



# Influence of Pitch Dimensions and Player Numbers on Physical and Physiological Responses During Small-Sided Games in Female Soccer Players: A Narrative Review

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## Abstract

**Aim:** This review examined the influence of pitch dimensions and player numbers on physical and physiological responses during small-sided games (SSGs) in female soccer players, addressing the gender-specific research deficit in training prescription guidelines.

**Methods:** A systematic literature search was conducted across MEDLINE, ScienceDirect, Web of Science, and Google Scholar databases (1984-2024) to identify studies examining pitch dimension and player number effects on exercise intensity in elite and youth female soccer populations. Eligible investigations reported quantitative physical (distance metrics, speed classifications, acceleration profiles) or physiological (heart rate, metabolic power, blood lactate, perceived exertion) outcomes during SSG participation. Seven studies met inclusion criteria and underwent qualitative synthesis.

**Results:** Medium pitch dimensions (600-800 m<sup>2</sup> for 4-a-side formats) elicited superior cardiovascular intensity (mean heart rate: 89.88±3.56% HRmax; time >85% HRmax: 84.43±12.68%) compared to small (84.11±5.80% HRmax; 45.89±34.28%) and large (84.92±6.06% HRmax; 57.83±32.64%) configurations. Player number reductions from large to small formats progressively increased cardiovascular stress (time >85% HRmax: 54.9±27.9% vs. 69.8±25.9%), although 2vs2 configurations demonstrated paradoxically lower heart rate responses (89.8±1.8% HRmax) despite elevated blood lactate concentrations (9.1±0.9 mmol/L). Total distance covered increased with player number expansion (888.5±88.0 m [2vs2] to 1756.8±393.6 m [4vs4]), while high-intensity running distance was maximized in larger pitch formats (55.06±31.27 m vs. 21.03±11.33 m for large vs. small dimensions).

**Conclusion:** Medium-to-large pitch dimensions combined with 3vs3 to 5vs5 player configurations optimize cardiovascular and metabolic intensity for aerobic conditioning in female soccer players. Substantial methodological limitations and limited study quantity necessitate systematic factorial investigations to establish evidence-based SSG prescription frameworks.

**Keywords:** Aerobic capacity, athletic performance, cardiovascular responses, exercise intensity, metabolic demand, sports training methods, team sports, time-motion analysis

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## 1. INTRODUCTION

Small-sided games (SSGs) constitute modified training modalities characterized by reductions in player numbers, pitch dimensions, and rule modifications relative to full-scale match formats (1). These adaptations enable targeted manipulation of physiological, technical, and tactical training stimuli while preserving the ecological validity of sport-specific movement patterns and decision-making contexts (2).

The theoretical foundation for SSG implementation derives from the principle of training specificity, whereby adaptations are maximized when training stimuli replicate the biomechanical, metabolic, and neuromuscular demands of competitive performance (3). Empirical evidence demonstrates that SSGs elicit concurrent improvements across multiple fitness components, including aerobic capacity, repeated sprint ability, and sport-specific technical proficiency, thereby offering superior training economy compared to isolated conditioning methodologies (4).

The physiological rationale for SSG utilization centers on the capacity to achieve and sustain exercise intensities sufficient for cardiorespiratory adaptation through game-based activities rather than traditional interval protocols (1). Hill-Haas et al. (1) established that appropriately designed SSGs generate heart rate responses exceeding 85% of individual maximum values, corresponding to intensities associated with improvements in maximal aerobic power and lactate threshold. Furthermore, the intermittent nature of SSG activity patterns, characterized by frequent transitions between high-intensity efforts and lower-intensity recovery phases, replicates the metabolic demands of competitive soccer more accurately than continuous running protocols (5). This specificity extends beyond energy system development to encompass technical execution under fatigue conditions and tactical decision-making under time and space constraints, elements inadequately addressed through decontextualized training approaches (4).

Manipulation of SSG design variables enables systematic modulation of training intensity and technical-tactical complexity. Player numbers represent a primary determinant of individual involvement frequency, with reduced team sizes (2 vs. 3) necessitating increased ball contacts, defensive actions, and decision-making frequency per player compared to larger formats (6,7). Concomitantly, pitch dimensions influence the space available per player, thereby affecting locomotor demands, sprint distances, and the balance between aerobic and anaerobic energy contribution (2,8). Additional variables

including bout duration (9), rule constraints such as touch limitations or directional restrictions (10,11,12), and coach encouragement (13) provide further capacity for training load titration. The multifactorial nature of these interactions necessitates systematic investigation to establish evidence-based prescription guidelines.

Despite extensive research characterizing SSG responses in male populations, comparable investigation in female soccer players remains limited (16,17). This research deficit represents a significant constraint on evidence-based training prescription for female athletes, given established physiological and anthropometric differences between sexes that may influence optimal SSG design parameters. Sex-specific differences in aerobic capacity, anaerobic power, muscle mass distribution, and movement economy suggest that training load-response relationships observed in male cohorts cannot be directly extrapolated to female populations without empirical verification (16).

Existing reviews addressing SSGs in female soccer have adopted either multidisciplinary analytical frameworks examining physiological, physical, and technical responses (16) or focused analyses of specific variables such as pitch size effects on external and internal loads (17). However, comprehensive synthesis examining the interaction between player numbers and pitch dimensions on exercise intensity in female populations remains absent from the literature.

Current evidence demonstrates inconsistent findings regarding optimal SSG configurations for female players. While some investigations report maximal physiological stress at intermediate pitch dimensions (24,25), others identify progressive intensity increases with expanded playing areas (26). Similarly, player number manipulations yield complex interaction effects, with metabolic and cardiovascular responses not following linear dose-response patterns (7,23,27). These inconsistencies may reflect methodological heterogeneity, including variations in fitness levels of investigated cohorts, measurement technologies employed, and specific SSG formats examined (18,19,20,21,22,23). The absence of standardized protocols and the limited number of studies conducted in female populations constrains the development of unified training recommendations.

