

# THE EFFECT OF DIFFERENTLY DESIGNED SMALL-SIDED GAMES IN SOCCER ON PHYSICAL AND PHYSIOLOGICAL PARAMETERS

Murat Tutar<sup>1\*</sup>

<sup>1</sup>Exercise and Sport Sciences, Department of Sport Sciences, Istanbul Gedik University, Istanbul, Turkey

ORCID: M.T. 0009-0009-1726-7581

**Corresponding author:** Murat Tutar, **E-mail:** tutarmurat@gmail.com

**Received:** 08.05.2025; **Accepted:** 20.06.2025; **Available Online Date:** 30.09.2025

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**Cite this article as:** Tutar M. The Effect of Differently Designed Small-Sided Games in Soccer on Physical And Physiological Parameters. J Basic Clin Health Sci 2025; 9: 516-527.

## ABSTRACT

**Purpose:** There are very few studies investigating the effects of field size on soccer-specific small-sided games. The aim of this study was to compare the physiological and performance effects of game-based training models (small-sided games versus large-sided games) using different training variables (intensity, volume and rest) for 8 weeks in soccer.

**Material and Methods:** A group of 28 male soccer players was randomly divided into two groups: a small-sided game (SSG) (Age 18.80±0.42) and a large-sided game (LSG) (Age 17.82±0.72). The groups practiced endurance training 2 days a week for 8 weeks. Before and after the training cycle, y-balance test, 30 m sprint tests; 30-15 intermittent fitness test (IFT); T-agility test values were measured.

**Results:** When the pre-test and post-test data are compared significant main effect of the IFT;  $F(1.24) = 44.68$ ,  $p < .001$ , ( $\eta^2 = 0.651$ ), T-test  $F(1.24) = 16.72$ , ( $p < .001$ ,  $\eta^2 = 0.411$ ) and RPE  $F(1.24) = 7.32$ , ( $p = 0.012$ ,  $\eta^2 = 0.234$ ) values. Agility and sprint performance data showed a statistically significant difference in SSG group agility and sprint performance ( $p < 0.05$ ).

**Conclusion:** Both interventions improved soccer players' balance, linear sprint, intermittent fitness levels and estimated maximal oxygen uptake. In particular, large-side games improved intermittent fitness and estimated maximal oxygen uptake better than small-sided games, while SSG showed a higher positive effect on sprint and agility performances. These findings suggest that manipulating the field size of narrow field games would be the right approach to respond to athlete-specific requirements.

**Keywords:** Small Sided Games, Large-Sided Games, Intermittent Fitness Test, Soccer, Linear Sprint, Agility

## INTRODUCTION

Soccer, which is a highly competitive sport, necessitates a variety of effective physical, physiological, technical, and tactical skills (1,2). The sophisticated adaptive system in which different movement patterns develop in reaction to the ever-changing surroundings (3). Success in soccer mostly relies on an integration of tactical, technical, and

physical capabilities. Soccer players can perform tactics and make sound tactical judgments when sprinting at high speeds. To mitigate pressure from adversaries, players must possess superior technical, physical, and skill competencies. In contemporary football, optimal outcomes are influenced by three primary factors: skill, tactics, and the comprehensive condition of each player (physical,

moral, psychological, etc.). High levels of anaerobic and aerobic endurance, muscle strength, speed, power, agility, and flexibility are among the physiological demands of the sport; these are all necessary for improving performance and preventing injuries (4,5). Players of all skill levels, from young athletes to top pros, are frequently trained using small-sided games (SSG) (6). Consequently, SSG in football have arisen as discrete segments of the sport that have been increasingly examined in football literature and research. The prevalence of SSGs in football arises from their capacity to provoke varied immediate reactions among players. These games are extensively used by coaches for football players of diverse age groups, experience levels, and competitive standards (3,4,5,6). It permits many ways that enable the diverse impacts of the football game without undermining the dynamics and movements of the sport (6). SSG, that use less players and smaller playing area when compared to standard 11-a-side matches, stimulate the enhancement of technical abilities, tactical comprehension, and physical performance. Coaches plan these sessions by altering variables such as field size, player count, tactical or technical instructions, and game style, which includes work-rest ratios, ball touch limitations, and whether goalkeepers are included (6,7,8). SSGs provide a valuable chance for coaches to replicate real game scenarios, providing players to improve specific abilities and tactics while improving overall performance (9). These training sessions activate different energy systems and present a variety of obstacles that mirror the demands of actual soccer matches (8). Some studies has been undertaken in the literature to better understand how varying task restrictions, such as field size and player space, affects training demands (7,8,10). In general, SSGs with higher pitch ratios per player are more intensive than the same exercise on smaller pitches (11,12,13). Moreover, SSGs promote a comprehensive approach to soccer training, providing benefits in movement specificity and decision-making participation, along with improved variability through sessions, supporting a replication of match movement patterns and the physiological and technical requirements of competition (14,15). Several SSG formats have been devised and described in the scientific literature to replicate competitive demands (16,17). The size of the field, the number of players and their various combinations (7), and the presence of goalkeepers (18) are some of the most often studied factors. The

