

The effect of a 12-week in-season combined training program on aerobic capacity of young soccer players

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Abstract

Purpose: The purpose of this study was to examine the effects of a 12-week in-season combined training program on aerobic performance in young soccer players. **Methods:** Forty-eight U15 male soccer players (14–15 years) participated in this study. Participants were divided into three groups: a Combined Fitness Training Group (CFTG; n = 16), a Soccer Training Group (STG; n = 16), and a Control Group (CG; n = 16). The intervention was conducted during the competitive season and consisted of four weekly training sessions and one official match. The CFTG followed a combined training program in addition to soccer training with functional strength training, sprint development, change-of-direction (COD) drills, and intermittent aerobic training, while the STG followed a program with physical condition being trained only with soccer training. Aerobic performance was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), recording performance level, final running velocity, total distance, and estimated VO₂max. A repeated-measures MANOVA (Group × Time) was applied. **Results:** Significant Group × Time interactions were observed for all aerobic variables (p < 0.001). The CFTG showed greatest improvements in Yo-Yo level (+25.83%), total distance (+62.64%), final velocity (+6.35%), and estimated VO₂max (+11.97%), with large to very large effect sizes (partial η² = 0.137–0.566). The STG showed smaller but significant improvements, whereas the CG demonstrated no meaningful changes. **Conclusion:** An in-season combined training program significantly enhances intermittent aerobic performance in young soccer players compared with soccer-only training. These findings support the integration of targeted conditioning strategies within competitive-season microcycles in youth soccer academies.

Keywords: Aerobic performance, Yo-Yo IR1, high-intensity interval training, youth soccer, in-season training, combined training

Introduction

Soccer involves repeated periods of intense activity alternating with periods of lower intensity movement. During a match, players frequently perform sprints, rapid accelerations and decelerations, changes of direction, and technical skills, all interspersed with phases of active recovery. Although short, high-intensity anaerobic actions are often decisive in goal-scoring situations, aerobic energy production predominates throughout the 90 minutes of play, with athletes typically performing at around 70–80% of their maximal oxygen uptake (VO₂max) (Stølen et al., 2005; Bangsbo et al., 2006). Furthermore, the aerobic system is essential for phosphocreatine restoration, lactate removal, and sustaining performance during repeated high-intensity efforts (Mohr et al., 2003; Krstrup et al., 2006; Bangsbo et al., 2008). Recent match-analysis research also highlights that a well-developed aerobic capacity supports the maintenance of high-intensity running and repeated sprint performance across competitive matches (Modrić et al., 2021; Morgans et al., 2023).

In youth soccer, the development of aerobic capacity is particularly important, as adolescence represents a sensitive period for cardiorespiratory adaptation due to ongoing maturation processes. Improvements in aerobic fitness may positively influence both performance and long-term athletic progression (Lloyd & Oliver, 2012; Malina et al., 2015). Furthermore, enhanced aerobic capacity has been associated with greater total distance covered, increased high-intensity running distance, and improved recovery between high-intensity bouts during match play (Helgerud et al., 2001; Castagna et al., 2009; Deprez et al., 2015). Systematic

reviews in youth athletes also suggest that high-intensity interval training (HIIT) is effective for improving aerobic and intermittent endurance performance during adolescence (Matzka et al., 2025).

The Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) is one of the most valid and practical field-based tools for assessing soccer-specific aerobic endurance (Bangsbo et al., 2008). Performance in the Yo-Yo IR1 correlates strongly with high-intensity running distance during matches and has been shown to be sensitive to training-induced adaptations (Krustrup et al., 2003; Schmitz et al., 2018). More recent evidence confirms its applicability in youth and academy settings as a reliable indicator of intermittent endurance and training responsiveness (Tan et al., 2025). Consequently, it represents a useful performance indicator in youth academies.

