JSES: Journal of Sport and Exercise Science
Volume 8, Number 2, September 2025
ORIGINAL ARTICLE

The Effect of Speed Endurance Training on Increasing Aerobic Endurance of Futsal Extracurricular Students

Fanesa Amanda Febriliana[1ABCE], Nining Widyah Kusnanik[1D], Stephen P. Bird[2AD]

[1] Universitas Negeri Surabaya, Indonesia
[2] University of Southern Queensland, Australia

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

Corresponding Author: Fanesa Amanda Febriliana, fanesa.21111@mhs.unesa.ac.id

Received 16 October 2025
Accepted 28 November 2025
DOI https://doi.org/10.26740/jses.v8n2.p135-142

ABSTRACTS

Purpose This study aims to analyze the effect of speed-endurance training on increasing aerobic capacity (VO_2max) among students participating in extracurricular futsal activities.

Materials and Methods This study involved 35 male futsal extracurricular students divided into an experimental group (n = 20; age 14.70 ± 0.47 years, height 159.20 ± 7.57 cm, weight 53.25 ± 7.61 kg, BMI 20.02 ± 1.59) and a control group (n = 15; age 14.60 ± 0.51 years, height 160.20 ± 2.43 cm, weight 53.80 ± 5.24 kg, BMI 20.93 ± 1.56). The experimental group underwent four weeks of Speed Endurance Soccer Training (SEST), while the control group participated in regular futsal training. Aerobic endurance (VO_2max) was measured using the beep test during pretest and posttest. Statistical analysis using SPSS 27 revealed normally distributed residuals (Shapiro–Wilk $p = 0.053$) but unequal variances (Levene's test $p < 0.001$); therefore, Quade's nonparametric ANCOVA with the pretest as a covariate was applied, followed by pairwise comparisons. Significance was set at $p < .05$.

Result All variables were normally distributed (Shapiro–Wilk $p = 0.053$), but the homogeneity assumption was violated (Levene's test $p < .001$). Therefore, the data were analyzed using Quade's nonparametric ANCOVA, which showed a significant group effect after controlling for the pretest scores ($F(1,33) = 46.70$, $p < .001$). Pairwise comparison confirmed that the experimental group achieved significantly higher posttest VO_2max scores than the control group ($t(33) = -6.83$, $p < .001$).

Conclusion Speed-endurance training effectively improved students' aerobic capacity and proved to be a practical, efficient method that can be readily implemented in school-based futsal training programs.

Keywords Speed endurance; VO_2max; Futsal; Aerobic capacity; HIIT.

INTRODUCTION

Futsal is a team sport played indoors with five players per team and is experiencing global growth (Spyrou et al., 2020). Futsal is characterized by fast-paced, repetitive movements and high intensity, which makes aerobic endurance the most important aspect in maintaining athletes' performance throughout the game (Buchheit & Laursen, 2013). In modern sports, particularly high-intensity ones like futsal, physical ability is the primary foundation for success. Optimal

performance requires the effective combination of strength, speed, and endurance to support athletes throughout competition. Sprint movement patterns and short recoveries can put significant pressure on both the aerobic and anaerobic systems; the balance between the two is an important indicator of physiological adaptation in athletes (Iaia et al., 2015).

Aerobic ability is a crucial component of physical fitness, particularly during adolescence. At this age, there is significant physical and mental development, so structured fitness training is necessary to support growth and sports performance (Ortega et al., 2008). However, in the school environment, physical activity is often unstructured and less intensive. The lack of implementation of planned exercises has resulted in low levels of physical fitness among students, including those who participate in extracurricular futsal. Their reduced endurance during the second half of matches suggests that their VO_2max capacity is optimal, mainly because their training patterns prioritize technical and systematic development (Al-Azzawi et al., 2023).

