 points; 'in part' = 1 point; 'no' = 0 points), except for Q4. The sum of points for all questions (0–12 points) represents the methodological quality classification. In addition, the values were converted to a percentage scale. The threshold for methodological quality scores considered appropriate was > 75% [12].

Data extraction

To analyse the acute effects of SSGs on physical, physiological, and kinematic indicators, the manipulation of 2 key constraints of the task was considered: the area and the rules. The area was calculated by

Table 1. Evaluation of the methodological quality of each included study [13]

	Questions	Answer	Score
Q1	The objectives of the study are clearly defined	Yes = 2 Partially = 1 No = 0	0–2
Q2	Characteristics of the participants are presented (level, country, position, age, height, body mass)	Yes = 2 Partially = 1 No = 0	0–2
Q3	The physical and/or physiological and/or technical/tactical variables are clearly informed	Yes = 2 Partially = 1 No = 0	0–2
Q4	The reliability of the system/equipment is (i) not mentioned; (ii) mentioned (a quote from previous study/studies); or (iii) measured under local conditions where data collection occurred	Measured = 2 Mentioned = 1 Not mentioned = 0	0–2
Q5	Detailed results (e.g., mean and standard deviation, confidence interval) are presented	Yes = 2 Partially = 1 No = 0	0–2
Q6	Insightful conclusions (clear and practical applications and future directions) are presented	Yes = 2 Partially = 1 No = 0	0–2
Total			0–12

using the relationship between the pitch area and the format reported in the papers [3, 6, 16–19]. For example, in an SSG performed in a 24 × 12 m (288 m^2) space with the 4vs4 player format, there is an area equal to 36 m^2 per player, which represents ca. 54% of the area of a formal game. This normalization aids the analysis of information obtained from the analysed task constraints (format and pitch area). Regarding the rules, we considered the application of the official rules of the modality, except for studies that evaluated actions with and without the application of physical contact between the players during the execution of the SSGs.

Methodological quality analysis of included studies

Table 2 presents the results of the analysis of the methodological quality of the studies included in this systematic review. On the basis of a previous study, we considered values above 75% of the score as the reference value to attribute good methodological quality to a paper [13]. Thus, we identified that the selected studies presented a mean of 80% in terms of methodological quality. Seven articles (35%) had a mean of 75% or less, and 13 articles had a mean above 75% (65%).

Considering the 6 questions used, question 4, which verifies the reliability of the systems applied for data analysis, presented the lowest concept, with only 25% of the studies demonstrating analysis and/or attribution of validation of the instruments. We identified that although the studies involved previously validated instruments, they did not verify the applicability of the reliability and reproducibility results to their data set.

Ethical approval

The conducted research is not related to either human or animal use. All procedures were conducted in accordance with the guidelines for studies of this nature and were approved by the Ethics Committee of the Ribeirão Preto School of Physical Education and Sports, University of São Paulo, Brazil (protocol No.: 78852817.2.0000.5659).

Results

Initially, 120 papers were found in the databases consulted. Of this total, 55 were identified in duplicate. Then, 45 articles were removed owing to some criteria: another sport (13 papers), only physical education class (5 papers), inadequate criteria (25 papers), review study (1 paper), another language (1 paper). Finally, 20 papers obeyed all the inclusion criteria for analysis (Figure 1).

Table 2. Analysis of the methodological quality of the studies included in the systematic review

Article	Q1	Q2	Q3	Q4	Q5	Q6	Total	%
	0–2	0–2	0–2	0–2	0–2	0–2	0–12	0–100
Iacono et al. [20]	2	2	2	2	2	2	12	100
Iacono et al. [21]	2	2	2	2	2	2	12	100
Iacono et al. [22]	2	2	2	0	2	2	10	83
Bělka et al. [6]	2	2	2	2	2	0	10	83
Clemente et al. [19]	2	2	2	0	2	2	10	83
Iacono et al. [23]	2	2	2	0	2	2	10	83
Madsen et al. [3]	2	2	2	0	2	2	10	83
Iacono et al. [24]	2	2	2	0	2	2	10	83
Ravier and Marcel-Millet [5]	2	2	2	0	2	2	10	83
Corvino et al. [17]	2	2	2	0	2	1	9	75
Buchheit et al. [25]	2	1	2	0	2	2	9	75
Abade et al. [4]	2	2	2	0	1	2	9	75
Bělka et al. [18]	2	1	2	0	2	2	9	75
Clemente and Rocha [26]	1	1	1	0	1	1	5	42
Clemente et al. [27]	2	2	2	0	2	2	10	80
Corvino et al. [16]	2	2	2	0	2	2	10	80
Belando and Arias-Estero [28]	2	2	2	1	2	2	11	92
Sánchez et al. [29]	2	1	1	1	2	2	9	75
Ortega-Becerra et al. [30]	2	2	2	0	2	2	10	80
Clemente and Rocha [31]	2	1	1	1	2	2	9	75
Mean ± *SD*	1.9 ± 0.3	1.7 ± 0.5	1.9 ± 0.3	0.5 ± 0.9	1.9 ± 0.4	1.7 ± 0.6	9.8 ± 1.8	80.2 ± 11.7

