

Effects of small-sided games on some recovery markers in football

Tayyar Karadağ^{1ABCDE}, Süleyman Patlar^{1ABCDE}, Ahmet Bayrak^{2ABCDE}

¹Department of Coaching Education, Faculty of Sports Sciences, Selcuk University, Turkey

²Department of Physical Therapy and Rehabilitation, Faculty of Health Science, Selcuk University, Turkey

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Abstract

Background and Study Aim Small-sided games (SSGs) are widely used in football training to replicate match conditions while controlling the physical load on players. Variations in the number of players during these games can significantly influence key recovery markers. This study aims to investigate the effects of variations in player numbers on maximal heart rate, blood lactate levels, and perceived exertion in small-sided games acutely applied in football.

Material and Methods The study involved 28 male football players who were also university students (mean age 24.89±4.59 years, mean height 179±0.04 cm, mean body weight 73.21±4.34 kg). The participants were divided into three groups based on the number of players (2 vs. 2, 4 vs. 4, and 8 vs. 8). Heart rate and lactate levels were measured at three time points: before training, immediately after training, and 30 minutes post-training.

Results The study revealed that post-training maximal heart rates (MHR) and lactate levels were significantly higher across all groups compared to pre-training levels, while measurements taken 30 minutes post-training were significantly lower than post-training levels ($P<0.05$). No significant differences were found between pre-training and 30-minute post-training MHR values across the three groups ($P>0.05$). Post-training MHR values were similar between the 2 vs. 2 and 4 vs. 4 groups ($P>0.05$), whereas the 8 vs. 8 group showed significantly higher values ($P<0.05$). Post-training and 30-minute post-training lactate levels were similar between the 4 vs. 4 and 8 vs. 8 groups ($P>0.05$), but the 2 vs. 2 group had significantly lower levels ($P<0.05$). Perceived exertion levels post-training were similar between the 2 vs. 2 and 4 vs. 4 groups ($P>0.05$), while the 8 vs. 8 group reported significantly higher perceived exertion levels ($P<0.05$).

Conclusions Small-sided games with varying numbers of players are an effective method for modulating physical load during football training. These findings underscore the importance of considering game format in designing training sessions to optimize player performance and recovery.

Keywords: small-sided games, football training, maximal heart rate, blood lactate, perceived exertion.

Introduction

In football, training methods are continuously evolving to optimize player performance and recovery. Small-sided games (SSGs) have gained widespread popularity due to their ability to replicate match conditions while allowing for controlled physical load. However, the variation in the number of players in these games introduces significant challenges in understanding their impact on key physiological markers. Despite their frequent use, there is a clear need for more effective solutions to address this issue.

In this context, the most important parameters for measuring performance in football encompass physical, physiological, technical, and tactical characteristics [1]. In contemporary football, coaches strive to integrate training exercises and organized game formats that enhance players' physical, technical, and tactical capacities simultaneously [2, 3]. Control of training load, manipulation of small-sided games through variables such as repetition

count, duration of each repetition, and rest intervals, along with the use of internal and external load metrics, have been identified as reliable methods for monitoring training stimulus response in football [4]. Given the necessity of training athletes in all requisite conditioning attributes, small-sided games are frequently employed in football training [5].

Small-sided games encompass movements performed during matches, such as passing, ball control under pressure, quick decision-making, directional changes in running, dribbling with the ball, and shooting [6]. A significant element of small-sided games lies in their potential to offer diverse variations to achieve different training objectives. By altering game conditions, such as rules, field size, player numbers, game duration, work-to-rest ratio, or the presence of goalkeepers, exercise intensity can be effectively regulated [7]. While small-sided games have been widely adopted by coaches as an integrated training approach that resembles football-specific skills, certain task constraints (field dimensions, space per player, and player numbers) can encourage physiological and physical stimuli

aligned with football demands [8, 9, 10, 11].

The capacity to replicate high-intensity movements of the same quality within short intervals during a game relies on the replenishment of depleted anaerobic energy sources through the utilization of aerobic energy sources [12]. This is closely associated with the time players spend below the anaerobic threshold [13]. During a football match, the average exercise intensity is reported to be around 80-90% of the anaerobic threshold or maximum heart rate. Increasing exercise intensity leads to the accumulation of lactic acid in the blood and muscles, which contributes to player fatigue and negatively impacts performance. The ability of players to perform repeated movements of the same quality during this period is closely linked to their enhanced endurance capacity [12].

During a football match, professional athletes maintain a running pace close to their anaerobic threshold, at approximately 80-90% of their maximal heart rate, covering a distance of about 10 kilometers. Intensive elements such as short sprints, passing, and jumping are heavily incorporated among the strength components. The aerobic nature of football is linked to its duration, with a footballer's effort throughout the match remaining near their maximum heart rate. In this high-duration sport, the accumulation of lactic acid due to prolonged intense effort makes sustaining performance at the same level exceedingly challenging. To facilitate the removal of lactic acid, athletes require moments of reduced effort during the competition [14].

One of the parameters used to determine the physiological demands of football is heart rate. Heart rate is defined as the total number of heartbeats per minute. Influenced by the sympathetic and parasympathetic nervous systems, heart rate is considered a significant indicator for monitoring circulatory function [15,16]. Heart rate averages obtained during preparation and official football matches have been reported to vary between 157 and 175 beats per minute (bpm) [17,18,19,20]. Generally, in elite or sub-elite footballers, the average heart rate during a match ranges from 170 to 180 bpm, with the maximal heart rate (MHR) reaching approximately 75-80% of MHR [21]. Workload ratios measured with maximal heart rate during match conditions typically reveal a profile close to the anaerobic threshold (around 80-90% of MHRmax or 75% of VO₂max) [22,23]. Average blood lactate (LA) concentrations during a football match typically range from 6 to 12 mmol/L, though they can exceed 12 mmol/L under specific or individual circumstances [23,24]. However, the average blood lactate level is generally observed to be around 7 mmol/L. It has also been reported that matches are played at a heart rate corresponding to 70% of maximum oxygen consumption, with lactate values ranging from 3 to 9 mmol/L [25].