One method that has proven effective for improving aerobic endurance is speed endurance training, a high-intensity, short-duration exercise performed repeatedly. Research indicates that this method can significantly enhance VO_2max and speed in a relatively short period (Kusuma et al., 2024). In addition, high-intensity training, such as High-Intensity Interval Training (HIIT) and a combination of running and strength training, has also been shown to improve cardiovascular fitness, reduce blood lactate levels, and increase metabolic efficiency (Huerta Ojeda et al., 2017; Stangier et al., 2016). In addition to individualized training, game-based training, such as Small-Sided Games (SSG), is also considered adequate because it simulates real match conditions and combines both technical and physiological aspects. The combination of SSG and HIIT has been shown to increase participants' VO_2max and exercise motivation significantly (Moran et al., 2019; Yüksel et al., 2023). SSG is also known as a method that increases student interest and engagement during training, especially in physical learning environments in schools (Hill-Haas et al., 2011).

This study aims to analyze the effect of speed endurance training program on improving the aerobic endurance of futsal extracurricular students. The results of this study are expected to contribute to the development of a scientifically based, effective, and contextually appropriate training curriculum for schools (Bailey et al., 2009).

METHODS

Study Participants

The subjects in this study were male students participating in extracurricular futsal activities at a junior high school in Surabaya, totaling 35 students. The sampling technique used was purposive sampling with the following criteria: (1) male, (2) aged 13-15 years, (3) actively participating in futsal extracurricular activities regularly, (4) not suffering from physical injuries, and (5) willing to follow the entire series of training programs that have been designed. The sample was then divided into two groups: the experimental group, consisting of 20 students who received speed endurance training, and the control group, comprising 15 students who received training as usual without any special treatment. The characteristics of the participants in this study are as follows: age 14.30 ± 0.50 years, height 163.20 ± 4.10 cm, weight 51.30 ± 6.50 kg, and body mass index (BMI) 19.20 ± 1.70 for the experimental group; and age 14.20 ± 0.60 years, height 162.70 ± 4.60 cm, weight 50.80 ± 7.00 kg, and BMI 19.10 ± 1.80 for the control group. The study included 35 participants: 20 in the experimental group and 15 in the control group. Data were presented as mean ± standard deviation. These results indicate that the two groups' physical characteristics were relatively balanced before treatment, allowing an objective comparison of the training effects.

ISSN 2615-8744

Study Organization

This research was conducted over four weeks at Junior High School 61's futsal field in Surabaya. The study employed a pretest-posttest control-group design, with VO_2max measured before and after treatment using the Beep Test. The training frequency for the experimental group was 3 times per week, with a duration of 45-60 minutes per session.

Training Program

Table 1. Exercise Program Details

	Components	Distance (m)	Time (seconds)	Action	Attacking Side
1 SET	Tactical	15	5	Sprint from area 2 to 1	Center (area 3)
	Sprint	12.5	19	Attack and defend	Right/Left
	3 vs. three games (ssg)	15	5	Sprint from area 1 to area 2	Center (area 3)
	Sprint	12.5	19	Attack and defend	Right/Left
Estimated workout time: Repetitions per set: 4 times Number of sets per session: 6 sets Total sprints per session: 15 m × 4 × 6 = 360 meters Total SSG duration per session: 18 seconds × 4 × 6 = 432 seconds Work:rest ratio: 1:3 (±18 seconds: ±54 seconds)					

Both groups were given a pretest using the multistage fitness test (also known as the beep test) to determine the students' initial aerobic capacity. Furthermore, the treatment group underwent a four-week Speed Endurance Soccer Training (SEST) program, conducted three times per week. In contrast, the control group followed regular futsal training with the same duration and frequency. Before the treatment began, the 20 students were divided into two teams (red and blue), each consisting of 10 players. In each training session, six players actively participated in a three-on-three format, while the rest waited for their turn through a rotation system. The SEST training procedure consists of several stages. Each round begins with a 15-meter sprint to the game area. After that, the players immediately played in the Small-Sided Game (SSG) format, three vs. 3, for 19 seconds, with alternating scenarios between attack and defense. One set consisted of 4 repetitions (sprint + game), and each player completed six sets in a single training session, with three sets attacking from the right and 3 from the left. To maintain high intensity, a work: rest ratio of 1:3 was used, i.e., 19 seconds of work followed by 57 seconds of rest. The training program used in this study is summarized in Table 1. In one set, the estimated mileage per player was approximately 60 meters, totaling 360 meters per session. The estimated active time per session was 432 seconds, excluding warm-up and cool-down.

