A comparison of VO_2max response of 15-year-old soccer athletes based on training time in the tropical climate of Bima

Firdaus[1*,A-F], Taty Hartati[2,B,C,E,F], Rabwan Satriawan[1,C,E,F], Shutan Arie Shandi[1,B,C,E,F], Nor Fazila Abd Malek[3,A,E,F]

[1] Department of Physical Education, STKIP Taman Siswa Bima, Indonesia
[2] Department of History, STKIP Taman Siswa Bima, Indonesia
[3] Faculty of Sports Science and Coaching, Sultan Idris Education University, Malaysia

***Corresponding author:** Firdaus; STKIP Taman Siswa Bima, Jl. Pendidikan Taman Siswa No. 1, 84173, Indonesia; email: syemfirdaus93@gmail.com

Received: 2026-02-02
Accepted: 2026-04-07
Published: 2026-04-14

A – Research concept and design
B – Collection and/or assembly of data
C – Data analysis and interpretation
D – Writing the article
E – Critical revision of the article
F – Final approval of article

ABSTRACT

Background: VO_2max is the primary indicator of a soccer athlete's aerobic capacity, but in tropical climates like Bima, high temperatures and humidity can affect VO_2max achievement. Hence, the timing of training is an important factor to consider.

Objectives: This study aims to analyze differences in VO_2max across training times (morning and afternoon) in 15-year-old youth soccer athletes from the Bima Football Association (PERSSEBI).

Methods: The study used a quantitative, comparative, cross-sectional observational design. The study subjects were 45 athletes (age 15.31±0.46; height 163.12±4.35 cm; weight 55.28±3.67 kg; and body mass index (BMI) 20.78±1.18 kg/m²) from the Bima Football Association (PERSEBI), selected by purposive sampling, and divided into morning (n=23) and afternoon (n=22) training groups. VO_2max was measured using a multistage fitness test (Bleep Test). Data analysis included descriptive statistics, the Shapiro–Wilk normality test, the Levene homogeneity test, and the independent-samples t-test at a significance level of 0.05, using IBM SPSS 25.

Results: The descriptive analysis showed that the average VO_2max of the morning group was 43.78 ± 2.34 ml/kg/minute, higher than that of the afternoon group (42.91 ± 2.29 ml/kg/minute). The results of the independent sample t-test showed that there was a significant difference in VO_2max between the two groups with a t value = 2.14 with df = 43 and a significant p value = 0.04 ($p < 0.05$) with an average difference of 0.87 ml/kg/minute indicating that the morning exercise group had a higher Vo2max value than the afternoon exercise group.

Conclusions: These findings suggest that training time contributes to differences in athletes' VO_2max values in tropical environments, with morning training resulting in higher performance than afternoon training. Therefore, scheduling training that accounts for environmental conditions is crucial for optimizing athletes' VO_2max.

Keywords: physiological adaptations, young soccer athletes, VO_2max.

How to cite this article: Firdaus, F., Hartati, T., Satriawan, R., Shandi, S. A., & Malek, N. F. A. (2026). A comparison of VO_2max response of 15-year-old soccer athletes based on training time in the tropical climate of Bima. *Physical Education and Sports: Studies and Research*, *5*(1), 125-134. https://doi.org/10.56003/pessr.v5i1.709

INTRODUCTION

VO_2max is a key indicator of an athlete's aerobic capacity and cardiorespiratory fitness. It plays an important role in supporting sports performance, especially in football, which demands high physical endurance throughout the match (Ansori et al., 2024). Athletes with high VO_2max are better able to maintain game intensity, accelerate recovery, and maintain optimal performance throughout the competition. Therefore, developing a systematic, structured, and sustainable training program is an important factor in improving an athlete's aerobic capacity and physical fitness (Simanjuntak et al., 2022). One approach that can be used is through training activities designed in the form of games or structured physical activities as a stimulus to increase fitness (Firdaus & Irfan, 2023), such as variations in training methods that can improve the physical condition component of agility (Prembanyu & Wiyanto, 2025).

