The impact of high-intensity interval training on VO2max of futsal student-athletes

El impacto del entrenamiento en intervalos de alta intensidad en el VO2máx de deportistas estudiantes de fútbol sala

Authors

Rasyono [1]
Bayu Insanistyo [2]
Yahya Eko Nopiyanto [3]
Arizky Ramadhan [4]
Cahyo Wibowo [5]

[1] Universitas Sriwijaya (Indonesia)
[2] Universitas Bengkulu (Indonesia)
[3] Universitas Bengkulu (Indonesia)
[4] Universitas Sriwijaya (Indonesia)
[5] Satya Wacana Christian University (Indonesia)

Corresponding author:
Bayu Insanistyo
bayuinsanistyo@unib.ac.id

Received: 26-01-25
Accepted: 08-09-25

How to cite in APA

Rasyono, R., Insanistyo, B., Nopiyanto, Y. E., Ramadhan, A., & Wibowo, C. (2025). The impact of high-intensity interval training on VO2max of futsal student-athletes. *Retos, 73*, 97-103. https://doi.org/10.47197/retos.v73.113264

Abstract

Introduction: The level of participation of student-athletes in futsal continues to increase significantly. However, this increase is not accompanied by a variety of training programs.
Objective: This study aims to analyze the impact of high-intensity interval training on the maximal oxygen uptake of student-athletes in futsal.
Methodology: A descriptive research method with a one group pretest and posttest design was used to achieve the research objectives. A total of 20 male student-athletes were involved as samples. The sampling technique used was total sampling. high-intensity interval training was carried out for six weeks. Each week consisted of three meetings. The maximal oxygen uptake level of student-athletes was measured using an instrument in the form of a Bleep Test. Paired sample t-test assisted by SPSS was used to determine the difference in maximal oxygen uptake before and after the implementation of high-intensity interval training.
Results: The results of the analysis showed that there was a significant increase in the mean, median, standard deviation, minimum value, and maximum value. The results of the paired sample t-test showed that there was a significant effect of maximal oxygen uptake before and after the implementation of high-intensity interval training (0.000 <0.05).
Discussion: This research highlights the undeniable impact of a six-week high-intensity interval training program in unlocking substantial increases in athletes' maximal oxygen uptake.
Conclusion: High-intensity interval training applied for six weeks can increase the maximal oxygen uptake of student-athletes in futsal. This study can be the basis for further research by implementing experiments involving a control group.

Keywords

Futsal; high intensity; student-athletes; VO2max.

Resumen

Introducción: El nivel de participación de los estudiantes-atletas en futsal continúa aumentando significativamente. Sin embargo, este aumento no se acompaña de una variedad de programas de entrenamiento.
Objetivo: Este estudio busca analizar el impacto del entrenamiento interválico de alta intensidad en el consumo máximo de oxígeno de los estudiantes-atletas en futsal.
Metodología: Se utilizó un método de investigación descriptivo con un diseño de pretest y postest de un grupo para alcanzar los objetivos de la investigación. Se incluyó una muestra de 20 estudiantes-atletas varones. La técnica de muestreo utilizada fue un muestreo total. El entrenamiento interválico de alta intensidad se llevó a cabo durante seis semanas. Cada semana consistió en tres sesiones. El consumo máximo de oxígeno de los estudiantes-atletas se midió mediante un instrumento llamado Bleep Test. Se utilizó una prueba t de muestras pareadas con la ayuda de SPSS para determinar la diferencia en el consumo máximo de oxígeno antes y después de la implementación del entrenamiento interválico de alta intensidad.
Resultados: Los resultados del análisis mostraron un aumento significativo en la media, la mediana, la desviación estándar, el valor mínimo y el valor máximo. Los resultados de la prueba t de muestras pareadas mostraron un efecto significativo en el consumo máximo de oxígeno antes y después de la implementación del entrenamiento interválico de alta intensidad (0,000 <0,05).
Discusión: Esta investigación destaca el innegable impacto de un programa de entrenamiento interválico de alta intensidad de seis semanas en el logro de aumentos sustanciales en el consumo máximo de oxígeno de los atletas.
Conclusiones: El entrenamiento interválico de alta intensidad aplicado durante seis semanas puede aumentar el consumo máximo de oxígeno de los estudiantes-atletas de futsal. Este estudio puede servir de base para futuras investigaciones mediante la implementación de experimentos con un grupo control.

