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Effects of an Eight-Week Game-Based Training Program on VO_2max in U15 Players at SSB Nggaro Lembo Sape

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Abstract
Objectives:Game-based training is a football training method that integrates physical, Under-15 (U15) development stage, improving aerobic capacity (VO_2max) is essential for maintaining performance intensity during training and competition. This study aimed to analyze the effectiveness of a game-based training program in improving the VO_2max of U15 players at SSB Nggaro Lembo Sape.
Materials and Methods: This study employed a quantitative approach with a pre-experimental one-group pretest–posttest design. The participants were 20 male U15 football players selected through purposive sampling. The intervention consisted of a structured game-based training program conducted over eight weeks, with three training sessions per week and 20–30 minutes of core training in each session. VO_2max was estimated using the Multistage Fitness Test, also known as the Beep Test. Data were analyzed using the Shapiro–Wilk normality test and a paired-samples t-test at a significance level of $\alpha = 0.05$.
Results: The mean VO_2max increased from 43.20 ± 3.60 $mL \cdot kg^{-1} \cdot min^{-1}$ at pretest to 47.00 ± 3.40 $mL \cdot kg^{-1} \cdot min^{-1}$ at posttest. The paired-samples t-test indicated a statistically significant improvement in VO_2max following the intervention ($t = -6.80$, $p < 0.001$).
Conclusions: The eight-week game-based training program significantly improved the VO_2max of U15 players at SSB Nggaro Lembo Sape. This training method may be used as an integrated and practical strategy for developing aerobic endurance in youth football training. However, the findings should be interpreted within the context of the one-group pre-experimental design.

Keywords: aerobic endurance; football training; game-based training; U15 football players; VO_2max

Introduction

Modern football is an intermittent team sport that requires players to repeatedly perform high-intensity activities, including sprinting, accelerating, decelerating, changing direction, pressing, and transitioning between attacking and defensive phases, interspersed with periods of lower-intensity activity and brief recovery(Kuswoyo et al., 2020; Kuswoyo & Betaubun, 2019). At the under-15 (U15) developmental stage, adequate aerobic capacity is essential because it

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supports players' ability to maintain work intensity, recover between repeated high-intensity efforts, and delay the onset of fatigue during training and competition (Hung et al., 2025; Jastrzębski et al., 2024). Although football performance is determined by the interaction of physical, technical, tactical, and psychological factors, maximal oxygen uptake (VO_2max) remains an important indicator of aerobic fitness and endurance capacity in youth football players (Düking et al., 2024; Pancar et al., 2025).

A well-developed aerobic system contributes not only to sustained running performance but also to more efficient recovery between intense actions. This capacity is particularly relevant in phases of play that involve repeated pressing, rapid transitions, and continuous repositioning. When aerobic fitness is inadequate, players may experience an earlier decline in running intensity, movement quality, concentration, and technical execution. Therefore, the systematic development and monitoring of VO_2max should constitute an important component of long-term player development, particularly during adolescence, when physical and physiological capacities are undergoing substantial development (Chmura et al., 2023; Düking et al., 2024).

One training method that may address the multidimensional demands of football is game-based training, commonly implemented through small-sided games. This approach uses modified forms of football in which coaches manipulate variables such as pitch dimensions, the number of players, work-to-rest intervals, scoring systems, tactical objectives, and specific rules. Such modifications allow coaches to regulate the physiological and physical demands imposed on players while maintaining technical actions, tactical interactions, perception, and decision-making within representative game situations. Consequently, game-based training possesses strong practical relevance because its movement patterns and decision-making demands closely resemble those encountered during actual match play (Chen et al., 2023; Clemente et al., 2021; Pancar et al., 2025).

The manipulation of game constraints can produce different training responses. Reducing the number of players may increase individual involvement, ball contacts, changes of direction, and the frequency of technical actions, whereas increasing the relative playing area may expose players to greater running distances and higher-speed movements. Similarly, continuous and intermittent game formats may produce different cardiovascular, perceptual, and fatigue responses. Therefore, game-based training should not be viewed merely as unrestricted match play; rather, it should be systematically designed by adjusting intensity, volume, recovery, pitch size, and task constraints according to the intended training outcomes(Chen et al., 2023; Jastrzębski et al., 2024; Pancar et al., 2025).