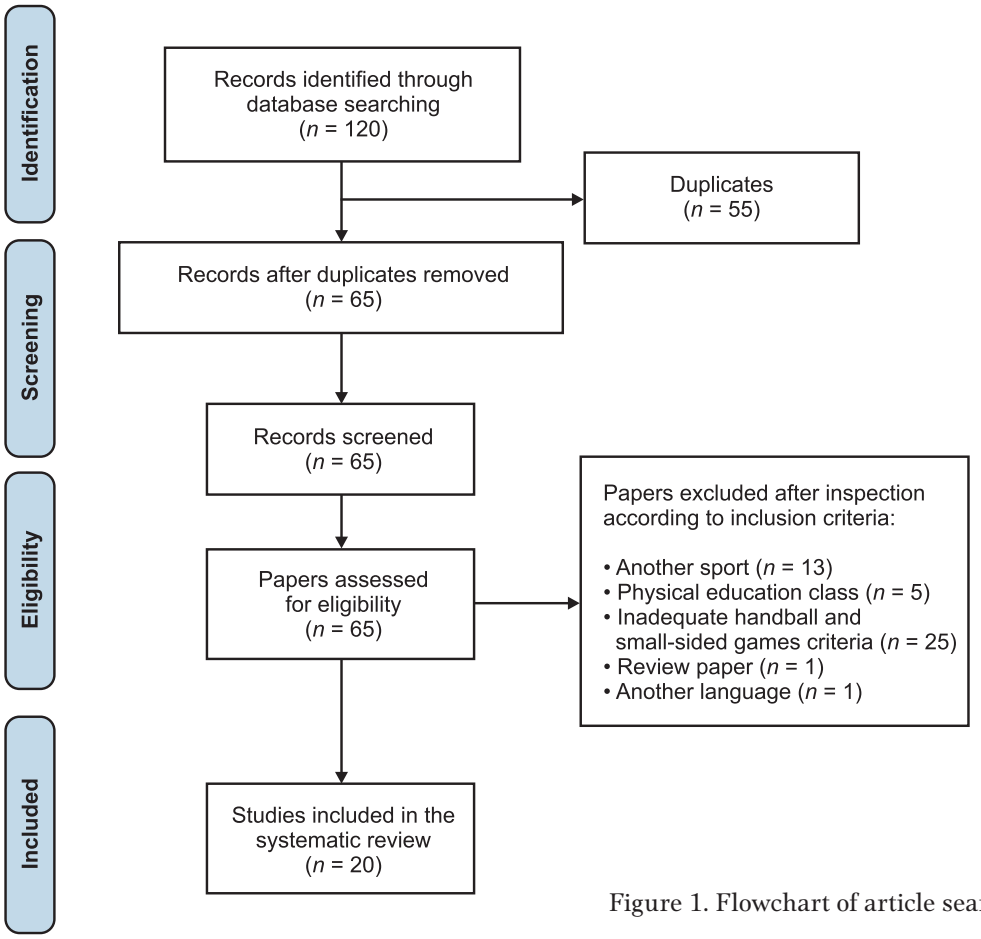

Figure 1. Flowchart of article search and selection

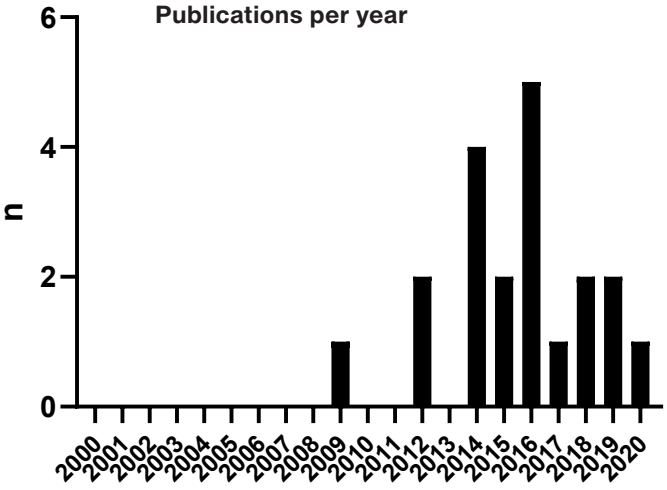

Figure 2. Years of publication of the studies included in the systematic review

Bibliometric analysis

When analysing the time scale for publication of research on SSGs, it was observed that 17 studies were published in years 2014–2019, corresponding to approximately 85% of the total publications (Figure 2). This result reinforces the increase in importance that this study theme has received as a mode of training in recent years.

Figure 3 shows the distribution of countries of authorship for the included studies. It can be seen that authors from Portugal correspond to 17% (9 authors) of the 52 authors who published on this theme, followed by those from Denmark and France, with 13% (7 authors) each. Overall, 65% of the publications on SSGs applied to handball were concentrated in 5 countries. Regarding the language of the papers, 15 studies (75%) were published in English, 3 (15%) in Portuguese, and 2 (10%) in Spanish, which demonstrates the hegemony of English as an international language for scientific communications.

Acute effects of SSG

Firstly, we identified the pitch area presented by the studies that evaluated the acute effects of SSG application, regardless of the variables analysed, and divided this by the format in each imposed situation. Thus, we obtained the playing area relative to each player for the different situations. Table 3 presents the variables analysed in each study.