The primary objective of this review is to systematically analyze the influence of pitch dimensions and player numbers on exercise intensity during SSGs in female soccer players. Specifically, this work examines how systematic manipulation of these variables modulates physical responses (locomotor

activity profiles, distance covered across intensity zones, acceleration and deceleration frequencies) and physiological responses (heart rate dynamics, metabolic power, blood lactate accumulation, and rating of perceived exertion). Through critical synthesis of available evidence, this review addresses the gender-specific research deficit and establishes empirical foundations for optimizing SSG prescription in female soccer training contexts. Secondary objectives include identifying methodological gaps in existing literature and proposing directions for future investigation to advance evidence-based practice in female soccer conditioning.

## 2. Search Strategy

A systematic literature search was conducted to identify studies examining the effects of pitch dimensions and player numbers on exercise intensity during SSGs in female soccer populations. The search protocol targeted peer-reviewed empirical investigations reporting physical and physiological responses to SSG participation in elite and youth female players. Four electronic databases were interrogated: MEDLINE (via PubMed), ScienceDirect, Web of Science, and Google Scholar. Database selection was determined by comprehensive indexing of sports science, exercise physiology, and performance analysis literature, ensuring maximum coverage of relevant publications.

The temporal search window extended from 1984 through 2024, selected to capture foundational SSG research while emphasizing contemporary investigations employing advanced monitoring technologies. Search terms were constructed using Boolean operators to combine concept clusters related to training modality, response variables, and population characteristics. The primary search string incorporated the following terms in various combinations: “small-sided games,” “physiological responses,” “physical responses,” “variables,” and “female players.” Additional searches employed expanded terminology including “reduced player formats,” “conditioned games,” “training games,” “heart rate,” “GPS monitoring,” “time-motion analysis,” “lactate,” “metabolic power,” “women soccer,” and “female football.” These searches were executed iteratively, with each database interrogated using both individual search terms and combined Boolean expressions to maximize retrieval sensitivity while maintaining specificity for relevant studies.

Study eligibility criteria required empirical investigations examining at least one of two primary independent variables (pitch dimensions or player numbers) in SSG formats involving female soccer players. Included studies were required to report quantitative physical or physiological outcome measures, including but not limited to heart rate responses, distance covered across intensity classifications, metabolic power indices, blood lactate concentrations, or perceived exertion ratings. Both cross-sectional comparative designs (examining multiple SSG formats within the same participant cohort) and between-group investigations were considered eligible. Studies involving mixed-sex cohorts were excluded unless sex-

disaggregated data were presented. Similarly, investigations examining exclusively male populations, studies reporting only technical or tactical outcomes without physical or physiological data, and non-peer-reviewed sources (conference abstracts, dissertations, unpublished reports) were excluded from analysis.

Following initial database searches, citation lists of retrieved articles underwent manual screening to identify additional relevant publications not captured through electronic search strategies. This supplementary approach addressed potential indexing limitations and identified seminal works cited consistently within the SSG literature. Two authors independently conducted all search procedures, with discrepancies regarding study eligibility resolved through discussion and consensus.

Retrieved studies were evaluated for methodological quality, with particular attention to sample size adequacy, measurement instrument validity and reliability, control of confounding variables, and appropriateness of statistical analyses. Studies demonstrating critical methodological limitations that compromised internal validity were excluded from synthesis. The final corpus of included investigations was analyzed to extract data on participant characteristics, SSG design parameters, measurement protocols, and reported physical and physiological outcomes, forming the empirical foundation for subsequent synthesis and interpretation.

## 3. Variables Affecting SSG Intensity

### 3.1. Pitch Dimension

Pitch area represents a fundamental determinant of physiological and physical stress during SSGs, with systematic variations in playing surface dimensions directly influencing cardiovascular load, locomotor output, and metabolic demand. Empirical investigations examining pitch size effects in female soccer players have consistently demonstrated non-linear relationships between available playing area and exercise intensity metrics, necessitating careful consideration of dimensional parameters when prescribing training loads (2,24,25,26).

López-Fernández et al. (24) examined cardiovascular responses across three pitch dimensions in 4-a-side SSGs (400 m<sup>2</sup>, 600 m<sup>2</sup>, 800 m<sup>2</sup>) using continuous heart rate monitoring in female soccer players (age: 19.56±1.97 years). Medium-dimension formats (600 m<sup>2</sup>) elicited significantly elevated cardiovascular stress relative to both smaller and larger playing areas, evidenced by mean heart rate values of 89.88±3.56% HR<sub>max</sub> compared to 84.11±5.80% HR<sub>max</sub> and 84.92±6.06% HR<sub>max</sub> for small and large formats respectively. Peak heart rate responses demonstrated comparable patterns, with medium formats achieving 95.47±3.64% HR<sub>max</sub> versus 92.58±4.46% HR<sub>max</sub> (small) and 92.77±4.57% HR<sub>max</sub> (large). The proportion of exercise duration exceeding 85% HR<sub>max</sub>, a threshold associated with high-intensity aerobic training adaptations, was substantially greater in medium formats

(84.43±12.68%) compared to small (45.89±34.28%) and large (57.83±32.64%) dimensions. These findings indicate an inverted U-shaped relationship between pitch area and cardiovascular intensity in this format, with intermediate dimensions optimizing aerobic system stimulation.

Metabolic power profiling across identical pitch dimensions revealed convergent patterns supporting optimal intensities at medium and large playing areas (25). Medium formats (600 m<sup>2</sup>) generated marginally higher metabolic demands than large formats (800 m<sup>2</sup>) across multiple indices: relative metabolic load (2.57±0.28 vs. 2.56±0.29 KJ/kg), average metabolic power (10.67±1.12 vs. 10.66±1.21 W/kg), and equivalent distance (552.21±57.63 vs. 551.89±62.80 m). Small formats (400 m<sup>2</sup>) consistently produced lower metabolic outputs (2.26±0.19 KJ/kg, 9.38±0.82 W/kg, 484.82±42.25 m for respective variables), suggesting insufficient space per player to sustain elevated metabolic rates despite potentially increased technical involvement. High metabolic load distance, however, progressively increased with expanding pitch dimensions (65.39±15.80 m, 89.48±26.72 m, 99.14±28.48 m for small, medium, and large formats respectively), indicating that larger playing areas facilitate greater absolute volumes of high-intensity activity even when average intensities plateau.