Palabras clave

Alta intensidad; estudiantes-atletas; fútbol sala; VO2max.

Introduction

Student-athletes face unique demands, balancing academic responsibilities with demanding training schedules (Pujianto et al., 2024). Physical fitness is key not only to athletic success but also to long-term health (Malm et al., 2019). Physical fitness is essential for student-athletes who engage in regular physical activity as a foundation for health (Snedden et al., 2019; Supriadi et al., 2023). As measured by VO2 max (volume oxygen maximal), aerobic capacity is critical to an athlete's endurance and performance potential (Srivastava et al., 2024).

VO2 max is very important for futsal players because this sport involves fast movements, high intensity, and frequent changes of direction (Naser et al., 2017; Taufik et al., 2021). High VO2 max allows players to consume oxygen optimally, helping the body produce the energy needed for intense physical activity while accelerating recovery during the match (Muttaqin et al., 2024) . For student-athletes, this ability is very important to maintain physical endurance during the match, especially since they have to manage academic demands in addition to training. By increasing VO2 max through a structured training program, such as high-intensity interval training (HIIT), student-athletes can improve performance, reduce the risk of fatigue, and ensure they remain competitive both inside and outside of sports (Campos et al., 2021).

HIIT has improved aerobic and anaerobic capacity, cardiovascular function, and muscle oxidative capacity (Jatmiko et al., 2024; Kul et al., 2022; Saleh et al., 2021). HIIT is recommended to improve an athlete's VO2 max because it optimizes aerobic capacity in a relatively short training period (Wen et al., 2019). HIIT involves brief periods of high-intensity exercise followed by active or passive recovery periods (Ma et al., 2023). This pattern promotes significant physiological adaptations, such as increased oxygen utilization efficiency, muscle work capacity, and cardiovascular function (Vigriawan et al., 2024). This intense training challenges the body's aerobic and anaerobic energy systems, leading to more rapid increases in VO2 max than steady-state moderate-intensity training.

Applying HIIT to student-athletes is an interesting study because it can save time. HIIT is ideal for student-athletes who must balance training schedules with academic demands (Sepang et al., 2023). However, its application must be adjusted to factors such as age, training status, and specific sports demands so that this exercise remains safe and effective. By understanding the physiological responses and body adaptations to HIIT, coaches can design appropriate programs to improve physical fitness while supporting athlete performance on the field and the sustainability of their academic achievement.

The problem formulation set in this study is there an effect of HIIT on VO2max of futsal student-athletes?

Method

This study uses a quantitative descriptive approach with a one-group pretest-posttest quasi-experimental design. This method is used to analyze the effect of HIIT on VO2max of student-athletes in futsal by comparing the pretest and posttest in the same group without a control group. This method was chosen because it is able to provide an initial picture of the effect of HIIT on VO2max of student-athletes.

Participants

Participants in this study were 20 male student-athletes in the futsal sport. Participants were taken using the total sampling technique which is a sampling technique by involving all members of the population. Participants are student-athletes who actively participate in training, are free from injury, and have no history of chronic disease.

Procedure

Each research sample provided the ability to be an active part in the implementation of HIIT. This was proven by filling out the willingness form. Each sample member was given the freedom to leave the sample members during the research process. HIIT was applied for six weeks. Each week consisted of three meetings. Each meeting consisted of 3-4 sets and 2 repetitions. HIIT movements consist of planks, jump squats, skipping rope, push ups and rotations, jumping jacks, and wall sits. Each HIIT session was

designed with high-intensity intervals (30 seconds to 1 minute) followed by an active recovery period (1–2 minutes). The HIIT sequence is shown in table 1.