However, maintaining or improving aerobic capacity during the competitive season presents a methodological challenge. In-season training is constrained by match frequency, recovery demands, and tactical preparation priorities. Excessive additional conditioning may increase fatigue and injury risk, whereas insufficient aerobic stimulus may lead to performance stagnation or decline. Contemporary training load research highlights the importance of appropriate microcycle structure, intensity distribution, and exposure to high-intensity efforts during the competitive season (Morgans et al., 2023; Nobari et al., 2021). Therefore, integrated or combined training approaches — in which strength, high-intensity intermittent efforts, and soccer-specific drills are structured synergistically — have been proposed as an efficient alternative to isolated endurance training models (Buchheit & Laursen, 2013; Blechschmied et al., 2024).

Previous research has demonstrated that high-intensity aerobic training can improve VO_2max and match performance in soccer players (Helgerud et al., 2001; Buchheit & Laursen, 2013). Similarly, Small-Sided games and sport-specific high-intensity drills have been shown to elicit substantial aerobic responses and improve intermittent endurance performance (Bangsbo et al., 2008; Hill-Haas et al., 2011; Rahmoune et al., 2025). Additionally, recent in-season HIIT interventions in youth soccer players have reported improvements in Yo-Yo IR1 performance without detrimental effects on neuromuscular measures (Thomakos et al., 2024). Nevertheless, evidence regarding structured combined conditioning models implemented systematically during the in-season period in adolescent players remains limited. Most studies have focused either on pre-season interventions, isolated modalities, or adult populations.

Material & Methods

Participants

Forty-eight young male soccer players (age 14–15 years) from a competitive soccer academy participated in the study, and divided into three groups: Combined Fitness Training Group (CFTG; $n = 16$), Soccer Training Group (STG; $n = 16$), Control Group (CG; $n = 16$). Following an analytical explanation of the study's goals, and procedures, the participants signed a written consent form and answered a series of medical questions. All participants were active football players in youth academy teams (U15) that competed in the local development league and were free from injury and actively competing during the intervention period. (**Table 1**)

Table 1. Participants' Characteristics at Baseline

Variable	CFTG ($n = 16$)	STG ($n = 16$)	CG ($n = 16$)
Age (years)	14.8 ± 0.4	14.7 ± 0.5	14.8 ± 0.3
Height (cm)	168.4 ± 6.2	169.1 ± 5.8	167.9 ± 6.5
Body Mass (kg)	59.3 ± 5.4	60.1 ± 6.0	58.7 ± 5.8
Training Experience (years)	4.1 ± 1.2	4.3 ± 1.0	4.0 ± 1.3

CFTG, combined fitness training group; STG, soccer training group; CG, control group; n , number.

Study Design

Before the intervention begins the height of participants was estimated as previously described (19). Also, the body mass of participants was measured as previously described (19). A 12-week intervention program of four mesocycles of three weeks each, during in-season using a pre–post repeated-measures design. Assessments were conducted one week prior to the intervention (Pre) and immediately after completion of the 12-week program (Post). A Group $\times$ Time repeated-measures analysis was applied to determine differential adaptations between groups.

Training Intervention

The intervention lasted 12 weeks (**Table 2**) and consisted of four mesocycles of three weeks each. Each week included four training sessions and one official match. The Combined Fitness Training Group (CFTG) followed a combined training model that included functional strength training (core and lower-limb strength circuits), speed and sprint development, change-of-direction and agility drills, intermittent aerobic training (4×4 min at $80\% \text{ vVO}_{2\text{max}}$), Small-Sided games (1v1–6v6 formats), and large-sided tactical games (7v7–11v11), with the program incorporating planned progressive overload across mesocycles, while the Soccer Training Group (STG) followed the standard soccer training program of the academy, which included technical–tactical drills, small-sided games (1v1–6v6 formats), large-sided tactical games (7v7–11v11), and match preparation

sessions, with no strength, sprint, or specific aerobic conditioning protocols implemented outside of soccer-specific drills.

Table 2. Weekly Microcycle Comparison

Day	CFTG	STG
Monday	25' Functional strength + core 55' Technical Session	80' Technical-Tactical session
Tuesday	35' Speed & sprint development 40' Technical – Tactical -Drills	75' Technical – Tactical drills
Wednesday	25' Intermittent aerobic training (4 × 4 min at 80% vVO ₂ max) 60' Tactical Session	85' Technical - Tactical session
Thursday	Small-sided games – Tactical Session	Small-sided games – Tactical Session
Saturday	Official match	Official match

CFTG, combined fitness training program; STR, soccer training program; vVO₂max, velocity at maximal oxygen uptake.