Movement profile analysis corroborated the superiority of medium and large pitch dimensions for locomotor output (2). Total distance covered increased systematically with pitch expansion: 398.98±33.35 m (400 m<sup>2</sup>), 457.18±45.17 m (600 m<sup>2</sup>), and 458.63±52.03 m (800 m<sup>2</sup>), with medium and large formats yielding statistically equivalent total outputs. High-intensity running distance demonstrated progressive elevation across formats (21.03±11.33 m, 42.98±23.74 m, 55.06±31.27 m respectively), with large formats enabling the greatest high-speed activity volumes. Maximal sprint speeds remained relatively stable across conditions (15.70±1.73 km·h<sup>-1</sup>, 15.91±1.12 km·h<sup>-1</sup>, 16.03±0.86 km·h<sup>-1</sup>), while peak acceleration demonstrated non-monotonic variation with the highest values observed in medium formats (2.50±0.15 m·s<sup>-2</sup>)

compared to small (2.39±0.15 m·s<sup>-2</sup>) and large (2.40±0.13 m·s<sup>-2</sup>) dimensions.

Contemporary investigations employing alternative format structures provide additional context for pitch dimension effects. González-García et al. (26) compared 6-a-side SSGs across two pitch dimensions (20×20 m, 30×30 m) with and without mini-goals in elite female players (age: 26.50±5.70 years). The 30×30 m format without goals (30NG) elicited the highest activity profiles across multiple locomotor variables: total distance (114.49±12.84 m·min<sup>-1</sup>), low-intensity running distance (110.83±12.47 m·min<sup>-1</sup>), high-intensity running distance (3.66±1.67 m·min<sup>-1</sup>), maximum speed (12.8±6.97 m·min<sup>-1</sup>), and acceleration frequency (3.89±1.83 m·min<sup>-1</sup>). Conversely, the 20×20 m format with mini-goals (20MG) consistently produced the lowest values across these same metrics (73.44±16.13 m·min<sup>-1</sup>, 55.81±21.61 m·min<sup>-1</sup>, 0.72±1.21 m·min<sup>-1</sup>, 9.06±6.65 m·min<sup>-1</sup>, 2.55±1.28 m·min<sup>-1</sup> respectively), suggesting that spatial restriction combined with goal-oriented constraints substantially attenuates physical output demands.

The mechanistic basis for elevated physical and physiological strain with expanded pitch dimensions derives from increased area per player, which amplifies movement opportunities and extends interception distances for defensive actions. Greater spatial distribution necessitates increased locomotor output to maintain tactical organization, particularly for non-ball-possessing players who must cover expanded defensive zones during both offensive and defensive phases. However, excessive pitch enlargement may reduce technical involvement frequency and tactical density, potentially diminishing skill execution opportunities and decision-making frequency. The observed plateau or slight reduction in certain intensity metrics beyond medium dimensions (600-800 m<sup>2</sup> for 4-a-side formats) suggests an optimal spatial range balancing locomotor demands with tactical engagement for aerobic and anaerobic conditioning objectives.

**Table 1.** Physiological and Physical Responses to Player Number Manipulation in Small-Sided Games: Evidence from Female Soccer Populations

Study	Sample Characteristics	SSG Format	Pitch Dimensions	Measured Variables	Key Findings
Mara et al. [7]	Elite female players. N = not specified. Age: 24.3±4.2 years	Small formats: 4vs4, 5vs5. Medium formats: 6vs6, 7vs7. Large formats: 8vs8, 9vs9	40×40 m (4vs4). 50×40 m (5vs5). 60×40 m (6vs6). 70×40 m (7vs7). 80×68 m (8vs8). 90×68 m (9vs9)	Physiological: Time >85% HRmax (%). Physical: Low-speed running (m·min <sup>-1</sup> ). High-speed running (m·min <sup>-1</sup> ). Sprint distance (m·min <sup>-1</sup> )	Physiological: Small: 69.8±25.9%, Medium: 62.1±31.6%, Large: 54.9±27.9%. Physical (Low-speed running): Small: 95.1±11.5, Medium: 98.7±9.6, Large: 91.7±13.8. (High-speed running): Small: 24.9±7.2, Medium: 23.0±6.5, Large: 26.2±8.0. (Sprint distance): Small: 1.3±1.8, Medium: 1.6±2.5, Large: 4.6±7.3.

Study	Sample Characteristics	SSG Format	Pitch Dimensions	Measured Variables	Key Findings
Trombeiro et al. [27]	Elite female players. N = not specified. Age: 26±4.42 years	Numerical equality: 3vs3. Numerical superiority: 3vs3+1 floater	36×27 m (both conditions)	Physiological: HRmax (bpm). Physical: Moderate-speed distance (m)	Physiological: 3vs3: 185±11, 3vs3+1: 181±12. Physical: 3vs3: 176±31, 3vs3+1: 195±32.
Köklü et al. [23]	Youth female players. N = not specified. Age: 16.1±2.3 years	2vs2, 3vs3, 4vs4	20×20 m (2vs2). 20×30 m (3vs3). 20×40 m (4vs4)	Physiological: %HRmax, [La <sup>-</sup> ] (mmol·L <sup>-1</sup> ), RPE. Physical: Total distance (m), Walking distance (m), Low-intensity running (m), High-intensity running (m)	Physiological (%HRmax): 2vs2: 89.8±1.8, 3vs3: 92.7±3.0, 4vs4: 92.0±1.9. ([La <sup>-</sup> ): 2vs2: 9.1±0.9, 3vs3: 7.7±0.8, 4vs4: 6.3±1.1. (RPE): 2vs2: 7.0±0.8, 3vs3: 5.0±0.8, 4vs4: 4.9±0.9. Physical (Total distance): 2vs2: 888.5±88.0, 3vs3: 1042.5±156.9, 4vs4: 1756.8±393.6. (Walking): 2vs2: 485.4±48.6, 3vs3: 547.0±121.4, 4vs4: 1067.3±169.3. (Low-intensity running): 2vs2: 315.1±41.6, 3vs3: 374.8±79.5, 4vs4: 549.3±218.6. (High-intensity running): 2vs2: 10.6±9.3, 3vs3: 15.7±11.2, 4vs4: 37.3±25.5.