Training intensity in small-sided games can be determined using tools such as heart rate measurement devices, GPS tracking systems, and blood lactate measurement tools. However, frequent blood lactate measurements during football training are often challenging to obtain. Therefore, heart rate monitors are commonly used as a convenient and reliable tool in scientific studies, training exercises, and matches in football [26, 27, 28, 29, 30, 31].

The concept of a recovery strategy involves the application of techniques or a combination of techniques to accelerate the process of full recovery and potentially reduce the risk of injury [32, 33]. The ability to maintain or achieve high exercise intensity during repetitions of small-sided games depends on effective post-exercise recovery. Coaches should ensure that the duration of small-sided games and the rest intervals between repetitions are appropriately adjusted based on the required physical effort for the exercises [4].

Familiarity with the physiological needs of footballers enhances coaches' ability to plan training, address energy demands, and minimize the risk of injuries [34]. The impact of small-sided games on aerobic or anaerobic demand and recovery strategies remains not fully understood [35]. Additionally, conflicting results exist in studies regarding the effects of variations in player numbers in different areas on recovery during football-specific small-sided games. Therefore, this study aims to investigate the effects of variations in player numbers on maximal heart rate, blood lactate levels, and perceived exertion in small-sided games acutely applied in football.

Materials and Methods

Participants

The study included 28 male football players who were also university students (mean age 24.89±4.59 years, mean height 179±0.04 cm, mean body weight 73.21±4.34 kg) actively engaged in football for an amateur league team (Table 1). Prior to the study, participants were informed about the research and asked to sign a voluntary consent form.

Research Design. Anthropometric Measurements

Height measurements of the players were taken using a wall-mounted stadiometer (Holtain, UK) with a precision of 0.1 cm. Body weight measurements were conducted using an electronic scale (Tanita TBF401A, UK) with a precision of 0.1 kg. Additionally, body fat percentage (%) was measured using the bioelectrical impedance analysis (BIA) method (Tanita TBF401A, UK).

Warm-up Protocol

Before beginning the training, the football players participated in a 20-minute active warm-up session tailored to the specific movements they would perform during the session.

Table 1. Perceived Exertion Level According to the Borg Scale [38].

Score	Degree of Exertion
6	
7	Very, very light
8	
9	
10	Very light
11	
12	Fairly light
13	
14	Somewhat hard
15	
16	Hard
17	
18	Very hard
19	
20	Very very hard

Maximal Heart Rate (MHR) Measurements

Heart rate measurements during the small-sided games were conducted using a heart rate monitor (Polar Team Pro 2, Polar Electro, Finland) capable of measuring at 1-second intervals. Maximal heart rates of the players were measured at three time points: before, immediately after, and 30 minutes after the small-sided game sessions, and the data were recorded.

Lactic Acid (La) Measurements

Following the training, the half-life of lactate in the blood ranges from 15 to 25 minutes. The return of blood lactate levels to pre-training levels occurs within 30 to 60 minutes [36, 37]. Based on this literature, blood lactate levels of the football players were measured at three time points—before, immediately after, and 30 minutes after a 3-set session of small-sided games conducted within a one-day training period. Blood lactate concentrations were measured using a lactic acid analyzer (Lactate Scout, Germany) capable of providing results within 10 seconds. Prior to all measurements, the analyzer was calibrated using control solutions with known low (1-1.6 mmol/L LA) and high (4-5.4 mmol/L LA) concentrations, according to the manufacturer’s instructions. Blood lactate concentration was measured from capillary blood obtained from the fingertip. A lancet (Vital Plus, China) and lancet device (Vital Plus, China) were used to collect blood samples. The samples were analyzed within 10 seconds, and the values obtained were recorded in mmol/L units.

Perceived Exertion Level (PEL) Measurements

Perceived exertion levels of the football players were measured using the 6-20 Borg Scale. At the end

of the study, the players were presented with the Borg Scale and asked to indicate how challenging they perceived the small-sided game to be. On the Borg Scale, 6 (No Fatigue at All) represents the lowest level of exertion, while 20 (Maximal Fatigue) represents the highest level (Table 2).

Small-Sided Games (SSGs)

When designing SSGs, the length and width of the field can be adjusted based on the desired training stimulus for football players, allowing for pre-planned and adjustable field dimensions [3, 39, 40]. In this study, field dimensions were measured in meters and marked with training cones. Standard-sized footballs (Nike, USA) were used during the SSGs. To objectively group the players, the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) was conducted, and groups were formed based on the distance covered. The football players were divided into three groups: 2 vs. 2, 4 vs. 4, and 8 vs. 8 SSG groups. Each group participated in a one-day acute training program that included three sets of SSGs.

1. 2 vs. 2 Small-Sided Game Group: In this group, 2 vs. 2 SSGs were played on a 20x25 meter field, with each set lasting 4 minutes, for a total of 3 sets. A 3-minute passive rest was provided between sets. The total playing area was 300 m², with 75 m² per player.

2. 4 vs. 4 Small-Sided Game Group: In this group, 4 vs. 4 SSGs were conducted on a 30x35 meter field, with each set lasting 4 minutes, for a total of 3 sets. A 3-minute passive rest was provided between sets. The total playing area was 750 m², with 94 m² per player.

3. 8 vs. 8 Small-Sided Game Group: In this group, 8 vs. 8 SSGs were conducted on a 40x45 meter field, with each set lasting 4 minutes, for a total of 3 sets. A 3-minute passive rest was provided between sets. The total playing area was 3000 m², with 188 m² per player. During the execution of the SSGs, assistant coaches immediately returned balls that went out of play back into the game. Players were encouraged by coaches throughout the game. Following the sessions, players engaged in 20 minutes of jogging and stretching exercises.

The statistical analysis was conducted using the SPSS for Windows 26.0 software package. The arithmetic means and standard deviations of all parameters were calculated. To assess the normality of the data, the Shapiro-Wilk test was performed, revealing that the data did not follow a normal distribution. To detect intergroup differences, the Kruskal-Wallis H test was employed, and the Mann-Whitney U test was used to identify the source of these differences. Within-group measurements at different time points were analyzed using the Repeated Measures Analysis of Variance test. Differences were considered significant at a level of $p < 0.05$.