The analysis of studies that measured the acute effects of SSGs related to the variation in pitch area [16, 17] revealed that as the pitch area increased, there was a trend for the total distance covered to increase. In turn, in the analysis of the variation in the format [6, 18], a decreasing number of players was associated with higher levels of total distance covered. For the variable of total time with heart rate above 90% of relative heart rate, an upward trend was noted as the number of players increased. By correlating the game area available to each player with rated perceived exertion, a median correlation of 0.36 was obtained ($p < 0.05$).

When investigating the application of SSGs with and without allowing physical contact, the possibility of making physical contact with the opponent resulted in more time in high-intensity runs and sprints [23], more jumps [23], and, consequently, a greater reduction in the performance of lower and upper limbs after SSGs, in addition to higher interleukin-6 count [22], which is an indicator of muscle inflammation. On the

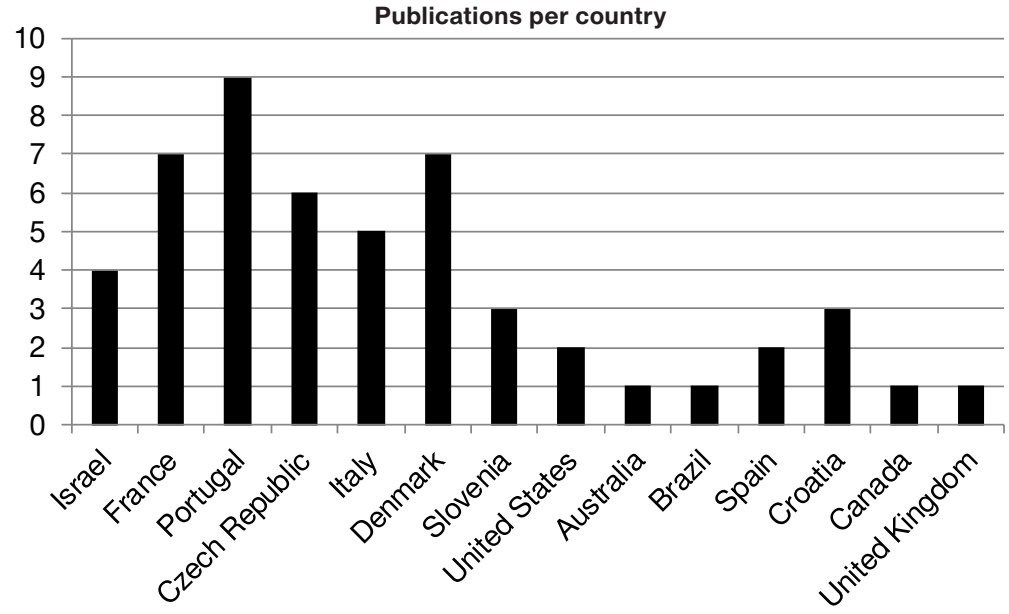

Figure 3. Country of origin of the authors of the studies included in the systematic review