Note: HRmax = maximum heart rate; [La<sup>-</sup>] = blood lactate concentration; RPE = rating of perceived exertion; m = meters; bpm = beats per minute; mmol·L<sup>-1</sup> = millimoles per liter. All values reported as mean±standard deviation unless otherwise specified.

### 3.2. Player Numbers

Player number manipulation constitutes a primary variable for modulating training intensity in SSGs, with systematic reductions in team size directly influencing individual involvement frequency, cardiovascular demand, and locomotor output patterns. Existing evidence demonstrates complex, non-linear relationships between player numbers and physiological responses in female populations, with format-specific effects varying according to the intensity domain examined (7,23,27).

Mara et al. (7) investigated physiological and physical responses across a comprehensive range of player numbers in elite female soccer players (age: 24.3±4.2 years), categorizing formats as small (4vs4, 5vs5), medium (6vs6, 7vs7), or large (8vs8, 9vs9) with standardized pitch dimensions per format. Cardiovascular intensity, quantified as the proportion of total exercise duration exceeding 85% HRmax, demonstrated systematic attenuation with increasing player numbers: 69.8±25.9% (small formats), 62.1±31.6% (medium formats), and 54.9±27.9% (large formats). This inverse relationship between team size and relative cardiovascular intensity reflects the increased rest-to-work ratio and reduced individual tactical involvement characteristic of larger-sided games.

Locomotor profiles, however, revealed divergent patterns across speed classifications. Low-speed running distance per minute was greatest in medium formats (98.7±9.6 m·min<sup>-1</sup>) compared to small (95.1±11.5 m·min<sup>-1</sup>) and large (91.7±13.8 m·min<sup>-1</sup>) configurations, suggesting intermediate player numbers optimize continuous low-intensity displacement. High-speed running demonstrated marginal variation across formats (24.9±7.2 m·min<sup>-1</sup>, 23.0±6.5 m·min<sup>-1</sup>, 26.2±8.0 m·min<sup>-1</sup> for small, medium, and large respectively), while sprinting distance was substantially elevated in large formats (4.6±7.3 m·min<sup>-1</sup>) relative to small (1.3±1.8 m·min<sup>-1</sup>) and medium (1.6±2.5 m·min<sup>-1</sup>) conditions, potentially attributable to increased spatial availability enabling sprint execution.

Numerical superiority conditions introduce additional complexity to player number effects on training intensity. Trombeiro et al. (27) compared 3-a-side SSGs under numerical equality versus offensive numerical superiority (3vs3+1 floater) in elite female players (age: 26±4.42 years). Numerical equality elicited significantly higher peak heart rates (185±11 bpm) compared to numerical superiority formats (181±12 bpm), suggesting that balanced team configurations impose greater cardiovascular demands through intensified defensive pressure and reduced ball possession security. Locomotor responses demonstrated inverse patterns, with numerical

superiority producing elevated moderate-speed running distances ( $195\pm 32$  m) relative to equal-number formats ( $176\pm 31$  m). This discordance between cardiovascular and locomotor intensity metrics indicates that numerical advantage facilitates increased total movement volume while paradoxically reducing peak cardiovascular stress, likely reflecting enhanced ball possession continuity and reduced defensive urgency.

Recent investigations examining smaller-sided formats provide critical insights into the lower boundary of effective player number manipulation. Köklü et al. (23) compared 2vs2, 3vs3, and 4vs4 SSGs in youth female players (age:  $16.1\pm 2.3$  years) using standardized pitch dimensions ( $20\times 20$  m,  $20\times 30$  m,  $20\times 40$  m respectively to maintain consistent relative area per player). Contrary to hypothesized inverse relationships between player numbers and cardiovascular intensity, 2vs2 formats elicited significantly lower mean heart rate responses ( $89.8\pm 1.8\%$  HRmax) compared to 3vs3 ( $92.7\pm 3.0\%$  HRmax) and 4vs4 ( $92.0\pm 1.9\%$  HRmax) configurations. However, anaerobic glycolytic stress, quantified via blood lactate accumulation, demonstrated the anticipated inverse pattern with player number reduction, achieving peak concentrations in 2vs2 formats ( $9.1\pm 0.9$  mmol·L<sup>-1</sup>) versus 3vs3 ( $7.7\pm 0.8$  mmol·L<sup>-1</sup>) and 4vs4 ( $6.3\pm 1.1$  mmol·L<sup>-1</sup>). Perceived exertion ratings paralleled lactate responses, with 2vs2 formats rated substantially higher ( $7.0\pm 0.8$ ) than 3vs3 ( $5.0\pm 0.8$ ) and 4vs4 ( $4.9\pm 0.9$ ). These divergent patterns between cardiovascular and metabolic intensity metrics suggest that extremely small team configurations may compromise sustained aerobic stimulation through excessive anaerobic demand and fatigue accumulation, despite elevated perceived effort and lactate production.

Locomotor output demonstrated consistent positive associations with player number increases in the Köklü et al. investigation (23). Total distance covered progressively expanded across formats:  $888.5\pm 88.0$  m (2vs2),  $1042.5\pm 156.9$

m (3vs3), and  $1756.8\pm 393.6$  m (4vs4). This pattern persisted across all speed classifications, including walking distance ( $485.4\pm 48.6$  m,  $547.0\pm 121.4$  m,  $1067.3\pm 169.3$  m), low-intensity running ( $315.1\pm 41.6$  m,  $374.8\pm 79.5$  m,  $549.3\pm 218.6$  m), and high-intensity running ( $10.6\pm 9.3$  m,  $15.7\pm 11.2$  m,  $37.3\pm 25.5$  m for respective formats). The disproportionate expansion of walking and low-intensity activity relative to high-intensity running with increasing player numbers indicates that larger formats facilitate greater total movement volumes while shifting the intensity distribution toward lower-velocity activities, consistent with reduced individual involvement frequency and increased off-ball positioning demands.