Results

When the intra-group maximal heart rate and lactate levels of the participants were examined, it was observed that the post-training heart rate and lactate levels in all groups were significantly higher than the pre-training values, and the measurements taken 30 minutes after training were consistently lower than the post-training levels ($P < 0.05$). Additionally, in all groups, the values obtained 30 minutes after training were significantly higher than the pre-training values ($P < 0.05$) (Table 3).

When the inter-group maximal heart rates of

the football players were examined, it was found that the pre-training and 30-minute post-training heart rates were not significantly different among the three groups ($P > 0.05$). After the training, while the heart rates of the 2 vs. 2 and 4 vs. 4 groups were similar ($P > 0.05$), they were significantly higher in the 8 vs. 8 group ($P < 0.05$) (Table 4).

Upon analyzing the inter-group lactate levels of the football players, it was found that the pre-training levels were not significantly different among the three groups ($P > 0.05$). The post-training and 30-minute post-training lactate levels of the 4 vs. 4 and 8 vs. 8 groups were similar ($P > 0.05$),

Table 2. Physical Characteristics of the Participants

Physical Characteristics	N	Mean	Standard Deviation	Range	Minimum	Maximum
Age, years	28	24.89	4.597	15	17	32
Height, cm	28	1.79	.047	.18	1.70	1.88
Body weight, kg	28	73.21	4.349	18	65	83
BMI, kg/m ²	28	22.76	1.241	4.00	20.65	24.66

Table 3. Intra-group comparisons of the maximal heart rate and lactate levels of the participants

Game Formats	Parameters	Pre-training (1)	Post-training (2)	30 minutes after the training (3)	P	Intra-group difference
2 vs. 2	Maximal heart rate	63.0±3.46	181.5±3.00	78.0±4.89	0.001	1<2
						1<3
						2>3
4 vs. 4	Lactate	1.35±0.26	11.65±2.73	3.1±1.03	0.001	1<2
						1<3
						2>3
8 vs. 8	Maximal heart rate	68.25±4.46	175.25±20.05	87.0±11.56	0.001	1<2
						1<3
						2>3
8 vs. 8	Lactate	1.47±0.27	7.72±1.89	2.38±0.49	0.001	1<2
						1<3
						2>3
8 vs. 8	Maximal heart rate	66.5±5.77	125.7±18.41	88.5±9.33	0.001	1<2
						1<3
						2>3
8 vs. 8	Lactate	1.44±0.25	6.22±2.38	2.09±0.50	0.001	1<2
						1<3
						2>3

$P < 0.05$. 1: Pre-training, 2: Post-training, 3: 30 minutes after the training

Table 4. The inter-group comparisons of maximal heart rate, lactate levels, and perceived exertion levels of the participants

Parameters	Time	2*2	4*4	8*8	p	Inter-group differences
Maximal heart rate	Pre-training	63.0±3.46	68.25±4.46	66.5±5.77	0.275	-
	Post-training	181.5±3.00	175.25±20.05	125.7±18.41	0.001	2>8 4>8
	30 minutes after the training	78.0±4.89	87.0±11.56	88.5±9.33	0.168	-
Lactate	Pre-training	1.35±0.26	1.47±0.27	1.44±0.25	0.735	-
	Post-training	11.65±2.73	7.72±1.89	6.22±2.38	0.001	2>4 2>8
	30 minutes after the training	3.1±1.03	2.38±0.49	2.09±0.50	0.018	2>8
Perceived exertion level (Borg Scale)		17.0±0.81	16.0±0.53	14.56±0.96	0.001	2>8 4>8

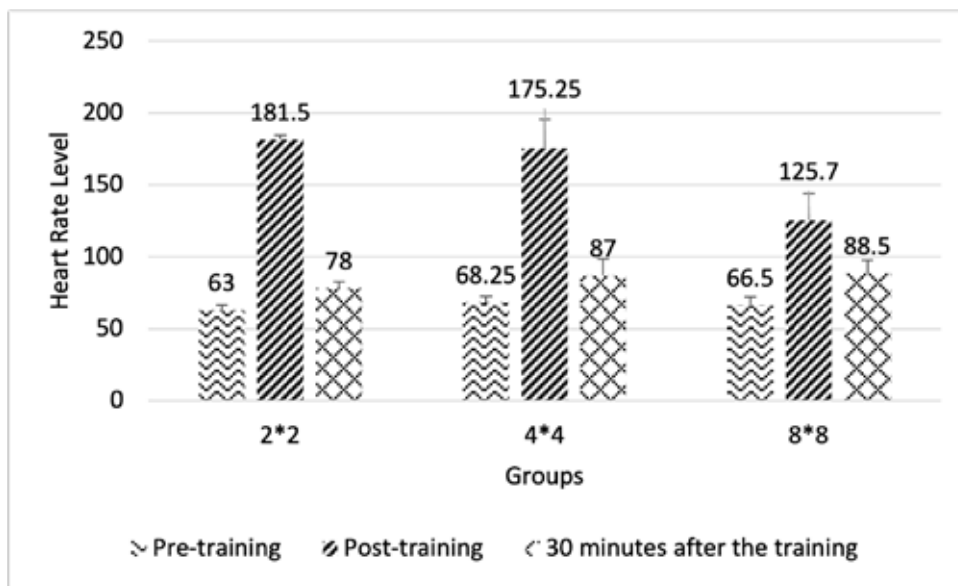


Figure 1. Group Comparisons of Maximal Heart Rates

while they were significantly lower in the 2 vs. 2 group ($P<0.05$). In the study, after the training, the perceived exertion levels of the 2 vs. 2 and 4 vs. 4 groups were similar ($P>0.05$), whereas they were significantly higher in the 8 vs. 8 group ($P<0.05$).