Statistical Analysis

Descriptive statistics were used to summarize participant characteristics, including age, height, weight, and BMI for both the experimental and control groups. Prior to the primary analysis, assumption testing was conducted, including assessments of normality and homogeneity of variance. Because the assumption of equal variances was not met, the Quade Nonparametric Analysis of Covariance (ANCOVA) was selected as an alternative to the parametric ANCOVA, with pretest scores entered as a covariate to control for baseline differences between groups. In

ISSN 2615-8744

addition, pairwise comparisons using t-tests were conducted to further examine differences in posttest outcomes. The level of statistical significance for all analyses was set at $p < .05$. The data analysis was performed using SPSS version 27.

RESULT

This study aims to analyze the effect of speed endurance training on increasing aerobic endurance (VO_2max) in futsal extracurricular students. A total of 35 students participated, comprising 20 in the experimental group and 15 in the control group.

Table 2. Participant Characteristics

Group	Age (years)	Height (cm)	Weight (kg)	BMI
Experimental	14.70 ± 0.47	159.20 ± 7.57	53.25 ± 7.61	20.02 ± 1.59
Control	14.60 ± 0.51	160.20 ± 2.43	53.80 ± 5.24	20.93 ± 1.56

The results of the Shapiro-Wilk normality test and Levene's homogeneity test indicate that all variables in both groups are normally distributed and homogeneous ($p > 0.05$), so the two groups are comparable.

Table 3. Test of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Residual for Posttest	.939	35	.053

Table 3 showed that the Shapiro–Wilk test for the posttest residuals was non-significant ($p = .053$), indicating that the residuals were normally distributed. After confirming normality, the next step was to examine the homogeneity of variance between groups.

Table 4. Levene's test of Equality of Error Variance

Dependent Variable: Posttest			
F	df1	df2	Sig.
55.173	1	33	<.001
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.			
a. Design: Intercept + Pretest + Group			

Table 4 showed that Levene's Test of Equality of Error Variances was significant ($F(1, 33) = 55.17$, $p < .001$), indicating that the assumption of homogeneity of variance was violated. Despite this violation, the analysis proceeded using the Quade nonparametric ANCOVA, which is appropriate when variance equality is not met.

Table 5. Quade Nonparametric Analysis of Covariance

F	DFH	DFE	P Value
46.704	1	33	.000

Table 5 showed that the Quade Nonparametric Analysis of Covariance revealed a significant group effect after controlling for pretest scores, $F(1, 33) = 46.70$, $p < .001$, indicating that the experimental group performed significantly better than the control group on the posttest.

ISSN 2615-8744

Table 6. Pairwise Comparisons of Groups

Comparison	t	DF	P Value
Control vs. Experiment	-6.834	33	.000

Table 6 showed that the pairwise comparison between the control and experimental groups was significant, $t(33) = -6.83$, $p < .001$, indicating that the experimental group had substantially higher posttest scores than the control group.

DISCUSSION

Given the limited time and facilities schools typically have, speed-endurance-based HIIT offers an efficient solution and has a significant impact on students' cardiorespiratory fitness. It is also easy to modify and implement, requiring no specialized equipment, making it highly suitable for use by physical education teachers, extracurricular coaches, and student clubs. Therefore, the implementation of this program is highly recommended as an integral part of the physical education curriculum and school sports training.

