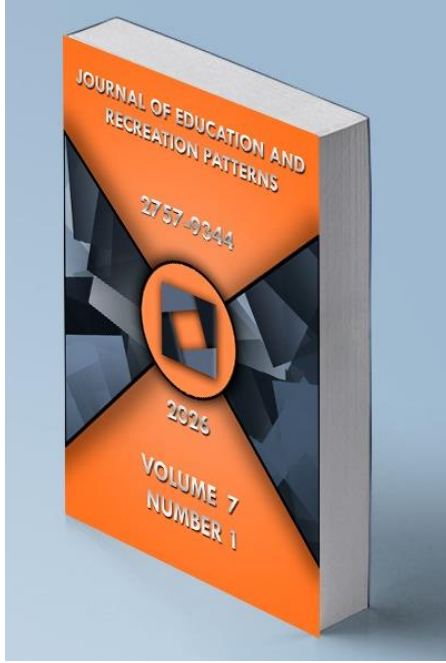




Journal of Education and Recreation Patterns (JERP)

www.jerpatterns.com

Acute Effects of Small-Sided Games with Different Pitch Sizes on Internal Load and Respiratory Responses in Soccer Players

Alirıza Han CİVAN¹

To cite this article:

Civan, A. H. (2026). Acute effects of small-sided games with different pitch sizes on internal load and respiratory responses in soccer players. *Journal of Education and Recreation Patterns (JERP)*, 7(1), 82–97. DOI: <https://doi.org/10.53016/jerp.v7i1.334>

Journal of Education and Recreation Patterns (JERP) is an international scientific, high quality open access, peer viewed scholarly journal provides a comprehensive range of unique online-only journal submission services to academics, researchers, advanced doctoral students and other professionals in their field. This journal publishes original research papers, theory-based empirical papers, review papers, case studies, conference reports, book reviews, essay and relevant reports twice a year (June and December) in online versions.

¹ Department of Coaching Education, Faculty of Sport Sciences, Karabük University, Karabük, Türkiye, alirizahancivan@karabuk.edu.tr,  <https://orcid.org/0000-0002-0634-3392>

Acute Effects of Small-Sided Games with Different Pitch Sizes on Internal Load and Respiratory Responses in Soccer Players

Aliriza Han Civan¹

ARTICLE INFORMATION

Original Research Paper

Received 19.04. 2026

Accepted 28.06. 2026

<https://jerpatterns.com>

June, 2026

Volume: 7, No: 1

Pages: 82-97

ABSTRACT

Previous studies on small-sided games in soccer have mainly focused on internal load indicators such as heart rate and perceived exertion, whereas acute respiratory responses have received limited attention. Therefore, this study aimed to examine the acute effects of small-sided games performed on different pitch sizes on internal load, perceived exertion, mental effort, and respiratory function in male soccer players. Sixteen amateur players (20.13 ± 1.63 years) participated in a randomized, counterbalanced, within-subject crossover design. Each participant completed two SSG conditions (small: 20×25 m; large: 30×35 m) on separate days with at least 48 hours of recovery. Both protocols consisted of 4×4 min bouts with 2 min passive recovery. Heart rate (HR), rating of perceived exertion (Borg), mental effort, and spirometric parameters were assessed before and immediately after exercise. Data were analyzed using repeated-measures ANOVA and, where appropriate, non-parametric tests such as the Friedman and Wilcoxon signed-rank tests ($p < 0.05$). No significant time $\times$ condition interactions were observed for respiratory variables, although FVC increased significantly following the small-pitch condition ($p = 0.021$). Heart rate, perceived exertion, and mental effort increased significantly across sets ($p < 0.05$), with no significant differences between pitch conditions. Overall, the findings suggest that, when the number of players and game structure are kept constant, pitch size alone may have a limited influence on acute internal load and respiratory responses. The progressive increases in heart rate, perceived exertion, and mental effort across sets indicate that the repeated and intermittent nature of small-sided games may play a more important role in shaping acute physiological and perceptual responses.

Keywords: Acute Effects, Internal Load, Respiratory Responses, Small-Sided Games, Soccer.



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

INTRODUCTION

Sports performance is influenced by numerous physiological and physical factors, and training interventions targeting these components can lead to improvements in performance related outcomes (Kızılcı & Okut, 2025). Today, sports disciplines are evolving into increasingly fast paced and multifaceted structures. This situation necessitates that coaches prepare athletes not only physically but through a comprehensive, multifaceted approach. It is now widely accepted that performance cannot be explained solely by physical fitness; rather, it arises from the interaction between physiological stressors and sport specific demands. For this reason, it is of great importance that training models accurately reflect competition conditions as closely as possible.

Soccer exhibits an intermittent performance pattern characterized by short bursts of high-intensity effort followed by recovery phases of lower intensity (Rampinini et al., 2007). Although the majority of energy production during a match is provided by the aerobic system, actions such as sprints, sudden accelerations, and changes of direction, which players perform at frequent intervals, result in significant anaerobic stress (Bangsbo, 1994). In this context, possessing a strong aerobic capacity is a critical requirement for soccer players to both repeat high-intensity activities and delay the effects of fatigue (Köklü et al., 2015).

It is well established that providing training loads similar to those encountered in competition is crucial for performance development (Reilly et al., 2009). Accordingly, training methods incorporating soccer specific movement patterns have come to the forefront. Small-sided game (SSG) training stands out as a method that reflects the multifaceted demands of soccer by integrating physical, physiological, technical, and game specific loads. Compared with traditional ball less running drills, SSG training can generate physiological stress while also allowing soccer specific movement patterns to be incorporated into the training process. Thanks to these characteristics, this method is widely preferred by coaches as an effective training tool due to its ability to simulate match specific demands and support a more goal oriented use of training time (Bujalance-Moreno et al., 2019).

Small-sided games provide modified game environments in which coaches can manipulate various task constraints to influence players' physiological responses and performance outcomes (Clemente & Sarmiento, 2020; Clemente et al., 2020; Sarmiento et al., 2018; Davids et al., 2013). In this context, field size is one of the most frequently modified parameters in SSG applications and plays a significant role in shaping the internal load experienced by players (Clemente et al., 2021). Differences in field dimensions directly affect the relative space available per player (Hill-Haas et al., 2011), which in turn can lead to significant changes in physiological responses and physical demands (Castellano et al., 2015; Castellano et al., 2016; Martone et al., 2017; Silva et al., 2016). Therefore, even if the game structure remains constant, identifying the workload variations caused by different field sizes is a critical element in training planning.