However, an athlete's VO_2max capacity is influenced not only by training method but also by environmental factors, especially the climatic conditions in which training takes place (Apriantono et al., 2020). Indonesia, as a tropical region with high temperatures and humidity, places additional physiological stress on athletes. These conditions can affect the efficiency of the cardiovascular and respiratory systems, thereby altering the body's response to exercise (Pelletier et al., 2023). Athletes who train in hot environments tend to experience increased core body temperature and heart rate (Périard et al., 2021) and greater dehydration than athletes in cold climates (Bassett & Howley, 2023). Long-term exposure to high temperatures can also reduce muscle oxygen efficiency and increase cardiac workload, with implications for aerobic capacity (Nybo et al., 2024).

Empirical conditions in the Bima region, West Nusa Tenggara Province, with average daytime and evening temperatures of 29–30°C, indicate that environmental factors may influence athlete performance. Based on initial interviews with football coaches from the Bima Football Association (PERSEBI), 15-year-old athletes tended to experience a decline in performance after the first 45 minutes of play. This indicates limited aerobic capacity, possibly related to athletes' VO_2max achievement under tropical training conditions.

Given these conditions, effective training management is important to support aerobic capacity and minimize environmental impacts on athletes' VO_2max (Crandall & Johnson, 2023). Factors such as blood volume, heart function, thermoregulation efficiency, and body fluid balance are known to influence VO_2max during physical activity (Sawka et al., 2022). In addition, temperature and humidity are related to thermoregulation. In addition, temperature and humidity conditions are also related to thermoregulation aspects (Maunder et al., 2021), energy metabolism (Melin et al., 2024), respiratory system and oxygen utilization (So et al., 2024), and hydration and electrolyte balance (Luetkens et al., 2023), which indirectly affect the athlete's aerobic performance.

In this context, training time is a relevant variable to study, as differences in environmental conditions between morning and evening in tropical regions can affect VO_2max. Lower air temperatures in the morning than in the afternoon improve cardiorespiratory efficiency. Although various studies have examined improvements in VO_2max through training interventions, research comparing VO_2max based on

training time under natural conditions in tropical environments remains limited. This study offers a novel ecological perspective by examining VO_2max differences across naturally occurring training times (morning vs. afternoon) without experimental intervention, in a tropical environment where daily climatic variations may influence aerobic performance.

Thus, this study aims to analyze differences in VO_2max, an indicator of aerobic capacity, among 15-year-old adolescent athletes based on training time in a tropical climate. The results are expected to provide practical contributions to coaches and sports practitioners in designing more optimal training patterns tailored to environmental characteristics.

METHODS

Study Design and Participants

This research is a quantitative, cross-sectional study aimed at comparing VO_2max among 15-year-old soccer athletes based on different training durations in a tropical climate (Bima). The study was an observational, untreated study that observed natural training patterns. The research subjects were 45 soccer athletes from the Bima Football Association (PERSEBI) club, Bima Regency, West Nusa Tenggara, selected by purposive sampling and grouped into 23 athletes in the morning training group and 22 in the afternoon training group, in accordance with the club's routine training schedule. The characteristics of the participants were an average age of 15.31±0.46 years, height of 163.12±4.35 cm, weight of 55.28±3.67 kg, and BMI of 20.78±1.18 kg/m². In general, these characteristics reflect physical conditions within the normal range for 15-year-old male adolescents participating in soccer activities in the Bima area. The study was conducted for one month in October 2025, with training held four times per week according to the club's routine schedule.

Ethical approval statement

All procedures performed in this study adhered to established ethical guidelines for human research, including the Declaration of Helsinki. Ethical clearance was granted by the Research Ethics Committee of STKIP Taman Siswa Bima (approval number: 70/002/STKIP-TSB/LPPM/X/2025). Participants were provided with detailed information regarding the study objectives and potential risks, and written informed consent was obtained prior to data collection.

