



Combining High-Intensity Interval Training and Game-Based Approach to Enhance Aerobic Endurance in Amateur Futsal Athletes

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Abstract

Background. Futsal players require a holistic training model that combines high-intensity interval training with a game-based approach, addressing their need to cover a total distance of 4000 meters at maximum aerobic speed.

Objectives. This study aimed to analyze the effect of combining high-intensity interval training with a game approach on the aerobic ability of amateur futsal athletes.

Materials and methods. This study used an experimental method. A total of 32 male futsal athletes from amateur clubs participated in this study, with an age of 17.00 ± 1.10 years, a height of 167.19 ± 3.80 cm, a body mass of 58.81 ± 3.80 kg, and a BMI of 21.05 ± 1.26 . Data analysis used the Wilcoxon signed-rank test and the Mann-Whitney U test, with a significance level of 0.05. The total distance covered and the VO_{2max} level of the sample were measured using a 12-minute Cooper test instrument.

Results. The statistical analysis using the Wilcoxon and Mann-Whitney tests revealed that the Experimental Group (EG) showed significant enhancements in both Total Distance (TD) and VO_{2max} ($p < 0.0001$ for both), while the Control Group (CG) did not ($p = 0.0747$ for TD, $p = 0.0701$ for VO_{2max}). The Mann-Whitney test confirmed that the EG's improvements were significantly more marked than the CG's ($p < 0.0001$ for both variables). The percentage improvements between the pre-test and post-test show that in the EG, TD increased by 8.12%, and VO_{2max} increased by 10.44%. In contrast, the CG demonstrated only a 1.11% increase in TD and a 1.44% increase in VO_{2max} .

Conclusions. These findings concluded that combining a high-intensity interval training model with a game approach had a positive effect on the aerobic endurance of amateur futsal athletes.

Keywords: combination training, high-intensity interval training, game approach, aerobic, futsal amateur.

Introduction

In recent decades, the characteristics of the futsal game have evolved significantly, characterized by high game intensity and players who are more flexible in changing or rotating positions (Iván-Baragaño et al., 2022; Spyrou et al., 2020). Research studies investigating this sport modality

have also increased significantly over the last two decades (Barbero-Alvarez et al., 2008; Castagna et al., 2009; De Oliveira Bueno et al., 2014; Ohmuro et al., 2020), which contribute to a better understanding of the physical needs of players, the technical and tactical skills of players during the match, as well as the preparation of futsal training materials. According to the research study above, the average total distance traveled by futsal players in one match is around 4000-4500 meters, of which 8-13% is done in high-speed running ($HSR > 15.5$ km/h) and 5-9% is done in sprinting (> 18.3 km / h). Statistical data analysis can be practically beneficial in designing training programs, as match analysis is highly useful for developing specific training programs

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that resemble the physiological conditions of the game (Di Salvo et al., 2007).

Aerobic endurance is an essential modality to support the characteristics of playing futsal with high intensity because, with aerobic endurance, players will be helped to avoid fatigue or decreased performance, especially at the end of the match session (Glänzel et al., 2020; Milanez et al., 2011). There are previous research studies on physical training in futsal, such as (Campos et al., 2021; Laursen, 2010; Saleh et al., 2021) related to the high-intensity interval training model. Although this training model positively impacts physical abilities, it primarily focuses on physical improvement, potentially neglecting the development of technical and tactical skills essential for compelling gameplay. To address the gap identified in the study, researchers have developed new methods to overcome the issue. These innovative approaches aim to fill the existing void and enhance the overall understanding of the subject matter. By implementing these methods, researchers hope to achieve more accurate and relevant outcomes, ultimately contributing to the advancement of knowledge in this field and aligning with previous research that explains that futsal has a specific development of game dynamics, such as offensive (4-in-line) and defensive (pressure throughout the zone) (Naser et al., 2017).

In a sports coaching survey by Thompson (2023), high-intensity interval training is the most popular method to improve physical abilities, especially aerobic endurance. Research has shown that high-intensity interval training positively impacts players' aerobic endurance (Helgerud et al., 2007). Given the very high physical demands during the game, combining high-intensity interval training with game training adjusted to an average total distance of 4000 meters is important (Ribeiro et al., 2020). Therefore, it is necessary to scientifically study the impact of combining these exercises to meet specific futsal training needs. The results of this study can help coaches and players design more effective training programs that combine physical, technical, and tactical components according to the needs of players in a match. This study can also provide valuable insights into how futsal games at the amateur level can improve.

