El entrenamiento de 5 minutos mejora el VO2máx y la agilidad? Un estudio sobre el entrenamiento de juego situacional en el fútbol sala

Does 5-minute training improve VO2max and agility? A study of situational game training in futsal

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Abstract

Introduction: Futsal is a sport that demands a combination of speed, agility, and high aerobic endurance. Improving VO2max and agility becomes crucial in enhancing the performance of futsal players in intense match conditions.
Objective: This study aims to evaluate the effect of situational game training with an additional 5-minute exercise load on the improvement of VO2max and agility in futsal players.
Methodology: The research design used in this study is experimental, employing a randomized controlled trial with a control group. The participants consisted of 16 futsal players divided into two groups: the experimental group undergoing situational game training with an additional 5-minute exercise load, and the control group undergoing regular training without additional load.
Results: After 6 weeks of training intervention, the experimental group showed a significant improvement in VO2max values ($p < 0.05$) compared to the control group. Additionally, there was a significant improvement in agility based on reaction time and maneuver measurements during situational training.
Conclusions: Situational game training with an additional 5-minute exercise load is effective in improving VO2max and agility in futsal players. The implications of this research suggest that integrating this training method can be an effective strategy to enhance aerobic capacity and motor response of futsal players, better preparing them for the physical and tactical demands of actual competitions.

Keywords

Situational game; training load 5 minutes; futsal.

Resumen

Introducción: El fútbol sala es un deporte que exige una combinación de velocidad, agilidad y alta resistencia aeróbica. Mejorar el VO2max y la agilidad se vuelve crucial para mejorar el rendimiento de los jugadores de fútbol sala en condiciones de juego intensas.
Objetivo: Este estudio tiene como objetivo evaluar el efecto del entrenamiento de juego situacional con una carga de ejercicio adicional de 5 minutos en la mejora del VO2max y la agilidad en jugadores de fútbol sala.
Metodología: El diseño de investigación utilizado en este estudio es experimental, empleando un ensayo controlado aleatorio con un grupo control. Los participantes consistieron en 16 jugadores de fútbol sala divididos en dos grupos: el grupo experimental sometido a entrenamiento de juego situacional con una carga de ejercicio adicional de 5 minutos, y el grupo control sometido a entrenamiento regular sin carga adicional.
Resultados: Después de 6 semanas de intervención de entrenamiento, el grupo experimental mostró una mejora significativa en los valores de VO2max ($p < 0,05$) en comparación con el grupo control. Además, hubo una mejora significativa en la agilidad basada en el tiempo de reacción y las mediciones de maniobra durante el entrenamiento situacional. Conclusiones: El entrenamiento de juego situacional con una carga de ejercicio adicional de 5 minutos es eficaz para mejorar el VO2max y la agilidad en jugadores de futsal. Las implicaciones de esta investigación sugieren que la integración de este método de entrenamiento puede ser una estrategia eficaz para mejorar la capacidad aeróbica y la respuesta motora de los jugadores de futsal, preparándolos mejor para las demandas físicas y tácticas de las competiciones reales.

Palabras clave

Juego situacional; carga de entrenamiento 5 minutos; fútbol sala.

Introduction

Futsal is a high-intensity sport with short recovery times in its activities. During a match, each player can perform approximately 26 sprints (i.e., ≥ 18.4 km·h-1), sometimes involving short recovery periods (i.e. 15 s) in between (Ayarra et al., 2018; Caetano et al., 2015). Futsal is characterized by high-intensity bursts interspersed with different lengths of rest periods during games. It's viewed as a balanced sport from a physiological perspective, where player performance relies on both aerobic and anaerobic metabolism. Good physical condition is essential for optimal performance (Bahtra, Putra, et al., 2023; Bahtra, Tohidin, et al., 2023; Bahtra, Zelino, et al., 2024; Karyono et al., 2024; Ningrum et al., 2024; Zanada, 2023). Moreover, the activity to rest ratio during gameplay typically stands at about 1:1 (Budal Arins et al., 2015). Futsal players experience fatigue as the game progresses due to the high-intensity nature of the game and the repeated maximal sprint efforts required (Naser et al., 2017; Ribeiro et al., 2024).