Research Instruments

The research instrument used a multistage fitness test (Bleep Test) to measure aerobic capacity via VO_2max estimation (ml/kg/min), with this as the only research variable observed from differences in training time. The bleep test has high validity, with a coefficient ranging from 0.90 to 0.95, and is performed by running a 20-meter round-trip at a gradual pace until maximum fatigue. VO_2max values are obtained from the athlete's final level and number of shuttle runs, then converted using a standard table. To minimize bias, all measurements are carried out consistently with uniform procedures, instruments, and environmental conditions.

Procedures

1. Initial Condition Standardization

The data collection process began with a standardization phase, during which all athletes were ensured to be in a relatively uniform physical condition, such as having adequate rest and not engaging in strenuous physical activity within 24 hours of the measurement. This phase aimed to minimize bias that could affect the VO_2max measurement results.

2. Initial Measurements

Initial measurements were conducted at the first meeting, with training times adjusted for each group: 7:00 a.m. for the morning training group and 4:00 p.m. for the afternoon training group. This phase aimed to obtain an initial picture of the athletes' aerobic capacity as a basis for comparison.

3. Training Observation Periode

In the second and third meetings, researchers observed routine training activities conducted according to the club's program. No additional treatment was provided at this stage, so the observed conditions reflected the natural and actual training situation.

4. Implementation of Final Measurements

The final measurements were conducted at the fourth session using the same procedures as the initial measurements, including instruments, location, and timing. Consistency in measurement times (morning remained morning, afternoon remained afternoon) was maintained to minimize the influence of circadian rhythms on athlete performance. The data obtained were then used to analyze the difference in VO_2max between the morning and afternoon training groups as an indicator of the difference.

Data Analysis

The data were analyzed using descriptive analysis to describe the initial data. After that, prerequisite tests were conducted using the Shapiro-Wilk normality test and Levene's test for homogeneity of variances. The final stage was a comparative inferential analysis using an independent-samples t-test. All statistical tests were conducted at a significance level of $p < 0.05$ using IBM SPSS version 25 software.

RESULTS

This study aims to analyze differences in VO_2max values among 15-year-old soccer athletes based on training time in a tropical climate, namely morning and afternoon. The results of the descriptive statistical analysis, which provide a general picture of VO_2max values for 15-year-old soccer athletes after the pretest and posttest, by time group, are shown in Table 1.

Table 1. Results of Descriptive Statistical Analysis of Pretest-Posttest Vo2max of Athletes

Group	Test	N	Mean	Std. Deviation	Minimum	Maximum
Morning Exercise	Pretest	23	38.62	2.11	35.10	42.00
	Posttest	23	43.78	2.34	40.20	47.50
Afternoon Exercise	Pretest	22	37.95	2.08	34.80	41.70
	Posttest	22	42.91	2.29	39.60	46.80

An overview of VO_2max values based on exercise groups is presented in Table 1 above. In general, the data show a difference in average VO_2max values between the

morning and afternoon exercise groups at the final measurement, with the morning group tending to have higher values than the afternoon group. Before conducting the comparison test, the data were first tested for normality using the Shapiro-Wilk test.

Table 2. Result Test of Normality (Shapiro-Wilk)

Group	Statistic	df	Sig.
Morning Exercise	0.11	23	0.11
Afternoon Exercise	0.09	22	0.09

Note: p > 0.05 indicates statistical significance

In Table 2, the Shapiro-Wilk normality test results indicate that all data have p-values greater than 0.05. This indicates that the VO_2max data in both groups are normally distributed, thus meeting the assumptions for parametric analysis. Next, a homogeneity-of-variance test was conducted using Levene's test.

Table 3. Results Levene's for Equality of Variances

	F	df1	df2	Sig.
VO2max Posttest	0.684	1	43	0.412

Note: p < 0.05 indicates statistical significance

The Levene test showed a p-value of 0.412 (p > 0.05) (Table 3), indicating that the variances of the two groups were homogeneous. With the normality and homogeneity assumptions met, the comparative analysis can proceed using the independent-samples t-test. A comparison test was conducted to determine differences in VO_2max values between athletes in each group. Table 4 shows the results of the comparison t-test.