Table 3. Numeric and spatial relations, playing area, number of players, playing area per player, total distance covered, sprint time, total actions, time in actions above 90% of relative HR, and subjective perception of effort in studies that evaluated acute effects of small-sided games application

Article	Relations		Court area (m^2)	Players (*n*)	Area/ player (m^2)	Total distance (m)	Sprint displacement time (%)	Actions (*n*)	Time over 90% HRrel (s)	RPE
	Numeric	Spatial								
[16]	4vs4	24 × 12 m	288	8	36	948 ± 64	3.9 ± 5.9	32 ± 2	56.1 ± 27.7	7.7 ± 1.0
		30 × 15 m	450	8	56.3	1087 ± 92	19.6 ± 25.4	27.1 ± 1	44.1 ± 33.6	8.2 ± 1.2
		32 × 16 m	512	8	64	1079 ± 90	13.9 ± 11.1	26 ± 2	32.9 ± 38.7	7.3 ± 1.2
[17]	4vs4	24 × 12 m	288	8	36	885 ± 66.7	0.4 ± 1.0	34 ± 1	53.7 ± 31.6	6.3 ± 0.5
		30 × 15 m	450	8	56	980 ± 73.5	6.2 ± 11.1	29 ± 1	22.7 ± 27.7	7.7 ± 0.8
		32 × 16 m	512	8	64	1095 ± 113	27.9 ± 35.9	28 ± 1	49.9 ± 39.3	8.2 ± 1.0
[6]	5vs5	Full court	800	10	80	497.4 ± 51.8	62.6 ± 31.2	18 ± 1.7	38	15.1 ± 2.3
	4vs4		800	8	100	503.9 ± 41.7	64.9 ± 32.9	19 ± 2.9	55	16 ± 1.8
	3vs3		800	6	133	527.3 ± 70.9	77.3 ± 45.6	19.6 ± 1.7	60	16.6 ± 1.5
[18]	5vs5	Full court	800	10	80	476.4 ± 52.1	12.1 ± 3.7	13.3 ± 0.9	30	12.3 ± 1.2
	4vs4		800	8	100	478.1 ± 72.7	19.2 ± 29.2	16.2 ± 2.6	42	14.6 ± 1.5
	3vs3		800	6	133	520.6 ± 61.4	32.5 ± 35.9	17.2 ± 1.9	57	17.7 ± 1.5
[3]	4vs4	Full court	800	10	80	1284 ± 162				–
	5vs5			12	66.7	1180 ± 158				–
	6 × 6									
[19]	4vs4	1/8 court	100	8	12.5	–	–	–		12.5 ± 1.3
	3vs3		100	6	16.7	–	–	–		12.6 ± 1.4
	2vs2		100	4	25.0	–	–	–		14.75 ± 1.91
	4vs4	1/4 court	200	8	25.0	–	–	–		14.6 ± 1.41
	3vs3		200	6	33.3	–	–	–		14.7 ± 1.5
	2vs2		200	4	50.0	–	–	–		16.9 ± 1.7

HRrel – relative heart rate, calculated from the Karvonen formula [32]; RPE – rated perceived exertion; total actions – sum of acyclic actions performed during the application of SSGs, such as sprints, change of direction of sprints

other hand, the application of SSGs without allowing physical contact resulted in a higher occurrence of runs at moderate intensity [23].

Chronic effects of SSG

Some studies sought to compare the effects of traditional physical training, performed through stimuli of high-intensity interval training (HIIT) and resistance exercises, with training through SSGs. Acutely, SSG training (composed of 2 sets of 8' 30" stimuli/30" passive recovery, with the entire game 3vs3), when compared with sprint training, presented lower results for the percentage of time of heart rate above 90% of maximum heart rate [33]. In turn, Ravier and Marcel-Millet [5] compared the acute effects of SSG, sprint training, and handball-specific circuit training; SSG was associated with higher levels of mean heart rate and maximum heart rate as compared with the other methods.

