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Enhancing anaerobic endurance in football players: A comparative study of 3-a-side and 5-a-side small-sided games

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ABSTRACT

The demands of modern football are to play at a high tempo for two 45-minute game⁷ or more. Aerobic endurance, power, maximum speed, and acceleration are not enough for today players. The purpose of this study was to reveal the impact of 3-a-side and 5-a-side small-sided games (SSGs) on increasing anaerobic endurance. This study employed a quasi-experimental design with a pretest-posttest group design involving 40 young football players who were randomly assigned to practice 3-a-side and 5-a-side for 4 weeks. Before and after carrying out the 4-week training, a Repeat Sprint Ability Test (RSAT) was performed to measure anaerobic endurance. The paired sample t-test was used to determine whether there was an effect of the exercise, and the independent sample t-test was used to see whether there was a difference in the results between the two groups at the 1% significance level. Before carrying out the parametric test, the data were first tested for normality using Kolmogorov-Smirnov^a and for homogeneity using Levene's. It was revealed that 3-a-side and 5-a-side SSGs were both capable of increasing anaerobic endurance, but there was no significant difference between the two groups. It can be concluded that anaerobic endurance can be increased within four weeks by using these two methods. The recommendations from this study are to conduct a randomized controlled trial with a larger and more diverse sample to validate and extend these findings. Further studies also need to explore the effects of SSGs exercise on anaerobic endurance over a longer exercise period and in different age groups to gain a more comprehensive understanding.

Keywords: Anaerobic endurance; football; small-sided games; 3-a-side; 5-a-side



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Authors' Contribution: a – Study Design; b – Data Collection; c – Statistical Analysis; d – Manuscript Preparation; e – Funds Collection

INTRODUCTION

During a football game, three moments are always visible on the field, namely “attacking, transitioning, and defense” (Chandra et al., 2022). Players who are in control of the ball or attacking will perform actions

using the ball such as passing, first touch, dribbling, heading, and shooting (Danurwindo et al., 2017). Players who move without the ball will perform jogging, running, maximal sprinting, accelerations, high-intensity accelerations, and decelerations (Leontijević et al., 2019). Until now, the tempo of playing football has continued to increase, so it is right to say that football is one of the sports with very high intensity (Rivilla-García et al., 2019). In the English Premier League (EPL), for several seasons, it has continued to increase the intensity of the game (Barnes et al., 2014; Bush et al., 2015), although there are differences in physical demands based on playing position (Trewin et al., 2018), such as center backs, whose running distance and intensity are smaller compared to midfielders, wing-backs, and forwards (Delaney et al., 2018). Identification of the physical performance of football players on the field is known to be due to the application of technology in sports that is developing rapidly (Malone et al., 2017), so coaches can evaluate the physical demands of each player in every game (Doncaster et al., 2020).

Analysis of football players using Global Positioning System (GPS) technology has been carried out to monitor physical performance during competitive matches (Núñez et al., 2018; Castillo et al., 2020; Nosek et al., 2021; de Dios-Álvarez et al., 2023). Related findings note that the midfielder is the player who runs the most distance, the full-back or wing-back is the player who sprints the most, and the center-back is the player who is the most active in accelerating (Modric et al., 2019). Aerobic and anaerobic endurance is also needed during football competitions (Aguiar et al., 2013) with the average VO_2Max requirement of football players ranging from 55 to 65 ml kg^{-1} (Metaxas, 2021), although VO_2Max requirements are also determined by playing position (Slimani et al., 2019). The consequence of today football demands is that coaches prepare training programs needed in competitive football matches, such as a form of linear and multi-directional movement activity with high intensity, by inserting appropriate recovery (Cunningham et al., 2018). Accurately identifying the needs of physical conditions in sports has implications for the preparation of appropriate training programs by coaches (Berrezokhy et al., 2020).

Small-sided games, which are included in the high-intensity interval training method have been implemented as training following the demands of football competitions (Selmi et al., 2020). The high-intensity interval training method has been shown to increase aerobic and anaerobic capacity in female ice-hockey players (Kinnunen et al., 2019). Small-sided games are exercises that modify the number of players, the size of the playing area, and the rules of the game according to the objectives of the exercise (Sgrò et al., 2018). Players involved start from 1 vs. 1, 2 vs. 2, up to 7 vs. 7 with an area that is smaller than the actual playing field of football (Sarmiento et al., 2018). The modification of the rules in question can be in the form of the number of touches of the ball for each player, without or using a goalkeeper, or with or without a neutral player (Kusuma & Kardiawan, 2018).

