The effect of large-sided games with HIIT protocol on the anaerobic ability of student futsal players

El efecto de los juegos de gran formato con protocolo HIIT en la capacidad anaeróbica de los jugadores de futsal estudiantil

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Abstract

Introduction: This research investigates the impact of Large Sided Games training using a High-Intensity Interval Training.
Objective: to determine the effectiveness of LSG training with the HIIT protocol in improving the anaerobic capacity of student futsal players.
Methodology: This research has used experimental design. The study sample consisted of 32 student futsal players with the following characteristics: height of 168.59 ± 5.85 cm, weight of 57.31 ± 4.14 kg, BMI of 20.19 ± 1.45, and average age of 16.50 ± 0.51 years. Cohen's effect size was utilized to assess group differences, and paired sample T-tests and independent T-tests with a significance level of <0.05 were employed in the data analysis.
Results: with regard to Peak Power (p = .012), Mean Power (p = .001), Peak Power per Weight (p = .012), Mean Power per Weight (p = .001), Fatigue Index (p = .002), and Total Effort Time (p = .000), on the other hand, the CG did not show any discernible changes for any of the variables.
Discussion: The increase occurs due to metabolic adaptation when performing combination exercises.
Conclusions: The study concludes that student futsal players' anaerobic endurance is efficiently increased by the LSG training model that incorporates the HIIT protocol.

Keywords

Large sided games; high-intensity interval training; anaerobic.

Resumen

Introducción: Esta investigación analiza el impacto del entrenamiento con Juegos de Campo Grande utilizando un protocolo de Entrenamiento Interválico de Alta Intensidad.
Objetivo: Determinar la efectividad del entrenamiento con LSG y protocolo HIIT en la mejora de la capacidad anaeróbica de los jugadores de futsal estudiantiles.
Metodología: En esta investigación se ha utilizado un diseño experimental. La muestra del estudio consistió en 32 jugadores de futsal estudiantiles con las siguientes características: altura de 168.59 ± 5.85 cm, peso de 57.31 ± 4.14 kg, IMC de 20.19 ± 1.45 y edad promedio de 16.50 ± 0.51 años. Se utilizó el tamaño del efecto de Cohen para evaluar las diferencias entre grupos, y pruebas T de muestras pareadas e independientes con un nivel de significancia de <0.05 en el análisis de datos.
Resultados: en relación con la Potencia Máxima (p = .012), la Potencia Media (p = .001), la Potencia Máxima por Peso (p = .012), la Potencia Media por Peso (p = .001), el Índice de Fatiga (p = .002) y el Tiempo Total de Esfuerzo (p = .000), por otro lado, el CG no mostró cambios apreciables en ninguna de las variables.
Discusión: El aumento se produce debido a la adaptación metabólica al realizar ejercicios combinados.
Conclusiones: el estudio concluye que el modelo de entrenamiento con LSG que incorpora el protocolo HIIT mejora eficazmente la resistencia anaeróbica de los jugadores de futsal estudiantiles.

Palabras clave

Juegos de gran formato; entrenamiento en intervalos de alta intensidad; anaeróbico.

Introduction

Futsal is a type of indoor football played on a smaller court. Due to the fast pace of the game and frequent bursts of intense activity, futsal players require a high level of anaerobic fitness (Barbero-Alvarez et al., 2008). The game demands a deep understanding of tactics, including transitions, attacking, and defending. As a competitive sport, futsal requires players to adhere to specific formations throughout the game (Narizuka & Yamazaki, 2019). Tactical skills not only influence match outcomes but also highlight individual player abilities and team coordination. High-intensity play is a hallmark of futsal, with a strong emphasis on physical strength, technical skills, and tactics, all of which are essential aspects of the sport (Naser et al., 2017). The intermittent nature of futsal—characterized by short bursts of high-intensity effort followed by rest intervals—can push players to their anaerobic threshold (Milioni et al., 2016; Ribeiro et al., 2020). Therefore, players must have the ability to execute offensive, defensive, and transition tactics quickly and efficiently under high-intensity pressure. Additionally, significant performance differences based on gender have been observed among elite European football players, where male athletes typically exhibit greater anaerobic capacity, while female athletes display higher resistance to fatigue (Bradley et al., 2014).

Coaches are constantly seeking innovative training techniques to help athletes reach their full potential (Clemente et al., 2019). Although anaerobic fitness and tactical skills are both critical, training methods that integrate both at high intensity are still scarce. Typically, physical conditioning and tactical preparation are treated separately in training programs, despite their interconnectedness in actual matches. Therefore, it is crucial to develop training methods that simultaneously combine physical and tactical conditioning, especially for student futsal players. Moreover, players often find high-intensity physical training during the season monotonous, as it lacks game-specific movements like direction changes, accelerations, and decelerations, making it less enjoyable (Los Arcos et al., 2015). Previous research that combined physical and tactical components in training has shown positive effects on internal and external physical loads, as well as player performance (Arslan et al., 2021; Castillo, Raya-González, Sarmento, et al., 2021; Köklü et al., 2020). However, these studies were conducted primarily in the context of football, suggesting that further research is needed to determine whether these methods are applicable to futsal.

