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Research Article

The Effect of Interval Training on VO2max in Futsal Players at SMPN 2 Wonoayu

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ABSTRACT
Futsal is a high-intensity sport that requires optimal aerobic capacity. The physical condition of futsal players at SMPN 2 Wonoayu was less than optimal, as evidenced by the inability of some players to play fully during the match due to fatigue that occurred in the second half. This indicates low VO2Max in players, which impacts performance in matches. This study aims to examine the effect of interval training on VO2Max in futsal players at SMPN 2 Wonoayu. This study used a quantitative approach with a quasi-experimental design of one group pretest-posttest. The research location was at SMPN 2 Wonoayu with 30 futsal players as research subjects. The data collection technique used tests and measurements with the Beep Test. The training program was a combination of long field running and wide field jogging, shuttle runs, and pyramid runs with moderate intensity and a frequency of three times a week for 8 weeks. Data analysis used the Paired Sample t-Test after fulfilling the normality test. The results of the study showed a significant effect of interval training on VO2Max of futsal players with a significance value (Sig.2-tailed) <0.05. It was concluded that structured, gradual, and consistent interval training had a positive effect on VO2Max of futsal players.

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KEYWORDS
Interval Training; VO2max; futsal; junior high school.

Introduction

Sports play a significant role in improving human quality, particularly in terms of physical fitness and athletic achievement. In school settings, sports activities serve a dual function: as a means of maintaining health and as a vehicle for developing character and mental resilience (Lukmananto, 2011). Among the various sports practiced in schools, futsal has grown rapidly in popularity due to its dynamic nature and minimal equipment requirements. Futsal is a five-a-side indoor soccer game that demands high physical abilities, including speed, strength, agility, and the capacity to change direction quickly and repeatedly throughout the match (Agischa & Wahyudi, 2022).

One of the most critical physical components in futsal is endurance. Endurance enables players to perform optimally throughout the match, maintain performance quality, and reduce the risk of premature fatigue. According to Morici et al. (2016), endurance is a person's ability to perform movement activities for a long time at a moderate to fast tempo without experiencing severe fatigue. Junaidi (2018) further emphasized that endurance is one of the main biomotor components that serves as a benchmark for an athlete's physical fitness level. Without adequate endurance, players are likely to experience a decline in technical performance, increased errors in ball possession, and reduced effectiveness in team coordination.

Endurance capacity is closely related to VO2Max, defined as the body's maximum ability to absorb and utilize oxygen during physical activity. VO2Max reflects the efficiency of the cardiovascular and respiratory systems in supplying oxygen to the muscles (Yunitaningrum, 2014; Festiawan et al., 2020). The higher a player's VO2Max, the greater their capacity to sustain high-intensity performance over a

prolonged period. In the context of futsal, which requires repeated sprints, rapid direction changes, and continuous high-tempo movement, VO2Max is widely recognized as a key indicator of aerobic fitness and overall playing performance.

One training method that has been proven effective in improving VO2Max is interval training. Interval training involves alternating high-intensity exercise with planned rest periods, allowing athletes to sustain quality performance across multiple repetitions (Dwitama & Wibowo, 2022). Common forms include High-Intensity Interval Training (HIIT), Sprint Interval Training (SIT), and Micro Interval Training, all of which have demonstrated improvements in both aerobic and anaerobic capacity. The intermittent nature of interval training closely mirrors the physical demands of futsal, making it a particularly suitable training method for futsal players.

However, existing research on interval training still presents several limitations. Most studies have been conducted on adult male athletes, while research targeting adolescents, particularly junior high school futsal players, remains scarce. Furthermore, commonly applied interval training protocols use a fixed work-to-rest ratio of 3:1 or 1:1 with flat, homogeneous running tracks, without variation in trajectory or combined speed methods (Agischa & Wahyudi, 2022; Junaidi, 2018). Given that adolescents possess different physiological conditions and adaptive capacities compared to adult athletes, a training approach tailored to their specific age characteristics and developmental stage is necessary.

Field observations and interviews conducted with the futsal coach at SMPN 2 Wonoayu confirmed this concern. In several matches, many players were unable to complete the full game due to fatigue experienced midway through the match, resulting in a decline in team performance, errors in ball possession, and defensive vulnerabilities. These findings indicate that the players' aerobic endurance is still below the required standard for competitive futsal play, highlighting the urgent need for an evidence-based and structured training intervention to improve VO2Max.