However, the findings regarding the effects of field size on internal load appear to be inconsistent. While some studies report that field size has a significant effect on heart rate and perceived exertion, other studies have failed to find significant differences in these variables (Rampinini et al., 2007a). This suggests that the effect of field size on physiological responses has not yet been fully elucidated.

During high-intensity intermittent exercise, the respiratory system is required to respond rapidly to repeated changes in metabolic demand. In this process, adequate ventilation is essential for supporting oxygen uptake and eliminating carbon dioxide produced during intense muscular activity. Spirometric parameters such as FVC, FEV₁, and PEF may provide useful information about lung volume, expiratory airflow, airway function, and exercise induced

changes in ventilatory mechanics. Since pulmonary function can be influenced by training status and sport specific demands, evaluating these parameters in soccer specific training settings may help to better understand the acute ventilatory demands imposed by small-sided games (Amann, 2012; Durmic et al., 2015).

On the other hand, the current literature on small-sided games has primarily focused on internal load parameters such as heart rate and perceived exertion, whereas respiratory variables have received relatively limited attention. Although respiratory parameters do not directly determine aerobic performance, they provide useful information about how the respiratory system responds to acute exercise demands. Therefore, examining respiratory responses together with HR and perceived exertion may offer a more comprehensive understanding of the physiological demands of SSG. In this context, the limited evidence regarding acute respiratory and ventilatory responses to soccer specific small-sided games highlights an important gap in the literature.

The aim of this study is to investigate the acute effects of small-sided games played on different pitch sizes on heart rate, perceived exertion, mental effort, and respiratory function in soccer players. By including respiratory parameters, this study aims to contribute to the literature on the acute physiological responses to soccer specific small-sided games.

Accordingly, it was hypothesized that the large pitch SSG condition would elicit higher physiological load, perceived exertion, and mental effort than the small pitch condition, and would also produce greater acute changes in respiratory function parameters such as FVC, FEV₁, and PEF.

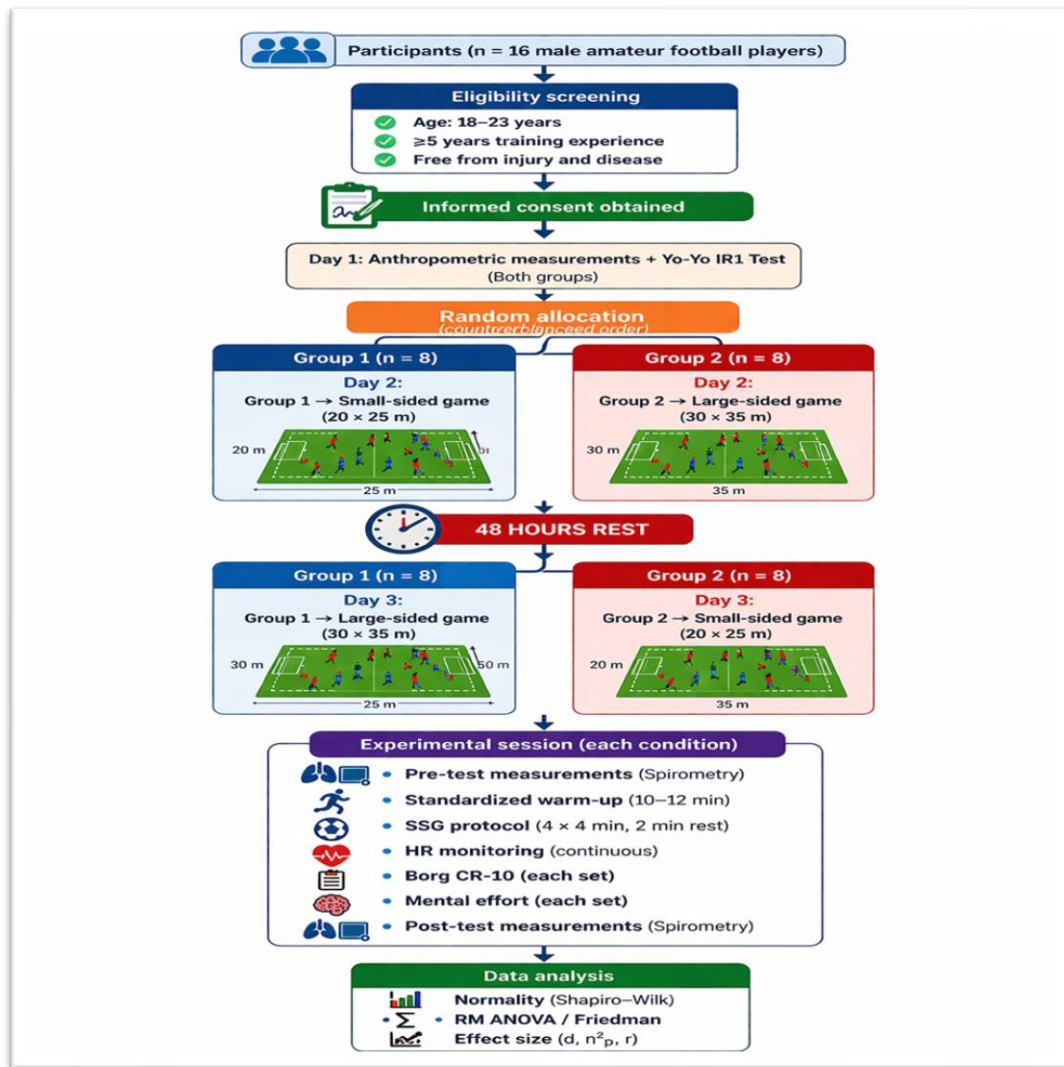
METHOD

Research Design

In this study, a balanced, within-subject counterbalanced crossover experimental design was used to investigate the acute effects of small-sided games (SSG) played on different field sizes on internal load and respiratory responses in soccer players (Figure 1). This design allowed each participant to serve as their own control by participating in both experimental conditions, thereby minimizing the influence of inter individual differences.