Table 1. Training Menu

First Week		
First Meeting	Second Meeting	Third Meeting
Wednesday (4.00 p.m -5.30 p.m) Plank (3 Set, 2 Rep, Intensity 70%)	Saturday (4.00 p.m -5.30 p.m) Jump Squat (3 Set, 2 Rep, Intensity 70%)	Sunday (4.00 p.m -5.30 p.m) Jump Squat (4 Set, 2 Rep, Intensity 70%)
Second Week		
Fourth Meeting	Fifth Meeting	Sixth Meeting
Wednesday (4.00 p.m -5.30 p.m) Push Up and Rotation (3 Set, 2 Rep, Intensity 70%)	Saturday (4.00 p.m -5.30 p.m) Jump Jack (3 Set, 2 Rep, Intensity 70%)	Sunday (4.00 p.m -5.30 p.m) Wall Sit (3 Set, 2 Rep, Intensity 70%)
Third Week		
Seventh Meeting	Eight Meeting	Nineth Meeting
Wednesday (4.00 p.m -5.30 p.m) Plank (3 Set, 2 Rep, Intensity 80%)	Saturday (4.00 p.m -5.30 p.m) Jump Squat (3 Set, 2 Rep, Intensity 80%)	Sunday (4.00 p.m -5.30 p.m) Skipping Rope (4 Set, 2 Rep, Intensity 80%)
Fourth Week		
Tenth Meeting	Eleventh Meeting	Twelfth Meeting
Wednesday (4.00 p.m -5.30 p.m) Push Up and Rotation (3 Set, 2 Rep, Intensity 80%)	Saturday (4.00 p.m -5.30 p.m) Jump Jack (3 Set, 2 Rep, Intensity 80%)	Sunday (4.00 p.m -5.30 p.m) Wall Sit (3 Set, 2 Rep, Intensity 80%)
Fifth Week		
Thirteenth Meeting	Fourteenth Meeting	Fiveteenth Meeting
Wednesday (4.00 p.m -5.30 p.m) Plank (3 Set, 2 Rep, Intensity 90%)	Saturday (4.00 p.m -5.30 p.m) Jump Squat (3 Set, 2 Rep, Intensity 90%)	Sunday (4.00 p.m -5.30 p.m) Skipping Rope (4 Set, 2 Rep, Intensity 90%)
Sixth Week		
Sixteenth Meeting	Seventeenth Meeting	Eighteenth Meeting
Wednesday (4.00 p.m -5.30 p.m) Push Up and Rotation (3 Set, 2 Rep, Intensity 90%)	Saturday (4.00 p.m -5.30 p.m) Jump Jack (3 Set, 2 Rep, Intensity 90%)	Sunday (4.00 p.m -5.30 p.m) Wall Sit (3 Set, 2 Rep, Intensity 90%)

Instrument

The Bleep Test is an instrument used to measure VO2max (Fajar et al., 2025). This test consists of a series of back-and-forth runs with increasing speed at each stage. Participants are asked to run between two lines for 20 meters, following sound cues (bleeps) that get faster at each level. Each cue indicates a change in running speed, and participants must complete the back-and-forth run before the following cue sounds. This test provides a reasonably accurate estimate of VO2max because running with gradually increasing intensity challenges the body's cardiovascular system and aerobic capacity. The bleep test is efficient because it does not require special equipment or facilities other than an ample open space.

Data analysis

Quantitative descriptive data analysis was used to determine the mean, median, standard deviation, minimum, and maximum. Data normality was analyzed using Kolmogorov-Smirnov and Shapiro-Wilk. Data homogeneity was analyzed using Levene's Test. If the data is considered normal and homogeneous, the analysis is continued with a paired t-test.

Results

The presentation of the results of this study begins with a descriptive analysis, which aims to describe and summarize the data that has been collected.

Table 2. The Results Descriptive Statistical Analysis

Pretest		Posttest	
Mean	24.27	Mean	41.57
Median	24.40	Median	41.85
Std.dev	2.379	Std.dev	3.837
Minimum	21	Minimum	36
Maximum	29	Maximum	50

The results of the descriptive analysis showed a significant increase in the VO2 max of student-athletes after participating in the HIIT program. The mean value increased from 24.27 in the pretest to 41.57 in the posttest, indicating a significant difference. The median value also increased from 24.40 in the pretest to 41.85 in the posttest, suggesting that most participants consistently increased their aerobic capacity. The standard deviation showed a slight increase from 2.379 in the pretest to 3.837 in the posttest, indicating a slight increase in the variation of VO2 max scores between participants after the program. The minimum value also increased from 21 to 36, while the maximum value increased from 29 to 50, indicating that all participants experienced a significant increase in their VO2 max scores. These data suggest that the HIIT program positively impacts improving aerobic fitness in student-athletes.