The physical, mental, technical and spiritual growth of athletes is part of sports training(Sofyan et al., 2024).A team that is in good physical shape and plays at its best on the field is likely to win because it can effectively attack to score goals and defend to prevent conceding goals (Christanto Sepang et al., 2023; Toruan & Setijono, 2017). For the majority of the game, specifically more than 80% of the time, the heart rate of futsal players often surpasses 85% of its maximum. This underscores the importance of having a high capacity for oxygen uptake in the sport (VO2max) values > 60 ml·kg-1·min-1 (Ayarra et al., 2018; Barbero-Alvarez et al., 2008; Pedro et al., 2013). Playing positions also have different VO2 max capacities. On-court players presented higher VO2max (58.99±5.86 mL/kg/min), goalkeepers (50.66±5.24 mL//kg/min) (Baroni, 2014).

In addition to aerobic capacity, anaerobic capacity is also necessary in futsal, considering that futsal is a high-intensity sport. Agility is one form of movement that focuses on the anaerobic system. Agility is one of the important factors in sports games (Simonek, 2014). When a team loses control of the ball and needs to switch from offense to defense, players might need to rapidly change their direction of running. Fast-paced activities in soccer and futsal can be divided into categories based on whether they require acceleration, top speed, or agility (Milanović et al., 2011). Futsal players also require high levels of explosive strength to move and change direction quickly during the game, increase numbers in defense and attack, excel in one-on-one situations, cover distances with or without the ball in both defense and attack, and demonstrate strong technical skills and tactical play (Kartal, 2016; Milanović et al., 2011).

Physical training within actual situational game scenarios brings numerous significant advantages for participants. Exercise improves quality of life, enhancing health and fitness (Yanti et al., 2024). It is an effective way to integrate physical exercise with the real context of games or sports, creating an experience closely resembling actual matches. Even to succeed in matches, physical fitness alone is not enough. In addition to optimal fitness, players must also possess good technique, a deep understanding of tactics, and strong mental skills to achieve high performance (Bahtra, Padang, et al., 2024; Finamore et al., 2021). According to the training specificity principle, futsal coaches frequently seek the most effective training models. (Finamore et al., 2021) found that by examining the offensive sequences leading to goals in elite futsal matches, drills that mimic game situations are crucial for developing both physical and technical fitness (Amani-Shalamzari et al., 2019). Small-sided games could be an effective multicomponent training strategy, offering greater benefits for specific skill tasks compared to interval or agility training, and providing moderate to significant improvements in physical fitness related to team sports (Medica et al., 2017). A strong relationship between the interaction of training techniques and VO2max on fundamental soccer playing abilities. These findings can be employed in the training of fundamental soccer game skills as a guide (Rampinini et al., 2007; Sari et al., 2024) demonstrated that 12 weeks of Small-Sided Games (SSG) can improve aerobic fitness just as effectively as common fitness training activities, such as interval running at an intensity of 90-95% of HRmax (Marcora et al., 2006). A 6-week conditioning training program using Small-Sided Games is an effective alternative for improving aerobic capacity and anaerobic power in futsal (Amani-Shalamzari et al., 2019). During 9-weeks of training, small-sided games/small-side games (SSG) can improve aerobic capacity, repeat sprint ability, and agility in soccer players to a comparable extent as high-intensity interval training sessions (Salazar, 2023). There is a positive effect of Small-Sided Games training after being administered for 12 sessions on the passing skills and endurance of Banteng Muda Indonesian men's

futsal players (Sofyan & Fauzi, 2023).