duration format, which comprises the lengths of the SSGs, the rest periods in between sets, and the number of sets, is another crucial factor to consider when designing an SSG. The duration of SSG is a determinant of players' loads and is heavily adjusted by coaches during daily training (19,20). According to the research mentioned above, soccer players prefer game-based training over running-based intervals because it is enjoyable, has developmental benefits, and can enhance both technique and physical performance. This situation increases the need to increase the diversity of game-based training by studying the physical and physiological adaptations of various variations of game-based training in depth and to support the field workers to acquire more training stimulation tools and to support multi-variation sessions. This study aimed at investigating the physiological and performance effects of game-based training models (small-sided games vs large-sided games) using various field dimensions, player numbers, and training factors (intensity, volume, and rest) during an 8-week period.

## MATERIALS AND METHODS

### Participants

Twenty-six male competitive soccer players (age  $18.18 \pm 0.78$ ), who had been playing the game on a regular basis for at least five years, made up the study participants. Participants and parents were adequately informed about the study's design, possible hazards, and their right to withdraw from participation at any time before the trial beginning. Every participant provided written agreement attesting to their voluntary participation. The requisite sample size was calculated with G-Power 3.1.9.4 software (Heinrich Heine University Düsseldorf, Germany). For evaluating the effects of a submaximal exercise session on the players, the sample size was calculated based on an alpha (error) level of 0.05 and an effect size of 0.40, which resulted in a required sample size of 24 participants. The inclusion criteria for the study were: players with at least five years of regular training history, training a minimum of five days per week for at least 60 minutes, and participation in national or international competitions. Additionally, participants should not have suffered a serious injury in the past six months and should not regularly consume alcohol or drugs. Exclusion criteria included training history of less than five years, any serious injury within the past six months, fewer than five training sessions per week, or the consumption

of alcohol or regular medication during the measurement period. The study was conducted according to with the Declaration of Helsinki (2023/06) and received authorization from the Nisantasi University Ethics Committee (Date: 08/11/2023, Decision No: 2023/42).

**Research design**

The research consisted of two different sessions (see Figure 1): a familiarization session and an experimental intervention session. Before the experimental intervention session, it was determined using the randomized distribution method. These groups included SSG and the other a LSG. The SSG consisted of 4 players and 2 goalkeepers competing against another 4 players within an area of 35 × 25 meters. In contrast, LSG had 8 players and 2 goalkeepers (8v8 + 2GK) facing 8 players on a 60 × 45 meters field. The effects of games designed in different sizes on the metabolic and internal loads of players were examined.

Participants of the research group were played a SSG 2 training day a week for 16 training periods of 8 week at the competition period. As a results of 16 units of training were conducted. The matches were played on Saturday. Studies were carried out from the Match+2 and Match+4 days after the competition. After the dynamic warm-up, rondo work and then SSG work were started.

SSG was applied in the form of a game of 4 players and 2 goalkeepers (4v4+2K) against 4 players in an area of 35 × 25m, 4 sets × 3 minutes load, 3 minutes of passive rest intra sets. LSG was applied in the form of a game of 60 × 45m, 8 players and 2 goalkeepers

(8v8+2GK) against 8 players, 2 sets × 10 minutes loading, 3 minutes of passive rest between sets.

**Pre-Session Standardization**

All tests in the pre- and post-test session were performed on a synthetic football surface for two days and at the same similar times. First day: anthropometric measurements, Y balance, T test and sprint test were taken. Second day: 30-15 IFT test was performed. The period of 24 hours of passive rest has been established between the tests to reduce fatigue effects during the endurance assessment. Participants experienced liquids and food deprivation for 2 hours before to each session.

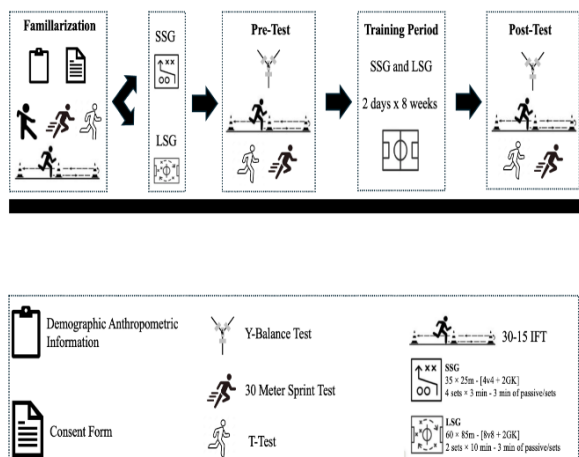
The load equalization between SSG and LSG was calculated as in the studies in the literature (19,20). The distances travelled in the small area and training loads are different from the distances and training loads in the wide area. For this reason, distance is determined according to the number of athletes in the applied methods. In addition, in small-sided games, the intensity of loading consists of short and repetitive movements, while in the wide-field, there are longer sprints and rest periods. According to the training plan, training variables were determined based on the metabolic loads between the methods applied in the small sided and the methods applied in the large field. Goalkeepers are involved in the game and use acceleration-deceleration change of direction and endurance skills. For this reason, they were not separated from the footballers and the playground was designed accordingly.