To address these gaps, this study introduces an interval training protocol with a 2:1 work-to-rest ratio (two minutes of exercise and one minute of rest), combined with a track variation in which the long side of the futsal field is used for sprinting and the wide side is used for jogging. This combination is designed to provide physiological stimuli that more closely replicate the dynamic, fast-paced, and direction-changing demands of futsal. To the best of the authors' knowledge, no previous study has examined this specific training configuration among junior high school futsal players, making this study a novel contribution to the field of youth sports science.

Therefore, this study aims to examine the effect of interval training on VO2Max improvement in futsal players at SMPN 2 Wonoayu. The findings are expected to contribute to the development of interval training models better suited to the characteristics of junior high school-aged futsal players and to serve as a scientific reference for coaches in designing effective, efficient, and age-appropriate training programs.

Method

Research Design

This study used a quantitative approach with a quasi-experimental method and a one-group pretest-posttest design. This design was used to measure changes in VO2Max before and after the interval training program was administered (Jamaludin & Kusuma, 2022). The quasi-experimental method was applied because subjects were not randomly assigned, yet the effects of treatment could still be measured systematically (Abraham & Supriyati, 2022).

Table 1. Research Design

Group	Pretest	Treatment	Posttest
Experiment	O_1	X	O_2

Notes:
O_1 = Pretest
X = Interval training
O_2 = Posttest.

Participants

The participants in this study were 30 male futsal players from SMPN 2 Wonoayu. Since the population was fewer than 100, the total sampling technique was applied, meaning the entire population served as the sample (Suharsimi, 2002). Participants were selected using purposive sampling based on the criteria that they were beginner athletes who actively participated in futsal extracurricular activities and had not yet fully developed the physical conditions being studied.

Research Instruments

VO2Max was measured using the Beep Test (Multi-Stage Fitness Test), conducted on a futsal field with cones, a sound player, audio beep test recordings, a stopwatch, a measuring tape, and a test recording sheet. After completing the test, the final level and number of shuttles were converted into an estimated VO2Max score using the following formula (TopEnd Sports, 2023):

$$VO2Max = 3.47 \times (L + S / Smax) + 12.1$$

Where L = last level completed; S = shuttles at the last level; Smax = maximum shuttles at that level. Results were categorized based on the aerobic capacity norms from The Cooper Institute for Aerobics Research (Brianmac, 2018), as shown in Table 2.

Table 2. VO2Max Category Norms by Age Group (ml/kg/min)

lee	Very Poor	Poor	Fair	Good	Excellent	Superior
13–19	<35.0	35.0–38.3	38.4–45.1	45.2–50.9	51.0–55.9	>55.9
20–29	<33.0	33.0–36.4	36.5–42.4	42.5–46.4	46.5–52.4	>52.4
30–39	<31.5	31.5–35.4	35.5–40.9	41.0–44.9	45.0–49.4	>49.4
40–49	<30.2	30.2–33.5	33.6–38.9	39.0–43.7	43.8–48.0	>48.0
50–59	<26.1	26.1–30.9	31.0–35.7	35.8–40.9	41.0–45.3	>45.3
60+	<20.5	20.5–26.0	26.1–32.2	32.3–36.4	36.5–44.3	>44.3

Data Analysis

Data were analyzed in three stages. First, descriptive statistics were calculated to obtain the minimum, maximum, mean, and standard deviation values. Second, the Shapiro-Wilk normality test was conducted using SPSS, appropriate for samples of fewer than 50; data were considered normally distributed if Sig. > 0.05. Third, hypothesis testing was performed using a paired sample t-test (parametric) to determine the significance of the difference between pretest and posttest scores (N = 30, α = 0.05). The criteria were: if Sig. < 0.05, interval training had a significant effect on VO2Max; if Sig. > 0.05, no significant effect was found. The frequency distribution percentage for each VO2Max category was calculated using the formula P = (f / N) × 100% (Sudijono, 2011).

Results and Discussion

A. Results

This study examined the effect of an 8-week interval training program on VO2Max in 30 male futsal players at SMPN 2 Wonoayu aged 13–15 years, with three training sessions per week. The training protocol combined long-field running, wide-field jogging, shuttle run, and pyramid running with a 2:1 work-to-rest ratio, structured progressively over October and November 2025. VO2Max was measured using the Beep Test on September 29, 2025 (pretest) and December 5, 2025 (posttest).