Substitutions in futsal are usually made by the coach for several reasons, such as game strategy, player fatigue, or to give an opportunity to players who haven't yet played. The coach can rotate players regularly to maintain the team's physical and tactical stability. This rotation can occur every few minutes or according to the game plan that has been previously arranged. High-intensity running in the most intense 5-min period during the game, the following 5-min period as well as the game average for elite players during competitive matches (n = 16). Significant difference between the 5-min period immediately after the most intense period during the game and the game average (Mohr et al., 2005). For that, a training load directed towards physical fitness specific to the sport is required, The small-sided games played 4 x 6 min smallsided soccer in the 20 x 25 m pitch dimension, with a 2 min passive recovery (Suud et al., 2022). The present study has revealed that the 15/15 and the 4x4 min training groups of healthy students that trained at aerobic high intensity (i.e., 90–95% HRmax) increased their VO2max significantly (Helgerud et al., 2007; Moxnes & Hausken, 2012). As previously explained, the small-sided games with fewer number of players increase the intensity of practice, achieving values greater than 90% HRmax in 2-aside, 3-a-side, and 4-a-side games (Rampinini et al., 2007). These activities can be used to develop anaerobic or VO2max programs (Clemente et al., 2014). Methodological suggesition to developing small-side-soccer game, protocol for development on VO_2max have intensity 90-95 % HRmax, RPE (rating of perceived exertion) stressful, 6-12 mmol/LL, duration total work 12-35 min, repetition 4-8 set, repetition work 3-6 min, recovery ratio 1:1 (Clemente, 2016; Clemente et al., 2014). Other references also mention that the development of small-sided games with a VO2max program involves an intensity of 90-95% HRmax, a high Rating of Perceived Exertion (RPE), 6-12 mmol/L, a total work duration of 12-35 minutes, 4-8 sets of repetitions, 3-6 minutes of work per repetition, and a recovery ratio of 1:1 (Clemente, 2016; Clemente et al., 2014). The objective of this study is to examine how situational training with a 5-minute training load influences improvements in VO2max and agility among futsal players. Situational training involves replicating real-game environments to help enhance multiple aspects of players' skills and physical performance.

Method

Participans: In this study, there were two groups of volunteers who agreed to participate under the specified terms and conditions. One team was designated as the experimental group (EG), while the other was designated as the control group (CG). This study involved 16 male amateur futsal players who participated in a regional amateur competition in East Java, Indonesia. consisting of 8 players for the experimental group (EG) and 8 players for the control group (CG).

The selection of tests used in this study is commonly employed in many studies to measure VO2max and agility. The first test conducted was the agility test using the T-Test Agility (Amalia et al., 2023). The second test focused on aerobic capacity to measure VO2max using the bleep test (multi fitness test), which is commonly conducted in many previous studies (Amalia et al., 2023; Berdejo-del-Fresno et al., 2015; Silvia et al., 2022).

The duration of this study is 6 weeks with a training frequency of 3 times per week, As in many previous studies, if there are significant positive changes after a 6-week training period (Ambuja Bhardwaj & Lokendra Bahadur Kathayat, 2021; Berdejo-del-Fresno et al., 2015; Lu et al., 2022; Turna, 2020).

Table 1. Research Schedule

Months	November		December				January	
Weekly	3	4	1	2	3	4	1	2
Pre-test	T1							
Treatment		V	V	V	V	V	V	
Post-test								T2

For the experimental group (EG). The game situation conducted was playing 4v4 + 2 goalkeepers on a field measuring 20x30 meters, with activities involving man-to-man marking with high pressure. If the