The physiological mechanisms underlying elevated intensity in reduced-player formats involve multiple interacting factors. Smaller team configurations necessitate greater individual tactical responsibility, increased ball contact frequency, and reduced passive recovery periods between high-intensity actions. These demands elevate cardiovascular stress and metabolic power requirements through sustained active engagement. However, the non-linear relationships observed across studies, particularly the cardiovascular intensity reduction in 2vs2 formats despite elevated lactate accumulation (23), suggest that excessive player number reduction may induce premature fatigue, limiting the capacity to sustain aerobic intensity zones optimal for endurance adaptation. Furthermore, the interaction between player numbers and pitch dimensions introduces additional complexity, as relative area per player fundamentally alters spatial constraints and locomotor demands independent of team size effects. Optimal player number selection therefore requires careful consideration of training objectives, target energy system stimulation, and the interplay with pitch dimensional constraints.

**Table 2.** Physiological and Physical Responses to Pitch Dimension Manipulation in Small-Sided Games: Evidence from Female Soccer Populations

Study	Sample Characteristics	SSG Format	Pitch Dimensions	Measured Variables	Key Findings
López-Fernández et al. [24]	University-level female players. N = not specified. Age: $19.56\pm 1.97$ years	4vs4	Small: 400 m <sup>2</sup> . Medium: 600 m <sup>2</sup> . Large: 800 m <sup>2</sup>	Physiological: HRmean (%HRmax), HRpeak (%HRmax), Time >85% HRmax (%)	HRmean: Small: $84.11\pm 5.80$ , Medium: $89.88\pm 3.56$ , Large: $84.92\pm 6.06$ . HRpeak: Small: $92.58\pm 4.46$ , Medium: $95.47\pm 3.64$ , Large: $92.77\pm 4.57$ . Time >85% HRmax: Small: $45.89\pm 34.28$ , Medium: $84.43\pm 12.68$ , Large: $57.83\pm 32.64$ .
López-Fernández et al. [25]	University-level female players. N = not specified.	4vs4	Small: 400 m <sup>2</sup> . Medium: 600 m <sup>2</sup> . Large: 800 m <sup>2</sup>	Metabolic power: Relative metabolic load (KJ·kg <sup>-1</sup> ), Average metabolic power	Relative metabolic load: Small: $2.26\pm 0.19$ , Medium: $2.57\pm 0.28$ , Large: $2.56\pm 0.29$ .

Study	Sample Characteristics	SSG Format	Pitch Dimensions	Measured Variables	Key Findings
	Age: 19.56±1.97 years			(W·kg <sup>-1</sup> ), Equivalent distance (m), High metabolic load distance (m), Absolute metabolic load (KJ)	Average metabolic power: Small: 9.38±0.82, Medium: 10.67±1.12, Large: 10.66±1.21. Equivalent distance: Small: 484.82±42.25, Medium: 552.21±57.63, Large: 551.89±62.80. High metabolic load distance: Small: 65.39±15.80, Medium: 89.48±26.72, Large: 99.14±28.48. Absolute metabolic load: Small: 132.57±19.40, Medium: 148.95±19.80, Large: 149.82±19.77.
López-Fernández et al. [2]	University-level female players. N = not specified. Age: 19.56±1.97 years	4vs4	Small: 400 m <sup>2</sup> . Medium: 600 m <sup>2</sup> . Large: 800 m <sup>2</sup>	Physical: Total distance (m), High-intensity distance (m), Sprint maxmean (km·h <sup>-1</sup> ), Acceleration maxmean (m·s <sup>-2</sup> )	Total distance: Small: 398.98±33.35, Medium: 457.18±45.17, Large: 458.63±52.03. High-intensity distance: Small: 21.03±11.33, Medium: 42.98±23.74, Large: 55.06±31.27. Sprint maxmean: Small: 15.70±1.73, Medium: 15.91±1.12, Large: 16.03±0.86. Acceleration maxmean: Small: 2.39±0.15, Medium: 2.50±0.15, Large: 2.40±0.13.
González-García et al. [26]	Elite female players. N = not specified. Age: 26.50±5.70 years	6vs6	20×20 m with mini-goals (20MG). 20×20 m without mini-goals (20NG). 30×30 m with mini-goals (30MG). 30×30 m without mini-goals (30NG)	Physical: Total distance (m·min <sup>-1</sup> ), Low-intensity distance (m·min <sup>-1</sup> ), High-intensity distance (m·min <sup>-1</sup> ), Speed (m·min <sup>-1</sup> ), Acceleration (m·min <sup>-1</sup> ), Deceleration (m·min <sup>-1</sup> )	Total distance: 20MG: 73.44±16.13, 30MG: 76.90±18.44, 20NG: 96.46±13.12, 30NG: 114.49±12.84. Low-intensity distance: 20MG: 55.81±21.61, 30MG: 74.45±16.34, 20NG: 95.42±12.96, 30NG: 110.83±12.47. High-intensity distance: 20MG: 0.72±1.21, 30MG: 2.44±3.98, 20NG: 1.04±1.22, 30NG: 3.66±1.67. Speed: 20MG: 9.06±6.65, 30MG: 10.85±6.53, 20NG: 11.29±6.61, 30NG: 12.8±6.97. Acceleration: 20MG: 2.55±1.28, 30MG: 3.13±1.57, 20NG: 3.91±1.44, 30NG: 3.89±1.83. Deceleration: 20MG: 0.63±0.58, 30MG:

Study	Sample Characteristics	SSG Format	Pitch Dimensions	Measured Variables	Key Findings
					0.92±0.81, 20NG: 0.77±0.45, 30NG: 1.01±0.63.