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Previous studies have demonstrated the potential of game-based and small-sided training to improve important physical-performance indicators among young football players. (Karahan, 2020) reported that small-sided games produced improvements in the physical performance of young football players, including aerobic fitness. More recent evidence indicates that both continuous and intermittent small-sided games can improve aerobic and anaerobic performance in male youth football players, although the magnitude of adaptation may depend on the training format and participants' initial fitness levels (Guo, 2025; Piotrowski et al., 2025; Rumpoko et al., 2025). An eight-week game-based high-intensity interval training intervention also showed that pitch dimensions influenced players' physical loads and time-motion responses, emphasizing the importance of carefully designing game formats to obtain the intended physiological stimulus(Kuswoyo et al., 2017; Mănescu, 2025; Purwanto et al., 2025).

In addition to its physiological benefits, game-based training can simultaneously facilitate technical execution, tactical awareness, and active involvement in training. A systematic review and meta-analysis found beneficial effects of small-sided game interventions on the technical execution of young team-sport players (Moore, 2026; Tampi et al., 2025). Game-based activities may also be perceived as more enjoyable than running-based high-intensity interval training performed at a comparable exercise intensity. Greater enjoyment may help maintain motivation, participation, and adherence among adolescent players, particularly when training is performed repeatedly over several weeksv(Selmi et al., 2020). Therefore, game-based training provides a potentially time-efficient method for integrating physical conditioning with football-specific learning rather than separating fitness exercises from technical and tactical practice.

Youth football development at community-based football schools, including Sekolah Sepak Bola Nggaro Lembo Sape, faces several practical challenges. These include limited facilities, variations in coaching experience, restricted training time because players are school students, and the absence of sophisticated equipment for monitoring training loads. Under these circumstances, training sessions may predominantly emphasize fundamental techniques and unrestricted games, while the intensity, volume, recovery, and progression of aerobic conditioning are not always systematically planned. Based on preliminary field observations, several players appeared to fatigue relatively quickly during internal matches, had difficulty maintaining their playing intensity in the second half, and demonstrated reduced effectiveness during pressing and repeated transition phases. These observations suggest that performance limitations may not result solely from technical deficiencies but may also be associated with insufficient aerobic preparedness.

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The local training environment represents an additional consideration. Training is commonly conducted in the afternoon after school, often under hot and humid conditions and on pitches of varying quality. These circumstances may increase players' perceived exertion and physiological strain, especially when the training load is not adjusted to environmental conditions and individual capabilities. Evidence from young male football players indicates that exposure to hotter conditions during small-sided games can increase psychophysiological demands and negatively affect certain aspects of technical performance (Kang et al., 2024). Therefore, training programs should be designed according to the players' developmental characteristics, environmental conditions, recovery status, and available facilities.

Despite growing evidence supporting small-sided and game-based training, context-specific evidence is still required to determine whether a structured program can effectively improve the aerobic capacity of U15 players in a community football school with limited resources. Game-based training is particularly relevant to this setting because it may address three developmental needs simultaneously: improving aerobic fitness, developing football-specific decision-making, and maintaining player motivation without requiring complex facilities or expensive training equipment.

Accordingly, this study aimed to examine the effects of an eight-week structured game-based training program on the VO_2max of U15 players at SSB Nggaro Lembo Sape. The findings are expected to provide practical evidence for youth football coaches in Sape and surrounding areas regarding the development of a focused, measurable, and contextually appropriate aerobic training program. It was hypothesized that the eight-week game-based training program would significantly increase players' VO_2max, thereby improving their capacity to maintain work intensity and recover between repeated high-intensity activities during training and match play.

Materials and Methods

Study Participants

This study involved 20 male players in the U15 category from SSB Nggaro Lembo Sape. Subjects were selected using purposive sampling with the following inclusion criteria: (1) actively participating in routine training at least three times per week, (2) not having experienced any injuries in the last three months, and (3) obtaining written permission from parents/guardians to participate in the study.

Study Organization (Research Organization/Design)

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This study used a pre-experimental design (*one-group pretest–posttest*) which was carried out for 8 weeks with 16 meetings . VO_2max measurements were carried out twice, namely before the intervention (pretest) and after the intervention (posttest). The intervention consisted of a game-based training program delivered three times per week. Each training session consisted of a 15-minute warm-up, 20–30 minutes of game-based core training, and a 10-minute cool-down.