Table 4. Results of the Independent Sample T-test Vo2max of Athletes

Variable	t	df	Sig. (2-tailed)	Mean Difference
VO_2max Posttest	2.14	43	0.04	0.87

Note: p < 0.05 indicates statistical significance

The results of the independent sample t-test showed a t-value of 2.14 with df = 43 and a significance value of p = 0.04 (p < 0.05). This finding indicates a statistically significant difference in VO_2max values between the morning and afternoon exercise groups. The average difference of 0.87 ml/kg/minute indicates that the morning exercise group had a higher VO_2max value than the afternoon exercise group.

Overall, the analysis results showed a difference in VO_2max values between the morning and afternoon training groups in 15-year-old PERSEBI (BIMA FOOTBALL UNIT) soccer athletes. This difference reflects the variance in athletes' VO_2max levels resulting from training time in tropical climates. The morning training group tended to show higher VO_2max values than the afternoon training group, indicating that training time influences athletes' aerobic capacity. Thus, these findings confirm that variations in environmental conditions across different training times can affect athletes' VO_2max, without generalizing these changes to a specific fitness level.

DISCUSSION

The findings of this study indicate that training time is a significant factor in determining differences in athletes' VO_2max values. The superiority of the morning

training group indicates that the relatively more stable environmental conditions in the morning result in a lower thermal load, allowing the cardiovascular system to work more efficiently to meet oxygen demands during physical activity. In this context, circadian rhythms and metabolic efficiency in the morning are thought to contribute to achieving more optimal VO_2max, particularly in tropical climates characterized by high temperatures and humidity. Therefore, the differences found not only reflect variations in VO_2max values but also underscore the importance of synchronizing training time and body condition to support the aerobic performance of adolescent athletes.

These findings align with previous studies that highlight the influence of environmental conditions on VO_2max during physical activity in tropical climates. These bioclimatic conditions involve relatively high temperatures and humidity (Ma et al., 2023). Potentially increased heat load during exercise, particularly in the afternoon, due to accumulated solar radiation. This situation can trigger competition for blood flow between the skin for cooling and skeletal muscles for mechanical activity, ultimately affecting the efficiency of oxygen utilization (Hudain, 2024). Conversely, lower ambient temperatures in the morning provide a more favorable thermal gradient, enabling athletes to maintain physical activity more efficiently.

From a physiological perspective, these findings are also supported by the concept that circadian rhythms influence aerobic metabolism (Bahtra et al., 2023). Although some studies suggest that physical performance can peak in the afternoon, in a tropical climate, higher heat exposure could be a limiting factor (Inzaghi et al., 2025). This condition can increase the risk of dehydration and reduce cardiovascular efficiency, especially in adolescent athletes whose thermoregulatory systems have not yet developed optimally (Plakias et al., 2024). Therefore, training in more moderate environmental conditions, such as early morning, is likely to support VO_2max stability without imposing excessive thermal load (Feng et al., 2024).

In addition, research by Hanief et al. (2025) found that approximately 45% of young soccer athletes exhibit hamstring impulse imbalances, which may increase injury risk. These findings reinforce the notion that adolescent athletes are still in a phase of physiological and neuromuscular development that is vulnerable to training stress. Therefore, timing training sessions that consider environmental conditions is crucial not only to support VO_2max achievement but also to minimize the risk of physical impairment. Other research also shows that pulmonary oxygen diffusion efficiency tends to be higher during early training sessions in high-humidity environments (Clemente et al., 2023), which aligns with this study's findings.

In practice, the results of this study imply that determining training timing should be part of the athlete development program planning in tropical regions. Scheduling training in the morning may be a more adaptive strategy for maintaining VO_2max during training activities. Theoretically, these findings enrich sports science research, particularly regarding the relationship between environmental factors and aerobic performance. This is also relevant to the concept of long-term athlete development (LTAD), which emphasizes adapting training loads to individual and environmental conditions (Kuswoyo, 2023).