Note: HR<sub>mean</sub> = mean heart rate; HR<sub>peak</sub> = peak heart rate; HR<sub>max</sub> = maximum heart rate; KJ = kilojoules; W = watts; kg = kilograms; m = meters; km·h<sup>-1</sup> = kilometers per hour; m·s<sup>-2</sup> = meters per second squared; m·min<sup>-1</sup> = meters per minute; MG = with mini-goals; NG = without mini-goals. All values reported as mean±standard deviation.

### 3.3. Integration of Pitch Dimension and Player Number Effects

The evidence synthesized across pitch dimension and player number manipulations reveals complex, interdependent effects on exercise intensity in female soccer players. Medium-to-large pitch dimensions (600-800 m<sup>2</sup> for 4-a-side; 30×30 m for 6-a-side) consistently optimize cardiovascular and metabolic intensity metrics while supporting elevated locomotor outputs, particularly in high-speed activity domains. Conversely, player number reductions generally enhance cardiovascular intensity and perceived exertion, with optimal formats appearing to reside in the 3vs3 to 5vs5 range where aerobic stress is maximized without inducing the premature anaerobic fatigue observed in 2vs2 configurations.

The divergence between cardiovascular intensity patterns and absolute locomotor volumes across player number conditions underscores the necessity of aligning SSG design with specific training objectives, whether prioritizing aerobic conditioning through sustained high heart rate zones or maximizing total movement volumes across varied intensity spectra.

Critical methodological limitations constrain definitive conclusions regarding optimal SSG configurations for female populations. The limited corpus of investigations (seven studies total), heterogeneity in participant characteristics (elite vs. youth; age range 16-27 years), measurement technologies (heart rate telemetry, GPS tracking, metabolic power algorithms), and statistical approaches preclude meta-analytic synthesis and restrict generalizability of observed effects. Furthermore, the absence of standardized pitch dimension-to-player number ratios across investigations introduces confounding through uncontrolled variations in relative area per player. Future research employing factorial designs systematically manipulating both variables within identical participant cohorts, utilizing validated physiological and physical monitoring technologies, and examining additional moderating variables (fitness level, playing position, competitive standard) is essential to establish evidence-based prescription guidelines for SSG implementation in female soccer training contexts.

## 4. DISCUSSION

This review synthesized existing evidence examining the influence of pitch dimensions and player numbers on exercise intensity during small-sided games in female soccer players.

The principal findings demonstrate that medium-to-large pitch dimensions (600-800 m<sup>2</sup> for 4-a-side formats, 30×30 m for 6-a-side configurations) optimize cardiovascular and metabolic intensity metrics while supporting elevated locomotor outputs, particularly in high-speed activity domains. Conversely, player number manipulations revealed complex, non-linear relationships with exercise intensity, wherein formats employing 3vs3 to 5vs5 configurations elicited maximal cardiovascular stress (62.1-69.8% of total time exceeding 85% HR<sub>max</sub>) without inducing the premature anaerobic fatigue observed in smaller team sizes. These findings provide empirical foundations for evidence-based SSG prescription in female soccer contexts, while simultaneously highlighting substantial knowledge gaps requiring systematic investigation.

The observed inverted U-shaped relationship between pitch area and cardiovascular intensity, wherein medium formats (600 m<sup>2</sup>) elicited superior heart rate responses (89.88±3.56% HR<sub>max</sub>) compared to smaller (84.11±5.80% HR<sub>max</sub>) and larger (84.92±6.06% HR<sub>max</sub>) dimensions (24), contradicts the linear dose-response patterns frequently reported in male cohorts. Casamichana and Castellano (8) demonstrated progressive intensity increases with pitch expansion in male players, suggesting potential sex-specific differences in spatial utilization and tactical behavior during SSGs. The physiological mechanism underlying optimal intensities at intermediate dimensions likely involves a balance between spatial availability for high-intensity running and tactical density sufficient to maintain continuous engagement. Excessive pitch restriction (400 m<sup>2</sup>) may constrain locomotor freedom, reducing opportunities for sustained aerobic running despite elevated technical involvement frequency. Conversely, overly expansive playing areas may reduce tactical pressure and ball contact frequency, diminishing the game-based intensity advantages that distinguish SSGs from traditional interval training methodologies.

Metabolic power profiling corroborated cardiovascular intensity patterns, with medium formats generating marginally superior relative metabolic loads (2.57±0.28 KJ/kg) and average metabolic power outputs (10.67±1.12 W/kg) compared to large dimensions (25). However, high metabolic load distance demonstrated progressive elevation with pitch expansion (65.39±15.80 m, 89.48±26.72 m, 99.14±28.48 m for small, medium, and large formats respectively), indicating that absolute volumes of high-intensity activity increase despite plateaus in average intensity metrics. This dissociation between average intensity and high-intensity volume suggests that larger

formats may preferentially benefit athletes requiring enhanced anaerobic capacity and repeated sprint ability, whereas medium dimensions optimize sustained aerobic stimulation. López-Fernández et al. (2) further demonstrated that high-intensity running distance and maximal sprint velocities were greatest in large formats ( $55.06\pm 31.27$  m and  $16.03\pm 0.86$  km/h respectively), supporting the utility of expanded playing areas for developing speed-endurance qualities in female players.

Player number manipulation yielded divergent effects across physiological domains, with critical implications for training periodization. The inverse relationship between team size and cardiovascular intensity observed by Mara et al. (7), wherein small formats (4vs4, 5vs5) elicited substantially greater proportions of exercise duration exceeding 85% HRmax ( $69.8\pm 25.9\%$ ) compared to medium ( $62.1\pm 31.6\%$ ) and large ( $54.9\pm 27.9\%$ ) configurations, aligns with established principles of individual involvement frequency. Reduced player numbers necessitate elevated tactical responsibility, increased ball contact frequency, and diminished passive recovery periods, collectively augmenting cardiovascular demand through continuous active engagement.