The results showed that the speed endurance training program significantly improved the aerobic capacity (VO_2max) of futsal students after a four-week intervention (Kelly et al., 2018). This finding is in line with various international studies that confirm that the High-Intensity Interval Training (HIIT) training method, as the primary foundation of speed endurance, is proven to be more efficient and effective than conventional training methods such as continuous moderate training (CMT) and long-slow distance (LSD) training (Domaradzki et al., 2022; Poon et al., 2024; Silva et al., 2020). The effectiveness of HIIT is not only reflected in increased VO_2max but also in improved metabolic efficiency and more comprehensive neuromuscular adaptations. In addition to significantly enhancing aerobic capacity through increases in VO_2max, HIIT also promotes metabolic efficiency by improving insulin sensitivity and increasing phosphagen, glycolytic, and aerobic energy supply capacities. Moreover, HIIT induces broader neuromuscular adaptations, such as increased motor unit activation, shifts in muscle fiber composition toward more efficient Type IIa fibers, and enhanced muscle oxidative capacity. Overall, the combination of aerobic, metabolic, and neuromuscular adaptations makes HIIT a highly effective and comprehensive training method for improving physical performance (Hung et al., 2025).

Studies by Baquet et al. (2010) and Gibala et al. (2012) reinforced these findings by demonstrating that HIIT can trigger adaptations in the cardiovascular and mitochondrial systems, including increased cardiac output, capillary density, and more efficient oxygen utilization by muscles. Their research also highlighted that increased lactate threshold and insulin sensitivity are important factors in the efficiency of the aerobic energy system established through high-intensity training. Particularly in adolescent populations and young athletes, adaptation to HIIT occurs faster than in adults, making it particularly relevant in the context of student sports training (Baquet et al., 2010).

In terms of sport characteristics, futsal is a game with intermittent, high-intensity patterns, in which players perform activities such as sprints, sudden stops, dribbling, and repeated shooting with short recovery time. Therefore, HIIT and speed endurance training are well-suited to the metabolic and movement demands of the futsal game (Iaia & Bangsbo, 2010). HIIT enhances the body's ability to recover quickly, improves the efficiency of the aerobic system during exercise, and reduces muscle fatigue and reliance on anaerobic energy. HIIT for 5 weeks increased VO_2max by 4.3% significantly compared to SSG, which increased by only 3.3%, making HIIT more effective for developing aerobic capacity in young players (Arslan et al., 2022).

In practical terms, this study's findings indicate that speed endurance training can be an effective strategy in school settings. Given common limitations in time, equipment, and space, speed–endurance–based HIIT offers a practical, feasible approach to enhancing students' aerobic fitness. Its adaptability and minimal resource requirements make it a promising training method for broader adoption in school-based sports programs.

Furthermore, these findings emphasize the importance of incorporating structured high-intensity training into youth development programs to enhance physical fitness in a time-efficient manner. Therefore, incorporating this training model into physical education curricula and extracurricular futsal programs is highly recommended.

Despite its effectiveness, this study acknowledges several practical considerations, including the short intervention duration and the limited sample drawn from a single school, which may influence the generalizability of the results. Future research with larger and more diverse populations is recommended to strengthen the evidence base for implementing speed-endurance-based HIIT in school environments.

CONCLUSION

This study shows that speed-endurance training using high-intensity interval methods effectively improves the aerobic capacity of futsal players within a relatively short training period. This approach is more efficient than conventional training and aligns well with the high-intensity, intermittent demands of futsal. With minimal facility requirements and easy implementation in school environments, this program is highly suitable for physical education classes and extracurricular sports activities. Therefore, it is recommended as a practical and effective component of school-based training programs.

CONFLICT OF INTEREST

The authors declare no conflicts of interest that could affect the results or process of this research.