Table 3. The Results of Normality Test

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig.
Pretest	.182	20	.082	913	20	.073
Post-test	.126	20	.200	953	20	.419

In the pretest, the significance value (Sig.) for Kolmogorov-Smirnov was 0.082, and for Shapiro-Wilk was 0.073, greater than the specified significance level ($\alpha = 0.05$). The same thing happened in the posttest, with a significance value for Kolmogorov-Smirnov of 0.200 and Shapiro-Wilk of 0.419, also more significant than $\alpha = 0.05$. These results indicate that the data did not deviate significantly from the normal distribution, so the parametric statistical test of the paired t-test can be continued.

Table 4. The Results of Homogeneity Test

Levene Statistic	df1	df2	Sig.
3.323	1	38	.076

The results of the homogeneity of variance test using Levene's Test show that the data variance between the pretest and posttest is homogeneous. The Levene Statistic value of 3.323 with degrees of freedom (df1 = 1 and df2 = 38) has a significance value (Sig.) of 0.076, which is greater than the specified significance level ($\alpha = 0.05$). This means there is no significant difference in variance between the two data groups, so the assumption of homogeneity is met. Thus, parametric statistical analysis such as paired t-test can be applied to test the difference in VO2max values between the pretest and posttest. These results indicate that the data conditions support the validity of further testing.

Table 5. The Results of Paired Sample t-test

	t	df	Sig. (2 tailed)
Pre-test & Post-test	-33.181	19	.000

The paired sample t-test results showed a significant difference between the VO2max pretest and posttest values. The resulting t-value was -33.181 with a degree of freedom (df) of 19 and a significance value (Sig. 2-tailed) of 0.000, which was much smaller than the specified significance level ($\alpha = 0.05$).

Discussion

This study revealed that HIIT can increase VO2max of futsal student-athletes. High-intensity exercise causes an increase in stroke volume, resulting in a temporary decrease in heart rate and a fixation in cardiac output levels (Nurjaya et al., 2021; Rosdiana et al., 2019). This increases the efficiency of the heart muscle in supplying blood flow throughout the body (Stöggl & Björklund, 2017). A reduction in heart rate indicates efficiency in heart rate. Low-intensity exercise interspersed with high-intensity exercise in interval training can help remove metabolism from the muscles during the rest period when the body performs high-intensity interval training (Ramos et al., 2015). Alternating changes in exercise periods can help the body increase the volume of oxygen during exercise. The oxygen that goes to the active muscles will reintegrate lactic acid into energy.

Intense training in HIIT is usually done at an intensity close to the athlete's maximum capacity, either in sprints, weight lifting, or other body movements that drain energy. When the body is forced to work at high intensity, the muscles need more energy and oxygen to function properly (Atakan et al., 2021). In

this condition, the body utilizes the anaerobic energy system, which relies on energy reserves such as muscle glycogen (Torma et al., 2019). However, when the intensity reaches its maximum point, the body begins to experience and switches to other energy reserves, including lactic acid produced during the process (Pelana et al., 2019). Although it feels tired, the body starts to respond with increased efficiency in using oxygen during recovery.

With regular exercise, the body becomes more efficient at using oxygen (Kilen et al., 2014). The heart can pump more blood with each contraction, increasing the efficiency of oxygen delivery throughout the body (Tauda et al., 2024). HIIT can stimulate increased lung ventilation, allowing the body to assimilate oxygen and quickly expel carbon dioxide (Salazar-Martínez et al., 2018). Blood vessels become more elastic and more able to distribute oxygen efficiently (Christensen et al., 2016). HIIT also has essential benefits in muscle strengthening and overall cardiovascular endurance (Milanović et al., 2015). HIIT workouts incorporate elements of strength training, which strengthen muscles and increase endurance (Bento et al., 2025). The more substantial muscles and heart are, the more efficiently your body uses oxygen, contributing to better athletic performance (Gómez et al., 2023).