Immediately after the training, the highest average heart rate was observed in the 2 vs. 2 group (181.5 bpm), while the 4 vs. 4 group reached a close average (175.25 bpm). In contrast, the 8 vs. 8 group exhibited a significantly lower average heart rate (125.7 bpm). Measurements taken 30 minutes post-training to assess recovery showed that the 2 vs. 2 group had the lowest average heart rate (78 bpm), the 4 vs. 4 group had a slightly higher average (87 bpm), and the 8 vs. 8 group maintained levels at

around 88.5 bpm (Figure 1).

Upon examining the lactate level findings, it was observed that athletes in the first group (2 vs. 2) reached a peak of 11.65 mmol/L and then decreased to 3.1 mmol/L during the recovery period 30 minutes after training. In the second group (4 vs. 4), lactate levels were noted at 7.72 mmol/L, which decreased to 2.38 mmol/L at the end of the 30-minute recovery period. For the third group (8 vs. 8), lactate levels reduced from an initial 6.22 mmol/L to 2.09 mmol/L during the recovery phase (Figure 2). When asked about the perceived exertion level of the training session, athletes in the 2 vs. 2 group rated the intensity with an average score of 17. In comparison, participants in the 4 vs. 4 group gave an average

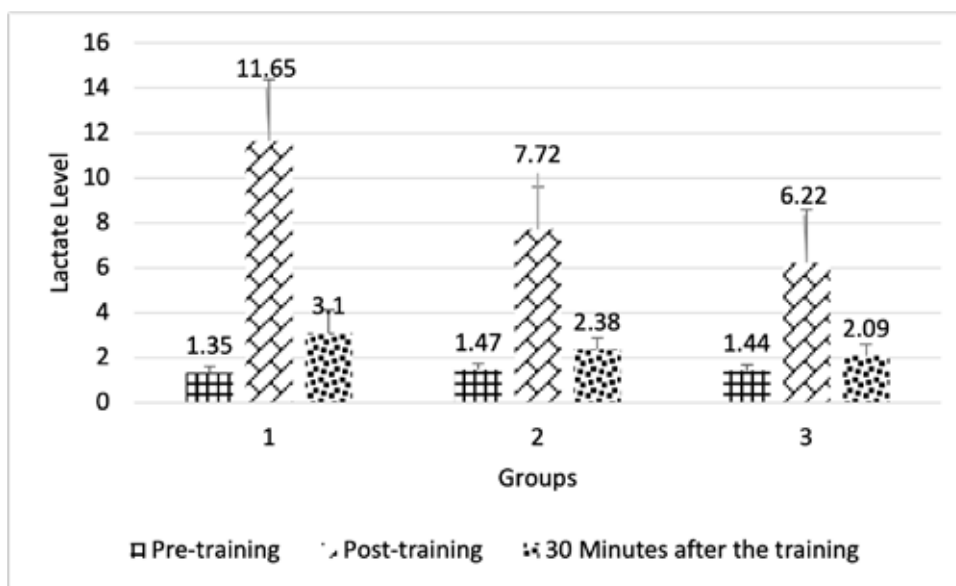


Figure 2. Group Comparisons of Lactate Values (group 1: 2 vs. 2, 2: 4 vs. 4 and 3: 8 vs. 8)

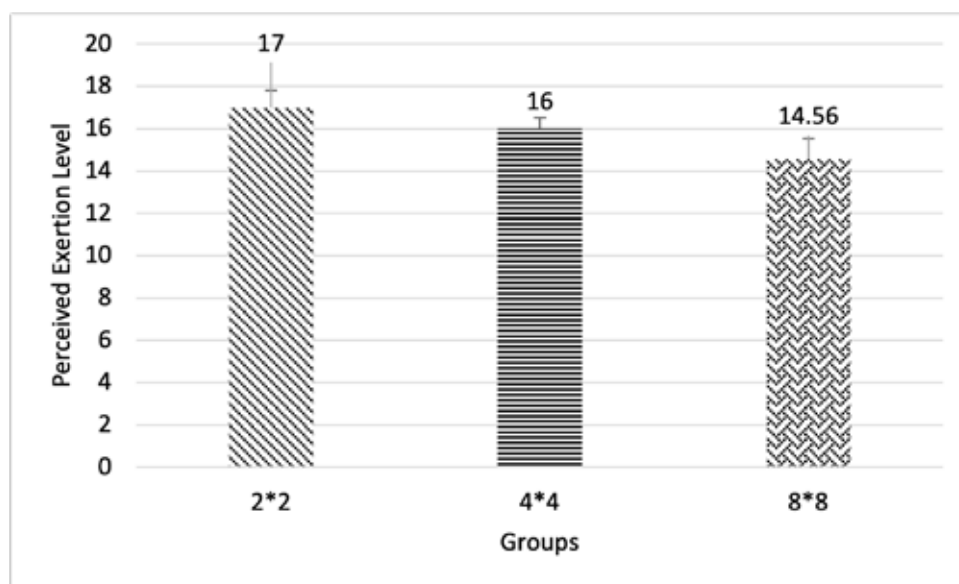


Figure 3. Inter-Group Comparisons of Perceived Exertion Levels

score of 16, while those in the 8 vs. 8 group reported a lower average difficulty rating of 14.56 (Figure 3).

Discussion

This study aimed to investigate the effects of variations in the number of players during acute small-sided games in football on maximal heart rates (MHR), blood lactate levels, and perceived exertion (PE) levels. It is suggested that small-sided games can increase athletes' heart rates, which in turn may enhance their endurance [41]. The study revealed that in the 2 vs. 2, 4 vs. 4, and 8 vs. 8 game groups, post-training MHR and lactate levels were significantly higher than pre-training levels, while measurements taken 30 minutes after the training were significantly lower than post-training levels. The notable increase in values 30 minutes after

training across all groups suggests that the football players were subjected to a heavy training load and had not fully recovered. The elevated heart rate after the 30-minute rest period might indicate insufficient endurance training levels among the participating footballers. Additionally, despite no significant intergroup differences in MHR values before and 30 minutes after the training, post-training measurements revealed a higher MHR in the 2 vs. 2 group. This finding aligns with previous research [42], which indicates that players respond with a higher MHR during 3 vs. 3 small-sided games compared to larger (9 vs. 9) small-sided games.