In the case of football players, this model of small-sided games has been extensively studied. Previous research findings in several articles found that the impact after conventional training with small-sided games on increasing aerobic endurance was the same for youth football players (Moran et al., 2019). Small-sided games training for 8 weeks with a frequency of training twice a week can increase anaerobic endurance, power, VO_2Max , acceleration, and vertical jump (Karahana, 2020). Intervention/training for 6 weeks was also reported to have an impact on 20-meter sprint time, counter-movement jump, squat jump, triple-hop distance, agility, and balance, although not as good as combined core strength training (Arslan et al., 2021). The VO_2Max of young football players also experienced an increase after practicing small-sided games for two weeks with a dose of training twice a week (Arslan et al., 2020). This means that there is a significant impact on the physical performance needed by football players, both of youth and adults, after training with the small-sided games method for 5 to 8 weeks.

However, there is currently no report on the impact of small-sided games training on the anaerobic endurance of young football players in the short term (4 weeks). In fact, based on findings in the field regarding the schedule for the Soeratin Cup (a competition based on age groups held by PSSI), it cannot be predicted with certainty. This has implications for the training program for football coaches from Persibu Buleleng, Persega Gerokgak, and Undiksha FC, they found it difficult to form the anaerobic endurance of their players when preparation for competition only took 1 or 2 months. So, it becomes urgent to know the impact of small-sided games when given to young players within 4 weeks. The implication is that short

competition preparation time is no longer a major problem in developing players' anaerobic endurance. The purpose of this study was to look at the impact of 3-a-side and 5-a-side small-sided games on increasing the anaerobic endurance of young football players.

METHOD

This study included a quasi-experiment with a pretest-posttest group design (Saifu et al., 2021; Sulistiyono et al., 2021; Ariani et al., 2022). Forty players of Persega Gerokgak were randomly divided into a 3-a-side group (age 15 ± 0.1 years) and a 5-a-side small-sided games group (age 15 ± 7.0 years). Table 1 below shows the pretest-posttest group design.

Table 1. Pretest-Posttest Group Design

Sample	Pretest	Treatment	Posttest
N	O ₁	X	O ₂
N	P ₁	X	P ₂

Notes:

N = Simple random sampling; X = Treatment; O₁ = 3-a-side small sided-games group pretest; O₂ = 3-a-side small-sided games group posttest; P₁ = 5-a-side small-sided games group pretest; P₂ = 5-a-side small-sided games group posttest (Sugiyono, 2017)

Repeat Sprint Ability Test (RSAT) that has a validity value of r 0.59-0.82, P < 0.05 was used to measure anaerobic endurance of the samples during the pretest and posttest (Barbero-Álvarez et al., 2013). This test requires a 20-meter track with clear start and finish markers. Participants sprint 10 times to start, with an active recovery time after the finish of 20 seconds (Lopes-Silva et al., 2019).

Exercise was carried out for four weeks, consisting of sixteen training sessions, or four times a week. The training was carried out at the Gerokgak Football Field in Buleleng, Bali. The training program for the 3-a-side group was carried out on a 24-meter by 10-meter field area, using two goals and a goalkeeper, no offside, and a maximum of two touches per player (table 2). The 5-a-side group was trained in a 40-meter by 15-meter area, using two goals and a goalkeeper, no offsides, and a maximum of two touches per player (table 3). Prior to the training, the players had to warm up using the RAMP protocol (Racinais et al., 2017; Jeffreys, 2019) and between sets using active recovery (Sarto et al., 2022).

Table 2. 3-a-side Small Sided-Games Group Training Program

Week	Game Duration	Recovery Between Set	Number of Set	Intensity
1	120 second	120 second	4	85% HRmax
2	120 second	120 second	5	85% HRmax
3	150 second	150 second	5	95% HRmax
4	180 second	150 second	6	100% HRmax

(Moran et al., 2019)