However, the anomalous findings reported by Köklü et al. (23), wherein 2vs2 formats produced significantly lower mean heart rate responses ( $89.8\pm 1.8\%$  HRmax) despite elevated blood lactate concentrations ( $9.1\pm 0.9$  mmol/L) and perceived exertion ratings ( $7.0\pm 0.8$ ), suggest a critical threshold beyond which player number reduction compromises sustained aerobic intensity. This apparent paradox likely reflects excessive anaerobic energy system contribution in extremely small formats, inducing premature fatigue that attenuates the capacity to maintain target heart rate zones. The substantially elevated lactate accumulation in 2vs2 configurations, approaching values associated with maximal anaerobic testing protocols, indicates predominant glycolytic metabolism rather than the sustained aerobic energy provision characteristic of moderate lactate steady-state intensities (typically 2-4 mmol/L). Gabbett and Mulvey (28) demonstrated similar patterns in male rugby players, wherein excessively small team configurations shifted metabolic profiles toward anaerobic dominance, compromising aerobic training adaptations despite high perceived effort. These findings underscore the necessity of matching player number selection to specific metabolic training objectives, with 3vs3 to 5vs5 formats appearing optimal for aerobic conditioning in female populations.

The interaction between player numbers and pitch dimensions introduces additional complexity requiring careful consideration. Trombeiro et al. (27) demonstrated that numerical superiority conditions (3vs3+1 floater) paradoxically reduced peak heart rates ( $181\pm 12$  bpm vs.  $185\pm 11$  bpm in numerical equality) while elevating moderate-speed running distances ( $195\pm 32$  m vs.  $176\pm 31$  m). This dissociation suggests that numerical advantage facilitates increased total movement volume through enhanced possession continuity and reduced defensive urgency, while simultaneously attenuating peak cardiovascular stress. These findings have direct implications

for training design, wherein numerical equality formats may preferentially target high-intensity aerobic development, while numerical superiority configurations optimize technical execution volume under reduced physiological stress.

Substantial methodological limitations constrain the generalizability of synthesized findings. The limited corpus of investigations (seven total studies) examining female populations represents a critical knowledge gap, particularly given established sex-specific differences in aerobic capacity, anaerobic power, muscle architecture, and movement economy that preclude direct extrapolation from male-derived evidence. The absence of standardized protocols for pitch dimension-to-player number ratios introduces confounding through uncontrolled variations in relative area per player, a fundamental determinant of locomotor demands independent of absolute pitch size or team configuration. Furthermore, heterogeneity in measurement technologies (heart rate telemetry, GPS tracking systems, metabolic power algorithms) and participant characteristics (elite vs. youth; age range 16-27 years; fitness levels) limits cross-study comparisons and prevents meta-analytic synthesis.

The review identified several critical gaps warranting systematic investigation. First, no studies examined the interaction between pitch dimensions and player numbers using factorial experimental designs within identical participant cohorts, precluding definitive conclusions regarding optimal configuration combinations for specific training objectives. Second, the influence of additional moderating variables including playing position, competitive standard, phase of season, and baseline fitness level remains unexplored in female populations. Third, technical and tactical outcomes were inadequately examined relative to physical and physiological responses, despite the purported advantage of SSGs in simultaneous skill and fitness development. Finally, longitudinal training studies examining chronic adaptations to systematically varied SSG configurations are entirely absent from the female soccer literature, limiting evidence-based prescription for training periodization across seasonal phases.

#### 4.1. Practical Recommendations

Coaches and conditioning specialists working with female soccer players should employ medium pitch dimensions (600-800 m<sup>2</sup> for 4-a-side formats; 30×30 m for 6-a-side configurations) when prioritizing cardiovascular and metabolic intensity development, particularly during pre-season and high-intensity training phases. Player number configurations should align with specific metabolic objectives: 3vs3 to 5vs5 formats optimize sustained aerobic intensity (>85% HRmax for 60-70% of exercise duration) suitable for aerobic capacity development, whereas 4vs4 formats balance cardiovascular stress with elevated total locomotor volumes including high-speed running. Extremely small formats (2vs2) should be employed judiciously and with abbreviated bout durations given excessive anaerobic demand and perceived exertion relative to sustainable aerobic intensity zones. Numerical superiority

conditions may facilitate technical development under reduced physiological stress during skill acquisition phases or recovery sessions. Practitioners should systematically monitor individual responses using heart rate telemetry and perceived exertion ratings to ensure prescribed configurations elicit target intensity zones across heterogeneous fitness levels within squads.

## 5. CONCLUSION

This review establishes that pitch dimensions and player numbers represent critical determinants of exercise intensity during small-sided games in female soccer players, with medium-to-large pitch areas (600-800 m<sup>2</sup>) and player

### Ethical Approval and Consent to Participate

The study protocol received approval from the local institutional ethics committee in accordance with the Declaration of Helsinki principles. All participants provided written informed consent after receiving comprehensive information regarding study objectives, procedures, potential risks, and the voluntary nature of participation.

### Consent for Publication

Not applicable.

### Competing Interests

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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### Authors' Contributions

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

### Declaration

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## References

1. Hill-Haas SV, Dawson B, Impellizzeri FM, Coutts AJ. Physiology of small-sided games training in football. *Sports Medicine*. 2011;41:199–220.
2. López-Fernández J, Gallardo L, Fernández-Luna Á, Villacañas V, García-Unanue J, Sánchez-Sánchez J. Pitch size and game surface in different small-sided games: Global indicators, activity profile, and acceleration of female soccer players. *Journal of Strength and Conditioning Research*. 2019;33:831–838.
3. Hammami A, Gabbett TJ, Slimani M, Bouhleb E. Does small-sided games training improve physical fitness and specific skills for team sports? A systematic review with meta-analysis. *Journal of Sports Medicine and Physical Fitness*. 2017;58:1446–1455.
4. Sarmiento H, Clemente FM, Harper LD, Costa ITD, Owen A, Figueiredo AJ. Small-sided games in soccer: A systematic review.

configurations of 3vs3 to 5vs5 optimizing cardiovascular and metabolic intensity for aerobic conditioning objectives. However, substantial limitations in the existing evidence base, including limited study quantity (seven investigations), methodological heterogeneity, and absence of factorial experimental designs, constrain definitive prescription guidelines. Future research employing standardized protocols, factorial designs systematically manipulating both variables, and longitudinal training interventions is essential to establish evidence-based frameworks for SSG implementation in female soccer populations, ultimately advancing training prescription quality and competitive performance outcomes in this underserved athletic cohort.