In our study, the high maximal heart rate (MHR) attained due to the reduction in player numbers aligns with previous research conducted with amateur and professional athletes [29, 43].

Furthermore, both the 2 vs. 2 and 4 vs. 4 game groups exhibited the highest intragroup and intergroup MHR values immediately after the training, which is consistent with other studies in the literature (>80% MHRmax) [44, 45, 46]. In a study conducted by Little & Williams [26], involving six different pitch sizes and player numbers (2 vs. 2: 27x18m, 3 vs. 3: 32x23m, 4 vs. 4: 37x27m, 5 vs. 5: 41x27m, 6 vs. 6: 46x27m, and 8 vs. 8: 73x41m) during small-sided games (SSGs) in football, a decrease in maximal heart rate percentage was observed (ranging from 88.9% to 87.9%), which is similar to our findings. Consistent with our study, previous research on small-sided games has demonstrated that a 4-minute training bout induces an intensity close to 90% of maximal heart rate (MHR) and contributes to enhancing players' physical fitness [47].

In our study, the higher perceived exertion levels observed in the 2 vs. 2 small-sided game group compared to the other groups indicate that the 2 vs. 2 game format places players under a greater physical load. Michailidis et al. [48] also showed that, based on GPS data, the average heart rate is higher in smaller areas than in larger ones. These findings highlight substantial differences in perceived exertion and lactate levels among players during small-sided games. Some studies [29, 49] have reported that an increase in individual playing area during small-sided games leads to a simultaneous increase in physical and physiological workloads as well as perceived exertion levels. However, our study and certain other research in the literature do not fully support this trend [50, 51]. The level of exertion can be further understood by examining lactate levels [2]. The study by Rampinini et al. [29], which reported an increase in lactate accumulation in athletes as the number of players decreased, is in line with our findings. Moreover, subsequent studies have also revealed that as the number of players decreases in small-sided games, lactate concentrations increase [52, 53]. In a study conducted on female soccer players, it was observed that the %HRmax responses were significantly lower during 2 vs. 2 small-sided games compared to 3 vs. 3 and 4 vs. 4 games, while La and PE responses showed significant differences [54].

Furthermore, in the study conducted by Köklü et al. [55], long-duration small-sided games were found to result in lower blood lactate levels and perceived exertion levels compared to short-duration and frequently played small-sided games. Boge et al. [56] observed that higher blood lactate levels occurred in small-sided games with fewer players, but this result did not produce a significant difference. They also found that there was no difference in heart rate and perceived exertion levels with an increasing number of players. According to Aguiar et al. [57], the decrease in perceived exertion and lactate levels with increasing player numbers could be

attributed to reduced interaction with teammates and opponents. Moreover, technical actions such as ball control can particularly increase perceived exertion and lactate concentrations in games with fewer players [58]. This result is consistent with our study's findings of lower lactate and perceived exertion levels in the 8 vs. 8 game group compared to the other groups. A study with two different small-sided game models, 3 vs. 3 and 5 vs. 5, found that perceived exertion was higher when the number of players decreased [59]. Beato et al. [60] revealed that the lowest perceived exertion level occurred during 8 vs. 8+2 small-sided games, as a result of small-sided games (10 vs. 10, 9 vs. 9+3, 8 vs. 8+2, 7 vs. 7+3, 6 vs. 6, and 6 vs. 4) applied to different numbers of soccer players.

Our study revealed that as the number of players decreased in the other groups compared to the 8 vs. 8 game group, lactate levels increased. Another study conducted with football players found that both a decrease in player numbers and a reduction in the playing area led to a return of high perceived exertion levels to normal levels [61]. Christopher et al. [62] investigated physical and technical skills by manipulating rest-exercise intervals between small-sided games in elite young football players. They found that the total duration of the game determined the exercise intensity in small-sided games. In our study, despite the 2 vs. 2 game group having the same duration as the other groups (4 minutes), it reached the highest lactate levels and perceived exertion levels. This result is significant as the 2 vs. 2 small-sided game involves fewer players and takes place in a smaller area compared to the other groups, indicating that players are exposed to more tackles and changes of pace. Therefore, the 2 vs. 2 game group places players under more locomotor and internal load compared to the 4 vs. 4 and 8 vs. 8 game groups.

Similarly, [53] reported higher lactate and perceived exertion levels in the 2 vs. 2 group compared to the other groups after applying 2 vs. 2, 3 vs. 3, and 4 vs. 4 small-sided games. [26] investigated the effect of different field sizes and player numbers (2 vs. 2: 27x18m, 3 vs. 3: 32x23m, 4 vs. 4: 37x27m, 5 vs. 5: 41x27m, 6 vs. 6: 46x27m, and 8 vs. 8: 73x41m) on football players' lactate and perceived exertion levels and found results (lactate: 9.6 mmol - 8.5 mmol - 9.5 mmol - 7.9 mmol - 5.6 mmol - 5.8 mmol) similar to our study. Changes in the number of players generally affect training intensity in small-sided games. Hill-Haas et al. [30] reported that time-motion characteristics (total distance covered) and acute perceptual responses were affected, but physiological responses were not. The perceived exertion levels of 3-player teams were higher than those of 4-player teams. This finding is consistent with other studies [63, 64] which reported an increase in perceived exertion levels with a

decrease in the number of players when field size remains constant. Similarly, studies have shown that with an increase in field sizes and the number of players (2 vs. 2: 27x18m, 3 vs. 3: 32x23m, 4 vs. 4: 37x27m, 5 vs. 5: 41x27m, 6 vs. 6: 46x27m), perceived exertion levels decrease (16.3 - 15.7 - 15.3 - 14.3 - 13.6, respectively) [15].