Table 3. 5-a-side Small Sided-Games Group Training Program

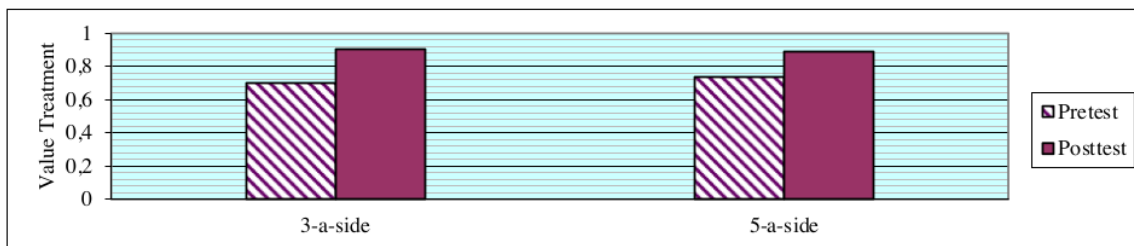
Week	Game Duration	Recovery Between Set	Number of Set	Intensity
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3	150 second	150 second	5	95% HRmax
4	180 second	150 second	6	100% HRmax

(Moran et al., 2019)

To determine whether there is an increase or not in the effect of 3-a-side and 5-a-side small-sided games on anaerobic endurance, the data collected in the field were then analyzed using a paired sample t-test (p < 0.01). However, the first step taken was to test the normality of the data using Kolmogorov-Smirnov^a, and the homogeneity of the data using Levene's at a significance level of 1%. The final stage, an independent sample t-test (p < 0.01) was used to answer whether there is a significant difference in scores between the 3-a-side group and 5-a-side group.

RESULTS AND DISCUSSION

This study aimed at examining the use of 3-a-side and 5-a-side in increasing anaerobic endurance in young football players. Descriptive data in the form of the mean in the 3-a-side group and 5-a-side group during the pretest and posttest are presented in Graph 1.



Graph 1. The Average Pretest-Posttest Result

In the Table 4 and 5 below, the results of data normality and data homogeneity are presented successively as prerequisites before carrying out the parametric test. Based on the data display, the data is normally distributed because of the sig. > 0.01 and is homogeneous because of the sig. > 0.01.

Table 4. Tests of Normality

Group	Kolmogorov-Smirnov ^a		
	Statistic	df	Sig.
Pretest 3-a-side	.164	20	.161
Posttest 3-a-side	.184	20	.074
Pretest 5-a-side	.164	20	.162
Posttest 5-a-side	.139	20	.200*

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Table 5. Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Anaerobic endurance	Based on Mean	3.568	3	76	.018
	Based on Median	2.922	3	76	.039
	Based on Median and with adjusted df	2.922	3	75.103	.039
	Based on trimmed mean	3.561	3	76	.018

After the data is declared to be normally distributed and homogeneous, the results of the different tests are displayed using the paired sample t-test (Table 6). Based on the data in Table 6, there is an increase in anaerobic resistance of the sample. This can be seen in the value of Sig. (2-tailed) < 0.01 which means that there is a significant difference between the results at the pretest and posttest after being given small-sided games exercises in all groups.

Table 6. Paired Samples Test

Variable	Mean	Std. Deviation	Std. Error Mean	Paired Differences		t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
				Lower	Upper			
Anaerobic endurance 3-a-side & 5-a-side small sided-games	-1.69137	1.17240	.13108	-1.95228	-1.43047	-12.904	79	.000

Furthermore, to find out whether there is a significant difference in the results between the two groups, it is proven by using an independent sample t-test (table 7). Looking at Table 7, the results stated that there

was no significant difference between the 3-a-side and 5-a-side small-sided games groups in terms of increasing anaerobic endurance.

Table 7. Independent Samples Test

Variable		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Anaerobic Endurance	Equal variances assumed	-1.069	38	.292	-.04100	.03837	-.11867	.03667
	Equal variances not assumed	-1.069	37.978	.292	-.04100	.03837	-.11868	.03668

Aerobic and anaerobic endurance capacity can increase after being given high-intensity interval training (HIIT) only in a shorter training time than constant-intensity endurance training (CIET) (Runacres et al., 2019). Small-sided games (SSGs), which are part of the HIIT method, have the characteristics of high activity intensity with a short recovery time to resume high-intensity training (Sabag et al., 2022). Obviously, this is very relevant to the needs of football players when competing. When carrying out the build-up of attacks until the scoring process is carried out with maximum running speed, as well as when losing the ball or the transition phase from attacking to defending, players try to get back the ball as quickly as possible. So that in this situation there is constant and continuous maximum running action, interspersed with walking or jogging in a short time to return to maximum running speed or acceleration. In terms of the energy system, there is coherence in the 3-a-side and 5-a-side SSGs exercises with the game rules for each player making a maximum of two touches to the ball.