To account for potential differences in participants' aerobic capacity levels, the Yo-Yo Intermittent Recovery Test Level 1 was administered and anthropometric measurements were taken at the beginning of the study. These assessments were conducted on the first day of the study. Participants were randomly and evenly assigned to two groups ($n = 8$) to reduce the effects of order of administration. On the second day, Group 1 performed the small pitch size (20×25 m), while Group 2 performed the large pitch size (30×35 m). On the third day, participants switched conditions: Group 1 participated in the large pitch size, and Group 2 in the small pitch size. This counterbalanced design ensured that all participants were exposed to both field sizes in different orders, thereby minimizing potential order effects.

A recovery period of at least 48 hours was allowed between experimental sessions to minimize the effects of fatigue. All measurements were conducted during the same time of day, under similar environmental conditions, and on the same field surface. Participants were asked to avoid strenuous physical activity, refrain from consuming caffeine and alcohol, and ensure they got adequate sleep prior to each test.

Figure 1*Experimental Design and Study Flow*

Participants

Sixteen male soccer players, aged 18–23 years (20.13 ± 1.63 years), who were actively playing soccer under license at amateur sports clubs operating in Karabük Province, voluntarily participated in this study. The participants competed at the amateur league level and were in the in season period during data collection. It was confirmed through club records and athlete statements that all participants had a history of at least five years of regular soccer training and trained at least three days per week, with each training session lasting approximately 90 minutes. The sample size was determined based on the within-subject crossover design of the study, the availability of eligible amateur soccer players, and sample sizes used in previous studies examining acute physiological responses to small-sided games. However, no formal a priori power analysis was conducted before data collection. Since each participant completed both experimental conditions, the within-subject design helped reduce the influence of inter individual variability. The study was approved by the Karabük University Non-Interventional Clinical Research Ethics Committee (Decision No: 2026/2728, Approval Date: 10 February 2026). Written informed consent was obtained from all participants prior to the study, and the research was conducted in accordance with the principles of the Declaration of Helsinki.

Experimental Procedure

All measurements were conducted at the same time of day (± 1 hour) and under similar environmental conditions to minimize the effects of circadian rhythms and environmental variables. Upon arrival at the field site, participants underwent a resting respiratory function test in a quiet, controlled environment prior to measurements. This approach was chosen to prevent exercise induced acute fatigue from affecting baseline measurements. Following the resting measurements, participants underwent a standard warm-up protocol lasting approximately 10–12 minutes. The warm-up consisted of low-intensity running, dynamic stretching exercises, and short bursts of acceleration. After the warm-up, participants were fitted with heart rate monitors (Polar Team system), and heart rate data were continuously recorded throughout the exercise. Following the warm-up, participants performed the small-sided game protocol according to the experimental conditions of the respective day. The small-sided game session was structured into 4×4 minute sets with 2-minute passive rest periods between sets.

During the exercise, the players' physiological workload was monitored using heart rate data, and their perceived exertion (Borg CR-10) (Borg, 1998) and mental effort levels were recorded within the first 30 seconds following the completion of each set. Respiratory functions were measured again immediately after the exercise protocol was completed, and the acute effects of the exercise were assessed. This allowed for a comparison of pre and post exercise changes for both field conditions. Each experimental session was concluded with a standard cool down protocol consisting of low-intensity running and stretching exercises lasting approximately 5 minutes.

Data Collection Tools

Anthropometric Measurements

Participants' height was measured using a stadiometer (Holtain Ltd, UK). Body weight, body fat percentage, and skeletal muscle mass were determined using bioelectrical impedance analysis (InBody 270, Seoul, South Korea) (Şahin & Uzun 2023).

Yo-Yo Interval Recovery Test (Level 1)

The Yo-Yo Intermittent Recovery Test Level 1 was administered before the experimental sessions to support the balanced allocation of participants into the two counterbalanced order groups according to their aerobic fitness levels (Bangsbo et al., 2008).

Small-Sided Game Protocol

In this study, a 4-on-4 small-sided game format was used to assess internal load and respiratory responses in soccer players. It has been reported that small-sided games with a low number of players significantly influence the frequency of game participation and physiological load (Clemente et al., 2021). For this reason, the 4-on-4 format was chosen for this study.

The sessions were conducted on two different field sizes: a small field (20×25 m) and a large field (30×35 m) (Owen et al., 2004). Protocols were implemented by varying only the field size while keeping the number of players, game duration, set structure, and rest intervals constant (Kaya & Gürol, 2021). In both conditions, games were conducted in 4×4 minute sets, with a 2 minute passive rest period between sets. The games were played without a goalkeeper, using small goals, and on an artificial turf field. To ensure the continuity of the game, spare balls were kept on the sidelines. No technical or tactical feedback was provided during the sessions; only verbal encouragement was used. All sessions were conducted under the supervision of the same researcher and coach, and the game rules were kept consistent across both conditions.

Heart Rate Measurements

Participants' physiological workload was assessed using heart rate (HR) data. Measurements were continuously recorded throughout the exercise using the Polar Team system. Mean heart rate (HRmean), maximum heart rate (HRmax), and relative intensity relative to maximum heart rate (%HRmax) were analyzed. Heart rate is a valid method widely used to assess internal load during intermittent high-intensity exercises such as soccer (Teixeira et al., 2021).

Perceived Exertion Level

Perceived exercise exertion was assessed using the Borg CR-10 Perceived Exertion Scale (Borg, 1998). Participants were asked to report their perceived exertion levels at the end of each set (Impellizzeri et al. 2004).

Mental effort

Mental effort was assessed using the Mental Effort Scale developed by Zijlstra. This scale consists of a vertical scale ranging from 0 (no effort) to 150 (extreme effort). Measurements were taken immediately following each set, concurrently with Borg CR-10 assessments (Zijlstra 1993).

Measurement of Respiratory Function

Respiratory function was assessed using a spirometer in accordance with standard procedures and in line with the reference values recommended by the American Thoracic Society. All participants underwent spirometric measurements before and after each experimental protocol. Measurements were performed using a calibrated portable spirometer (Pony FX, COSMED, Rome, Italy) (Özmen et al., 2017). Spirometry tests were conducted in accordance with standard operating protocols. Participants participated in the test while seated, using a nose clip and a mouthpiece (Bilici et al., 2025). After maximal inspiration, each subject was instructed to perform a forced expiration as strongly and rapidly as possible until all air was expelled from the lungs. The maneuver was completed with a subsequent maximal inspiration. As part of the spirometric evaluation, forced vital capacity (FVC), forced expiratory volume in the first second (FEV₁), the FEV₁/FVC ratio, and peak expiratory flow rate (PEF) values were recorded. At least three valid measurements were obtained for each participant, and the highest value was used in the analyses (Amonette & Dupler, 2002).