This study demonstrates that the number of players in small-sided games significantly influences physiological and perceptual responses in football players. Smaller game formats, such as 2 vs. 2, place a greater physical load on players, leading to higher lactate concentrations and perceived exertion levels compared to larger formats like 8 vs. 8. These findings highlight the importance of carefully considering player numbers and field size when designing training sessions to achieve specific conditioning goals. Future research should explore

the long-term effects of different small-sided game formats on player performance and recovery, as well as investigate potential strategies to optimize training outcomes across various levels of play.

Conclusions

Small-sided games in football, particularly those played in limited space with fewer players, have a profound impact on the physiological and perceptual demands placed on athletes. These game formats can be strategically utilized in training to target specific performance outcomes, depending on the desired balance between aerobic and anaerobic conditioning. Understanding the relationship between game structure and training load is crucial for optimizing player development and ensuring effective recovery management.

References

- Rösch D, Hodgson R, Peterson TL, Graf-Baumann T, Junge A, Chomiak J, et al. Assessment and evaluation of football performance. *The American Journal of Sports Medicine*. 2000; 28(5): 2939. https://doi.org/10.1177/28.suppl_5.s-29
- Dellal A, Chamari K, Owen AL, Wong DP, Lago-Penas C, Hill-Haas S. Influence of technical instructions on the physiological and physical demands of small-sided soccer games. *European Journal of Sport Science*. 2011; 11(5): 34146. <https://doi.org/10.1080/17461391.2010.521584>
- Clemente FM, Afonso J, Sarmiento H. Small-sided games: An umbrella review of systematic reviews and meta-analyses. *PLoS One*, 2021;16(2), e0247067. <https://doi.org/10.1371/journal.pone.0247067>
- Branquinho L, Ferraz R, Travassos B, Marinho DA, Marques MC. Effects of Different Recovery Times on Internal and External Load During Small-Sided Games in Soccer. *Sports Health*. 2021; 13(4): 324331. <https://doi.org/10.1177/1941738121995469>
- Bizati Ö. The Importance of Forming Planned Groups in Football-Specific Small-Sided Games in Determining Training Quality. *Türkiye Klinikleri Journal of Sports Sciences*. 2010; 2(2):759.
- Köklü Y. *The Effect of Different Grouping Methods on 4x4 Small-Sided Game Performance in Young Football Players*. [PhD Thesis]. Ankara University Institute of Health Sciences; 2011.
- Sarmiento H, Clemente FM, Harper LD, Costa IT, Owen A, Figueiredo AJ. Small sided games in soccer—a systematic review. *International Journal of Performance Analysis in Sport*. 2018; 18(5): 693749. <https://doi.org/10.1080/24748668.2018.1517288>
- Bujalance-Moreno P, Latorre-Román PÁ, & García-Pinillos F. A systematic review on small-sided games in football players: Acute and chronic adaptations. *Journal of Sports Sciences*. 2019; 37(8): 921–949. <https://doi.org/10.1080/02640414.2018.1535821>
- Clemente FM, Martins FMI, Couceiro MS. Inspecting teammates coverage during attacking plays in a football game: a case study. *International Journal of Performance Analysis in Sport*. 2014; 14(2):1–27. <https://doi.org/10.1080/24748668.2014.11868729>
- Silva AF, González-Fernández FT, Aquino R, Akyildiz Z, Vieira LP, Yıldız M, et al. Analyzing the within and between Players Variability of Heart Rate and Locomotor Responses in Small-Sided Soccer Games Performed Repeatedly over a Week. *In Healthcare*. 2022; 10(8): 1412. <https://doi.org/10.3390/healthcare10081412>
- Barnes C, Archer DT, Hogg B, Bush M, Bradley PS. The evolution of physical and technical performance parameters in the English Premier League. *International Journal of Sports Medicine*. 2014; 35(13): 1095-100. <https://doi.org/10.1055/s-0034-1375695>
- Helgerud J, Engen LC, Wisløff U, Hoff J. Aerobic endurance training improves soccer performance. *Medicine & Science in Sports & Exercise*. 2001; 33(11):1925–31. <https://doi.org/10.1097/00005768-200111000-00019>
- Hoff J, Helgerud J. Endurance and strength training for soccer players. *Sports Medicine*. 2004; 34(3): 165–180. <https://doi.org/10.2165/00007256-200434030-00003>
- Stolen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer. *Sports Medicine*. 2005; 35(6):501–36. <https://doi.org/10.2165/00007256-200535060-00004>
- Ergen E, Demirel H, Güner R, Turnagöl H, Başoğlu S, Zergeroğlu AM, et al. *Exercise Physiology*. Nobel Publishing; 2007.
- Günay M. *The Effect of Different Strength Training Methods on Body Composition*. [PhD Thesis]. Gazi University, Institute of Health Sciences, Department of Physical Education and Sports; 1993.
- James FG, Reilly T. The Physiological demands of gaelic football. *British Journal of Sports Medicine*. 1995; 29(1):41–45. <https://doi.org/10.1136/bjism.29.1.41>
- Gatterer H. Oxygen uptake during soccer.VI World