**Familiarization Session**

The testing techniques, possible dangers, safety measures, and any particular instructions or hazards related to the study were all fully explained to all participants. Each participant completed an informed consent form, which documented their voluntary participation. After providing a clear explanation of the experimental protocol, demographic information was collected from the participants. Following this, the tests used in the study were administered at least once to each participant.

**Height and weight measurement**

The players' height was measured in centimeters using a Mesilife (MC-210, Turkey) device. Body weight (kg) and body fat were assessed using a Tanita BC418 (Japan) device, which utilizes the bioimpedance method. Measurements were taken



**Figure 1.** Study Design.

while the players stood barefoot on the platform, wearing only shorts and t-shirts.

### Y Balance Test

The assessment of dynamic postural control was conducted via the "Y Balance Test." Measurements in millimeters were recorded along the taped lines that formed a "Y" pattern on the ground. Participants were given directions to position their hands on their waist or iliac crest, keep their heels flat on the floor, and lightly touch the most distant location with the toe of their reaching foot during the test. Participants reached in three different directions during the barefoot test: anterior (ANT), posterolateral (PL), and posteromedial (PM). For the anterior distance was assessment from the central toe tip; for the posterolateral and posteromedial reaches, it was measured from the heel. The test was completed nine times by the participants, three times in a row in each direction. If the participants removed their hands from their hips, raised the heel of the stance foot off the ground, or placed their body weight onto the supporting foot, their errors were noted. In these situations, the individual was verbally corrected before the measurement was taken again (21). Each of the legs have been measured in centimetres from the anterior superior iliac spine to the distal end of the medial malleolus while the participants were in the supine position. Every reaching distance was measured in cm, and the scores were normalized using the following method to take into consideration any leg length advantage:  $\text{Best Reaching Distance} / \text{Leg Length} \times 100 = \% \text{ Best Reaching Distance}$  for each direction. This helped ensure the results were comparable across participants (22).

### Intermittent Fitness Test (30-15 IFT)

30-15-IFT test was assessment maximum oxygen consumption (VO<sub>2</sub>) levels. Total 40 meters of test, A-B-C (20 meters between A-B and 20 meters between B-C) regions that were repeated every 30 seconds, interspersed with a 15-second active resting area with 0.5 km/h pace increases at per stage. The last running and distance level that the runner who was unable to reach the striped area completed was noted with two beeps. The players' aerobic capacity was evaluated using the test protocol created by Martin Buchheit, which was verified and shown to be reliable in determining aerobic fitness (VIFT = 0.91, VO<sub>2</sub>max = 0.94, p > 0.05) in a research carried out by Covic et

al. in 2016. The maxVO<sub>2</sub> values were automatically calculated and recorded in an Excel file (23).

### T Test

The T test were assessed agility and change of direction performance using a T-shaped track measuring 10 meters in length and 10 meters in width. In this test, the athlete begins by sprinting 10 meters forward from the starting point, then continues with 5 meters of sliding steps to the left and right for a total of 10 meters. Following this, the athlete runs 5 meters to the left, returns to the center, and completes the final 10 meters back to the starting point. The entire test covers a distance of 40 meters, and the time taken to complete the course was recorded. The Performanz (Turkey) measuring device was used to measure the test. Each player performed the test twice, with the best time recorded as their final result.

### Sprint Test (30 Meter)

In accordance with the traditional warm-up protocol, a warm-up run was conducted at low-intensity aerobic speeds for an average duration of 5 minutes at a personalized pace. A 2 × 10 meter sprint was used in the protocol to enhance neuromuscular activation towards the conclusion (24) Participants conducted the test using photocells (Witty, Italy) positioned 30 meters apart. The running times were automatically transmitted to the computer through the Witty software and documented in seconds. Every athlete undertook the test twice, and the superior score was utilized for the ultimate outcome.

### Rating of perceived exertion (RPE)

The Rating of Perceived Exertion (RPE) was evaluated with the Modified Borg scale to determine exercise intensity during all exercise. RPE is intricately associated with several physiological parameters, including peak oxygen consumption (VO<sub>2</sub> peak), percentage of heart rate reserve, minute breathing, and blood lactate concentrations. As exercise intensity escalates, the Rate of Perceived Exertion (RPE) correspondingly rises in a linear manner, indicating the heightened physiological demand on the body throughout training (25).