In recent years, several training approaches have been explored to improve the anaerobic capacity of futsal players. One promising method is combining Large-Sided Games (LSGs) with High-Intensity Interval Training (HIIT) protocols (Milanović et al., 2015). This study integrates both methods. Large-Sided Games (LSGs) are a form of game-based training that involves a larger number of players and a wider playing area compared to Small-Sided Games. LSGs simulate game-like scenarios that closely resemble real match conditions, providing both tactical and physical challenges similar to actual gameplay (Díaz-García et al., 2023; Zlojutro et al., 2023). On the other hand, HIIT focuses on enhancing both aerobic and anaerobic capacity through repeated high-intensity intervals (Abouzeid et al., 2023; Guo et al., 2023). The combination of LSG and HIIT is based on the principles of specificity and overload, allowing for match-like training conditions that better align with the tactical and physical demands of futsal.

The combination of these two training methods facilitates continuous training that aligns with the characteristics of the match while embracing the high intensity required in futsal (Trecroci et al., 2020). Additionally, this approach offers a time-efficient alternative by providing short but highly intense sessions that can be performed near the players' maximum threshold. This method has the potential to improve anaerobic performance and endurance in youth athletes while saving time (Engel et al., 2018). This study hypothesizes that the integration of LSG with HIIT in futsal training programs will significantly improve the anaerobic capacity and tactical performance of student futsal players. Furthermore, it is expected that this training method will have a positive impact on players' anaerobic endurance, speed, and tactical abilities, while also reducing fatigue during training compared to conventional training programs. Additionally, gender-specific adaptations in training are worth exploring, as male and female players may respond differently to high-intensity futsal training due to physiological and hormonal factors.

Method

A pre-test was administered to the treatment and control groups to determine their baseline levels of anaerobic endurance. Following that, the treatment group participated in six weeks of three-time-a-week LSG and HIIT Protocol training. Meanwhile, the control group persisted in their customary exercise routine, maintaining the same frequency and duration of exercise as the treatment group but without any additional support. In order to assess how the LSG with HIIT Protocol training had affected their anaerobic endurance, both groups completed a post-test in the last week of the six-week period.

Participants

Thirty-two student futsal players took part in the study. The sample's dimensions were as follows: height of 168.59 ± 5.85 cm, body mass of 57.31 ± 4.14 kg, age of 16.50 ± 0.51 years, and BMI of 20.19 ± 1.45. Next, the participants were split into two groups at random: the experimental group consisted of 16 players, while the control group consisted of 16 players.

Training Program

Four smaller groups, each with four players, were formed from the treatment group. In order to provide a beneficial playing environment, an additional neutral player—the assistant coach—was added to the two players versus two LSG arrangements. This LSG's playing field was a full 20 × 40 meter pitch with two modest goals and no goalkeeper. Aiming to achieve between 85% and 90% of their maximal heart rate, group one completed 100-second treatment sessions. Groups two, three, and four awaited their turn and engaged in active recovery. Each group did 10 sets in the first and second weeks, 12 sets in the third and fourth weeks, and 14 sets in the fifth and sixth weeks of the training, which had an interval ratio of 1:3. The Polar Verity Sense was used to track the training's intensity and make sure the desired heart rate was reached.

Instrument

The Running-based Anaerobic Sprint Test (RAST) involves performing six 35-meter sprints with 10-second recovery intervals between each sprint, aiming to evaluate anaerobic power. The test is conducted on a flat, stable surface, with a photo timer used to capture the sprint times. Each sprint is initiated by a beep, signaling the athlete to run at full speed. Upon completing all six sprints, the recorded times are used to calculate key metrics, including total effort time (s), fatigue index (%), peak power (w), mean power (w), and peak power per weight (w.kg^-1).

Data analysis

The means and standard deviations of the data in this study are displayed. Tests for homogeneity and normalcy were among the prerequisites. The Levene test was used to verify homogeneity, and the Shapiro-Wilk test was used to determine whether the data was normal. The formula used to compute the percentage change (Δ%) between pre- and post-training outcomes was Δ% = ((Post-Pre)/Pre)*100. Independent sample tests were utilized to analyze differences between the experimental and control groups, while paired sample tests were used to look at differences within each group. At $p<0.05$, statistical significance was established. The size of the differences between the groups was assessed using Cohen's effect size (ES), where an ES above 0.8 is regarded as high, between 0.8 and 0.5 as moderate, between 0.5 and 0.2 as minor, and less than 0.2 as unimportant (Cohen, 2013).