This study proves that HIIT training carried out for six weeks can have an effect on VO2max of student-athletes in futsal. However, the limitation of this study is that it did not involve a control group, thus limiting the ability to ensure that changes in VO2 max are caused by HIIT training. Despite the limitations of the study, these results provide a useful initial picture and serve as a basis for further research.

Conclusions

The HIIT program implemented can increase the VO2max of student-athletes in futsal. Thus, HIIT can be a reference for futsal coaches presenting varied training programs. For future research, combining it with psychological factors such as motivation and stress management skills is recommended. These psychological skills are needed because HIIT is identical to fast and heavy movements, so without good psychological skills, it will cause boredom in training.

Acknowledgements

The authors sincerely acknowledge the valuable contributions of all student-athletes and coaches in this study. Special thanks are also extended to colleagues who provided constructive comments and critical reviews that enhanced the scientific quality of this article. The commitment and collaboration of all parties involved supported this work, for which the authors are deeply grateful.

Financing

The authors declare that this research received no external funding.

References

Atakan, M. M., Li, Y., Koşar, Ş. N., Turnagöl, H. H., & Yan, X. (2021). Evidence-based effects of high-intensity interval training on exercise capacity and health: A review with historical perspective. *International Journal of Environmental Research and Public Health*, *18*(13), 1–27. https://doi.org/10.3390/ijerph18137201

Bento, F., Junior, D. M., Tadiotto, M. C., Ribeiro, P., Corazza, P., & Leite, N. (2025). Increased motor performance and responsivity in physical fitness after high-intensity functional training in excess weight adolescents. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación*, *2025*, 567–579.

Campos, F. de S., Borszcz, F. K., Flores, L. J. F., Barazetti, L. K., Teixeira, A. S., Hartmann Nunes, R. F., & Guglielmo, L. G. A. (2021). HIIT Models in Addition to Training Load and Heart Rate Variability Are Related With Physiological and Performance Adaptations After 10-Weeks of Training in Young Futsal Players. *Frontiers in Psychology*, *12*(January), 1–14. https://doi.org/10.3389/fpsyg.2021.636153

Christensen, P. M., Jacobs, R. A., Bonne, T., Flöck, D., Bangsbo, J., & Lundby, C. (2016). A short period of high-intensity interval training improves skeletal muscle mitochondrial function and pulmonary oxygen uptake kinetics. *Journal of Applied Physiology*, *120*(11), 1319–1327. https://doi.org/10.1152/japplphysiol.00115.2015

Fajar, M., Setyawati, H., Hidayah, T., Hartono, M., Kusuma, D. W. Y., Yunowo, C., & Pranata, D. Y. (2025). The impact of physical fitness , cognitive ability , and age on soccer playing skills in young players. *RETOS. Nuevas Tendencias En Educación Física, Deporte y Recreación*, *63*, 1132–1139.

Gómez, E. M., Atef, H., Elsayed, S. H., Zakaria, H. M., Navarro, M. P., & Sulé, E. M. (2023). Effects of high-intensity interval training with an eccentric hamstring exercise program in futsal players: A randomized controlled trial. *Medicine (United States)*, *102*(31), E34626. https://doi.org/10.1097/MD.0000000000034626

Jatmiko, T., Kusnanik, N. W., & Sidik, R. M. (2024). High-Intensity Interval Training (HIIT) Progressive Sprint-Release Model: Its Effect in Increasing Speed, Aerobic Capacity, and Anaerobic Capacity of Athletes. *Retos*, *57*, 318–323. https://doi.org/10.47197/retos.v57.104857

Kilen, A., Larsson, T. H., Jørgensen, M., Johansen, L., Jørgensen, S., & Nordsborg, N. B. (2014). Effects of 12 weeks high-intensity & reduced-volume training in elite athletes. *PLoS ONE*, *9*(4), 1–8. https://doi.org/10.1371/journal.pone.0095025