### Statistical Analysis

JASP—just another statistical program, version 0.16.3 were analyses all statistical periods. The

normal distribution of the all data was determined Shapiro-Wilk test (Y Balance Test, 30 Meter Sprint Test Score, IFT Score, T Test Score, and RPE Values) across times (pre-test and post-test), directions (right and left), and groups (SSG and LSG). The data were found to be regularly distributed. Repeated Y Balance Test analyzed using a three-way analysis of variance (3x3 ANOVA) considering Time, Direction, and Groups. Scores from the 30-meter sprint test, IFT, T test, and RPE values in sessions with normally data were analyzed two-way analysis of variance (2x2 ANOVA) time and groups. In all ANOVA studies, the Greenhouse-Geisser correction was utilized to assess the impact of interference on values. Subsequent analyses of the acquired data were conducted, and the significance of the values was assessed using Bonferroni correction (26). Results for F, partial eta squared, p (<0.05), mean (M), and standard deviation. The significance limit in statistical studies was established at less than 0.05.

**RESULTS**

The average age of 28 male participants in the study was 18.18±0.78 years, with a height of 178.63±6.41 cm, body weight of 71.69±5.13 kg, fat percentage of 9.36±1.47%, and a minimum training duration of 5 years included. Table 1 presents the comprehensive descriptive characteristics of the subjects.

**Y Balance Test**

Three-way ANOVA analysis was performed to evaluate the main effects of direction (right and left side) and Y balance test score change times (post-test), and the main effects of factors and interaction were evaluated. There is not significant main effect of direction on y-balance test score change times, F(1, 24) = 34.32, p 0.060, ηp2= 0.007. There was a statistically significant effect in the three-way interaction (y balance test score changes times x performance groups), F(1, 24) = 89.48, p = < .001, ηp2 = 0.04. There was no significant difference in the between-subject effect, F(1, 24) = 3.52, p = 0.073, ηp2 = 0.128. This result shows that groups do not

have a different effect on the main variable. However, within-subject effects and their interactions between groups were evaluated by post-hoc analysis and are presented below. Considering group-specific y balances scores changes;

The SSG Right Direction Y Balance Pre-Score (centimeters - cm) was compared: Pre-Test: 85.60 ± 5.57 cm, Post-Test: 86.97 ± 5.45 cm. A substantial increase was observed in the correct direction. Pre-Test against Post-Test (pbonf = <.001, Cohen's d = - 0.219, Δ = 1.37 cm). The left direction y balance pre-score (cm) was compared: Pre-Test: 87.23 ± 6.01 cm, Post-Test: 88.55 ± 5.63 cm. A substantial increase was observed in the correct direction. Pre-Test against Post-Test (pbonf = <.001, Cohen's d = -0.209, Δ = 1.32 cm). Figure 2-a illustrates the notation related to the change procedures. The Large Side Groups (LSG) were compared for the Right Direction Y Balance Pre-Score (cm); (Pre-Test: 81.93 ± 5.73 cm, Post-Test: 82.30 ± 5.76 cm). A substantial increase was observed in the correct direction. Pre-Test compared to Post-Test (pbonf = 0.019, Cohen's d = -0.059, Δ = 0.37 cm). Figure 2-b illustrates the notation related to the change procedures.

**Intermittent Fitness Test (30-15 IFT)**

A two-way ANOVA was conducted to assess the primary impacts of game groups SSG and LSG on IFT scores, along with the evaluation of the main effects of the components and their interaction (refer to Figure 3-b). A substantial main impact of the Test Time IFT Score (Pre-Test and Post-Test) was observed, F(1.24) = 44.68, p < .001, ηp2 = 0.651. A substantial main effect was observed in the interaction of Test Time and Groups, F(1.24) = 41.48, p < .001, ηp2 = 0.633. A significant difference was seen in the between-subject effect, F(1, 24) = 7.05, p = 0.014, ηp2 = 0.227. This outcome indicates that groups exert varying influences on the primary variable. Evaluating Session-Specific Modifications in IFT Score: The SSG exhibited a pre-test value of 55.36 ± 3.05 ml/kg/min and a post-test value of 57.65 ± 2.26 ml/kg/min for comparison. A substantial

**Table 1.** Descriptive characteristics results of the participants

Groups	Ages (years)	Height (cm)	Body Weight (kg)	Body Fat Ratio %
SSG	18.80±0.42	174.0±5.96	68.7±3.38	9.12±1.33
LSG	17.82±0.72	181.3±4.99	73.28±5.39	9.74±1.20
ALL	18.18±0.78	178.6±6.41	71.69±5.13	9.36±1.47

SSG: Small Side Group, LSG: Large Side Group, ALL: All Group, BMI = Body Mass Index

increase was seen in the post-test (pbonf = < .001, Cohen's d = -0.815,  $\Delta$  = 2.29 ml/kg/min). The LSG exhibited a pre-test value of  $53.52 \pm 2.88$  ml/kg/min and a post-test value of  $53.56 \pm 0.71$  ml/kg/min for comparison. A substantial increase was seen in the post-test (pbonf = 0.38, Cohen's d = 0.253,  $\Delta$  = 0.4 ml/kg/min). The comparisons of SSG and LSG revealed that the SSG pre-test measured  $55.36 \pm 3.05$  ml/kg/min, while the LSG pre-test measured  $53.52 \pm 2.88$  ml/kg/min. Consequently, no significant differences were seen in the LSG (pbonf = 0.804, Cohen's d = 0.658). The SSG-Post-Test measured  $57.65 \pm 2.26$  ml/kg/min, while the LSG-Post-Test measured  $53.56 \pm 0.71$  ml/kg/min for comparison. A substantial difference was seen in the LSG Post-Test (pbonf = 0.005, Cohen's d = 1.458). Figure 3-b illustrates the notation related to the change procedures.