game stops due to the ball going out of play or one team scoring, it resumes immediately from the spot where the ball stopped. Every player is required to constantly move to create space and opportunities to receive passes for attacking players, while defensive players always maintain tight marking wherever they go. Treatment during the first and second weeks involved starting with a training intensity of 80-95%, a work time of 5 minutes, 3 repetitions, and a recovery time ratio of 1:1. In the third and fourth weeks, the training load involved an intensity of 80-95%, a work time of 5 minutes, 6 repetitions, and a recovery time ratio of 1:1. In the fifth and sixth weeks, the training load involved an intensity of 80-95%, a work time of 5 minutes, 9 repetitions, and a recovery time ratio of 1:1. For control group (CG), For the control group (CG), the frequency of training sessions and the total amount of training were the same as the experimental group (EG). The only difference was the training load, which consisted of a moderate-intensity running program for 30 minutes. (a) Warm-up for 5 minutes with an intensity of 40-50% HRmax, b) Running at moderate intensity of 60-70% HRmax, which is continuous running for 20 minutes without stopping, c) Cool down by walking and stretching for 5 minutes). The data obtained from the pretest and posttest were analyzed using a paired sample t-test. This test was employed to determine whether there was a significant difference between the pretest and posttest results within both the experimental and control groups. Data analysis was conducted using the latest version of the statistical software SPSS. The analysis techniques used include: A normality test to ensure the data is normally distributed. A paired sample t-test to identify significant differences between pre-test and post-test results in the experimental and control groups.

Results

This study aims to evaluate the effects of situational training with a 5-minute training load on improving VO2max and agility in futsal players. Situational training is a method that emphasizes the simulation of real match conditions, aiming to enhance various aspects of players' skills and physical performance. The study's findings indicated a notable improvement in VO2max and agility following several weeks of game situation training with a 5-minute interval load.

Tabel 2. Fitness test results in EG on the November (pre-test)

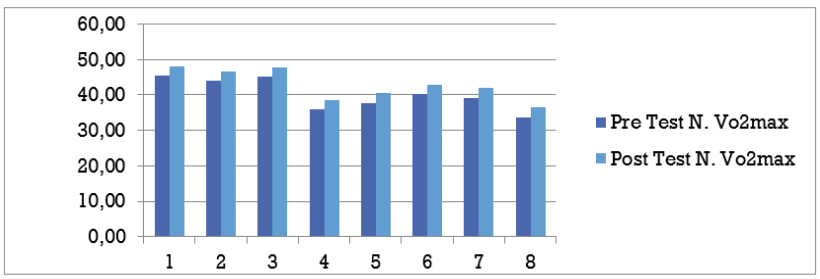
N = 8	N	VO_2Max (ml/kg/min)	Agilty (s)
Mean	8	40.18	11.02
Maximum	8	45.56	12.41
Minimum	8	33.68	10.03
Range	8	11.88	2.38

Tabel 3. Fitness test results in EG on the January (post-test)

N = 8	N	VO_2Max (ml/kg/min)	Agilty (s)
Mean	8	42.82	10.68
Maximum	8	48.00	12.08
Minimum	8	36.60	9.78
Range	8	11.40	2.30

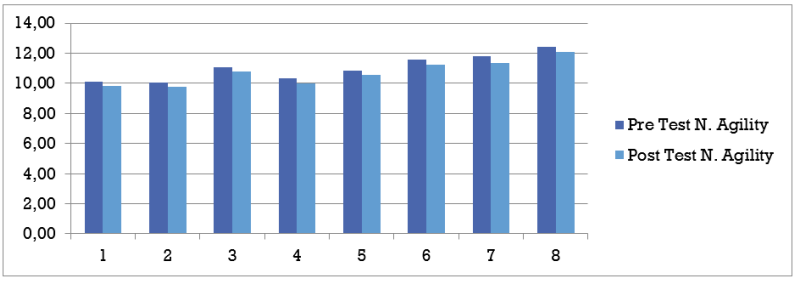
From the data collection results, it was found that in November, the experimental group's average VO2max was 40.18 ml/kg/min, and the average agility score was 11.02 seconds. After 6 weeks of treatment, the average VO2max increased to 42.82 ml/kg/min, and the average agility score improved to 10.68 seconds.

Figure 1. The results of VO2max players between pre-test until post-test in November-January (treatment programs training).



From the image above, we can observe that the VO2max of each player individually improved after the 6-week intervention.

Figure 2. The results of agility players between pre-test until post-test in November-January (treatment programs training).