*International Journal of Performance Analysis in Sport*. 2018;18:693–749.

5. Clemente FM, Sarmiento H. The effects of small-sided soccer games on technical actions and skills: A systematic review. *Human Movement*. 2020;21:100–119.
6. Aguiar MV, Botelho GM, Goncalves BS, Sampaio JE. Physiological responses and activity profiles of football small-sided games. *Journal of Strength and Conditioning Research*. 2013;27:1287–1294.
7. Mara JK, Thompson KG, Pumpa KL. Physical and physiological characteristics of various-sided games in elite women's soccer. *International Journal of Sports Physiology and Performance*. 2016;11:953–958.
8. Casamichana D, Castellano J. Time–motion, heart rate, perceptual and motor behaviour demands in small-sided soccer games: Effects of pitch size. *Journal of Sports Sciences*. 2010;28:1615–1623.
9. Casamichana D, Castellano J, Dellal A. Influence of different training regimes on physical and physiological demands during small-sided soccer games: Continuous vs intermittent format. *Journal of Strength and Conditioning Research*. 2013;27:690–697.
10. Sanchez-Sanchez J, Hernández D, Casamichana D, Martínez-Salazar C, Ramirez-Campillo R, Sampaio J. Heart rate, technical performance, and session-RPE in elite youth soccer small-sided games played with wildcard players. *Journal of Strength and Conditioning Research*. 2017;31:2678–2685.
11. Dellal A, Hill-Haas S, Lago-Penas C, Chamari K. Small-sided games in soccer: Amateur vs professional players' physiological responses, physical and technical activities. *Journal of Strength and Conditioning Research*. 2011;25:2371–2381.
12. Lorenzo-Martínez M, de Dios-Álvarez VM, Padrón-Cabo A, Costa PB, Rey E. Effects of score-line on internal and external load in soccer small-sided games. *International Journal of Performance Analysis in Sport*. 2020;20:231–239.
13. Rampinini E, Impellizzeri FM, Castagna C, Abt G, Chamari K, Sassi A, Marcora SM. Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences*. 2007;25:659–666.
14. Aguiar M, Botelho G, Lago C, Maças V, Sampaio J. A review on the effects of soccer small-sided games. *Journal of Human Kinetics*. 2012;33:103–113.
15. Halouani J, Chtourou H, Gabbett T, Chaouachi A, Chamari K. Small-sided games in team sports training: A brief review. *Journal of Strength and Conditioning Research*. 2014;28:3594–3618.
16. De Dios-Alvarez V, Lorenzo-Martinez M, Padron-Cabo A, Rey E. Small-sided games in female soccer players: A systematic review.

Journal of Sports Medicine and Physical Fitness. 2022;62(11):1474–1480.

**17.** Sannicandro I. Small-sided games and pitch size in elite female soccer players: A short narrative review. *Journal of Human Sport and Exercise*. 2021;16(S2):S361–S369.

**18.** Sarmiento H, Clemente FM, Harper LD, Teoldo da Costa I, Owen A, Figueiredo AJ. Small-sided games in soccer: A systematic review. *International Journal of Performance Analysis in Sport*. 2018;18:693–749.

**19.** Travassos B, Coutinho D, Gonçalves B, Pedroso P, Sampaio J. Effects of manipulating the number of targets in futsal players' tactical behavior. *Human Movement Science*. 2018;61:19–26.

**20.** Sannicandro I. Small-sided games configuration and external motor load in young soccer players: Narrative review. *Journal of Physical Education and Sport*. 2019;19(S5):1989–1993.

**21.** Gonçalves B, Esteves P, Folgado H, et al. Effects of pitch area restrictions on tactical behavior, physical, and physiological performance in soccer large-sided games. *Journal of Strength and Conditioning Research*. 2017;31(9):2398–2408.

**22.** Lopez-Fernandez J, Sanchez-Sanchez J, Gallardo L, Garcia-Unanue J. Metabolic power of female footballers in various small-sided games with different pitch surfaces and sizes. *Sports*. 2017;5:24.

**23.** Köklü Y, Türkdöğän H, Bölükbaşı T, Alemdaroğlu U. Comparison of internal and external loads during different small-sided games in young female soccer players. *Science & Sports*. 2024;29(3):260–266.

**24.** López-Fernández J, Sánchez-Sánchez J, Rodríguez-Cañamero S, et al. Physiological responses, fatigue and perception of female soccer players in small-sided games with different pitch size and sport surfaces. *Biology of Sport*. 2018;35(3):291–299.

**25.** López-Fernández J, Sánchez-Sánchez J, Gallardo L, Garcia-Unanue J. Metabolic power of female footballers in various small-sided games with different pitch surfaces and sizes. *Sports*. 2017;5:24.

**26.** González-García J, Morencos E, García-de-Alcaraz A, Ramírez-Campillo R, Romero-Moraleda B. Exploring external load variations in elite female soccer players during 6v6 small-sided games. *JUMP*. 2022;5:11–19.

**27.** Trombiero DS, Praça GM, Borges EP, de Lira CAB, Leonardi TJ, Laporta L, Castro HO, Costa GDCT. Physiological, physical, and tactical responses in small-sided games in women's soccer: The effect of numerical superiority. *Applied Sciences*. 2023;13:8380.

**28.** Gabbett TJ, Mulvey MJ. Time-motion analysis of small-sided training games and competition in elite women rugby sevens. *Journal of Strength and Conditioning Research*. 2008;22(2):543–552.