Results

Table 1. The age, height, weight, and body mass index of the two groups under study are displayed above. Additionally, all variables in the EG group and CG group had a normal distribution with a significance value of Sig>0.05, according to the Shapiro-Wilk normality test. The Levene homogeneity test revealed the same issue, with a significance level of > 0.05.

Table 2. The discrepancies between the EG and CG pre- and post-tests are displayed above. Peak power (p =.012, ES =0.71), mean power (p =.001, ES = 1.07), peak power per weight (p =.012, ES =0.72), mean power per weight (p =.001, ES = 1.03), fatigue index (p =.002, ES =0.95), and total effort time (p =.000,

ES =1.11) were all significantly different in the EG group. It is noteworthy that all variables in CG remain unchanged

Table 3. The above shows significant differences between EG and CG. All variables have a significance value of $p < 0.05$, which shows significant differences between EG and CG. If viewed from the ES value, Peak Power has an effect of 0.75, Mean Power has an effect of 0.77, Peak Power per Weight has an effect of 0.81, Mean Power per Weight has an effect of 0.79, Fatigue Index has an effect of 0.96, and Total effort time has an effect of 0.80.

Table 1. Characteristics of group.

Group	Age (year)	Height (cm)	Body Mass (kg)	BMI
EG	16.56±0.51	169.25±6.43	56.13±4.90	19.61±1.66
CG	16.44±0.51	167.94±5.08	58.50±2.37	20.77±1.02

Data are presented as mean±SD

Table 2. Results of RAST Pre and Post-test in both groups.

Variable	Group	Pre	Post	Δ%	P	ES
Peak Power (W)	EG	535.19±53.45	579.44±77.03	7.64	.012*	0.71
	CG	531.47±101.81	532.41±75.99	0.18	.944	0.01
Mean Power (W)	EG	401.97±39.50	440.45±51.04	8.74	.001*	1.07
	CG	418.81±64.99	432.30±61.99	3.12	.081	0.4
Peak Power per Weight (W.kg-1)	EG	9.57±1.04	10.37±1.44	7.70	.012*	0.72
	CG	9.16±2.12	9.15±1.63	0.10	.967	0.01
Mean Power per Weight (W.kg-1)	EG	7.18±0.64	7.87±0.82	8.76	.001*	1.03
	CG	7.21±1.38	7.44±1.35	3.10	.079	0.47
Fatigue Index (%)	EG	43.62±6.26	38.38±6.75	13.64	.002*	0.95
	CG	40.89±7.82	40.84±7.27	0.12	.979	0.01
Total effort time (s)	EG	33.66±0.97	32.59±1.07	3.27	.000*	1.11
	CG	33.72±2.06	33.35±1.88	1.09	.095	0.44

Data are presented as mean±SD; Δ (%): percentage of change between pre and post-training performance; p: level of significance; ES: effect size; * Significant difference, $p < 0.05$.

Table 3. Comparison of RAST in both groups.

Variable	EG	CG	P	ES
Peak Power (W)	44.25±62.09	0.94±52.25	.041*	0.75
Mean Power (W)	38.51±35.94	13.49±28.81	.038*	0.77
Peak Power per Weight (W.kg-1)	.80±1.11	-.01±.90	.032*	0.81
Mean Power per Weight (W.kg-1)	.69±.67	.23±.49	.035*	0.79
Fatigue Index (%)	-7.74±8.14	-0.05±7.81	.011*	0.96
Total effort time (s)	-1.08±0.97	-0.36±0.82	.031*	0.80

Data are presented as mean±SD; p: significance level; ES: effect size; * Significant difference, $p < 0.05$.

Discussion

The main findings in this study showed that after six weeks of research, the LSG treatment group with HIIT Protocol showed a significant increase in anaerobic ability compared to the control group. Variables that indicate an increase in anaerobic ability can be seen from the RAST results in peak power increasing by 44.25 W mean power increasing by 38.51 W, peak power per weight by 0.80 W.kg-1, mean power per weight by 0.69 W.kg-1 and decreasing Fatigue index -7.74 % and total effort time is -1.08 s.

Several studies have investigated the effects of LSGs with HIIT protocol on the anaerobic ability of futsal players, yielding promising results. For example, a study reported improvements in repeated sprint ability and agility performance among semi-professional futsal players following the integration of LSGs with HIIT into their training regimen (Aquino et al., 2017). The increase in anaerobic power observed in this study aligns with findings from previous research, which also reported improvements in power among the experimental group using LSG training (Sannicandro & Cofano, 2023). Power is an essential element to improve for futsal players, especially the lower body (Luís Marques et al., 2022; Naser et al., 2017; Spyrou et al., 2020).