Aerobic Performance Assessment

Aerobic performance was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Testing was conducted twice: one week prior to the intervention (Pre) and immediately after the 12-week training period (Post). All tests were performed on the same outdoor soccer field under standardized environmental conditions. Participants were instructed to avoid strenuous activity 24 hours prior to testing. A standardized warm-up preceded each assessment session.

The following performance variables were recorded: Yo-Yo performance level, Final running velocity (vVO₂max), Total distance covered (m), Estimated maximal oxygen uptake (VO₂max) (**Table3**)

Table 3. YO-YO IR1 performance variables

Variable	Code Used	Unit	Description
Final Running Velocity	vVO₂max	km·h ⁻¹	Running speed at test termination
Total Distance Covered	YY_Distance	m	Total distance covered during the test
Estimated VO ₂ max	VO₂max_est	ml·kg ⁻¹ ·min ⁻¹	Predicted maximal oxygen uptake derived from Yo-Yo IR1 performance

Statistical Analysis

Data were analyzed using SPSS (version 25). One-way ANOVA was used to verify baseline homogeneity. Repeated-measures ANOVA (Group × Time) was applied to determine interaction effects and paired t-tests were used for within-group comparisons. Statistical significance was set at $p \leq 0.05$.

Results

For velocity (km·h⁻¹), significant improvements were observed in both intervention groups, particularly in the CFTG group. The CFTG group increased from 15.3 ± 0.7 to 16.2 ± 0.6 ($t = -10.040$, $p < 0.001$), corresponding to a +6.35% change. The STG group showed a smaller but statistically significant increase from 15.2 ± 0.5 to 15.4 ± 0.4 ($t = -4.392$, $p = 0.001$), with a +1.86% change. Statistical differences among CFTG and STG and CG also showed after the intervention program with better improvements for the CFTG group ($p = 0.000$). The CG group demonstrated a minimal and non-significant improvement from 14.9 ± 0.7 to 15.0 ± 0.6 ($t = -0.752$, $p = 0.464$), corresponding to a +1.05% change. (**Figure 1**)

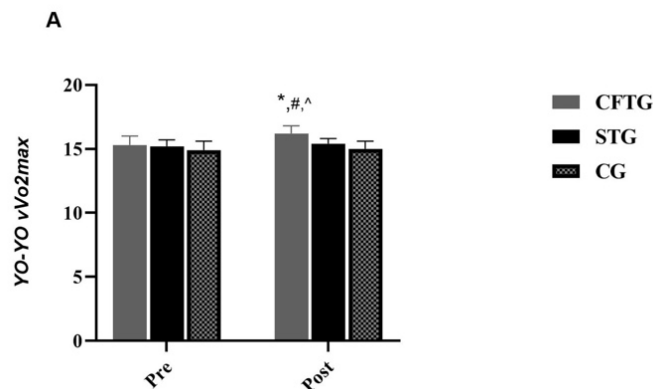


Figure 1. Changes in YO-YO Test vVo₂max. Means and standard deviations are presented via vertical bars (N = 46). * Differences between pre and post timepoints, # Differences among CG and CFTG and STG, ^Differences between CFTG and STG.

For total distance (m), both intervention groups showed substantial improvements, with the CFTG group demonstrating the largest increase. Specifically, CFTG improved from 1023.8 ± 400.3 m to 1665.0 ± 414.4 m ($t = -12.277$, $p < 0.001$), corresponding to a +62.64% change. The STG group also showed a significant

increase from 1071.3 ± 315.6 m to 1370.0 ± 275.1 m ($t = -3.993$, $p = 0.001$), with a +27.89% change. Statistical differences among CFTG and STG and CG also showed after the intervention program with better improvements for the CFTG group ($p = 0.000$). The CG group showed a smaller, non-significant improvement from 837.5 ± 383.3 m to 953.8 ± 434.6 m ($t = -1.930$, $p = 0.073$), corresponding to a +13.88% change. (**Figure 2**).