Kul, M., Turkmen, M., Yildirim, U., Ceylan, R., Sipal, O., Cabuk, R., Akova, A., Aksoy, O. F., & Adatepe, E. (2022). High-Intensity Interval Training with Cycling and Calisthenics: Effects on Aerobic Endurance, Critical Power, Sprint and Maximal Strength Performance in Sedentary Males. *Retos*, *204*(46), 538–544. https://doi.org/10.47197/retos.v46.94255

Ma, X., Cao, Z., Zhu, Z., Chen, X., Wen, D., & Cao, Z. (2023). VO2max (VO2peak) in elite athletes under high-intensity interval training: A meta-analysis. *Heliyon*, *9*(6), 1–13. https://doi.org/10.1016/j.heliyon.2023.e16663

Malm, C., Jakobsson, J., & Isaksson, A. (2019). Physical Activity and Sports Real Health Benefits. *Sports*, *7*(2), 1–28.

Milanović, Z., Sporiš, G., & Weston, M. (2015). Effectiveness of High-Intensity Interval Training (HIT) and Continuous Endurance Training for VO2max Improvements: A Systematic Review and Meta-Analysis of Controlled Trials. *Sports Medicine*, *45*(10), 1469–1481. https://doi.org/10.1007/s40279-015-0365-0

Muttaqin, A. F., Candra, O., & Parulian, T. (2024). Vo2 Max Level For Female Futsal Athletes WKB Pekanbaru. *International Journal Of Humanities Education and Social Sciences (IJHESS)*, *3*(5), 2594–2601. https://doi.org/10.55227/ijhess.v3i5.992

Naser, N., Ali, A., & Macadam, P. (2017). Physical and physiological demands of futsal. *Journal of Exercise Science and Fitness*, *15*(2), 76–80. https://doi.org/10.1016/j.jesf.2017.09.001

Nurjaya, D. R., Septina, T. A., Purnamasari, I., & Wibowo, R. (2021). The Effect of High Intensity Interval Training (HIIT) Training Method Using Elevation Training Mask (ETM) on Anaerobic Capacity. *COMPETITOR: Jurnal Pendidikan Kepelatihan Olahraga*, *13*(3), 518. https://doi.org/10.26858/cjpko.v13i3.24378

Pelana, R., Maulana, A., Winata, B., Widiastuti, W., Sukur, A., Kuswahyudi, K., Juriana, J., & Hermawan, R. (2019). Effect of contrast water therapy on blood lactate concentration after high-intensity interval training in elite futsal players. *Physiotherapy Quarterly*, *27*(3), 12–19. https://doi.org/10.5114/pq.2019.86463

Pujianto, D., Nopiyanto, Y. E., Wibowo, C., Kardi, I. S., Raibowo, S., Insanistyo, B., Ibrahim, Hasan, B., & Sutriawan, A. (2024). High School Student-Athletes: Their Motivation, Study Habits, Self-Discipline, Academic Support, and Academic Performance. *Physical Education Theory and Methodology* , *24*(1), 22–31. https://doi.org/10.17309/tmfv.2024.1.03

Ramos, J. S., Dalleck, L. C., Tjonna, A. E., Beetham, K. S., & Coombes, J. S. (2015). The Impact of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training on Vascular Function: a Systematic Review and Meta-Analysis. *Sports Medicine*, *45*(5), 679–692. https://doi.org/10.1007/s40279-015-0321-z

Rosdiana, F., Sidik, D. Z., & Rusdiana, A. (2019). The Implementation Impact of High Intensity Interval Training (HIIT) Methods for the Increase of Anaerobic Abilities (Experimental study of physical training for 28 day meeting on student activity unit women futsal UPI Bandung). *International Conference on Sport Science, Health, and Physical Education*, *11*(Icsshpe 2018), 17–19. https://doi.org/10.2991/icsshpe-18.2019.5

Salazar-Martínez, E., Santalla, A., Orellana, J. N., Strobl, J., Burtscher, M., & Menz, V. (2018). Influence of high-intensity interval training on ventilatory efficiency in trained athletes. *Respiratory Physiology and Neurobiology*, *250*(November 2017), 19–23. https://doi.org/10.1016/j.resp.2018.01.016