**T Test Score**

T test scores, along with the evaluation of the main effects of the components and their interaction (refer to Figure 3-c). A substantial main effect was seen for the test time of the T test score (pre-test and post-test),  $F(1.24) = 16.72$ ,  $p < .001$ ,  $\eta^2 = 0.411$ . A substantial main effect was observed in the interaction of Test Time and Game Groups,  $F(1.24) = 15.51$ ,  $p < .001$ ,  $\eta^2 = 0.393$ . The between-subject effect was not significantly different,  $F(1, 24) = 3.33$ ,  $p = 0.080$ ,  $\eta^2 = 0.122$ . This outcome indicates that groups exert varying influences on the primary variable.

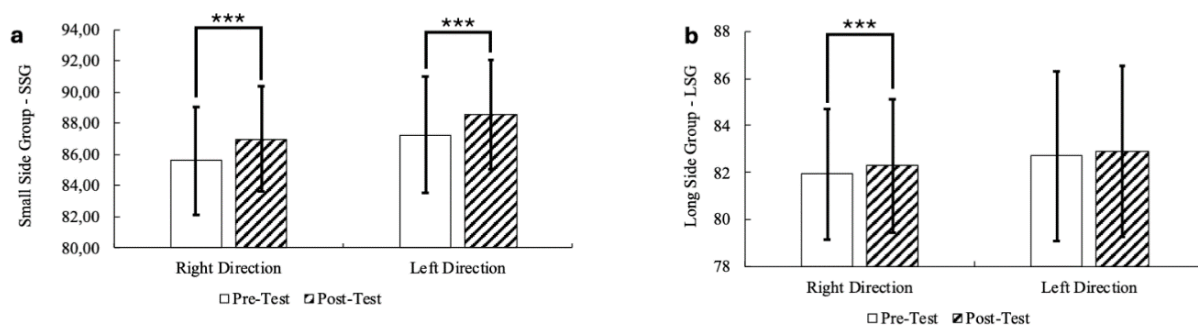
Evaluating Session-Specific Variations in T-Test Scores: The SSG Pre-Test ( $9.65 \pm 0.47$  sec) and Post-Test ( $9.39 \pm 0.09$  sec) were analyzed. A substantial drop was seen in the post-test (pbonf = < .001, Cohen's d = -0.845,  $\Delta$  = -0.26 sec). The LSG

were compared with pre-test results of  $9.74 \pm 0.23$  seconds and post-test results of  $9.74 \pm 0.24$  seconds. A substantial change was not observed in the post-test (pbonf = 1.00, Cohen's d = 0.16,  $\Delta$  = 0.00 sec). Figure 3-c illustrates the notation pertaining to the change procedures.