Data Analysis

Data analyses were performed using IBM SPSS Statistics 26. The normality of the data was assessed via the Shapiro–Wilk test. For variables demonstrating a normal distribution, repeated measures analysis of variance (ANOVA) was conducted. The assumption of sphericity was examined using Mauchly's test, and when violated, the Greenhouse–Geisser correction was applied. When significant effects were identified, Bonferroni-adjusted post hoc comparisons were performed. For variables that did not meet normality assumptions, non-parametric tests were employed, including the Friedman test for repeated measures and the Wilcoxon signed-rank test for pairwise comparisons. Effect sizes were calculated using Cohen's d, partial eta squared (η^2p), and r values. For Wilcoxon signed-rank tests, r was calculated using the formula $r = Z / \sqrt{N}$. Effect sizes were interpreted according to conventional thresholds proposed by Cohen (1988), with small, moderate, and large effects defined as 0.20, 0.50, and 0.80 for Cohen's d; 0.01, 0.06, and 0.14 for η^2p ; and 0.10, 0.30, and 0.50 for r, respectively. Statistical significance was set at $p < 0.05$.

FINDINGS

Table 1*Anthropometric Measurements of Participants*

Variable	Mean $\pm$ SD	Minimum	Maximum
Age (years)	20.13 $\pm$ 1.63	18.00	23.00
Height (cm)	177.19 $\pm$ 4.90	170.00	187.00
Body Mass (kg)	70.24 $\pm$ 7.70	59.20	88.20
Skeletal Muscle Mass (kg)	34.27 $\pm$ 3.11	29.20	40.10
Body Fat (%)	14.51 $\pm$ 4.09	9.60	24.20
Training Experience (years)	6.94 $\pm$ 1.65	5.00	10.00

Table 2*Acute Effects Of Small And Large Sided Games On Respiratory Parameters In Soccer Players*

Variable	Protocol	Pre (Mean $\pm$ SD)	Post (Mean $\pm$ SD)	Δ (Mean $\pm$ SD)	p (paired)	Cohen's d	Effect	F	p	η^2p
FVC (L)	Large	4.95 $\pm$ 0.61	4.99 $\pm$ 0.67	0.04 $\pm$ 0.17	0.337	0.248	Time	0.047	0.830	0.003
	Small	4.92 $\pm$ 0.58	5.01 $\pm$ 0.68	0.09 $\pm$ 0.14	0.021*	0.643	Condition	3.600	0.077	0.194
							Time $\times$ Condition	2.341	0.147	0.135
FEV1 (L)	Large	3.77 $\pm$ 0.62	3.91 $\pm$ 0.73	0.15 $\pm$ 0.56	0.314	0.261	Time	0.357	0.559	0.023
	Small	3.81 $\pm$ 0.64	3.77 $\pm$ 0.99	-0.04 $\pm$ 0.45	0.730	0.088	Condition	0.397	0.538	0.026
							Time $\times$ Condition	0.961	0.343	0.060
FEV1/FVC (%)	Large	76.13 $\pm$ 11.52	77.63 $\pm$ 8.90	1.50 $\pm$ 11.67	0.615	0.128	Time	0.519	0.482	0.033
	Small	77.00 $\pm$ 8.81	74.31 $\pm$ 15.12	-2.69 $\pm$ 8.67	0.234	0.310	Condition	0.132	0.722	0.009
							Time $\times$ Condition	1.115	0.308	0.069
PEF (L/s)	Large	5.82 $\pm$ 1.86	6.08 $\pm$ 1.86	0.26 $\pm$ 1.40	0.472	0.185	Time	0.471	0.503	0.030
	Small	5.75 $\pm$ 1.90	5.79 $\pm$ 2.24	0.04 $\pm$ 1.50	0.927	0.023	Condition	0.261	0.617	0.017
							Time $\times$ Condition	0.253	0.622	0.017

*p < 0.05

Table 2 presents the acute changes in respiratory parameters across pitch size conditions. A statistically significant pre–post difference was determined only for FVC in the small-pitch condition, with a moderate effect size. No significant pre–post differences were found for the other respiratory parameters. Repeated measures analyses showed no significant differences in time, condition, or time $\times$ condition interaction effects for FVC, FEV1, FEV1/FVC, or PEF.

Table 3*Perceived Exertion and Mental Effort Levels during Small-Sided Games at Different Pitch Sizes*

Variables	Sets	Large				Small				
		Mean $\pm$ SD	Mean Rank	$\chi^2(3)$	P	Sets	Mean $\pm$ SD	Mean Rank	$\chi^2(3)$	P
Borg (score)	Set 1	5.88 $\pm$ 1.75	1.38	34.896	< 0.001*	Set 1	5.81 $\pm$ 2.11	1.44	29.180	< 0.001*
	Set 2	6.88 $\pm$ 1.86	1.91			Set 2	7.06 $\pm$ 1.61	2.06		
	Set 3	8.50 $\pm$ 1.51	3.06			Set 3	7.94 $\pm$ 1.57	2.94		
	Set 4	9.06 $\pm$ 1.29	3.66			Set 4	8.75 $\pm$ 1.29	3.56		
Mental Effort (score)	Set 1	63.88 $\pm$ 29.32	1.25	35.285	<0.001*	Set 1	72.50 $\pm$ 28.64	1.28	30.021	< 0.001*
	Set 2	77.31 $\pm$ 30.24	2.00			Set 2	89.38 $\pm$ 26.45	2.22		
	Set 3	96.44 $\pm$ 36.32	3.13			Set 3	96.88 $\pm$ 27.50	3.00		
	Set 4	103.69 $\pm$ 35.18	3.63			Set 4	103.75 $\pm$ 27.05	3.50		

*p < 0.05

Table 3 presents the findings related to perceived exertion (Borg) and mental effort levels. In the large-pitch condition, Borg values showed a statistically significant difference across sets ($p < 0.001$). Similarly, in the small-pitch condition, Borg values also differed significantly between sets ($p < 0.001$). For mental effort, a statistically significant difference across sets was observed in the large-pitch condition ($p < 0.001$). Likewise, mental effort values in the small-pitch condition also showed a significant variation across sets ($p < 0.001$).