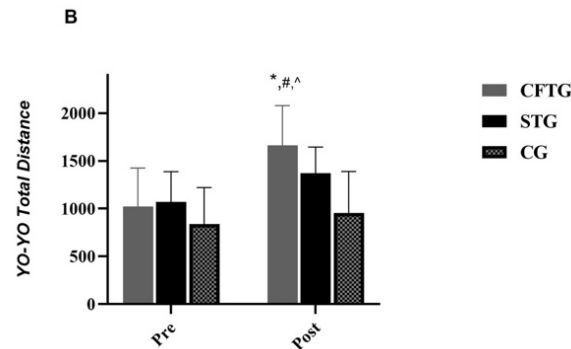


Figure 1. Changes in YO-YO Test Total Distance. Means and standard deviations are presented via vertical bars (N = 46). * Differences between pre and post timepoints, # Differences among CG and CFTG and STG, ^Differences between CFTG and STG.

For estimated $\text{VO}_{2\text{max}}$ ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$), both intervention groups again showed significant improvements, with the CFTG group demonstrating the greatest enhancement. The CFTG group improved from 45.00 ± 3.36 to 50.39 ± 3.48 ($t = -12.282$, $p < 0.001$), corresponding to a +11.97% change. The STG group showed a smaller but significant increase from 45.40 ± 2.65 to 46.23 ± 2.31 ($t = -3.998$, $p = 0.001$), with a +1.83% change. Statistical differences among CFTG and STG and CG also showed after the intervention program with better improvements for the CFTG group ($p = 0.000$). In contrast, the CG group demonstrated a slight, non-significant improvement from 43.50 ± 3.20 to 44.10 ± 3.20 ($t = -1.627$, $p = 0.125$), corresponding to a +1.38% change. (**Figure 3**)

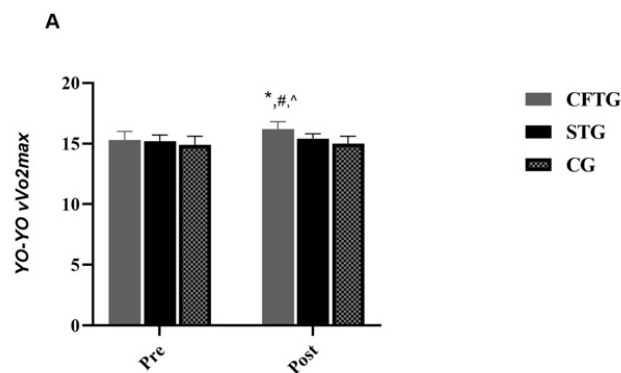


Figure 1. Changes in YO-YO Test estVo2max. Means and standard deviations are presented via vertical bars (N = 46). * Differences between pre and post timepoints, # Differences among CG and CFTG and STG, ^Differences between CFTG and STG.

Discussion

Why combined training can work in-season

Combined approaches may succeed because they increase overall exposure to targeted aerobic stimuli without requiring large additional session volumes, and integrating intermittent endurance, strength, and soccer-specific work. The effectiveness of combined models depends on program design—work density, intensity control, recovery allocation, and sequencing. Recent experimental evidence in young soccer players highlights that the sequencing of strength and intermittent endurance within a session can influence training outcomes, underscoring the importance of microcycle structure and session order (Blechschiemied et al., 2024). When strength and intermittent endurance are appropriately integrated, the feared “interference effect” may be minimized, while players still achieve robust aerobic improvements.

Comparison with HIIT and SSG-based evidence

In-season supplementary HIIT is useful because it is a time-efficient, high-potency aerobic stimulus. Recent in-season work shows that short-format HIIT can improve endurance outcomes and Yo-Yo IR1 performance without negative effects on neuromuscular performance, suggesting compatibility with competition

when dosing is appropriate (Thomakos et al., 2024). The present findings align with that premise: aerobic qualities can improve in-season when high-intensity intermittent exposure is systematically implemented. A recent youth-athlete meta-analysis indicates that HIIT can outperform some comparators for aerobic and intermittent endurance improvements, but effects vary according to the nature of the control intervention and program characteristics (Matzka et al., 2025). Combined training models can be interpreted as a “hybrid” approach—incorporating HIIT-like intermittent elements, potentially within soccer-specific contexts, and supported by strength work that may enhance movement economy and fatigue resistance.