Materials and Methods

Study Participants

Thirty-two male futsal athletes from amateur clubs participated in this study. They were 17.00 ± 1.10 years old, 167.19 ± 3.80 cm tall, 58.81 ± 3.80 kg in body mass, and 21.05 ± 1.26 in BMI. All samples involved in this study had 1 year of physical training experience. The researchers randomly divided the sample into an experimental group (EG) and a control group (CG)

Study Organization

The researchers administered a pretest to the experimental and control groups to determine their initial aerobic endurance ability. Furthermore, the experimental group was given high-intensity interval training treatment with a game approach for four weeks with a frequency of three times a week. The control group was not given any

special treatment but continued to undergo training with the same duration and frequency as the experimental group. After four weeks of training, in the last week, the experimental and control groups were given a post-test to determine the difference in aerobic endurance ability with high-intensity interval training with a game approach. This study used the 12-minute Cooper Test. The 12-minute Cooper Test variables analyzed were VO_{2max} .

Training Program

The training program involves two groups of players, each consisting of 8 people, with a High-Intensity Interval Training (HIIT) approach that combines games and fast dribbling. Group 1, consisting of 8 players, trains in a four vs four with game format in a 15×15 meter area. Meanwhile, Group 2 undergoes fast dribbling training with a distance of 40 meters, repeated 10 times so that the total distance covered reaches 400 meters. After completing their respective tasks, the two groups switch roles, with a rest time equal to the duration required to complete the 400-meter dribble. Each player will complete five games and five fast dribbling sets in one training session. Thus, each player will cover a total distance of around 2000 meters, and the entire group will cover a distance of 4000 meters.

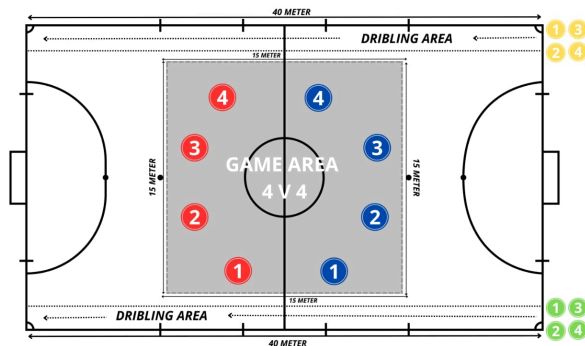


Fig. 1. HIIT Training and Game Combination Area

This program aims to improve the players' maximal aerobic capacity by emphasizing high intensity and high training volume. The combination of four vs four with games in a small area and fast dribbling in the HIIT pattern encourages players to work at high intensity repeatedly, which is very effective in increasing VO_{2max} (maximal oxygen consumption). This training aims to increase the players' cardiorespiratory system efficiency, improve their aerobic endurance, and optimize recovery between periods of intensive work, helping them achieve optimal levels of maximal aerobic capacity.

Statistical Analysis

This study presents the data as means and standard deviations and uses the Shapiro-Wilk test to assess normality. The researchers used the Wilcoxon test for non-normally distributed data and the Mann-Whitney test to compare differences between two non-normally distributed groups. The researchers calculated the percentage of improvement between pretest and post-test results during the training period using the formula: $(\text{mean difference} / \text{mean pretest}) \times 100\%$.

Results

Table 1. Characteristics Samples

Group	Age	Height (cm)	Weight (kg)	BMI
EG	17.00 ± 1.10	167.19 ± 3.80	58.81 ± 3.80	21.05 ± 1.26
CG	17.13 ± 1.09	167.31 ± 3.46	57.13 ± 3.61	20.42 ± 1.42

The data is presented as mean ± SD to indicate central tendency and variability

Table 1 above shows the demographic characteristics of the experimental group (EG) and the control group (CG). The average age of the experimental group is 17.00 ± 1.10 years, while the control group has an average age of 17.13 ± 1.09 years. For height, the experimental group has an average of 167.19 ± 3.80 cm, and the control group has an average of 167.31 ± 3.46 cm. In terms of weight, the experimental group has an average of 58.81 ± 3.80 kg, while the control group has an average of 57.13 ± 3.61 kg. Finally, the average BMI for the experimental group is 21.05 ± 1.26, while the control group has an average BMI of 20.42 ± 1.42.

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Group	Age	Height (cm)	Weight (kg)	BMI
EG	17.00 ± 1.10	167.19 ± 3.80	58.81 ± 3.80	21.05 ± 1.26
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The data is presented as mean ± SD to indicate central tendency and variability

Table 2 above shows the results of the normality test using Shapiro-Wilk. In the Experimental Group (EG), Pre Total Distance and Pre VO₂max have a normal distribution ($p > 0.05$), while Post Total Distance and Post VO₂max are generally not distributed ($p < 0.05$). In the Control Group (CG), all pretest and post-test variables have a normal distribution ($p > 0.05$). For the change (delta), Delta Total Distance and Delta VO₂max in the EG have a normal distribution ($p > 0.05$), while in the CG, they are generally not distributed ($p < 0.05$). Based on these results, the researchers will apply the Wilcoxon test to assess differences in non-normally distributed data and the Mann-Whitney test to compare the experimental group (EG) and control group (CG) on variables that do not follow a normal distribution.