Prior to normality and hypothesis testing, descriptive statistical analysis was conducted to provide an overview of players' aerobic capacity before and after the intervention. Based on frequency distribution analysis (P = f/N × 100%), the pretest showed that most players were in the poor category (40%) and fair category (40%), with 20% in the very poor category, and no players in the good or excellent categories. Following the 8-week program, the posttest revealed a clear improvement: the very poor category was completely eliminated, the poor category decreased to 10%, the fair category increased to 60%, and a good category emerged at 30%. This shift in category distribution indicates that the interval training program effectively improved the aerobic capacity of the players.

Table 1. Descriptive Statistics of VO2Max (ml/kg/min)

Descriptive Statistics							
	N	Range	Minimum	Maksimum	Mean	Std. Deviation	Variance
Pretest	30	10,86	32,16	43,02	37,6527	2,81429	7,920
Posttest	30	14,05	34,66	48,71	43,0107	3,52957	12,458

As shown in Table 1, the mean VO2Max increased from 37.65 ml/kg/min (pretest) to 43.01 ml/kg/min (posttest), an average improvement of 5.36 ml/kg/min. The minimum value rose from 32.16 to 34.66 ml/kg/min and the maximum from 43.02 to 48.71 ml/kg/min. The standard deviation increased slightly from 2.814 to 3.530, reflecting variability in individual training responses, as some players improved substantially while others progressed more moderately. These descriptive results provide initial evidence that interval training improved players' aerobic capacity.

Before conducting hypothesis testing, a Shapiro-Wilk normality test was performed using SPSS Version 25, as this test is most appropriate for sample sizes below 50. The criteria applied were: Sig. > 0.05 indicates normal distribution; Sig. < 0.05 indicates non-normal distribution.

Table 2. Normality Test Results (Shapiro-Wilk)

Tests of Normality			
	Kelompok	Kolmogorov-Smirnov[a]	Shapiro-Wilk

		Statistic	df	Sig.	Statistic	df	Sig.
VO2Max	*Pretest*	,094	30	,200	,975	30	,687
	Posttest	,137	30	,154	,948	30	,146

The Shapiro-Wilk test yielded Sig. = 0.687 for the pretest and Sig. = 0.146 for the posttest, both exceeding the 0.05 threshold. Both datasets were therefore confirmed to be normally distributed, justifying the use of a parametric paired sample t-test for hypothesis testing.

A paired sample t-test was then conducted to determine whether there was a statistically significant difference between pretest and posttest VO2Max scores, with the following hypotheses: H_0 = no significant difference between pretest and posttest scores; H_1 = a significant difference exists between pretest and posttest scores (α = 0.05).

Table 3. Paired Sample t-Test Results

Paired Samples Test									
		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre - Post	-4,17500	7,84777	1,43280	-7,10541	-1,24459	-2,914	29	,007

The results yielded a mean difference of −4.175 (indicating posttest scores were higher than pretest), with Std. Deviation = 7.848 and Std. Error Mean = 1.433. The 95% confidence interval ranged from −7.105 (lower) to −1.245 (upper), with both bounds negative, confirming a consistent and directionally clear improvement. The t-value of −2.914 with df = 29 produced Sig. (2-tailed) = 0.007 < 0.05. Therefore, H_0 is rejected and H_1 is accepted: the interval training program had a statistically significant effect on VO2Max improvement in futsal players at SMPN 2 Wonoayu.

B. Discussion

The results confirm that the 8-week interval training program significantly improved VO2Max in junior high school futsal players, with a mean increase of 5.36 ml/kg/min (approximately 14.2%). This outcome aligns with the American College of Sports Medicine (ACSM) benchmark, which considers a VO2Max increase of 5–15% physiologically meaningful following a structured aerobic training program, indicating that the intervention successfully achieved its objective. Physiologically, interval training at moderate-to-high intensity repeatedly stresses the oxygen transport system, promoting cardiovascular and respiratory adaptations including increased cardiac output, stroke volume, capillary density, and mitochondrial enzyme activity. These adaptations are particularly effective during adolescence, when the body is in a sensitive developmental phase that is highly responsive to training stimuli. The combination of varied training patterns — long-field sprinting, wide-field jogging, shuttle runs, and pyramid running — also ensured that multiple energy pathways relevant to futsal were engaged, contributing to the breadth of improvement observed.