When comparing the chronic adaptations of the 2 training modes, it was observed in 4 studies that analysed these 2 training modes over a period of more than 8 weeks compared with protocols composed of high-intensity interval stimuli (HIIT) outside the context of the game, that SSGs in 2vs2 and 3vs3 situations were more efficient for increasing the capacity to perform sprint displacements [20, 25], mean sprint time [34], agility [20, 21], stand throw speed [21], maximum upper limb strength [20], and lower limb power measured by jumping with and without countermovement [20].

In addition, the application of resistance training + SSGs promoted an enhancement of playing time above 85% of maximum heart rate and possibly a greater muscle overload, which can negatively affect the ability to maintain the intensity of efforts and technical quality of players during SSG performance [4]. On the other hand, according to the same authors, the fatigue result-

ing from the greater overload will promote the development of aerobic resistance in players. In addition, members of the technical committee reported their preference for using SSGs over HIIT training without the specific game context, given their lack of structural specificity [20].

In relation to tactical analysis, we identified a study with this theme [29], which proposed to analyse the effects of 8 weeks of SSG application on the decision-making capacity of adolescent practitioners. A significant development was observed in decision making after this period of activities (decision made index: 0.27–0.62; $p < 0.05$), identifying the effectiveness of SSG application for the tactical development of handball practitioners.

When comparing the effects of a traditional warm-up (8' of specific throws) with those of SSGs (3 sets of 2' of SSG, with 1' of passive recovery), it was observed that SSG presented greater variations in heart rate, rated perceived exertion, and vertical jump with countermovement, indicating that this mode of play favoured better preparation of the players for the match [24].

Discussion

The aim of the current study was to systematically review the available literature on the effects of applying SSGs in handball on technical-tactical, physical, physiological, and kinematic indicators in 20 studies that met the assumptions for inclusion. The main results were: (i) the methodological quality of the studies with this theme was 80.2 ± 11.7%, with 10% receiving the maximum score (100%); (ii) the European continent presented a predominance of authors dedicated to this subject of study (43 from 52 authors), with few researchers from the Americas and Oceania; (iii) 95% of the studies were published in the last decade, 55% in the previous 5 years; (iv) pitch areas closer to the official dimensions of the court (40 × 20 m) resulted in an increase in the total distance covered, while smaller numerical relations showed a trend to maintain the total distance covered and time in sprints; (v) in relation to the variable of total time with the heart rate above 90% of relative heart rate, we observed an increasing trend as the format increased; and (vi) considering the development of muscle power within a macrocycle, physical training based on SSGs was as efficient as traditional training consisting of interval exercises; however, the latter was unrelated to the specificity of the game task.

The percentage score presented in the methodological quality of the studies is compatible with other published systematic reviews [13, 35] and indicates that the selected works present a good rigor of methodological actions. It is important to highlight that only 1 article received a score below 75%. Regarding the bibliometric analysis, we identified that Europe could be considered a reference in research involving SSGs and handball. It is important to note that researching the SSG theme, although consolidated in the literature, presented a greater volume of publications in the last decade [36, 37]. Handball seems to follow the trend of receiving more scientific attention from the second half of this decade. Another highlight is the predominance of publications in English, representing 75% of the papers selected in this study.

Regarding the constraints related to the pitch area, in the included studies it was observed that an increase in the pitch area resulted in greater total distances covered by the players and higher levels of heart rate, which corroborates other systematic review studies [38]. For example, on the basis of the results found, it is hypothesized that a reduction in pitch area can be explored when the aim is to develop the offensive transition game with the team, favouring understanding of the game strategy proposed by the coach. However, future research should test this hypothesis.

When analysing the constraints related to the number of players, the 4vs4 format presented higher indices of total distance travelled, time in sprints, and playing time above 90% of maximum heart rate. These results are compatible with the application of soccer SSGs in 4vs4, 3vs3, and 2vs2 formats [39] and with basketball [40, 41]. The median correlation (0.36) found to compare the distance covered by each player and the rated perceived exertion presented indicates that this variable has little explanation for the use of the pitch area [16, 17]. Higher results for this variable can be attributed to the higher frequency of moderate-intensity actions. It is also noteworthy that the use of SSGs on a half-court is associated with a higher frequency of short movements and changes in direction, which reflects the characteristics of invasion games, such as handball and basketball [42–44], providing a greater intensity of actions and, consequently, greater physiological overload [45].