Similarly, SSG training is widely used in soccer because it integrates technical, tactical, and physical components. Recent controlled work continues to report positive effects of SSG-driven interventions on physical capacities, including aerobic-related outcomes, alongside benefits for engagement (Rahmoune et al., 2025). The combined approach in the present study may share mechanisms with SSG training (high intermittent intensity + decision-making + repeated accelerations), while also providing more structured conditioning doses and supplementary strength/core work.

Role of in-season load distribution and monitoring

Another explanation for the observed adaptations is that the combined program provided a clearer and more consistent high-intensity stimulus within the weekly microcycle compared with typical training routines. In-season monitoring research shows that load distribution across the week and across seasons can differ between age groups and levels, potentially influencing development of fitness qualities (Morgans et al., 2023). In professional contexts, evidence also suggests that exposure to high-intensity bouts during key training days is important for maintaining fitness during the in-season (Modrić et al., 2021). Thus, the present program may have improved aerobic outcomes by strategically increasing the frequency/quality of intermittent high-intensity exposures while still respecting match demands.

Practical implications for academies

For youth academies, the current findings support the use of structured in-season combined training as a pragmatic strategy to enhance intermittent endurance without relying on high volumes of continuous running. Practitioners may consider, retaining soccer-specific conditioning elements (e.g., SSGs, intermittent drills), supplementing with short, high-intensity running formats when needed, and integrating strength/core work to support robustness and movement quality. The evidence base indicates that both HIIT-style interventions and combined/concurrent approaches can work in youth populations when appropriately implemented (Thomakos et al., 2024; Blechschmied et al., 2024; Matzka et al., 2025).

Conclusion

In summary, the findings demonstrate that a structured 12-week in-season combined training program can substantially enhance Yo-Yo IR1-derived aerobic performance in adolescent soccer players. These results add applied support to the growing evidence that well-designed intermittent conditioning—delivered through combined or integrated approaches—can improve aerobic qualities during the competitive season in youth soccer.

Declaration of generative AI and AI-assisted technologies in the writing process. During the preparation of this work, Corresponding Author, Stergios N. Komsis used ChatGPT (OpenAI) to enhance the quality of figures and to assist with the refinement of formal English translations where appropriate. Following the use of this tool, all generated content was carefully reviewed and edited by the author, who assumes full responsibility for the accuracy and integrity of the final publication.

Reference

- Bangsbo, J., Iaia, F. M., & Krstrup, P. (2008). The Yo-Yo intermittent recovery test: A useful tool for evaluation of physical performance in intermittent sports. *Sports Medicine*, 38(1), 37–51. <https://doi.org/10.2165/00007256-200838010-00004>
- Bangsbo, J., Mohr, M., & Krstrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of Sports Sciences*, 24(7), 665–674. <https://doi.org/10.1080/02640410500482529>
- Blechschmied, R., Hermse, F., Hotfiel, T., Kellmann, M., Mayer, F., & Engel, F. A. (2024). Sequencing effects of concurrent strength and intermittent endurance training on selected measures of physical fitness in young male soccer players: A randomized matched-pairs trial. *Sports Medicine – Open*, 10, 26. <https://doi.org/10.1186/s40798-024-00726-4>
- Buchheit, M., & Laursen, P. B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I and II. *Sports Medicine*, 43(5), 313–338 & 339–356. <https://doi.org/10.1007/s40279-013-0029-x>
- Castagna, C., Impellizzeri, F. M., Cecchini, E., Rampinini, E., & Alvarez, J. C. B. (2009). Effects of intermittent-endurance fitness on match performance in young male soccer players. *Journal of Strength and Conditioning Research*, 23(7), 1954–1959. <https://doi.org/10.1519/JSC.0b013e3181b7f743>