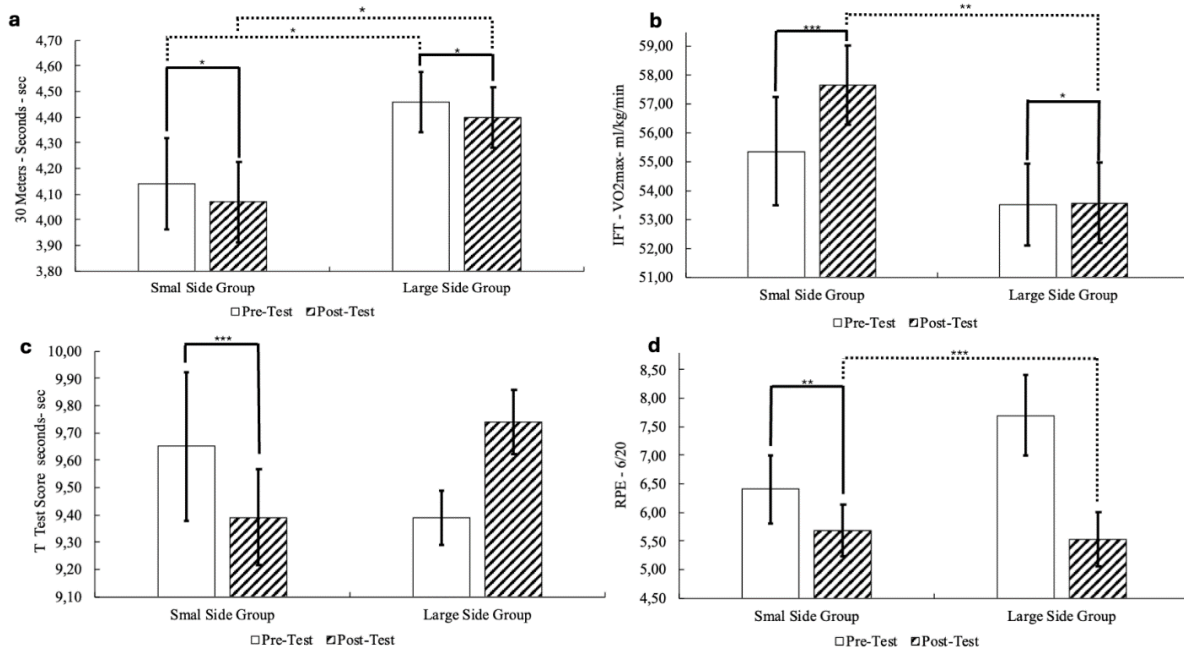
**30 meter Sprint Test**

30 Meter Sprint Test Score, along with the evaluation of the components' main effects and their interaction (refer to Figure 3-a). A substantial main effect was seen for the Test Time 30 Meters Sprint Score (Pre-Test and Post-Test),  $F(1.24) = 19.60$ ,  $p < .001$ ,  $\eta^2 = 0.450$ . A non-significant main effect was observed in the interaction of Test Time and Groups,  $F(1.24) = 0.06$ ,  $p = 0.799$ ,  $\eta^2 = 0.003$ . A substantial difference was observed in the between-subject effect,  $F(1, 24) = 10.13$ ,  $p = 0.004$ ,  $\eta^2 = 0.297$ .

This outcome indicates that groups exert varying influences on the primary variable. Examining Session-Specific Variations in 30 Meters Sprint Score; The SSG; Pre-Test:  $4.14 \pm 0.31$  seconds and Post-Test:  $4.07 \pm 0.25$  seconds were analyzed. A substantial drop was seen in the Post-Test (pbonf = 0.38, Cohen's d = 0.253,  $\Delta$  = 0.7 sec). The LSG exhibited a Pre-Test duration of  $4.46 \pm 0.24$  seconds and a Post-Test duration of  $4.40 \pm 0.24$  seconds for comparison. A substantial drop was seen in the Post-Test (pbonf = 0.38, Cohen's d = 0.253,  $\Delta$  = 0.6 sec). The comparisons of SSG and LSG revealed that the SSG pre-test recorded a time of  $4.14 \pm 0.31$  seconds, whereas the LSG pre-test recorded a time of  $4.46 \pm 0.24$  seconds. A substantial difference was seen in the LSG (pbonf = 0.38, Cohen's d = -1.258). The SSG-Post-Test mean of  $4.07 \pm 0.25$  seconds, whereas the LSG-Post-Test recorded a mean of  $4.40 \pm 0.24$  seconds for comparison. A substantial



**Figure 2.** Two-way ANOVA results of the Y Balances scores. (The left panel SSG and the right panel LSG are demonstrated. The hatched columns denote the Pre-Test results, while the unfilled columns indicate the Post-Test results. \*  $p < 0.05$ ; \*\*  $p < 0.005$ ; \*\*\*  $p < 0.001$ .)



**Figure 3.** 30-Meter Score, IFT Score, T-Test Score, and RPE Values between Groups. Note: Panel a illustrates the 30-meter score, panel b depicts the 30-15 IFT score, panel c presents the T-test score, and panel d displays the RPE values. The hatched columns denote the post-test, while the unfilled columns signify the pre-test. \*  $p < 0.05$ , \*\*  $p < 0.005$ , \*\*\*  $p < 0.001$ .

difference in the LSG Post-Test ( $p_{\text{bonf}} = 0.16$ , Cohen's  $d = 1.285$ ). Figure 3-a illustrates the notation pertaining to the change procedures.

**RPE Values**

The RPE values, along with the evaluation of the main effects of the factors and their interaction (refer to Figure 3-d). There was a significant main effect of the test time of the T test score (pretest and posttest),  $F(1.24) = 7.32$ ,  $p = 0.012$ ,  $\eta^2 = 0.234$ . A substantial main effect was observed in the interaction of Test Time and Game Groups,  $F(1.24) = 10.76$ ,  $p = 0.003$ ,  $\eta^2 = 0.310$ . A substantial difference was observed in the between-subject effect,  $F(1, 24) = 17.66$ ,  $p < .001$ ,  $\eta^2 = 0.424$ . This outcome indicates that groups exert varying influences on the primary variable.