Figure 2 above presents the statistical analysis results using the Wilcoxon and Mann-Whitney tests to compare

the Experimental Group (EG) and Control Group (CG) on two variables: Total Distance (TD) in meters and VO₂max in ml·min⁻¹·kg⁻¹. For the TD variable, the Wilcoxon test results show that the EG experienced a significant increase between the pretest and post-test ($p < 0.0001$). In contrast, the CG did not show a significant difference ($p = 0.0747$). The Mann-Whitney test confirms that the increase in TD for the EG was significantly more significant than the CG ($p < 0.0001$). For the VO₂max variable, the Wilcoxon test indicates that the EG also experienced a significant increase between the pretest and post-test ($p < 0.0001$), while the CG showed no significant difference ($p = 0.0701$). The Mann-Whitney test again reveals that the increase in VO₂max for the EG was significantly more significant than that of the CG ($p < 0.0001$). These results indicate that the intervention in the EG was effective in improving performance related to distance covered and aerobic capacity (VO₂max)

Table 3 Percentage of improvement

Variable	Pretest	Post-test	Percentage Improvement (%)
EG TD (meter)	2316.25 ± 112.24	2501.88 ± 80.02	8.12
CG TD (meter)	2271.88 ± 85.18	2296.88 ± 90.97	1.11
EG VO ₂ max (ml·min ⁻¹ ·kg ⁻¹)	40.49 ± 2.51	44.46 ± 1.79	10.44
CG VO ₂ max (ml·min ⁻¹ ·kg ⁻¹)	39.50 ± 1.90	40.06 ± 2.03	1.44

The data is presented as mean ± SD to indicate central tendency and variability

Table 3 above shows the percentage improvements in Total Distance (TD) and VO₂max between pretest and post-test. In the Experimental Group (EG), TD increased by 8.12 %, and VO₂max increased by 10.44 %. Meanwhile, in the Control Group (CG), TD only increased by 1.11 %, and VO₂max increased by 1.44 %. The EG shows a higher percentage of improvement compared to the CG.

Discussion

The combination of high-intensity interval training with a game approach has a positive effect on increasing aerobic endurance. The improvement in aerobic endurance is closely related to the impact of the maximal aerobic speed control system during training sessions, which is essential for planning the training program and adjusting the training load, particularly during high-intensity intermittent training (Psarras & Bogdanis, 2024). The training program adapts high-intensity interval training with a game-based approach, using the average total distance of 4000 meters covered in a futsal match as a reference, and incorporates a maximal aerobic intensity more significant than 90 % Hrmax with a 1:1 interval ratio.

The selection of a high-intensity interval training program with a game approach is an essential aspect in efforts to achieve goals in futsal, in this context, to increase aerobic endurance. This unique training allows players to develop technical and tactical skills in situations similar to real matches. Conversely, the high-intensity interval training approach can improve physical quality (Stankovic et al., 2023).

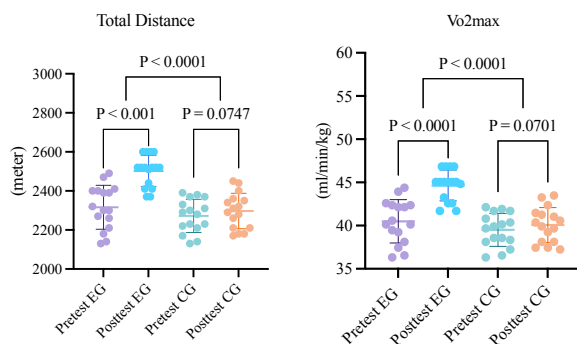


Fig. 2. Comparison of Total Distance and VO₂max between EG and CG

In the process, high-intensity interval training with a game approach will affect the increase in player confidence; this is because in each training session, the players not only focus on physical training but also technical and tactical skills so that it can indirectly improve the player's mentality (Méndez-Dominguez et al., 2022). Increasing training intensity gradually is also an effort to encourage physiological adaptation and improve player performance. In line with previous studies that the high-intensity interval method applied with the principle of progressiveness can coordinate muscle work simultaneously to produce optimal energy for motor performance and is the fastest way to obtain muscle development because it increases power production and protects joints from injury (Atakan et al., 2021; Liu et al., 2023).

Applying a training frequency of three times a week can affect aerobic endurance in amateur futsal athletes. Previous studies have reported that high-intensity interval training is practical when done in three sessions per week to reduce the adverse reactions due to glycogen depletion, accumulation of metabolites in muscles, and neuromuscular tension on athlete performance (Vigh-Larsen et al., 2021). In addition, this organized and continuous training will provide positive results in developing training goals (Barbieri et al., 2016).