- Congress on Science and Football, Antalya/Türkiye. *Journal of Sport Science and Medicine*. 2007; 6:15–20.
19. Reilly T. Energetics of high intensity exercise (soccer) with particular reference to fatigue. *Journal of Sports Sciences*. 1997; 15(3): 257–63. <https://doi.org/10.1080/026404197367263>
 20. Köklü Y, Aşçı A, Koçak Ünver F, Alemdaroğlu U, Dündar U. Comparison of the physiological responses to different small-sided games in elite young soccer players. *The Journal of Strength & Conditioning Research*. 2011; 25(6): 1522–28. <https://doi.org/10.1519/JSC.0b013e3181e06ee1>
 21. Al Haddad H, Laursen PB, Ahmaidi S, Buchheit M. Nocturnal heart rate variability following supramaximal intermittent exercise. *International Journal of Sports Physiology and Performance*. 2009; 4(4): 435–47. <https://doi.org/10.1123/ijsp.4.4.435>
 22. Hoff J, Wisløff U, Engen LC, Kemi OJ, Helgerud J. Soccer specific aerobic endurance training. *British Journal of Sports Medicine*. 2002; 36(3): 218–21. <https://doi.org/10.1136/bjism.36.3.218>
 23. Mohr M, Krstrup P, Bangsbo J. Fatigue in soccer: A brief review. *Journal of Sports Sciences*. 2005; 23(6): 593–99. <https://doi.org/10.1080/02640410400021286>
 24. Bangsbo J. Physiological demands. In: Ekblom B, editor. *Football (soccer)*. London: Blackwell: Scientific; 1994.
 25. Bangsbo J. *Physiology of training*. Science and Soccer; 2003.
 26. Little T, Williams AG. Suitability of soccer training drills for endurance training. *Journal of Strength and Conditioning Research*. 2006; 20(2):316–19. <https://doi.org/10.1519/R-17094.1>
 27. Little T, Williams AG. Measures of exercise intensity during soccer training drills with professional soccer players. *The Journal of Strength & Conditioning Research*. 2007; 21(2): 367–71. <https://doi.org/10.1519/R-19445.1>
 28. Dellal A, Chamari K, Pintus A, Girard O, Cotte T, Keller D. Heart rate responses during small-sided games and short intermittent running training in elite soccer players: a comparative study. *The Journal of Strength & Conditioning Research*. 2008; 22(5):1449–57. <https://doi.org/10.1519/JSC.0b013e31817398c6>
 29. Rampinini E, Impellizzeri FM, Castagna C, Abt G, Chamari K, Sassi A, et al. Factors influencing physiological responses to small-sided soccer games. *Journal of Sports Sciences*. 2007; 25(6): 659–66. <https://doi.org/10.1080/02640410600811858>
 30. Hill-Haas SV, Coutts AJ, Dawson BT, Rowsell GJ. Time motion characteristics and physiological responses of small-sided games in elite youth players; the influence of player number and rule changes. *The Journal of Strength & Conditioning Research*. 2010; 24(8): 2140–56. <https://doi.org/10.1519/JSC.0b013e3181af5265>
 31. Hill-Haas SV, Dawson BT, Impellizzeri FM, Coutts, AJ. Physiology of small-sided games training in football: a systematic review. *Sports Medicine*. 2011; 41(3):199–220. <https://doi.org/10.2165/11539740-000000000-00000>
 32. Ekstrand J, Walden M, Hagglund M. A congested football calendar and the wellbeing of players: correlation between match exposure of European footballers before the World Cup 2002 and their injuries and performances during that World Cup. *British Journal of Sports Medicine*. 2004; 38(4):493–7. <https://doi.org/10.1136/bjism.2003.009134>
 33. Dupont G, Nedelec M, McCall A, McCormack D, Berthoin S, Wisløff U. Effect of 2 soccer matches in a week on physical performance and injury rate. *The American Journal of Sports Medicine*. 2010; 38(9): 1752–8. <https://doi.org/10.1177/0363546510361236>
 34. Köklü Y, Özkan A, Alemdaroğlu U, Ersöz G. Comparison of Some Physical Fitness and Somatotype Characteristics of Young Football Players According to Their Playing Positions. *Sportmetre Journal of Physical Education and Sports Sciences*. 2009; 7(2): 61–68. https://doi.org/10.1501/Sporm_0000000151
 35. Moran J, Blagrove RC, Drury B, Fernandes, JFT, Paxton K, Chaabene H, et al. Effects of small-sided games vs. conventional endurance training on endurance performance in male youth soccer players: A meta-analytical comparison. *Sports Medicine*. 2019; 49(5): 731–742. <https://doi.org/10.1007/s40279-019-01086-w>
 36. Plowman SA, Smith DL. *Exercise physiology for health, fitness, and performance*. Baltimore, MD: Lippincott Williams & Wilkins; 2011.
 37. Cairns SP. Lactic acid and exercise performance: culprit or friend? *Sports Medicine*. 2006; 36(4): 279–291. <https://doi.org/10.2165/00007256-200636040-00001>
 38. Williams, N. The Borg rating of perceived exertion (RPE) scale. *Occupational medicine*, 2017; 67(5): 404–405. <https://doi.org/10.1093/occmed/kqx063>
 39. Castillo D, Raya-González J, Yanci J, Clemente FM. Influence of pitch size on short-term high intensity actions and body impacts in soccer sided games. *Journal of Human Kinetics*. 2021; 78:187–196. <https://doi.org/10.2478/hukin-2021-0037>
 40. Gantois P, Piqueras-Sanchiz F, Cid MJFA, Pino-Ortega J, Castillo D, Nakamura FY. The effects of different small-sided games configurations on heart rate, rating of perceived exertion, and running demands in professional soccer players. *European Journal of Sport Science*. 2022; 23(7): 1–9. <https://doi.org/10.1080/17461391.2022.2092427>
 41. Sannicandro I, Cofano G. Large-Sided Games and Sport-Specific Training: Parameters of High Intensity in Professional Soccer Players. *Physical Education Theory and Methodology*, 2023;23(1): 124–132. <https://doi.org/10.17309/tmfv.2023.1.18>
 42. Owen AL, Wong DP, McKenna M, Dellal A. Heart rate responses and technical comparisons between small vs. large sided games in elite professional soccer. *Journal of Strength Conditioning and Research*. 2011; 25(8): 2104–2110. <https://doi.org/10.1519/JSC.0b013e3181f0a8a3>
 43. Casamichana D, Castellano J. Time-motion, heart rate, perceptual and motor behaviour demands