When considering the need to carry out a greater volume of technical actions in training, with a view to solving problems in specific game situations, increasing the pitch area from 24 × 12 m to 30 × 15 m [16, 17], or even reducing the format from 5vs5 to 4vs4 [6, 18] will promote the greatest volume of actions and, consequently, the greatest number of problem situations for players to solve. This greater number of responses to

emerging problems could contribute to greater functional variability for players.

The analysis of the proposed application of SSGs as a parameter of physical training proved to be of great value for training. Comparing the effects of applying this training mode with traditional training (performed by using HIIT), both forms demonstrated, in the long term, a development in the variables of best sprint time, agility, lower limb power (by the stopped jump test with countermovement), supported and jump throw speeds, upper limb strength, and fatigue index. In addition, the investigated coaches reported greater preference for the use of SSGs owing to the specificity and representativeness compared with traditional training through HIIT outside of the game context [20, 37, 46]. It is important to highlight that the traditional training method provided significant results ($p < 0.05$) when compared with SSGs for 10-m sprint, countermovement jump, and upper limb strength, while SSGs presented superior results for agility and stationary throw. Thus, it should be emphasized that the variation in training stimuli throughout training planning is important, highlighting a certain form of training depending on the objectives to be developed in the training session.

With respect to the total acyclic actions (pitches, pivot movements, passes, jumps, defensive blocks, changes of direction), these increase in frequency with the pitch area increase from 24 × 12 m to 32 × 16 m [16, 17] and with a reduction in the format from 5vs5 to 3vs3 [6, 18]. Thus, the application of SSGs with a larger pitch area or lower format will favour a greater incidence of acyclic actions and, consequently, a greater volume of technical actions. This training proposal is interesting if the coach wants to apply a training strategy based on a transition game with more speed.

In the application of SSGs with and without physical contact, it was observed that tasks with physical contact presented greater results in high-intensity actions, such as sprints and jumps, while tasks without physical contact provided results in moderate-intensity actions [22, 23]. This information aids in the distribution of activities within training planning, with emphasis on the application of contactless SSGs at the beginning of the training program, to gradually increase the aerobic conditioning of the players, preserving their integrity. In a second step, when the players are in better condition, it is possible to emphasize the use of SSGs with physical contact.

As limitations of the present study, we indicate the fact that grey bibliography (e.g., books) was not included. In addition, the heterogeneity of the population of the studies analysed, which ranged from initiation sports players to the competitive elite of the sport of both sexes, promotes the presentation of conflicting information for some analysed items. As an example, we can mention the variables of sprint time with heart rate above 90% of relative heart rate, which presented linear variations proportionally to the increase in pitch area [16]. However, in another study [17], the same linearity of the results was not observed. The comparison between SSGs and sprint training presented discrepant results concerning the method promoting higher levels of maximum heart rate [5, 33]. The rated perceived exertion also presented divergences in results, with both a linear increase associated with a rise in the pitch area [17] and non-linearity of results observed [16]. In addition, a gap was identified, which should be explored in further studies, which lies in the analysis of the effects of pitch area and format constraints on tactical indicators; there is a lack of studies presenting results with this theme.

Conclusions

In summary, it is concluded that the manipulation of several key constraints in SSGs, based on the training objectives, can be considered an effective way to stimulate and develop technical, physical, and physiological indicators in handball players. We identified that as the pitch area increased, there was a trend for the total distance covered to increase. In turn, the format decreasing presented higher levels of total distance covered. The literature still lacks more information for better understanding of the effects of SSG application on tactical indicators (e.g., dispersion of players, area of team occupation, interactions or interpersonal coordination) in handball.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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Supplement 1. Effects of small-sided games on physical, physiological, and kinematic parameters