Examining Session-Specific Modifications at RPE values;

The SSG exhibited a pre-test score of  $6.40 \pm 0.96$  and a post-test score of  $7.70 \pm 1.16$  for comparison. A substantial rise was observed in the post-test ( $p_{\text{bonf}} = 0.005$ , Cohen's  $d = -1.302$ ,  $\Delta = 1.30$ ). The LSG were compared with pre-test values of  $5.68 \pm 0.94$  and post-test values of  $5.56 \pm 0.96$ . A significant difference was not seen in the post-test ( $p_{\text{bonf}} = 1.00$ , Cohen's  $d = -2.015$ ,  $\Delta = -0.12$ ). The comparisons of SSG and LSG were as follows: SSG Pre-Test:  $6.40 \pm 0.96$  and LSG Pre-Test:  $5.68 \pm 0.94$ . Consequently,

no significant differences were seen in the LSG ( $p_{\text{bonf}} = 0.457$ , Cohen's  $d = 0.713$ ). The SSG post-test result was  $7.70 \pm 1.16$ , whereas the LSG post-test result was  $5.56 \pm 0.96$ , and these were compared. A substantial difference was seen in the LSG Post-Test ( $p_{\text{bonf}} = < .001$ , Cohen's  $d = 2.140$ ). Figure 3-d illustrates the notation related to the change procedures.

**DISCUSSION**

Small-sided game training can vary widely in terms of duration, sets, rest periods, and the inclusion of technical drills. Research indicates that various factors, including the motivational impact of the coach, restrictions on ball touches, the presence of goalkeepers, and the utilization of wild card players, can substantially modify the dynamics of SSG (27, 28, 29). These variations can lead to distinct physical, cognitive, and technical improvements in players. Moreover, goalkeepers are increasingly being incorporated into more technical and soccer-specific endurance training, especially with the growing focus on build-up play strategies (16-30).

The significant main effect of the Test Time IFT Score (Pre-Test and Post-Test),  $F(1.24) = 44.68$ ,  $p < .001$ ,  $\eta^2 = 0.651$ . In addition, a significant main effect was found in the interaction of Test Time\* Game Groups,  $F(1.24) = 41.48$ ,  $p < .001$ ,  $\eta^2 = 0.633$ . There was

a significant difference in the between-subject effect,  $F(1, 24) = 7.05$ ,  $p = 0.014$ ,  $\eta^2 = 0.227$ . Upon reviewing the studies assessing aerobic performance, it was noted that the aerobic capacity of both training groups improved in the research conducted by Karahan (31). In addition, a similar increase was reported in the study by Dellal et al. (27), in which high-intensity endurance and narrow-field games were examined for 6 weeks. Similarly, Arslan et al. (1) observed an increase in  $VO_2$  max values in narrow field endurance studies. According to the data obtained from our study, it was shown that both maximum-intensity skill-based training and soccer-specific planned small-sided games affected aerobic capacity. While aerobic capacity enhancement is typically linked to continuous or intermittent training, it has been highlighted that brief, high-intensity intermittent exercises markedly elevate the  $VO_2$ max levels of soccer players (32). In the present study, players' heart rates during SSGs were not monitored to obtain information on training intensity; however, previous studies suggest that workload intensities are approximately 85-91% of maximum heart rate for SSGs of different formats (19-32) and 93-95% for one minute of soccer ball dribbling at maximum intensity (33). A possible explanation is that both training modalities and intensities are appropriate and provide an increase in aerobic enzymes and consequent improvement in performance or  $VO_2$ max (34).

SSG training can differ significantly in terms of duration, number of sets, rest intervals, and the incorporation of technical drills. Various factors, like as motivation, coaching advice, limitations on ball touches, the participation of goalkeepers, and the utilization of wild card players, can affect the dynamics of SSG. These variances result in distinct physical, cognitive, and technical advancements in players. Goalkeepers are progressively incorporated into technical and soccer-specific endurance training, especially as build-up play methods gain prominence. Endurance training during competitive phases is often scheduled for 4-12 weeks, with sessions conducted biweekly at an intensity of 85-95% of  $VO_2$ max. Each session generally endures for 2-8 minutes and may be repeated up to six times. Studies indicate that this training can result in a 10-30% enhancement in  $VO_2$ max when executed at 90-95% of maximum heart rate, and a 5-10% improvement when conducted at 60-80% of maximum heart rate. This enhancement is partly ascribed to the training load