- in small-sided soccer games: Effects of pitch size. *Journal of Sport Science*. 2010; 28(14):1615–23. <https://doi.org/10.1080/02640414.2010.521168>
44. Bradley PS, Mohr M, Bendiksen M, Randers MB, Flindt M, Barnes C, et al. Sub-maximal and maximal Yo–Yo intermittent endurance test level 2: heart rate response, reproducibility and application to elite soccer. *European Journal of Applied Physiology*. 2011; 111(6):969–978. <https://doi.org/10.1007/s00421-010-1721-2>
 45. Bondarev DV. Factors influencing cardiovascular responses during small-sided soccer games performed with recreational purposes. *Physical Education of Students*. 2011;2:115–118.
 46. Bertolaccini MS, Orsatti FL, Neto OB, Mendes EL, Penaforte FRO, Ide BN, et al. Soccer only once a week generates excessive cardiac responses. *Journal of the Health Sciences Institute*. 2010; 28(3), 272–274.
 47. Fanchini M, Azzalin A, Castagna C, Schena F, McCall A, Impellizzeri FM. Effect of bout duration on exercise intensity and technical performance of small-sided games in soccer. *Journal of Strength Conditioning and Research*. 2011; 25(2): 453–8. <https://doi.org/10.1519/JSC.0b013e3181c1f8a2>
 48. Michailidis, Y. Correlations of Aerobic Capacity with External and Internal Load of Young Football Players during Small-Sided Games. *Sensors* 2024; 24: 2258. <https://doi.org/10.3390/s2407225>
 49. Owen A, Twist C, Ford P. Small sided games: The physiological and technical effect of altering pitch size and player numbers. *Insight: F.A. Coaches Association Joutnal*. 2004; 7(2): 50–53.
 50. Kelly DM, Drust B. The effect of pitch dimensions on heart rate responses and technical demands of small-sided soccer games in elite players. *Journal of Science and Medicana in Sports*. 2009; 12(4): 475–79. <https://doi.org/10.1016/j.jsams.2008.01.010>
 51. Tessitore A, Meeusen R, Piacentini M, Demarie S, Capranica L. Physiological and technical aspects of “6-a-side” soccer drills. *Journal of Sports Medicine and Physical Fitness*. 2006; 46(1): 36–43.
 52. Hill-Haas SV, Dawson BT, Coutts AJ, Rowsell GJ. Physiological responses and time–motion characteristics of various small-sided soccer games in youth players. *Journal of Sports Sciences*. 2009; 27(1):1–8. <https://doi.org/10.1080/02640410902761199>
 53. Köklü Y, Alemdaroğlu U. Comparison of the Heart Rate and Blood Lactate Responses of Different Small Sided Games in Young Soccer Players. *Sports (Basel)*. 2016; 4(4): 48. <https://doi.org/10.3390/sports4040048>.
 54. Köklü Y, Türkdoğan H, Bölükbaşı T, Alemdaroğlu U. Comparison of internal and external loads during different small-sided games in young female soccer players. *Science & Sports*, 2024;39(3), 260–266.
 55. Köklü Y, Alemdaroğlu U, Cihan H, Wong DP. Effects of bout duration on players’ internal and external loads during small-sided games in young soccer players. *International Journal of Sport Physiology and Performance*. 2017; 12(10): 1370–1377. <https://doi.org/10.1123/ijsp.2016-0584>
 56. Böge V, Suleyman P, Bekir M. Cytokine responses to small sided games in young soccer players. *Pedagogy of Physical Culture and Sports*, 2022;26(4):222–227. <https://doi.org/10.15561/26649837.2022.0401>
 57. Aguiar MV, Botelho GM, Gonçalves BS, Sampaio JE. Physiological responses and activity profiles of football small-sided games. *Journal of Strength Conditioning and Research*. 2013; 27(5): 1287–94. <https://doi.org/10.1519/JSC.0b013e318267a35c>
 58. Köklü Y. A comparison of physiological responses to various intermittent and continuous small-sided games in young soccer players. *Journal of Human Kinetics*. 2012; 31: 89–96. <https://doi.org/10.2478/v10078-012-0009-5>
 59. Xu Q, Silva RM, Qi K, Ma D, Li T, Clemente FM. Physiological and locomotor variations of 3v3 and 5v5 small-sided games soccer formats: A 4-month study on sedentary young adults. *Science Progress*, 2024;107(1): 00368504231224606. <https://doi.org/10.1177/00368504231224606>
 60. Beato M, De Keijzer KL, Costin AJ. External and internal training load comparison between sided-game drills in professional soccer. *Frontiers in Sports and Active Living*, 2023;5: 1150461. <https://doi.org/10.3389/fspor.2023.1150461>
 61. 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; 33:103–13. <https://doi.org/10.2478/v178-012-0049-x>
 62. Christopher J, Beato M, Hulton AT. Manipulation of exercise to rest ratio within set duration on physical and technical outcomes during small-sided games in elite youth soccer players. *Human Movement Science*. 2016; 48: 1–6. <https://doi.org/10.1016/j.humov.2016.03.013>
 63. Aroso J, Rebelo AN, Gomes-Pereira J. Physiological impact of selected game-related exercises. *Journal of Sports Sciences*. 2004; 22(6):522.
 64. Sampaio J, Garcia G, Maças V, Ibanez JS, Abrantes C, Caixinha, P. Heart rate perceptual responses to 2x2 and 3x3 small-sided youth soccer games. *Journal of Sports Science & Medicine*. 2007; 6(10):121–122.

Information about the authors:

Tayyar Karadağ; <https://orcid.org/0000-0003-0008-3582>; tayyarkaradag10@gmail.com; Department of Coaching Education, Faculty of Sports Sciences, Selcuk University; Konya, Turkey.

Süleyman Patlar; <https://orcid.org/0000-0003-3817-3575>; spatlar@gmail.com; Department of Coaching Education, Faculty of Sports Sciences, Selcuk University; Konya, Turkey.

Ahmet Bayrak; (Corresponding Author); <https://orcid.org/0000-0001-7854-6407>; ahmetbayraklaw@gmail.com; Department of Physical Therapy and Rehabilitation, Faculty of Health Science, Selcuk University; Konya, Turkey.

Cite this article as:

Karadağ T, Patlar S, Bayrak A. Effects of small-sided games on some recovery markers in football. *Physical Education of Students*, 2024;28(5):250–260.

<https://doi.org/10.15561/20755279.2024.0501>

This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited <http://creativecommons.org/licenses/by/4.0/deed.en>

Received: 01.08.2024

Accepted: 02.09.2024; Published: 30.10.2024