Table 4

Heart Rate Responses during Small-Sided Games at Different Pitch Sizes

Variable	Protocol	Set 1 (Mean $\pm$ SD)	Set 2 (Mean $\pm$ SD)	Set 3 (Mean $\pm$ SD)	Set 4 (Mean $\pm$ SD)	Effect	F	p	η^2p
HRmean (bpm)	Large	171.76 $\pm$ 15.58	179.27 $\pm$ 11.19	179.00 $\pm$ 10.84	180.63 $\pm$ 11.62	Set (GG)	15.706	< 0.001*	0.512
	Small	173.01 $\pm$ 15.59	179.75 $\pm$ 12.70	181.50 $\pm$ 10.98	180.12 $\pm$ 10.96	Condition	0.656	0.431	0.042
						Set $\times$ Condition	1.298	0.287	0.080
HRmax (bpm)	Large	186.63 $\pm$ 13.39	190.01 $\pm$ 9.58	190.12 $\pm$ 8.63	191.87 $\pm$ 9.63	Set (GG)	10.370	< 0.001*	0.409
	Small	185.88 $\pm$ 12.81	191.49 $\pm$ 10.62	192.75 $\pm$ 8.06	190.74 $\pm$ 9.91	Condition	0.404	0.535	0.026
						Set $\times$ Condition	2.953	0.043	0.164
%HRmean (%)	Large	85.94 $\pm$ 7.78	89.69 $\pm$ 5.51	89.56 $\pm$ 5.46	90.38 $\pm$ 5.83	Set (GG)	15.671	< 0.001*	0.511
	Small	86.56 $\pm$ 7.79	89.94 $\pm$ 6.37	90.81 $\pm$ 5.55	90.13 $\pm$ 5.58	Condition	0.658	0.430	0.042
						Set $\times$ Condition	1.295	0.288	0.079
%HRmax (%)	Large	93.38 $\pm$ 6.67	95.06 $\pm$ 4.67	95.13 $\pm$ 4.32	96.00 $\pm$ 4.82	Set (GG)	10.387	0.001*	0.409
	Small	93.00 $\pm$ 6.37	95.81 $\pm$ 5.34	96.44 $\pm$ 4.05	95.44 $\pm$ 5.02	Condition	0.407	0.533	0.026
						Set $\times$ Condition	2.975	0.041*	0.166

* $p < 0.05$

Table 4 presents heart rate responses across sets in the large and small pitch conditions. A significant set effect was determined for HRmean ($p < 0.001$), HRmax ($p = 0.001$), %HRmean ($p < 0.001$), and %HRmax ($p = 0.001$), with large effect sizes. No significant condition effect was found for any heart rate variable ($p > 0.05$), and the corresponding effect sizes were small. Significant set $\times$ condition interactions were determined only for HRmax ($p = 0.043$) and %HRmax ($p = 0.041$), with large effect sizes.

Table 5

Comparison of Perceived Exertion and Mental Effort Between Pitch Sizes in Small-Sided Games

Variables	Sets	Large (Mean $\pm$ SD)	Small (Mean $\pm$ SD)	Z	p	r
Borg (score)	Set 1	5.88 $\pm$ 1.75	5.81 $\pm$ 2.11	-0.040	0.968	0.010
	Set 2	6.88 $\pm$ 1.86	7.06 $\pm$ 1.61	-0.157	0.875	0.039
	Set 3	8.50 $\pm$ 1.51	7.94 $\pm$ 1.57	-1.327	0.185	0.332
	Set 4	9.06 $\pm$ 1.29	8.75 $\pm$ 1.29	-1.089	0.276	0.272
	Mean	7.57 $\pm$ 1.33	7.39 $\pm$ 1.33	-0.432	0.666	0.108
Mental Effort (score)	Set 1	63.88 $\pm$ 29.32	72.50 $\pm$ 28.64	-1.174	0.240	0.294
	Set 2	77.31 $\pm$ 30.24	89.38 $\pm$ 26.45	-1.086	0.278	0.272
	Set 3	96.44 $\pm$ 36.32	96.88 $\pm$ 27.50	-0.493	0.622	0.123
	Set 4	103.69 $\pm$ 35.18	103.75 $\pm$ 27.05	-0.835	0.404	0.209
	Mean	85.33 $\pm$ 30.79	90.63 $\pm$ 25.54	-0.063	0.950	0.016

Table 5 presents the comparison of perceived exertion (Borg) and mental effort levels between pitch sizes. For Borg values, no statistically significant differences were found between the large and small pitch conditions across all sets ($p > 0.05$). Effect sizes were small ($r = 0.010$ – 0.332). Similarly, no significant difference was observed in the mean Borg values between pitch conditions ($p > 0.05$; $r = 0.108$). For mental effort, no statistically significant differences were found between large and small pitch conditions across all sets ($p > 0.05$). Effect sizes were also small ($r = 0.123$ – 0.294). Likewise, no significant difference was observed in the mean mental effort values between pitch conditions ($p > 0.05$; $r = 0.016$).

DISCUSSION

The main findings of this study indicate that, when the number of players and the game structure were kept constant, pitch size alone did not lead to marked differences in most acute internal load and respiratory responses during 4-on-4 small-sided games. Although FVC increased significantly only in the small pitch condition, no consistent changes were observed in FEV₁, FEV₁/FVC, or PEF. In contrast, heart rate responses, perceived exertion, and mental effort increased across sets in both pitch size conditions. Taken together, these findings suggest that the accumulated physiological and perceptual stress across repeated game bouts may play a more prominent role than pitch size alone in determining acute exercise responses (Hill-Haas et al., 2011).

The heart rate responses are particularly important in terms of the set effect. The progressive increase in HRmean, HRmax, %HRmean, and %HRmax across sets indicates that players were exposed to greater cardiovascular load as the game repetitions progressed. This finding is consistent with previous research showing that small-sided games can induce high internal load and that repeated game periods may progressively increase physiological responses (Dellal et al., 2008). Similarly, Kelly and Drust (2009) reported that heart rate responses during small-sided games performed on different pitch sizes may occur at similar levels, although differences may emerge between game periods. These findings indicate that internal load responses should not be attributed only to pitch size, but should also be considered in relation to the structural characteristics of the exercise.