encountered during official or friendly competitions, which may be up to 25% of the load applied in weekday training, greatly aiding the development of aerobic endurance (35). Numerous research have investigated the effects of SSG on endurance and various performance indicators. Trombiero et al. (36) discovered that SSG with 4-minute intervals of 3 vs. 3 and 3 vs. 4, including a goalie, resulted in an increase in distance traveled at speeds of 7.20-14.29 km/h and a reduction in maximum heart rate (maxHR) among elite female soccer players. They proposed that the increased incidence of SSGs in women's soccer, mostly for tactical reasons, along with the propensity of female players to move positions less frequently and expend reduced physical effort, accounted for the disparities seen between male and female players. A 12-week study conducted by Akdoğan et al. (37) revealed substantial enhancements in endurance performance by combination training (28.4%), sprint endurance (23.4%), and SSG training (18.1%) relative to a control group. Hill-Haas et al. (30) evaluated the impacts of 7-week SSG and interval running protocols via the Yo-Yo IR1 test, revealing a 17% enhancement in the SSG cohort and a 22% improvement in the interval running cohort. Kaplan (38) observed a substantial enhancement in  $VO_2$ max following 8 weeks of SSG training, with  $VO_2$ max rising from  $52.93 \pm 17.18$  to  $61.93 \pm 17.92$  in the control group and from  $54.64 \pm 12.69$  to  $72.78 \pm 17.77$  ml.kg.min<sup>-1</sup> in the experimental group. Helgerud et al. (39) reported an 11% enhancement in  $VO_2$ max (from 58.1 ml/kg/min to 64.3 ml/kg/min,  $p < 0.01$ ) following SSG exercises performed at 90-95% of maximum heart rate for 4x4 minutes, twice weekly over a duration of 8 weeks. Randers et al. (40) documented a 5% enhancement in  $VO_2$ max among elite soccer players after a 12-week SSG intervention, which comprised a single set of 2-4 minute intervals with 1-2 minutes of rest, amounting to less than 30 minutes per session. Paul et al. (41) observed a notable enhancement in  $VO_2$ max following SSG conducted as 4 vs. 4, comprising four repetitions of 4 minutes each, alongside running velocities at 110% of maximum aerobic speed in young athletes, who executed two repetitions of 4 minutes with 15 seconds of exertion and 15 seconds of recovery. Arslan et al. (1) reported a 3.3% enhancement in  $VO_2$ max following 5 weeks of small-sided games and a 4.3% improvement with high-intensity interval training in 14-year-old athletes. Chaouachi et al. (42) observed superior

enhancements in aerobic capacity in the SSG group relative to the control group after conducting linear sprint and SSG experiments. The data indicate that SSG training is an efficacious approach for improving aerobic endurance, with diverse intensities and forms customized to individual player requirements and training objectives.

There is no-significant main effect was observed in the interaction of Test Time and Game Groups ( $p = 0.799$ ). A substantial difference was observed in the between-subject effect ( $p = 0.004$ ). Our investigation revealed a statistically significant difference in agility and 30 m sprint performance among the SSG group ( $p < 0.05$ ). Upon reviewing the literature, it is evident that there are studies that corroborate our research. Davies et al. (43) discovered that in three sets of 45-second SSG played 3 vs. 3, players executed 11 change-of-direction maneuvers and participated in sprint activities for 0.8% of the total running distance. There is no significant main effect of direction on the change in y balance test scores. A statistically significant effect was seen in the three-way interaction (y balance test score change by x performance groups) ( $p < .001$ ). No substantial difference was observed in the between-subject effect ( $p = 0.073$ ). These findings corroborate earlier research, which demonstrated that an eight-week game profile and multidirectional sprint training were superior to small-sided games in improving change-of-direction and sprint performance. Dellal et al. (44) documented comparable enhancements in the capacity for repeated directional shifts between SSG and high-intensity interval training in amateur soccer players. Conversely, Radziminski et al. (45) discovered that neither the four-week SSG nor the high-intensity running (4 x 4 minutes) programs significantly affected the sprint performances of young soccer players. A substantial main effect was observed in the interaction of Test Time and Game Groups ( $p < .001$ ). The between-subject effect was not significantly different ( $p = 0.080$ ). Although the movement patterns in SSG entail multiple directional changes accompanied by acceleration and deceleration, as well as increased sprinting due to the game format, various internal and external factors—including pitch dimensions, team tactical strategies, and player motivation can influence performance and restrict maximal change-of-direction and sprint activities. A prior study revealed that 96% of maximal speed sprints in soccer matches occurred over distances less than 30 meters (46). Consequently, it

is advised that coaches incorporate SSG into their soccer training regimens twice weekly to enhance physical and physiological performance throughout the season.

## CONCLUSION

Our study findings showed that large-sided group improved the estimated maximum oxygen uptake level and perceived difficulty level per session more effectively than small side group in soccer players, while small side group showed more improvement in linear sprint and agility performance improvement than large side group. Small-sided games have been observed to have the potential to improve motor components in a complex way along with the acquisition of technical skills. Football coaches and strength and conditioning coaches can use these findings as a training weapon by considering the individual needs of the athlete in training. In-depth studies with larger participant groups are needed in future research.

## Limitation and Recommendations

The study has some limitations. A low number of participants can be considered a limitation of the study. Tracking internal load in small and long side games can be done with tracking methods such as heart rate data. Monitoring and calculation of internal loads during training can be recommended for future studies. In addition, during endurance training, different coach motivations or technical skill exercises where quick decision-making skills can be used can be added. In this study, goalkeepers were included in the game programmes. There is a need for a study without goalkeepers and with players in similar positions.

**Acknowledgements:** The authors gratefully thank the students for their cooperation during the study.

**Author contribution:** Conception, Design, Supervision, Materials, Data Collection and/or Processing, Analysis & Interpretation, Literature Review, Writing, Critical Review: MT.

**Conflict of interest:** There is no conflict between authors.

**Ethical approval:** Ethical approval for this study was granted by the Nişantaşı University Ethics Committee (Date: 08/11/2023, Decision No: 2023/42).

**Funding:** There is no fundings.

**Peer-Review:** Externally peer-reviewed.

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