Saleh, H. H., Radhi, M. N., & Abdullah, A. W. (2021). The Effect of Combined High-Intensity Interval Training Exercises on Some of the Technical Skills and Endurance of Performance for Advanced Futsal Players. *Indian Journal of Forensic Medicine & Toxicology*, *15*(3), 1309–1317. https://doi.org/10.37506/ijfmt.v15i3.15491

Sepang, O. C., Budi Raharjo, B., Sulaiman, S., & Sumartiningsih, S. (2023). The effect of training methods and lung vital capacity on vo2max in student futsal athletes. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *9*(2), 339–354. https://doi.org/10.29407/js_unpgri.v9i2.20662

Snedden, T. R., Scerpella, J., Kliethermes, S. A., Norman, R. S., Blyholder, L., Sanfilippo, J., McGuine, T. A., & Heiderscheit, B. (2019). Sport and Physical Activity Level Impacts Health-Related Quality of Life Among Collegiate Students. *American Journal of Health Promotion*, *33*(5), 675–682. https://doi.org/10.1177/0890117118817715

Srivastava, S., Tamrakar, S., Nallathambi, N., Vrindavanam, S. A., Prasad, R., & Kothari, R. (2024). Assessment of Maximal Oxygen Uptake (VO2 Max) in Athletes and Nonathletes Assessed in Sports Physiology Laboratory. *Cureus*, *16*(5), 1–10. https://doi.org/10.7759/cureus.61124

Stöggl, T. L., & Björklund, G. (2017). High intensity interval training leads to greater improvements in acute heart rate recovery and anaerobic power as high volume low intensity training. *Frontiers in Physiology*, *8*(AUG), 1–8. https://doi.org/10.3389/fphys.2017.00562

Supriadi, D., Friskawati, G. F., & Karisman, V. A. (2023). Physical Fitness of Futsal Athletes in Competition Preparation. *International Journal of Human Movement and Sports Sciences*, *11*(1), 71–76. https://doi.org/10.13189/saj.2023.110109

Tauda, M. E., Cruzat Bravo, E. J., & Suárez Rojas, F. I. (2024). Dosage strategies of hiit and their influence on vo2max in patients with heart failure: A systematic review. *Retos*, *58*, 683–699. https://doi.org/10.47197/retos.v58.106943

Taufik, M. S., Widiastuti, Setiakarnawijaya, Y., & Dlis, F. (2021). Effect of circuit and interval training on vo2max in futsal players. *Journal of Physical Education and Sport*, *21*(4), 2283–2288. https://doi.org/10.7752/jpes.2021.s4305

Torma, F., Gombos, Z., Jokai, M., Takeda, M., Mimura, T., & Radak, Z. (2019). High intensity interval training and molecular adaptive response of skeletal muscle. *Sports Medicine and Health Science*, *1*(1), 24–32. https://doi.org/10.1016/j.smhs.2019.08.003

Vigriawan, G. E., Kusnanik, N. W., Wahjuni, E. S., Herawati, L., Kinanti, R. G., Rozy, F., Daulay, D. A., Permatasari, D. S., Syamsudin, F., Ayubi, N., & Solikah, N. L. (2024). The Influence of High Intensity Interval Training on Improving Physiological Performance and Social Status in a Sedentary Lifestyle: Review of the Literature. *Retos*, *55*, 483–489. https://doi.org/10.47197/retos.v55.103025

Wen, D., Utesch, T., Wu, J., Robertson, S., Liu, J., Hu, G., & Chen, H. (2019). Effects of different protocols of high intensity interval training for VO2max improvements in adults: A meta-analysis of randomised controlled trials. *Journal of Science and Medicine in Sport*, *22*(8), 941–947. https://doi.org/10.1016/j.jsams.2019.01.013

Authors' and translators' details:

Rasyono	rasyono@fkip.unsri.ac.id	Author
Bayu Insanistyo	bayuinsanistyo@unib.ac.id	Author
Yahya Eko Nopiyanto	yahyaekonopiyanto@unib.ac.id	Author
Arizky Ramadhan	arizkyramadhan@fkip.unsri.ac.id	Author
Cahyo Wibowo	cahyo.wibowo@uksw.edu	Author
Muhammad Fadhli	mfadhli@unib.ac.id	Translator