One possible explanation for the absence of a clear pitch size effect on most heart rate variables is that both protocols produced relatively high cardiovascular responses. The similar work to rest ratio and repeated high-intensity efforts in both conditions may have caused internal load to reach a high threshold. Therefore, possible differences related to pitch size may have been reduced when the overall physiological demand of the game was already high.

Physiological and perceptual responses in small-sided games are shaped by the interaction of several task constraints, including field size, number of players, game rules, and coach intervention (Rampinini et al., 2007). Therefore, the effect of pitch size should be evaluated together with these contextual variables rather than as an isolated determinant. The literature also presents inconsistent findings regarding the influence of pitch size on internal load. Some studies have reported that larger pitch sizes are associated with higher heart rate and perceived exertion responses (Casamichana & Castellano, 2010; McLaren et al., 2018; Casamichana et al., 2013). However, this relationship does not appear to be linear in all contexts, and consistent increases may not always be observed, particularly for heart rate based internal load indicators (Rumpf et al., 2025).

In this regard, while some studies have shown that increasing pitch size may lead to higher heart rate responses when the number of players is kept constant (Owen et al., 2004; Williams & Owen, 2007), other studies have reported that physiological load may decrease on

larger playing areas (Little & Williams, 2006; López-Fernández et al., 2018). These conflicting findings suggest that the effect of pitch size is context dependent and may vary according to the interaction of game format, player number, rules, and training organization.

In the present study, the lack of a significant condition effect for most heart rate variables may be related to both protocols inducing a similar level of internal load. However, the significant set $\times$ condition interaction observed for HRmax and %HRmax suggests that pitch size may influence the distribution of peak intensity moments rather than the overall average load. This may indicate that pitch size affects the structure and timing of physiological responses more than the general magnitude of internal load (Hill-Haas et al., 2011). In line with this interpretation, previous research has shown that changes in pitch size can affect players' movement behavior and spatial organization, but these changes do not always translate directly into physiological responses (Silva et al., 2014).

The findings related to perceived exertion and mental effort showed a similar pattern. Both variables increased across sets in both pitch size conditions, indicating that players perceived greater load as the game progressed. However, the absence of significant differences between pitch sizes suggests that perceptual responses may have been more closely associated with repeated exposure to game bouts than with pitch size alone. In addition, perceived exertion and mental effort may be influenced not only by physical demands but also by cognitive involvement, decision making requirements, and the continuous adaptation required during game play.

There are limited studies directly examining the effects of pitch size on respiratory responses during small-sided games. Spirometric parameters such as FVC, FEV₁, and PEF are not direct indicators of aerobic capacity; rather, they provide information about respiratory function and acute post exercise responses. Therefore, the respiratory findings of the present study should be interpreted within the context of acute physiological responses rather than long-term respiratory adaptation.

The absence of significant changes in most spirometric parameters may be related to the nature of respiratory responses to acute intermittent exercise. During high-intensity intermittent activity, ventilation is largely regulated through changes in respiratory rate and tidal volume, and these dynamic responses may not be fully reflected in static spirometric measurements obtained after exercise (Sheel, 2002). Therefore, the limited differences observed in spirometric variables may partly be explained by the timing and nature of the measurement method.

The significant increase in FVC observed only in the small pitch condition may be related to the greater frequency of short accelerations, changes of direction, and repeated high-intensity actions in a more restricted playing area. These demands may have increased respiratory muscle involvement acutely. However, because no significant changes were observed in FEV₁, FEV₁/FVC, or PEF, this response should be interpreted cautiously and considered limited rather than as a broad respiratory effect.

In the evaluation of post exercise respiratory function, exercise induced bronchoconstriction provides an important reference point. This condition is generally characterized by marked decreases in FEV₁ and does not occur in all types of exercise among healthy, trained individuals. In the present study, the absence of a significant decrease in FEV₁ and FEV₁/FVC suggests that the small-sided game protocols did not induce a level of respiratory stress sufficient to cause airway narrowing (Rundell & Slee, 2008).

The limitations of spirometric measurements in assessing acute post exercise changes should also be considered. Spirometry may not fully capture the dynamic ventilatory adjustments occurring during exercise. Therefore, the inability to identify clear pitch size

related respiratory differences may be partly associated with the measurement method rather than the complete absence of respiratory demand.

In this context, the present study contributes to the literature by examining the isolated effect of pitch size on acute internal load and respiratory responses while keeping the number of players and game structure constant. This methodological approach is important because many previous studies have manipulated multiple task constraints simultaneously. Overall, the findings suggest that pitch size alone may not be sufficient to determine acute physiological and perceptual responses during 4-on-4 small-sided games; rather, these responses appear to be shaped by the combined structure of the exercise.

Practical Implications

The findings of this study may provide practical guidance for coaches and practitioners in the planning of small-sided game training. Since both small and large pitch conditions elicited high heart rate responses and progressive increases in perceived exertion and mental effort across sets, both formats can be used to create substantial internal load in soccer specific training. However, the absence of a consistent condition effect indicates that pitch size alone should not be considered the only factor determining training intensity.

From a practical perspective, small pitch games may be preferred when the training aim is to increase player involvement, decision making frequency, and technical actions in a restricted space. Large pitch games may be used when coaches aim to provide greater movement space and create a game context that allows longer running actions. Therefore, pitch size should be planned together with other task constraints such as the number of players, work to rest ratio, coach encouragement, and the specific goal of the training session. In addition, monitoring heart rate, perceived exertion, and mental effort together may help coaches evaluate the internal load imposed by different small-sided game formats more effectively.

Conclusion

In conclusion, the findings of this study suggest that field size may have a limited effect on acute cardiovascular and respiratory responses during 4-on-4 small-sided games. In contrast, the observed increases in heart rate, perceived exertion, and mental effort levels across sets suggest that the exercise load may be attributed more to the repetitive nature of small-sided games. In this regard, rather than considering field size as the sole determining factor, it can be argued that evaluating game format and task constraints together in training planning may be more effective. Additionally, it is recommended that future research examine long-term adaptations and a broader range of physiological variables.