- Deprez, D., Valente-dos-Santos, J., Coelho-e-Silva, M. J., Lenoir, M., Philippaerts, R., & Vaeyens, R. (2015). Longitudinal development of explosive leg power from childhood to adulthood in soccer players. *International Journal of Sports Medicine*, 36(8), 672–679. <https://doi.org/10.1055/s-0034-1398571>
- Helgerud, J., Engen, L. C., Wisløff, U., & Hoff, J. (2001). Aerobic endurance training improves soccer performance. *Medicine & Science in Sports & Exercise*, 33(11), 1925–1931. <https://doi.org/10.1097/00005768-200111000-00019>
- Hill-Haas, S. V., Dawson, B., Impellizzeri, F. M., & Coutts, A. J. (2011). Physiology of small-sided games training in football: A systematic review. *Sports Medicine*, 41(3), 199–220.
- Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The Yo-Yo intermittent recovery test: Physiological response, reliability, and validity. *Medicine & Science in Sports & Exercise*, 35(4), 697–705. <https://doi.org/10.1249/01.MSS.0000058441.94520.32>
- Krustrup, P., Mohr, M., Ellingsgaard, H., & Bangsbo, J. (2006). Physical demands during an elite female soccer game: Importance of training status. *Medicine & Science in Sports & Exercise*, 38(7), 1242–1248. <https://doi.org/10.1249/01.mss.0000227302.76194.06>
- Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength and Conditioning Journal*, 34(3), 61–72. <https://doi.org/10.1519/SSC.0b013e31825760ea>
- Malina, R. M., Rogol, A. D., Cumming, S. P., Coelho-e-Silva, M. J., & Figueiredo, A. J. (2015). Biological maturation of youth athletes: Assessment and implications. *British Journal of Sports Medicine*, 49(13), 852–859. <https://doi.org/10.1136/bjsports-2015-094623>
- Matzka, M., Lenk, M., Meixner, B., & Sperlich, B. (2025). Meta-analysis of high-intensity interval training versus alternative training methods for enhancing aerobic and anaerobic endurance in youth athletes. *Physiological Reports*, 13(19), e70598. <https://doi.org/10.14814/phy2.70598>
- Modrić, T., Jeličić, M., & Sekulić, D. (2021). Relative training load and match outcome: Are professional soccer players actually undertrained during the in-season? *Sports*, 9(10), 139. <https://doi.org/10.3390/sports9100139>
- Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences*, 21(7), 519–528.
- Morgans, R., Adams, D., Mullen, T., McLellan, C., Williams, M. D. (2023). Quantification of training load across two competitive seasons in elite senior and youth male soccer players. *Biology of Sport*, 40(4), 1029
- Nobari, H., Oliveira, R., Clemente, F. M., Pérez-Gómez, J., & Ardigo, L. P. (2021). Weekly training load monitoring in professional soccer players: A systematic review. *International Journal of Environmental Research and Public Health*, 18(15), 8070.
- Rahmoune, M. A., Selmi, O., Bouali, S., Bouassida, A., Alexe, D. I., Aldhahi, M. I., Cojocaru, A. M., Ștef, M. (2025). Effects of small-sided games and dribbling circuit training on physical and technical performance in youth soccer players. *Scientific Reports*, 15, Article 31382.
- Schmitz, B., Pfeifer, C., Kreitz, K., Borowski, M., Faldum, A., & Brand, S.-M. (2018). The Yo-Yo intermittent tests: A systematic review and structured compendium of test results. *Frontiers in Physiology*, 9, 870.
- Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: An update. *Sports Medicine*, 35(6), 501–536. <https://doi.org/10.2165/00007256-200535060-00004>
- Tan, Z., Castagna, C., Krustrup, P., Wong, D. P., Póvoas, S., Boullosa, D., Xu, K., & Cuk, I. (2025). Exploring the use of 5 different Yo-Yo tests in evaluating VO₂max and fitness profile in team sports: A systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports*, 35(5), e70054.
- Thomakos, P., Tsekos, P., Tselios, Z., Spyrou, K., Katsikas, C., Tsoukos, A., & Bogdanis, G. C. (2024). Effects of in-season supplementary short high-intensity interval training on endurance performance in soccer players. *Journal of Sports Science & Medicine*, 23(4), 812–821.