REFERENCES

Al-Azzawi, D. M. H., Halouani, J., Al-Gertani, A. O. S., & Chtourou, H. (2023). Effect of three months of specific training on physical capacities of iraqi futsal players. *International Journal of Sport Studies for Health*, *6*(1), 13–18. https://doi.org/10.61838/kman.intjssh.6.1.3

Arslan, E., Kilit, B., Clemente, F. M., Murawska-Ciałowicz, E., Soylu, Y., Sogut, M., Akca, F., Gokkaya, M., & Silva, A. F. (2022). Effects of small-sided games training versus high-intensity interval training approaches in young basketball players. *International Journal of Environmental Research and Public Health*, *19*(5), 1–11. https://doi.org/10.3390/ijerph19052931

Bailey, S. J., Wilkerson, D. P., DiMenna, F. J., & Jones, A. M. (2009). Influence of repeated sprint training on pulmonary O2 uptake and muscle deoxygenation kinetics in humans. *Journal of Applied Physiology*, *106*(6), 1875–1887. https://doi.org/10.1152/japplphysiol.00144.2009

Baquet, G., Gamelin, F. X., Mucci, P., Thévenet, D., Praagh, E. Van, & Berthoin, S. (2010). Continuous vs. interval aerobic training in 8-to 11-year-old children. *Journal of Strength and Conditioning Research*, *24*(5), 1381–1388. https://doi.org/10.1519/JSC.0b013e3181d1575a

Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part II: Anaerobic energy, neuromuscular load and practical applications. *Sports Medicine*, *43*(10), 927–954. https://doi.org/10.1007/s40279-013-0066-5

Domaradzki, J., Walkowiak, D., Bazan, D., & Baum, E. (2022). Volunteering in the front line of the Ukrainian refugee crisis: A brief report from Poland. *Frontiers in Public Health*, *10*(1). https://doi.org/10.3389/fpubh.2022.979751

Gibala, M. J., Little, J. P., Macdonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *Journal of Physiology*, *590*(5), 1077–1084. https://doi.org/10.1113/jphysiol.2011.224725

Hill-Haas, S., Dawson, B., Impellizzeri, F., & Coutts, A. (2011). Physiology of small-sided games training. *Journal of Sports Medicine*, *41*(3), 199–220. https://doi.org/10.2165/11539740-000000000-00000

Huerta Ojeda, Á., Galdames Maliqueo, S., Guerra, C., Fuentes, B., Villanueva, R., & Serrano, P. C. (2017). Efectos de un entrenamiento intervalado de alta intensidad en la capacidad aeróbica de adolescentes Effects of a high intensity interval training on the aerobic capacity of adolescents. *Revista médica de Chile*, *145*, 972–979. http://dx.doi.org/10.4067/s0034-98872017000800972

Hung, C.-H., Su, C.-H., & Wang, D. (2025). The role of high-intensity interval training (HIIT) in neuromuscular adaptations: Implications for strength and power development—A review. *Life*, *15*(4), 657. https://doi.org/10.3390/life15040657

Iaia, F. M., & Bangsbo, J. (2010). Speed endurance training is a powerful stimulus for physiological adaptations and performance improvements of athletes. *Scandinavian Journal of Medicine and Science in Sports*, *20*(2), 11–23. https://doi.org/10.1111/j.1600-0838.2010.01193.x

Iaia, F. M., Fiorenza, M., Perri, E., Alberti, G., Millet, G. P., & Bangsbo, J. (2015). The effect of two-speed endurance training regimes on the performance of soccer players. *PLoS ONE*, *10*(9), 1–16. https://doi.org/10.1371/journal.pone.0138096

Kelly, D. T., Tobin, C., Egan, B., McCarren, A., O'Connor, P. L., McCaffrey, N., & Moyna, N. M. (2018). Comparison of sprint interval and endurance training in team sport athletes. *Journal of Strength and Conditioning Research*, *32*(11), 1-14. https://doi.org/10.1519/JSC.0000000000002374