Limitations of the study

However, this study has limitations, particularly in controlling for external variables such as athletes' sleep patterns and nutritional intake, which could potentially influence conditions during VO_2max measurements. Furthermore, variations in specific humidity at the study location (Bima) are also dynamic. Future research is recommended to integrate biochemical parametric measurements, such as hemoglobin levels or oxygen saturation, using the latest sensor technology, as recommended by Zoila et al. (2025). In addition, further exploration of the long-term effects of morning training patterns on competitive performance in real soccer matches is needed to expand the generalizability of these findings.

CONCLUSION

This study demonstrates that training time is a contextual factor associated with differences in VO_2max values among adolescent soccer athletes in tropical environments, with morning training tending to provide more favorable conditions than afternoon training, thus resulting in higher VO_2max levels. These findings emphasize the importance of integrating training load and environmental conditions into the planning of athlete development programs. In practice, coaches are advised to prioritize morning aerobic training to optimize VO_2max while minimizing the impact of environmental heat stress. Future research should control for external variables such as sleep patterns, nutritional intake, and hydration. It should also integrate additional physiological measurements and longitudinal designs to gain a more comprehensive understanding of the factors influencing VO_2max in adolescent athletes in tropical regions.

ACKNOWLEDGMENTS

The author would like to thank the coaches, assistant coaches, administrators, and 15-year-old athletes of SSB PERSEBI Bima for their support and participation in this research. Appreciation is also expressed to the Head of STKIP Taman Siswa Bima and LPPM for their financial support through the 2025 Internal Research Grant Program, which enabled this research to be successfully implemented. This article is one of the mandatory outputs of the 2025 STKIP Taman Siswa Bima Internal Research Grant.

AI DISCLOSURE STATEMENT

During the preparation of the manuscript, the authors used ChatGPT-5.3, OpenAI, as an aid in language editing, sentence structure improvement, and scientific narrative development. AI is not used in data collection or analysis. The entire manuscript has been reviewed and edited by the authors, who take full responsibility for the accuracy and integrity of the research.

DATA AVAILABILITY

The datasets generated and analyzed during this study, including VO_2max measurements and statistical analysis results, are available from the corresponding

author upon reasonable request. However, the data are not publicly accessible due to ethical and privacy considerations, as they contain sensitive information about individual adolescent participants' performance.

FUNDING

This research was funded by the 2026 Internal Research Grant Program of STKIP Taman Siswa Bima through funding support distributed by the Institute for Research and Community Service (LPPM) of STKIP Taman Siswa Bima. The funding was used to support research activities, data collection, and the preparation of research outputs in the form of scientific articles.

CONFLICT OF INTEREST

This research was funded by the STKIP Taman Siswa Bima Internal Research Grant Program (2026). The funding body had no role in the study design, data collection, analysis, or interpretation, or in the writing of the manuscript.

PUBLISHER'S NOTE

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors, and the reviewers. Any product that may be evaluated in this article, or a claim its manufacturer may make, is not guaranteed or endorsed by the publisher.

REFERENCES

Altmann, S., Forcher, L., Ruf, L., Beavan, A., Groß, T., Lussi, P., Hartel, S. (2021). Match-related physical performance in professional soccer: Position or player specific. *PLoS ONE*, *16*(9), 22–24. https://doi.org/10.1371/journal.pone.0256695

Ansori, M. K., Sudarko, R. A., Primasoni, N., Widodo, H., & Anggraeni, E. (2024). Effect of small-sided game versus high-intensity interval training method in increasing anaerobic endurance in youth football athletes (15-17 years). *Pedagogy of Physical Culture and Sports*, *28*(5), 353–359. https://doi.org/10.15561/26649837.2024.0503

Apriantono, T., Herman, I., Juniarsyah, A. D., Hasan, M. F., Ihsani, S. I., Hidayat, I. I., Hindawan, I. (2020). The effect of temperature and humidity on VO2max of PPLP athletes in Java, Indonesia. *Sportif : Jurnal Penelitian Pembelajaran*, *6*(1), 59–68. https://doi.org/10.29407/js_unpgri.v6i1.13872