Game formats used include 3 vs. 3, 4 vs. 4, and 5 vs. 5, with modified court sizes to help control the intensity of the training. The work and rest ratio is set at 1:1 (e.g. 4 × 4 minutes of play interspersed with 4 minutes of recovery). Exercise intensity is monitored using the Rate of Perceived Exertion (RPE) scale.

VO_2max was estimated using the Multistage Fitness Test (Beep Test). The final level and shuttle reached by each player were recorded, then converted to a VO_2max value (ml/kg/min) according to standard conversion procedures.

Statistical Analysis

Data were analyzed using descriptive statistics including mean, standard deviation , minimum, and maximum values. Normality tests were performed using the Shapiro–Wilk test. Differences in VO_2max values between the pretest and posttest were analyzed using a paired t-test, with a significance level set at $\alpha = 0.05$.

Results

Descriptive Statistics

Table 1. Descriptive Statistics of Pretest and Posttest VO ₂ max Scores

Variables	N	Min	Max	Mean	Elementary School
VO_2max Pretest	20	37.0	49.0	43.20	3.60
VO_2max Posttest	20	41.0	53.0	47.00	3.40

Based on descriptive statistics, the average VO_2max value increased from 43.20 ± 3.60 ml/kg/min in the pretest to 47.00 ± 3.40 ml/kg/min in the posttest. Thus, there was an average increase of 3.80 ml /kg/min after the game-based exercise intervention.

Normality Test

The Shapiro–Wilk test results showed that VO_2max data in the pretest and posttest were normally distributed ($p > 0.05$) . Therefore, the analysis of pretest–posttest differences was continued using parametric tests.

Paired t-test

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Table 2. Paired-Samples t-Test Results for Pretest and Posttest VO ₂ max

Variables	Mean Difference	t	df	p
VO₂max Pre–Post	-3,800	-6,800	19	0,000

t -test results showed a **significant difference** between the pretest and posttest VO₂max values ($t = -6.800$; $df = 19$; $p < 0.001$). This finding confirms that the 8-week game-based training program **significantly increased the VO₂max** of SSB Nggaro Lembo Sape U15 players.

Discussion

The results showed that an 8-week *game-based training program* significantly increased VO₂max in U15 players. The average increase of 3.80 ml /kg/min indicates significant aerobic adaptations, potentially supporting players' ability to maintain work intensity and accelerate recovery during repetitive activities in training and matches.

Physiologically, game-based training encourages intermittent activity patterns dominated by moderate- to high-intensity running, which more closely resembles the demands of competition than conventional running training. This can stimulate adaptations in the cardiovascular and metabolic systems, such as increased cardiac efficiency, improved oxygen transport capacity, and increased muscle oxygen utilization. Furthermore, the use of modified pitches and reduced-player game formats (e.g., 3v3–5v5) tends to increase player engagement, frequency of action, and total activity per unit of time, resulting in a more consistent and effective aerobic stimulus.

From a practical perspective, *game-based training* offers a dual benefit: in addition to improving physiological capacity (aerobic endurance), it also enhances technical and tactical aspects through quick decision-making, transitions, and spatial awareness. Therefore, coaches are advised to structure *game-based sessions* by adjusting the number of players, field size, game rules, and work-rest durations to ensure that training intensity can be controlled according to the goal (e.g., developing aerobic endurance).

However, this study has limitations, particularly the lack of a control group and the relatively small sample size, so generalization of the findings should be done with caution. Future research is recommended to use an experimental design with a control group or *a randomized controlled trial* , involving a larger sample size, and incorporating more objective measures of training load such as heart rate monitoring, GPS, or other internal load indicators to strengthen the interpretation of the relationship between training dose and changes in VO₂max.

Conclusions

8-week *game-based* training program has been shown **to significantly** improve VO₂max of SSB Nggaro Lembo Sape U15 players. With training characteristics that mimic the demands of a match, this method is worthy of recommendation as an integrated, practical, and relevant

aerobic endurance development strategy for implementation in youth soccer development programs .

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