Similarly, agility showed improvement, with players demonstrating faster times or shorter durations in the agility run tests conducted.

Tabel 4. Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Pre Vo2max	.179	8	.200*	.934	8	.553
Pre Agility	.160	8	.200*	.941	8	.624
Post Vo2max	.180	8	.200*	.932	8	.538
Post Agility	.170	8	.200*	.932	8	.533

The results of the Kolmogorov-Smirnov test showed a p-value of 0.200, which is greater than the significance level of 0.05, indicating that the data follows a normal distribution. Similarly, the Shapiro-Wilk test results displayed p-values ranging from 0.5 to 0.6, which are also above 0.05, further confirming that the data is normally distributed

Tabel 5. Paired Samples Test

		t	df	Sig.(2-tailed)
Pair 1	Pre-Post Vo2max	-46.297	7	.000
Pair 2	Pre-Post Agility	12.793	7	.000

The paired sample t-test is used to compare two measurements taken from the same subjects before and after an intervention or treatment. If the p-value from the paired sample t-test is smaller than the predetermined significance level, such as 0.05, it indicates that the difference between the two measurements is statistically significant. This means there is sufficient evidence to reject the null hypothesis, which states that there is no significant difference between the two measurements. Using a paired sample t-test with a p-value less than 0.05 provides robust statistical evidence to assert that the intervention or treatment has led to a significant change in the observed variable within the same subjects. The paired sample t-test with a p-value less than 0.05 is in the context of research measuring physical performance before and after an intensive training program in athletes.

Discussion

The findings provide a clear picture of the short-term impact of intensive training on cardiorespiratory health and athletic motor skills. Therefore, a comprehensive and specific physical training program is essential to enhance individual and team performance in futsal. When defending, futsal players must possess endurance, strength, and speed to prevent the opponent from scoring. Good physical condition enables players to stay focused and reactive in defensive situations. When attacking, the players' physical condition is crucial in creating goal-scoring opportunities, including speed and agility, strength and explosiveness, as well as coordination and balance. Good physical abilities enhance the efficiency and effectiveness of the team's attacks. Transitioning from defense to offense, or vice versa, demands quick changes in movement and positioning, requiring speed and anaerobic endurance.

VO2max, or maximum oxygen uptake by the body during maximal aerobic exercise, is closely related to the human body's energy system. The energy system is divided into three main systems: ATP-CP (phosphocreatine), anaerobic glycolysis, and aerobic metabolism (Spriet, 2017; Swanwick, 2018). The aerobic system in the human body becomes dominant after continuous activity for about 3 minutes. This occurs because the aerobic system utilizes oxygen to produce energy from the metabolism of fats and carbohydrates in a more efficient process, which can sustain physical activity for longer periods. When physical activity begins, the body initially relies on the anaerobic energy system to meet sudden energy demands. However, as activity extends beyond a few minutes, such as in futsal, the body shifts towards the aerobic system due to its need for more stable and sustained energy.

Mastering the three key moments in futsal—defending, attacking, and transitioning—is crucial for becoming a successful team. In futsal, there are several crucial moments that can affect the outcome of the match. First, the attacking momentum is the phase when the team attempts to score a goal. Second, the defending momentum becomes very important when the team loses control of the ball. In this situation, the team must quickly adapt and organize their position to thwart the opponent's attack. Next, the transition momentum arises when the team shifts from the defending phase to the attacking phase, or vice versa. The speed of adapting to changing situations greatly influences the effectiveness of the attack or defense (Rika Widianita, 2023). Finally, set pieces also play an important role in futsal, where approximately 25% of the goals scored come from set pieces such as free kicks and corner kicks (CERRAH et al., 2016). The team's readiness to capitalize on these moments can be a decisive factor in the final outcome of the match.

In futsal, we know that all energy systems can be utilized during activities. VO2max is a measure of the body's ability to produce energy through aerobic metabolism. The higher someone's VO2max, the more oxygen their muscles can utilize to generate energy, allowing the body to sustain high-intensity aerobic activities for longer periods before fatigue sets in (Budal Arins et al., 2015; Naser et al., 2017; Ribeiro et al., 2024).