Author	Journal	Class	Methods	Main conclusions
Abade et al. (2014) [4]	Science & Sports	Adult males *n* = 12	3vs3 and 6 × 6 with and without strength training, 4 series × 5', half-court	3vs3 presented higher HR values
Corvino et al. (2016) [16]	Kinesiology	Adult males *n* = 8	4vs4, 3 series, 8', at dimensions: 12 × 24 m, 30 × 15 m, 32 × 16 m	Court dimensions reducing promotes greater physiological overload, while dimensions enhancement promotes more time in sprints and total distance covered
Corvino et al. (2014) [17]	Journal of Sports Science and Medicine	Adult males *n* = 6	3vs3, 8', at dimensions: 12 × 24 m, 30 × 15 m, 32 × 16 m	Court dimensions reducing promotes greater physiological overload, while dimensions enhancement promotes more time in sprints and total distance covered and RPE
Iacono et al. (2016) [21]	Journal of Strength and Conditioning Research	Adult males *n* = 18	SSG: 5 series, 2'25''–3'10''/1' passive recovery, 3vs3 SSG Sprint training: 2 series, 14–17 20-m sprints + jumps, 20'' active recovery, 4' passive recovery between series	SSG enhances agility and stand throw Sprint training enhances 10-m sprint, countermovement jump, and jump throw
Bělka et al. (2017) [6]	International Journal of Exercise Science	Adult females *n* = 12	3vs3, 4vs4, 5vs5 4' SSG / 3' passive recovery	Numerical decreasing enhances HR over 90% max, total distance covered, and sprint total distance
Buchheit et al. (2009) [46]	International Journal of Sports Medicine	Young males (15.5 ± 0.9 years) *n* = 32	10-week macrocycle, 2 times/week, 2 groups HIT: 12–24 15'' sprints at 95% Vmax HBT: SSG (from 2vs2 30'' to 3vs3 40'') Practice time equalized	Both methods presented enhancements on players' conditioning. In this way, handball game is more indicated for sprint enhancement because of its specificity
Iacono et al. (2015) [20]	Journal of Strength and Conditioning Research	Adult males *n* = 18	2 groups HIIT: 12–24 15'' sprints/ 15'' passive recovery at 90–95% max_{speed}) SSG: 3vs3, from 2 × 5 × 2'25'' to 2 × 5 × 3'10'' 8-week macrocycle	Both methods presented enhancement on players' conditioning. In this way, handball game is more indicated for sprint enhancement
Clemente and Rocha (2012) [26]	Brazilian Journal of Biomotricity	Young males (18.25 years) *n* = 8	SSG, 2vs2, 3vs3, 4vs4, 5'	Court dimensions decreasing promotes enhancement on useful game time, as HR, on each formation

Clemente et al. (2014) [19]	Revista Mackenzie de Educação Física e Esporte	Young males (18.25 years) *n* = 8 Young females (15 years) *n* = 8	SSG, 5' 2vs2, 1/8 court 2vs2, 2/8 court 3vs3, 1/8 court 3vs3, 2/8 court	Court dimensions decreasing at 1/4 presents RPE enhancement in comparison with 1/8 court dimension, basically at 2vs2 in comparison with 3vs3 and 4vs4
Iacono et al. (2017) [22]	Scandinavian Journal of Medicine and Science in Sports	Young males (19.3 years) *n* = 12	Contact and non-contact SSG 2 training sessions 5 × 3' series / 1' passive recovery	Both methods enhance physiological responses in comparison with handball regular game. Contact SSG promotes jump decreases and inflammatory markers
Bělka et al. (2016) [18]	Acta Gymnica	Young males (16 years) *n* = 12	SSG, 3vs3, 4vs4, 5vs5, 4'	Player reduction enhances total distance covered, sprint total distance covered, RPE, % HR max, and technical actions total
Iacono et al. (2018) [23]	Journal of Sports Science	Adult males (*n* = 12)	Contact and non-contact SSG	Contact SSG enhances high-intensity running, back displacements and sprints Non-contact SSG enhances moderated running time and side displacements
Madsen et al. (2019) [3]	Sports	Adult males and females	SSG (M 4vs4, M 5vs5, M 6 × 6) and 40 × 20 m (F 5vs5, F 6 × 6), 10' at 30 × 20 m court dimensions	M 4vs4 presented total throws, goals scored, total distance covered running, and moderated HR 40 × 20 m court dimensions presented higher sprint total distance covered and HR above 90% HRmax Spatial and numerical relations decreasing enhanced quantity of accelerations and HR peak
Iacono et al. (2021) [24]	Journal of Strength and Conditioning Research	Adult males *n* = 12	8' shooting drills 8' SSG (3vs3, 3 × 2' / 1' passive recovery)	Warm-ups with SSGs offer greater benefits than a more traditional warm-up, despite similar HR and RPE responses, even when matched for duration among elite-level handball players
Ravier and Marcel-Millet (2020) [5]	Journal of Human Kinetics	Adult males *n* = 14	Sprints: 2 × 6 × 25 m (12.5 + 12.5 m) Handball-specific circuit training: 10' intermittent actions SSG: 2 × 8' matches / 2' passive recovery	SSG presents higher levels of HRmean and HRmax compared with the other training methods