Limitations

The findings of this study should be interpreted within the context of certain limitations. In addition, the relatively small sample size and the absence of a formal a priori power analysis should be considered when interpreting the findings. First, the sample consisted solely of male amateur soccer players, and the generalizability of the findings to different age groups, performance levels, and female athletes is limited. Because the study employed an acute design, the results reflect only short-term physiological and respiratory responses. Additionally, due to the nature of small-sided games, individual behavior and decision-making processes could not be fully controlled. Furthermore, external load variables were not assessed in this study, and respiratory responses were limited to spirometric measurements. Future studies are recommended to incorporate more comprehensive physiological and performance measurements.

Acknowledgements: The author would like to thank all participants for their voluntary participation in this study.

REFERENCES

- Amann, M. (2012). Pulmonary system limitations to endurance exercise Performance in humans. *Experimental Physiology*, 97, 311–318. <https://doi.org/10.1113/expphysiol.2011.058800>
- Amonette, W. E., & Dupler, T. L. (2002). The effects of respiratory muscle training on $\text{VO}_{2\text{max}}$, the ventilatory threshold, and pulmonary function. *Journal of Exercise Physiology Online*, 5(2), 29–35.
- Bangsbo, J. (1994). The physiology of soccer: With special reference to intense intermittent exercise. *Acta Physiologica Scandinavica Supplementum*, 619, 1–155.
- Bangsbo, J., Iaia, F. M., & Krstrup, P. (2008). The Yo-Yo intermittent recovery test: A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, 38(1), 37–51. <https://doi.org/10.2165/00007256-200838010-00004>
- Bilici, M. F., Çelik, M., Balica, D., & Bilici, Ö. F. (2025). Effects of Cross-Country Skiing and Volleyball Training Characteristics on Some Respiratory Parameters in Female Athletes. *Journal of Education and Recreation Patterns*, 6(2), 325–335. <https://doi.org/10.53016/jerp.v6i2.303>
- Borg, G. (1998). Borg's perceived exertion and pain scales. *Human Kinetics*.
- Bujalance-Moreno, P., Latorre-Román, P. Á., & García-Pinillos, F. (2019). A systematic review on small-sided games in football players: Acute and chronic adaptations. *Journal of Sports Sciences*, 37(8), 921–949. <https://doi.org/10.1080/02640414.2018.1535821>
- Casamichana, D., & Castellano, J. (2010). Time–motion, heart rate, perceptual and motor behaviour demands in small-sided soccer games: Effects of pitch size. *Journal of Sports Sciences*, 28(14), 1615–1623. <https://doi.org/10.1080/02640414.2010.521168>
- Casamichana, D., Castellano, J., Calleja-González, J., San Román, J., & Castagna, C. (2013). Relationship between indicators of training load in soccer players. *Journal of Strength and Conditioning Research*, 27(2), 369–374. <https://doi.org/10.1519/JSC.0b013e3182548af1>
- Castellano, J., Puente, A., Echeazarra, I., & Casamichana, D. (2015). Influence of the number of players and the relative pitch area per player on heart rate and physical demands in youth soccer. *Journal of Strength and Conditioning Research*, 29(6), 1683–1691. <https://doi.org/10.1519/JSC.0000000000000788>
- Castellano, J., Puente, A., Echeazarra, I., Usabiaga, O., & Casamichana, D. (2016). Number of players and relative pitch area per player: Comparing their influence on heart rate and physical demands in under-12 and under-13 football players. *PLoS ONE*, 11(1), e0127505. <https://doi.org/10.1371/journal.pone.0127505>
- Clemente, F. M., Afonso, J., & Sarmiento, H. (2021). Small-sided games: An umbrella review of systematic reviews and meta-analyses. *PLoS ONE*, 16(2), e0247067. <https://doi.org/10.1371/journal.pone.0247067>
- Clemente, F. M., Afonso, J., Castillo, D., Arcos, A. L., Silva, A. F., & Sarmiento, H. (2020). The effects of small-sided soccer games on tactical behavior and collective dynamics: A systematic review. *Chaos, Solitons & Fractals*, 134, 109710. <https://doi.org/10.1016/j.chaos.2020.109710>
- Clemente, F., & Sarmiento, H. (2020). The effects of small-sided soccer games on technical actions and skills: A systematic review. *Human Movement*, 21(3), 100–119. <https://doi.org/10.5114/hm.2020.93014>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.
- Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and Sport Sciences Reviews*, 41(3), 154–161. <https://doi.org/10.1097/JES.0b013e318292f3ec>