Bahtra, R., Crisari, S., Dinata, W. W., Susanto, N., & Andria, Y. (2023). VO 2 Max in Soccer Players : Comparison of Interval Training and Continuous Running. *JOSSAE (Journal of Sport Science and Education)*, *8*(1), 46–53. https://doi.org/10.26740/jossae.v8n1.p46-53

Bassett, D. R., & Howley, E. T. (2023). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine and Science in Sports and Exercise*, *32*(1), 70–84. https://doi.org/10.1097/00005768-200001000-00012

Clemente, F. M., Moran, J., Ramirez-campillo, R., Beato, M., Verlag, G. T., Sciences, E., Ireland, N. (2023). Endurance Performance Adaptations between

SSG and HIIT in Soccer Players : A Meta-analysis Authors. *International Journal of Sports Medicine*, *45*(3), 183–209. https://doi.org/10.1055/a-2171-3255

Crandall, C. G., & Johnson, J. M. (2023). The cardiovascular challenge of exercising in the heat. *The Journal of Physiology*, *586*(1), 45–53. https://doi.org/10.1113/jphysiol.2007.142158

Feng, D., Li, L., Xu, Q., & Li, T. (2024). Heliyon Evaluating the impact of a combined aerobic and strength training intervention on the physical performance of male Chinese People ' s Liberation Army air force pilots. *Heliyon*, *10*(11), 32177. https://doi.org/10.1016/j.heliyon.2024.e32177

Firdaus, F., & Irfan, I. (2023). The Effect of Bocce Games on the Physical Fitness of Children with Grahita SLB AL-GIFARI During the Covid-19 Pandemic. *Journal of Physical and Outdoor Education*, *5*(1), 27–36. https://doi.org/10.37742/jpoe.v5i1.200

Hanief, Y. N., Sumartiningsih, S., Rahayu, S., & Setyawati, H. (2025). Neuromuscular hamstring profile based on strength imbalance as a basis for injury prevention in youth football players. *Indonesian Journal of Research in Physical Education, Sport, and Health (IJRPESH)*, *3*(2), 107–115. https://doi.org/10.17977/um086v3i22025p107-115

Hudain, M. A. (2024). Journal Sport Area Aerobic training as an approach to increasing VO2max in amateur football athletes. *Jurnal Sport Area*, *9*(2),207–216. https://doi.org/10.25299/sportarea.2024.vol9(2).15338

Inzaghi, M F, Sulastio, A, & Aspa, A. P. (2025). Pengaruh Latihan Interval Training terhadap Peningkatan VO2Max Siswa Sekolah Sepak Bola (SSB) Prima Taruna U-15 Kabupaten Indragiri Hulu. *Journal Sport Science Indonesia*, *4*(2), 48–58. https://doi.org/10.31258/jassi.4.2.48-58

Kuswoyo, D. D., & L. (2023). The effects of high-intensity interval training (HIIT) in improving VO2 max football student activity unit, University of Musamus. *Enfermería Clínica*, *30*, 507-511. https://doi.org/10.1016/j.enfcli.2019.10.130

Luetkens, J. A., Voigt, M., Faron, A., Isaak, A., Mesropyan, N., Dabir, D., Thomas, D. (2023). Influence of hydration status on cardiovascular magnetic resonance myocardial T1 and T2 relaxation time assessment: An intraindividual study in healthy subjects. *Journal of Cardiovascular Magnetic Resonance*, *22*(1), 63. https://doi.org/10.1186/s12968-020-00661-9

Ma, X., Cao, Z., Zhu, Z., Chen, X., & Wen, D. (2023). Heliyon Review article VO 2 max (VO 2 peak) in elite athletes under high-intensity interval training : A meta-analysis. *Heliyon*, *9*(6), e16663. https://doi.org/10.1016/j.heliyon.2023.e16663