On the physiological aspect, football players are required to have aerobic and anaerobic endurance that can support performance on the field constantly (Dolci et al., 2018). In a competitive football match, a combination of explosive and powerful movements is carried out by each player, together with 90 minutes of technical and tactical football action that takes place intermittently (Turner & Stewart, 2014; Dolci et al., 2020). It is important for football players to be able to implement the technical and tactical skills of the coach with high intensity from the start to the end of the match in order to achieve maximum results. This can be realized if the players can continue to improve and maintain their level of activity intensely without experiencing significant fatigue at the same time (Koklu et al., 2015).

1 Discussing the current findings that the number of players, field areas, and playing rules have not shown significantly different results between the 3-a-side and 5-a-side SSGs groups, even though the training dose was intended for 16 sessions. Playing with a total of 3 versus 3 to 5 versus 5 in a small area and with a limited number of touches of the ball for each player reinforces previous findings, namely being able to significantly influence endurance and football-specific performance (Kunz et al., 2019; Halouani et al., 2019; Clemente et al., 2023). The intense movement in this finding is also due to the players' rules for touching or controlling the ball, which are limited to a maximum of two touches. So there is no game delay or slowing down of the tempo when playing the ball, which implies that of course all players are very active when they are without the ball.

Another interesting thing from the current findings is that a short training time can increase anaerobic endurance. Anaerobic endurance is the main activity of playing football with submaximal and maximum intensity (Donie et al., 2021). In the periodization of training, this makes it possible to make the transition from the special preparation phase to the pre-competition phase (Hadi & Yudhistira, 2023). However, to be able to significantly increase anaerobic endurance capacity, players already have high VO₂Max (Sidik et al., 2019; Bompa & Buzzichelli, 2019). VO₂Max development is carried out in the general periodization phase or during the pre-season (Mara et al., 2015; Mexis et al., 2022). The rules of the game are the same in all samples, and the ability to accelerate is a limitation in this study. Therefore, there is an opportunity for

further research to uncover current limitations so that more comprehensive results have been obtained to add to the knowledge of football coaching.

CONCLUSION

The conclusion of this study shows that small-sided games (SSGs) with 3-a-side and 5-a-side formats are effective training methods for improving anaerobic endurance in youth football players. Football is a sport that requires good anaerobic endurance capacity, especially when players run at maximum speed without much rest during the game. In this study, engaging young players in a 4-week training program with a frequency of 4 workouts per week was shown to improve their anaerobic endurance.

The limitations of this study need to be noted in order to interpret the results carefully. Firstly, this study only focused on youth football players, so the results may not be generalizable to adult players or players of different age groups. Furthermore, the sample size used in this study may be limited, which may affect the generalizability of the results. In addition, the duration of this study only included a 4-week training program, so the long-term effects of SSGs training on anaerobic endurance were not evaluated. Furthermore, this study assumed that participants had previous training experience or had a high VO₂Max, which may not reflect the condition of all youth football players. Factors such as baseline fitness level and previous training experience may influence training outcomes and need to be considered in the interpretation of the results of this study.

The recommendations from this study are to conduct a randomized controlled trial with a larger and more diverse sample to validate and extend these findings. Further studies also need to explore the effects of SSGs exercise on anaerobic endurance over a longer exercise period and in different age groups to gain a more comprehensive understanding. In addition, it is recommended to investigate the effects of SSGs on anaerobic endurance in different phases of the football season, including pre-season, competitive season, and post-season, to determine the optimal timing of the application of this training method.

The findings from this study make an important contribution by highlighting the importance of anaerobic endurance in football and showing that SSGs are an effective training option to improve it. This training method is also suited to the characteristics of competitive football matches. Thus, the recommendation of using SSGs as part of youth football training may assist players in dealing with intense game conditions. Furthermore, the different playing rules for each group (3-a-side and 5-a-side) could be the subject of future research to find out if there is a significant difference between the SSGs groups in improving anaerobic endurance. Thus, this study provides a foundation for coaches to consider using SSGs as part of routine training to improve the anaerobic endurance of their youth football players.

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CONFLICT OF INTEREST

Researchers believe there is no conflict of interest in the process of preparing this manuscript.

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