- Dellal, A., Chamari, K., Pintus, A., Girard, O., Cotte, T., & Keller, D. (2008). Heart rate responses during small-sided games and short intermittent running training in elite soccer players: A comparative study. *Journal of Strength and Conditioning Research*, 22(5), 1449–1457. <https://doi.org/10.1519/JSC.0b013e31817398c6>
- Durmic, T., Lazovic, B., Djelic, M., Lazic, J. S., Zikic, D., Zugic, V., ... & Mazic, S. (2015). Sport-specific influences on respiratory patterns in elite athletes. *Jornal brasileiro de pneumologia*, 41, 516-522. <https://doi.org/10.1590/S1806-37562015000000050>
- Hill-Haas, S. V., Dawson, B., Impellizzeri, F. M., & Coutts, A. J. (2011). Physiology of small-sided games training in football: A systematic review. *Sports Medicine*, 41(3), 199–220. <https://doi.org/10.2165/11539740-000000000-00000>
- Impellizzeri, F. M., Rampinini, E., Coutts, A. J., Sassi, A., & Marcora, S. M. (2004). Use of RPE-based training load in soccer. *Medicine & Science in Sports & Exercise*, 36(6), 1042–1047. <https://doi.org/10.1249/01.MSS.0000128199.23901.2F>
- Kaya, K., & Gürol, B. (2021). Futbolda dar alan oyunları değişkenlerinin incelenmesi. *Sportive*, 4(2), 117–131. <https://doi.org/10.53025/sportive.979126>
- Kelly, D. M., & Drust, B. (2009). The effect of pitch dimensions on heart rate responses and technical demands of small-sided soccer games in elite players. *Journal of Science and Medicine in Sport*, 12(4), 475–479. <https://doi.org/10.1016/j.jsams.2008.01.010>
- Kızılca, S., & Okut, S. (2025). The effect of a 4-week quick strength training program on body composition, strength, and jumping performance in kickboxers. *Journal of Education and Recreation Patterns*, 6(1), 113-125. <https://doi.org/10.53016/jerp.v6i1.279>
- Köklü, Y., Sert, Ö., Alemdaroglu, U., & Arslan, Y. (2015). Comparison of the physiological responses and time-motion characteristics of young soccer players in small-sided games: The effect of goalkeeper. *Journal of Strength and Conditioning Research*, 29(4), 964–971. <https://doi.org/10.1519/JSC.0b013e3182a744a1>
- Little, T., & Williams, A. G. (2006). Suitability of soccer training drills for endurance training. *Journal of Strength and Conditioning Research*, 20(2), 316–319.
- López-Fernández, J., Sánchez-Sánchez, J., Rodríguez-Cañamero, S., Ubago-Guisado, E., Colino, E., & Gallardo, L. (2018). Physiological responses, fatigue and perception of female soccer players in small-sided games with different pitch size and sport surfaces. *Biology of Sport*, 35(3), 291–299. <https://doi.org/10.5114/biolsport.2018.77829>
- Martone, D., Giacobbe, M., Capobianco, A., Imperlini, E., Mancini, A., Capasso, M., & Orrù, S. (2017). Exercise intensity and technical demands of small-sided soccer games for under-12 and under-14 players: Effect of area per player. *Journal of Strength and Conditioning Research*, 31(6), 1486–1492. <https://doi.org/10.1519/JSC.0000000000001615>
- McLaren, S. J., Macpherson, T. W., Coutts, A. J., Hurst, C., Spears, I. R., & Weston, M. (2018). The relationships between internal and external measures of training load and intensity in team sports: A meta-analysis. *Sports Medicine*, 48(3), 641–658. <https://doi.org/10.1007/s40279-017-0830-z>
- Owen, A., Twist, C., & Ford, P. (2004). Small-sided games: The physiological and technical effect of altering pitch size and player numbers. *Insight*, 7(2), 50–53.
- Özmen, T., Güneş, G. Y., Uçar, I., Doğan, H., & Gafuroğlu, T. U. (2017). Effect of respiratory muscle training on pulmonary function and aerobic endurance in soccer players. *Journal of Sports Medicine and Physical Fitness*, 57(5), 507–513. <https://doi.org/10.23736/S0022-4707.16.06283-6>
- Rampinini, E., Coutts, A. J., Castagna, C., Sassi, R., & Impellizzeri, F. M. (2007). Variation in top-level soccer match performance. *International Journal of Sports Medicine*, 28(12), 1018–1024. <https://doi.org/10.1055/s-2007-965158>
- Rampinini, E., Impellizzeri, F. M., Castagna, C., Abt, G., Chamari, K., Sassi, A., & Marcora, S. M. (2007a). Factors influencing physiological responses to small-sided soccer games.

- Journal of Sports Sciences, 25(6), 659–666. <https://doi.org/10.1080/02640410600811858>
- Reilly, T., Morris, T., & Whyte, G. (2009). The specificity of training prescription and physiological assessment: A review. *Journal of Sports Sciences*, 27(6), 575–589. <https://doi.org/10.1080/02640410902729741>
- Rumpf, M. C., Jäger, J., Clemente, F. M., Altmann, S., & Lochmann, M. (2025). The effect of relative pitch size on physiological, physical, technical and tactical variables in small-sided games: A literature review and practical guide. *Frontiers in Sports and Active Living*, 7, 1592536. <https://doi.org/10.3389/fspor.2025.1592536>
- Rundell, K. W., & Slee, J. B. (2008). Exercise and other indirect challenges to demonstrate asthma or exercise-induced bronchoconstriction in athletes. *Journal of Allergy and Clinical Immunology*, 122(2), 238–246. <https://doi.org/10.1016/j.jaci.2008.06.014>
- Sarmento, H., Clemente, F. M., Harper, L. D., Costa, I. T., Owen, A., & Figueiredo, A. J. (2018). Small-sided games in soccer: A systematic review. *International Journal of Performance Analysis in Sport*, 18(5), 693–749. <https://doi.org/10.1080/24748668.2018.1517288>
- Sheel, A. W. (2002). Respiratory muscle training in healthy individuals: Physiological rationale and implications for exercise performance. *Sports Medicine*, 32(9), 567–581. <https://doi.org/10.2165/00007256-200232090-00003>
- Silva, P., Aguiar, P., Duarte, R., Davids, K., Araújo, D., & Garganta, J. (2014). Effects of pitch size and skill level on tactical behaviours of association football players during small-sided and conditioned games. *International Journal of Sports Science & Coaching*, 9(5), 993–1006. <https://doi.org/10.1260/1747-9541.9.5.993>
- Silva, P., Vilar, L., Davids, K., Araújo, D., & Garganta, J. (2016). Sports teams as complex adaptive systems: Manipulating player numbers shapes behaviours during football small-sided games. *SpringerPlus*, 5(1), 191. <https://doi.org/10.1186/s40064-016-1813-5>
- Şahin, M., & Uzun, M. E. (2023). The effect of 8 weeks preparatory training program on body composition and blood parameters in elite wrestlers. *Journal of Education and Recreation Patterns*, 4(2), 641–652. <https://doi.org/10.53016/jerp.v4i2.165>
- Teixeira, J. E., Forte, P., Ferraz, R., Leal, M., Ribeiro, J., Silva, A. J., & Barbosa, T. M. (2021). Monitoring accumulated training and match load in football: A systematic review. *International Journal of Environmental Research and Public Health*, 18(8), 3906. <https://doi.org/10.3390/ijerph18083906>
- Williams, K., & Owen, A. (2007). The impact of player numbers on the physiological responses to small-sided games. *Journal of Sports Science and Medicine*, 6(Suppl. 10), 100.
- Zijlstra, F. R. (1993). Efficiency in work behaviour: A design approach for modern tools. Delft University Press.

Author(s)' statements on ethics and conflict of interest

Ethics statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Karabük University Non-Interventional Clinical Research Ethics Committee (Decision No.: 2026/2728, Approval Date: 10 February 2026).

Conflicts of Interest: There are no conflicts of interest declared by the author.

Funding: None.