Our findings align with research that indicates combining LSG training leads to increased acute mechanical loads and high-intensity running stimuli (Beato et al., 2023; Clemente et al., 2019; Owen et al., 2011). We indicate this increase to be a supporting factor in increasing anaerobic ability. Apart from

that, this training has particular stimuli according to the characteristics of the game, which include the presence of teammates, opponents and limited duration with a training intensity that can be determined and has advantages in making playing decisions (Caro et al., 2021; Castillo, Raya-González, Weston, et al., 2021; Davids et al., 2013). Using a field size that is appropriate to the actual game and reducing the number of players playing has an impact on the internal load carried by each player so that the high-intensity target is achieved in this research.

The effectiveness of LSGs with HIIT protocol in enhancing anaerobic capacity can be attributed to several physiological and training-related mechanisms (Hill-Haas et al., 2008). Firstly, the intermittent nature of HIIT induces metabolic adaptations that enhance the anaerobic energy systems, including increased muscle buffering capacity and improved glycolytic enzyme activity (J. P. Little et al., 2010). Secondly, LSGs provide a competitive and dynamic training environment that promotes skill acquisition, decision-making, and tactical awareness alongside physical conditioning (Rampinini et al., 2009).

High-intensity interval training is believed to increase anaerobic ability by interspersing rest periods, the body is forced to adapt physiologically to the fatigue that occurs during high-intensity exercise (Sporis et al., 2008). A player's fatigue tolerance often occurs between 88% and 92% of maximum heart rate (J. Chmura & Nazar, 2010). This aligns with our research procedure, namely achieving a 90% maximum heart rate. The findings of this research are also consistent with studies that indicate training involving high-intensity skills can enhance anaerobic power by 10.7% in female futsal players (Karahan, 2012). In line with previous research, one training modality that can trigger physiological responses is interval training, which involves short, high-intensity exercises alternated with periods of incomplete recovery (Polczyk & Zatoń, 2015). In addition, it has been found that HIIT intervention in 14-year-old soccer players caused a shift in anaerobic and fatigue thresholds to higher levels, thereby effectively increasing their training capacity (P. Chmura et al., 2023).

Interestingly, apart from increasing anaerobic capacity, psychologically, the results of this study were also able to reduce fatigue index after six weeks of training. The results of this study are consistent with research showing that HIIT training reduces the fatigue index in adults. This reduction is crucial because it is related to neuromuscular performance (Cour et al., 2022). This reduction in fatigue index is crucial because it is related to neuromuscular performance. In addition, the relatively lower fatigue index indicates a higher drive in maintaining energy output in hypohydration conditions of 3 and 4% body weight (Naharudin & Yusof, 2013).

This research provides the latest description of the LSG training method, which usually impacts aerobic capacity, but it affects anaerobic capacity in this study. This increase in anaerobic capacity cannot be separated from using high-intensity training. Apart from that, this research also proves that increasing anaerobic capacity also has a psychological impact where there is a decrease in fatigue index. Mental health for futsal players is essential because futsal games that use a fast play tempo will cause high stress for each player. With low fatigue, it is more possible for athletes to manage stress during the game. Integrating LSGs with HIIT protocol into futsal training programs requires careful planning and periodization to optimize results while minimizing the risk of overtraining and injury (Impellizzeri et al., 2019). Coaches should tailor the intensity, duration, and structure of LSGs and HIIT sessions based on the specific needs and fitness levels of their players (Mujika & Padilla, 2000). Additionally, monitoring players' workload, recovery, and physiological responses is essential for adjusting training parameters and ensuring progression over time (Halson, 2014).

The findings of this study show an improvement in anaerobic capacity in the group that underwent LSG training with HIIT. However, these results should be considered within the context of limitations, such as the variability in the effectiveness of the protocol among players with different skill levels. The transferability of these findings to real-world settings and the gender impact also need further exploration, as physiological and hormonal factors may affect responses to high-intensity training. Future studies should measure specific futsal performance indicators and psychological aspects of players, such as motivation and satisfaction, to provide a more complete picture of the training's impact. Therefore, further research with a larger sample size and more diverse contexts is needed to optimize the application of this method

Conclusions

In conclusion, the integration of Large-Sided Games (LSG) with the High-Intensity Interval Training (HIIT) protocol has been shown to effectively enhance the anaerobic capacity of futsal players. However, its effectiveness may vary among players with different skill levels and competitive contexts. Further research is needed to explore the transferability of these findings to real-world settings and to increase the sample size. Additionally, this study did not analyze the gender impact, so further research with a mixed sample or a focus on women is needed to assess whether this approach is effective for both genders

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