Maunder, E., Plews, D. J., Wallis, G. A., Brick, M. J., Wee-, W. B. L., Chang, L., Kilding, A. E. (2021). Temperate performance and metabolic adaptations following endurance training performed under environmental heat stress. *Physiological Reports*, *9*(9), 1–14. https://doi.org/10.14814/phy2.14849

Melin, A. K., Areta, J. L., Heikura, I. A., Stellingwerff, T., Torstveit, M. K., & Hackney, A. C. (2024). Direct and indirect impact of low energy availability on sports performance. *Scandinavian Journal of Medicine and Science in Sports*, *34*(1), 1–23. https://doi.org/10.1111/sms.14327

Nybo, L., Rasmussen, P., & Sawka, M. N. (2024). Performance in the heat—physiological factors of importance for hyperthermia-induced fatigue.

Comprehensive Physiology, *4*(2), 657–689. https://doi.org/10.1002/j.2040-4603.2014.tb00554

Pelletier, C. A., Pousette, A., Ward, K., Keahey, R., Fox, G., Allison, S., Faulkner, G. (2023). Implementation of Physical Activity Interventions in Rural , Remote , and Northern Communities : A Scoping Review. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing, 57,* 0046958020935662. https://doi.org/10.1177/0046958020935662

Périard, J. D., Eijsvogels, T. M., & Daanen, H. A. (2021). Exercise Under Heat Stress : Thermoregulation, Hydration, Performance Implications, and Mitigation Strategies Exercise Under Heat Stress : Thermoregulation , Hydration. *Physiological Reviews*, *101*(4), 1873–1979. https://doi.org/10.1152/physrev.00038.2021

Plakias, S., Tsatalas, T., Mina, M. A., Kokkotis, C., Flouris, A. D., & Giakas, G. (2024). The Impact of Heat Exposure on the Health and Performance of Soccer Players : A Narrative Review and Bibliometric Analysis. *Sports*, *12*(9), 1–14. https://doi.org/10.3390/sports12090249

Prembanyu, P. H., & Wiyanto, A. (2025). Impact of five-cone and ladder drill training on agility among U15 football athletes, *4*, 266–274. https://doi.org/10.56003/pessr.v4i3.613

Sawka, M. N., Leon, L. R., Montain, S. J., & Sonna, L. A. (2022). Integrated physiological mechanisms of exercise performance, adaptation, and maladaptation to heat stress. *Comprehensive Physiology*, *1*(4), 1883–1928. https://doi.org/10.1002/j.2040-4603.2011.tb00385

Simanjuntak, V., Rahayu, T., & Yudhistira, D. (2022). Analysis of Body Mass Index and Physical Condition of Martial Athletes in West Kalimantan Province: Study towards PON 2021. *International Journal of Human Movement and Sports Sciences*, *10*(4), 768–774. https://doi.org/10.13189/saj.2022.100417

Sitompul, S. R., Yulianingsih, I., & Fajriansyah, M. N. S. (2025). The Impact of HIIT type II on endurance optimization in young amateur futsal players. *Jurnal SPORTIF : Jurnal Penelitian Pembelajaran*, *11*(1), 32–49. https://doi.org/10.29407/js_unpgri.v11i1.24780

So, C. L., Cheung, C. Y., Zheng, Y. P., Kwok, M. Y., Man, Y. K., Mok, T., Ng, S. M. (2024). Effect of moderate-intensity aquatic treadmill exercise on cognitive function and cerebral blood flow for healthy older adults. *Experimental Gerontology*, *197*(9), 112–605. https://doi.org/10.1016/j.exger.2024.112605

Zoila, F., Filannino, F. M., Panaro, M. A., Sannicandro, I., Cianciulli, A., & Porro, C. (2025). Enhancing active aging through exercise : a comparative study of high-intensity interval training and continuous aerobic training benefits. *Frontiers in Aging*, *2*(6), 1–14. https://doi.org/10.3389/fragi.2025.1493827