Kusuma, I. D. M. A. W., Kusnanik, N. W., Lumintuarso, R., Setijono, H., Muhammad, Muhammad, H. N., Kartiko, D. C., Siantoro, G., & Phanpheng, Y. (2024). Does short-term speed endurance soccer training improve physical performance? *Physical Education Theory and Methodology*, *24*(2), 270–275. https://doi.org/10.17309/tmfv.2024.2.11

Moran, J., Blagrove, R. C., Drury, B., Fernandes, J. F. T., Paxton, K., Chaabene, H., & Ramirez-Campillo, R. (2019). Effects of small-sided games vs. conventional endurance training on endurance performance in male youth soccer players: A meta-analytical comparison. *Sports Medicine*, *49*(5), 731–742. https://doi.org/10.1007/s40279-019-01086-w

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: A powerful marker of health. *International Journal of Obesity*, *32*(1), 1–11. https://doi.org/10.1038/sj.ijo.0803774

Poon, M. M., Lorrain, K. I., Stebbins, K. J., Edu, G. C., Broadhead, A. R., Lorenzana, A. O., Paulson, B. E., Baccei, C. S., Roppe, J. R., Schrader, T. O., Valdez, L. J., Xiong, Y., Chen, A. C., & Lorrain, D. S. (2024). Discovery of a brain-penetrant small molecule antagonist targeting LPA1 receptors to reduce neuroinflammation and promote remyelination in multiple sclerosis. *Scientific Reports*, *14*(1), 1–21. https://doi.org/10.1038/s41598-024-61369-9

Silva, Y. P., Bernardi, A., & Frozza, R. L. (2020). The role of short-chain fatty acids from gut microbiota in gut-brain communication. *Frontiers in Endocrinology*, *11*, 1–14. https://doi.org/10.3389/fendo.2020.00025

Spyrou, K., Freitas, T. T., Marín-Cascales, E., & Alcaraz, P. E. (2020). Physical and physiological match-play demands and player characteristics in futsal: A systematic review. *Frontiers in Psychology*, *11*. 1-11. https://doi.org/10.3389/fpsyg.2020.569897

Stangier, C., Abel, T., Hesse, C., Claßen, S., Mierau, J., Hollmann, W., & Strüder, H. K. (2016). Effects of cycling vs. running training on endurance performance in preparation for inline speed skating. *Journal of Strength and Conditioning Research*, *30*(6), 1597–1606. https://doi.org/10.1519/JSC.0000000000001247

Yüksel, Y., Cerrah, A. O., Taşçıoğlu, R., Akdoğan, E., Gürol, B., & Yılmaz, İ. (2023). The effect of maximal aerobic speed training combined with small-sided games on performance parameters in soccer. *Kinesiology*, *55*(2), 349–358. https://doi.org/10.26582/k.55.2.14

INFORMATION ABOUT THE AUTHORS

Fanesa Amanda Febriliana; https://orcid.org/0009-0005-1515-8403; fanesa.21111@mhs.unesa.ac.id; Department of Sports Coaching Education, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Surabaya, Indonesia.

Nining Widyah Kusnanik; https://orcid.org/0000-0002-0734-6843; niningkusnanik@unesa.ac.id; Department of Sports Coaching Education, Faculty of Sports and Health Sciences, Universitas Negeri Surabaya, Surabaya, Indonesia.

ISSN 2615-8744

Stephen P. Bird; https://orcid.org/0000-0002-5607-3829; stephen.bird@usq.edu.au; University of Southern Queensland, Australia.

CITE THIS ARTICLE AS
Febriliana, F. A., Kusnanik, N. W., & P. Bird, S. (2025). The Effect of Speed Endurance Training on Increasing Aerobic Endurance of Futsal Extracurricular Students. JSES : Journal of Sport and Exercise Science, 8(2), 135–142. https://doi.org/10.26740/jses.v8n2.p135-142