Players and coaches must understand the importance of each aspect and train to quickly adapt to every game situation. The physical condition of players greatly affects their effectiveness in executing the three key moments in futsal—defending, attacking, and transitioning (Royana, 2017). Futsal players frequently need significant stamina to maintain their level of play for the entire game (Castillo et al., 2022; Naser et al., 2017). Players with good cardiovascular endurance, muscle strength, speed, and optimal agility can adapt quickly and efficiently in every game situation (Cao et al., 2024; Mijatovic et al., 2022). High-intensity, 5-minute situational game exercises offer a substantial stimulus to the cardiovascular system. The impact of this training is similar to high-intensity interval training (HIIT), resulting in an improvement in aerobic capacity (Atakan et al., 2021; Batacan et al., 2017). Research indicates that this game-oriented training approach may be more effective in enhancing VO2 max among futsal players (Berdejo-del-Fresno et al., 2015; Fitrian et al., 2023).

Using game-centered strategies in physical training provides a fresh, more enjoyable alternative to conventional training techniques, making the process both engaging and motivating (Cocca et al., 2020; Review, 2023). In futsal, players must be prepared to handle sudden shifts in play, demanding quick reactions, agility, and adaptability to effectively respond to both opponents and evolving team tactics (Cocca et al., 2020). The inherent competition in games motivates players to consistently test and extend their skills and capabilities to new levels (Ives et al., 2020). In competitive training environments, players are driven to push their limits, striving to improve physical abilities like speed, jumping height, and endurance, especially when competing against themselves or their teammates (DiMenichi & Tricomi, 2015). As a result, training in game-like situations stimulates the heart rate and enhances cardiovascular activity, which plays a role in improving VO_2 max levels (Berdejo-del-Fresno et al., 2015).

In futsal, agility is a key component that supports maneuverability, facing opponents, and quickly adapting to changing situations (Komang Ari Selin et al., 2024; Sekulic et al., 2019). Game-situation training provides stimuli that closely resemble actual match conditions, including sudden changes in direction, acceleration, deceleration, and maneuvers to evade opponents (Nygaard Falch et al., 2019; Tanyeri & Öncen, 2020). By incorporating these elements, players are required to adapt dynamically and swiftly, leading to enhanced agility skills (Bhagat et al., 2020; Suryadi et al., 2023; Wubale et al., 2023). Agility in sports is not only the physical ability to change direction swiftly but also requires cognitive skills to recognize and respond to situations effectively (Büchel et al., 2022; Zhu et al., 2024).

Game-like situations train both aspects simultaneously, as players are constantly required to monitor the opponent's movements and the ball's position (Young et al., 2022). In game-like situations, players learn to anticipate opponents' actions and synchronize their own movements, which strengthens the connection between perceptual skills and motor execution (Bidzan-Bluma & Lipowska, 2018).

A situational game training program is designed to simulate actual match conditions. This involves exercises that combine physical, technical, and tactical elements within different game scenarios. The primary focus is to create intense, dynamic, and realistic training sessions to comprehensively develop players' physical abilities. Integrating situational game training is an effective approach to enhancing the physical condition of futsal players. By simulating real match conditions, players can develop the cardiovascular endurance, strength, agility, and speed required. Additionally, this training helps improve players' technical and tactical skills, making them better prepared to face challenges in actual matches. Consistent implementation of this program can help the team achieve peak performance on the field.

Conclusions

This study concludes that situational game training with a 5-minute exercise load is effective in improving VO2max and agility in futsal players. The implications of this research may lead to the development of more effective and efficient training strategies to enhance the cardiorespiratory aspects and agility that are crucial for overall futsal player performance. Therefore, this article makes a valuable contribution to the sports literature on training methods that can be applied to improve physical and technical performance in the context of futsal.

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