These findings are consistent with Fachrezi et al. (2024), who demonstrated that 6 weeks of HIIT increased VO2Max in futsal players from 48.19 to 49.20 ml/kg/min (+1.01 ml/kg/min). Both studies confirm that interval training improves aerobic capacity in futsal players and used the same Beep Test instrument; however, this study produced a larger improvement. The difference is likely due to the longer training duration (8 vs. 6 weeks), the use of a moderate-intensity multi-pattern protocol better

suited to junior high school players, and the lower initial baseline (37.65 vs. 48.19 ml/kg/min) allowing greater room for physiological adaptation. Similarly, Attamimi et al. (2025), reported significant VO2Max improvements in professional soccer players (Bhayangkara FC) using high-intensity interval training measured with the Yo-Yo Test, and Izzudin et al. (2022) found significant gains in sport science university students through interval running measured with the Balke Test. While all three studies support the effectiveness of interval-based training, key differences lie in population (professional adult athletes and university students vs. junior high school players), training intensity (very high vs. moderate), and measurement instruments, which limit direct numerical comparison but collectively reinforce the conclusion that interval training is effective across diverse populations and activity levels.

Marhardika et al. (2025) reported a significant VO2Max increase in badminton athletes from 44.50 to 47.67 ml/kg/min (Sig. = 0.000) following HIIT. Both studies confirm that interval training improves aerobic capacity across different sports; however, badminton is dominated by explosive movements and short rallies, whereas futsal demands sustained aerobic output and continuous directional changes, making the moderate-intensity multi-pattern protocol in this study more ecologically relevant to futsal's physiological demands. ,Syarif et al. (2023) compared circuit training and interval training in senior high school futsal students, finding that circuit training produced a larger VO2Max increase (6.42 points) than interval training (3.55 points), though both were significant. Despite this, the present study shows that a well-structured 8-week interval protocol with progressive intensity and varied tracks can generate improvements (+5.36 ml/kg/min) exceeding Syarif's interval group, confirming that program design and duration are critical determinants of training outcomes. Amelya & Faruk (2025) reported that 60% of East Java provincial field hockey athletes improved VO2Max during a training period, which, despite the descriptive design and different sport context, reinforces the broader finding that structured and sustained physical training drives aerobic capacity improvement across sports and age groups.

Based on these findings, coaches and physical education teachers are recommended to implement interval training as part of the physical conditioning program for school-aged futsal players. Training programs should be structured progressively, adjusted to players' initial capacity, and accompanied by periodic VO2Max assessment to monitor development and adjust intensity accordingly. Future research should address the limitations of this study by employing a randomized controlled design with a control group, expanding the sample across multiple schools, and monitoring confounding variables such as nutrition, sleep quality, and daily physical activity to enable more robust causal conclusions about the effect of interval training on aerobic capacity development in adolescent futsal players.

Conslusions

This study confirms that interval training has a significant positive effect on VO2Max in futsal players at SMPN 2 Wonoayu. An 8-week program conducted three times per week with a 2:1 work-to-rest ratio produced a mean VO2Max increase of 5.36 ml/kg/min (37.65 to 43.01 ml/kg/min), with a Paired Sample t-Test result of Sig. (2-tailed) = 0.007 < 0.05. This confirms that the research question is answered affirmatively: interval training significantly improves the aerobic capacity of junior high school futsal players.

These findings carry meaningful practical implications. The shift in player distribution from predominantly very poor and poor categories (pretest) to fair and good categories (posttest) reflects a real improvement in players' ability to sustain performance throughout a match, directly addressing the fatigue-related decline observed in competition. This demonstrates that a well-designed, progressive interval training program is a practical and sport-specific solution applicable within school extracurricular settings without the need for specialized equipment, making it a viable approach for

coaches and physical education teachers in developing physical conditioning programs for school-aged futsal players.

Future research should incorporate a randomized controlled design with a control group to strengthen causal inference, expand the sample across multiple schools to improve generalizability, and monitor confounding variables such as nutrition and sleep quality. Exploring the combined effects of interval training with other training modalities and examining the sustainability of VO2Max gains after the program ends will further contribute to the development of evidence-based, age-appropriate training frameworks for youth futsal in Indonesia.

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