The results of this study indicate that high-intensity interval training with a game approach can significantly increase aerobic endurance. In line with research As-Safa et al. (2024), rotational tactic training with a high-intensity interval training protocol can improve anaerobic performance in amateur futsal athletes. This training method can also be an alternative to improve several physiological parameters such as cardiometabolic, oxygen uptake kinetics, aerobic capacity, and resistance to muscle fatigue. The cardiometabolic increase in question is high-intensity interval training in increasing insulin sensitivity performance, which can help the body more efficiently regulate blood sugar levels (Weston et al., 2014). Increasing oxygen uptake kinetics is high-intensity interval training in increasing blood volume and hemoglobin, allowing muscle cells to use oxygen more quickly and efficiently during exercise (Buchheit & Laursen, 2013). The increase in aerobic capacity is due to high-intensity interval training in increasing cardiac output due to increased stroke volume and heart rate (Gibala & Jones, 2013). Meanwhile, the accumulation of lactic acid and hydrogen ions during high-intensity interval training triggers increased resistance to muscle fatigue, as these are the main factors causing muscle fatigue (Enoka & Duchateau, 2008).

This approach lets athletes experience game-like conditions during training, potentially increasing their match performance. However, it is essential to acknowledge the limitations of this study, including the small sample size and the short duration of the intervention, which may affect the generalizability of the results. Future research should consider more extensive, more diverse samples and explore the long-term effects of this training method on various physiological parameters in different age groups and competitive levels.

The findings of this study emphasize the effectiveness of combining high-intensity interval training with a game-based approach to enhance aerobic endurance in amateur futsal athletes. This approach can significantly benefit coaches in designing training programs that improve physical capabilities and integrate technical and tactical skills relevant to match scenarios.

Conclusions

Based on the research results achieved in high-intensity interval training with a game approach, the researchers concluded that this method can positively contribute to increasing aerobic endurance.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Поєднання високоінтенсивного інтервального тренування та ігрового підходу сприяє підвищенню аеробної витривалості у футзалістів-аматорів

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 6 с., 3 табл., 2 рис., 28 джерел.

Історія питання. Футзалісти потребують застосування холістичної моделі тренувань, яка передбачає поєднання високоінтенсивних інтервальних тренувань з ігровим підходом, що відповідає їхній необхідності долати загальну дистанцію 4000 метрів з максимальною аеробною швидкістю.

Мета дослідження. Мета дослідження полягала в аналізі впливу поєднання високоінтенсивного інтервального тренування з ігровим підходом на показники аеробної здатності футзалістів-аматорів.

Матеріали та методи. У цьому дослідженні застосовано експериментальний метод. Загалом у дослідженні взяли участь 32 футзалісти-чоловіки з аматорських клубів, вік яких становив $17,00 \pm 1,10$ року, зріст — $167,19 \pm 3,80$ см, маса тіла — $58,81 \pm 3,80$ кг, ІМТ — $21,05 \pm 1,26$. Для аналізу даних використовували критерій знакових рангів Уїлкоксона та U-критерій Манна-Уїтні з рівнем значущості 0,05. Загальна пройдена відстань і рівень максимального споживання кисню (VO_{2max}) вимірювалися за допомогою 12-хвилинного тесту Купера.

Результати. Згідно з результатами статистичного аналізу із застосуванням критеріїв Уїлкоксона та Манна-Уїтні встановлено, що експериментальна група (ЕГ) помітно покращила показники як загальної відстані (ЗВ), так і VO_{2max} ($p < 0,0001$ для обох змінних), тоді як контрольна група (КГ) не досягла істотного прогресу ($p = 0,0747$ для ЗВ, $p = 0,0701$ для VO_{2max}). За допомогою критерію Манна-Уїтні підтверджено, що покращення показників в ЕГ виявилися значно суттєвішими, ніж у КГ ($p < 0,0001$ для обох змінних). Відсоткове співвідношення поліпшень між даними перед початком і після завершення тестування свідчить про підвищення показників ЗВ в ЕГ на 8,12 %, а VO_{2max} — на 10,44 %. Натомість КГ продемонструвала лише зростання ЗВ на 1,11 % та VO_{2max} на 1,44 %.

Висновки. Отримані дані дозволяють зробити висновок, що поєднання моделі високоінтенсивного інтервального тренування з ігровим підходом позитивно впливає на аеробну витривалість спортсменів-аматорів з футзалу.

Ключові слова: комбіноване тренування, високоінтенсивне інтервальне тренування, ігровий підхід, аеробний, аматор з футзалу.

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