F – females, HBT – handball training, HIIT – high-intensity interval training, HIT – high-intensity training, HR – heart rate, M – males, max_{speed} – maximum speed, RPE – rated perceived exertion, SSG – small-sided game, Vmax – maximum speed

Supplement 2. Effects of small-sided games on technical actions

Author	Journal	Class	Methods	Results	Main conclusions
Corvino et al. (2016) [16]	Kinesiology	Adult males *n* = 8	SSG 4vs4, 3 series 8', on the dimensions: 24 × 12 m, 30 × 15 m, 32 × 16 m	**24 × 12:** 46 ± 2 throws 78 ± 8 passes 5 ± 1 tackles 4 ± 2 fixations 32 ± 2 total actions by each team **30 × 15:** 41 ± 4 throws 75 ± 10 passes 5 ± 1 tackles 3 ± 1 fixations 27 ± 1 total actions by each team **32 × 16:** 41 ± 5 throws 74 ± 13 passes 3 ± 2 tackles 2 ± 1 fixations 26 ± 2 total actions by each team	On 4vs4 SSG situation, court dimensions decreasing promotes enhancement on total technical actions
Corvino et al. (2014) [17]	Journal of Sports Science and Medicine	Adult males *n* = 6	3vs3 SSG, 8' on the dimensions: 24 × 12 m, 30 × 15 m, 32 × 16 m	**Total actions:** 24 × 12: 34 ± 1.0 30 × 15: 29.0 ± 1 32 × 16: 28 ± 2 **Throws:** 24 × 12: 58 ± 5 30 × 15: 49.0 ± 3 32 × 16: 48 ± 4 **Passes:** 24 × 12: 71 ± 6 30 × 15: 65 ± 6 32 × 16: 72 ± 4 **Tackles:** 24 × 12: 15 ± 3 30 × 15: 4 ± 1 32 × 16: 6 ± 1 **Fixations:** 24 × 12: 8 ± 2 30 × 15: 6 ± 1 32 × 16: 3 ± 1	Court dimensions decreasing promotes enhancement on total actions
Iacono et al. (2016) [21]	Journal of Strength and Conditioning Research	Adult males *n* = 18	Full-court 3vs3 SSG, 5 × 3' game / 1' rest between series	**Throws:** Contact: 0.57 ± 0.08 Non-contact: 0.56 ± 0.11	No differences in technical actions on contact and non-contact SSG

Belka et al. (2017) [6]	International Journal of Exercise Science	Adult females *n* = 12	3vs3, 4vs4, 5vs5 4' SSG / 3' passive recovery	**Total of attacks:** 5vs5: 18 ± 1.7 4vs4: 19 ± 2.9 3vs3: 19.6 ± 1.7 **Throws:** 5vs5: 15.1 ± 1.2 4vs4: 16.6 ± 2.5 3vs3: 18.7 ± 2.8 **Passes:** 5vs5: 59.88 ± 7.4 4vs4: 63.6 ± 8.5 3vs3: 53.8 ± 5.1 **Dribbling:** 5vs5: 12.6 ± 2.5 4vs4: 16.8 ± 1.1 3vs3: 21.4 ± 1.4	3vs3 SSG mimics an official game intensity
Belka et al. (2016) [18]	Acta Gymnica	Young males (16 years) *n* = 12	3vs3, 4vs4, 5vs5 4' SSG	**Total of attacks:** 5vs5: 13.3 ± 0.9 4vs4: 16.2 ± 2.6 3vs3: 17.2 ± 1.9 **Throws:** 5vs5: 13.0 ± 1.5 4vs4: 14.3 ± 2.5 3vs3: 17.3 ± 2.3 **Passes:** 5vs5: 79.3 ± 9.1 4vs4: 67.2 ± 7.4 3vs3: 66.9 ± 9.5 **Dribbling:** 5vs5: 18.8 ± 2.4 4vs4: 19.2 ± 4.2 3vs3: 21.8 ± 4.5 **Technical errors:** 5vs5: 3.1 ± 0.9 4vs4: 4.7 ± 1.5 3vs3: 2.8 ± 1.1	Numerical relation decreasing: more attacks and dribbling Numerical relation increasing: less attacks and dribbling

SSG – small-sided game