Effects of resistance training and technical soccer exercises on anaerobic performance

Efectos del entrenamiento de resistencia y ejercicios técnicos de fútbol en el rendimiento anaeróbico

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Abstract

Introduction: This study aims to analyze the effects of Speed Endurance Training (SET) and technical drills on the anaerobic performance of amateur male soccer players, measured through peak power, average power, and fatigue index.
Methodology: A pre-experimental method with a one-group pretest-posttest design was applied. The Running-Based Anaerobic Sprint Test (RAST) assessed peak power (PP), average power (AV), and fatigue index (FI). A paired sample test was conducted, preceded by the Shapiro-Wilk normality test. Eighteen players participated in the study, with an average age of 20.28±0.89 years, soccer experience of 5.06±0.86 years, height of 170.94±4.71 cm, body mass of 61.07±5.52 kg, body mass index of 20.89±1.72, PP of 460.83±54.79 watts, AV of 355.22±61.91 watts, and FI of 42.54±9.98.
Results: The results revealed significant differences across all variables, with a significance value of <0.05. The mean differences were 40.77±21.24 watts for PP, 39.14±19.42 watts for AV, and -3.52±4.94 for FI.
Conclusions: The conclusion is that combining SET and technical drills impacts the anaerobic performance of amateur male soccer players, as demonstrated by the increases in PP and AV and the decrease in FI.

Keywords

Speed endurance training; anaerobic capacity; peak power; average power; fatigue index; soccer training intervention.

Resumen

Introducción: Este estudio tiene como objetivo analizar los efectos del Entrenamiento de Resistencia a la Velocidad (SET) y los ejercicios técnicos en el rendimiento anaeróbico de futbolistas aficionados, medido mediante potencia máxima, potencia media e índice de fatiga.
Metodología: Se aplicó un método preexperimental con un diseño pretest-postest de un grupo. El Test de Sprint Anaeróbico Basado en la Carrera (RAST) evaluó la potencia máxima (PP), la potencia media (VA) y el índice de fatiga (IF). Se realizó una prueba con muestras pareadas, precedida por la prueba de normalidad de Shapiro-Wilk. Dieciocho jugadores participaron en el estudio, con una edad promedio de 20,28 ± 0,89 años, experiencia futbolística de 5,06 ± 0,86 años, altura de 170,94 ± 4,71 cm, masa corporal de 61,07 ± 5,52 kg, índice de masa corporal de 20,89 ± 1,72, PP de 460,83 ± 54,79 vatios, AV de 355,22 ± 61,91 vatios y FI de 42,54 ± 9,98.
Resultados: Los resultados revelaron diferencias significativas en todas las variables, con un valor de significancia de <0,05. Las diferencias medias fueron 40,77 ± 21,24 vatios para PP, 39,14 ± 19,42 vatios para AV y -3,52 ± 4,94 para FI.
Conclusiones: La conclusión es que la combinación de SET y ejercicios técnicos impacta el rendimiento anaeróbico de los jugadores de fútbol amateur masculino, como lo demuestran los aumentos en PP y AV y la disminución en FI.

Palabras clave

Entrenamiento de resistencia a la velocidad; capacidad anaeróbica; potencia máxima; potencia media; índice de fatiga; intervención en el entrenamiento de fútbol.

Introduction

The increasing demands of modern soccer, such as rapid transitions, higher pass frequency, and shorter distances between players, have significantly impacted players' performance and health. These changes emphasize the need for integrated collaboration between medical teams, sports scientists, and competent coaches (Nassis et al., 2020). Historically, soccer relied more on individual skills and long passes. However, in the modern era, it has evolved into a more tactical and dynamic game with high-intensity transitions and tighter player spacing, leading to a notable increase in the number of passes (Dello Iacono et al., 2018). This high-intensity nature of modern soccer can be characterized by aerobic and anaerobic demands, with players often performing at intensities ranging from 70% to 90% of VO2max or maintaining heart rates (HR) at 80% to 95% of their maximum during competitive matches.

This shift in playing style presents significant challenges for players, who are required to excel in technical and tactical skills and maintain optimal physical fitness. Specifically, players must perform frequent quick transitions and short sprints throughout matches. Players need to develop anaerobic capacity to sustain physical performance during these sprints and accelerations. This capacity helps players minimize fatigue and maintain performance levels during the game (Mohr & Krustrup, 2016; Spencer et al., 2005).

Coaches must specifically design soccer training programs to meet players' physical and physiological demands based on their positions during matches. This approach involves a combination of technical skills and tactical drills to ensure players are prepared for the dynamics of modern soccer (Mota et al., 2023; Pramanik et al., 2022). This study explores the combination of Speed Endurance Training (SET) and technical drills specifically to enhance anaerobic capacity, as reflected in peak power, average power, and fatigue indeks.

SET is a training method designed to enhance a player's ability to sustain high intensity while reducing recovery time (Iaia et al., 2015). This method involves high-intensity anaerobic training, which can be categorized into speed endurance production and speed endurance maintenance (Akdoğan et al., 2021). Speed endurance production training, for example, involves high-intensity exercises with intervals of around 30 seconds and rest periods of 2-3 minutes to ensure adequate recovery (Mohr & Krustrup, 2016). In soccer, anaerobic endurance is crucial for supporting rapid transitions between defense and attack, often requiring repeated sprints (Juliano F. et al., 2010).

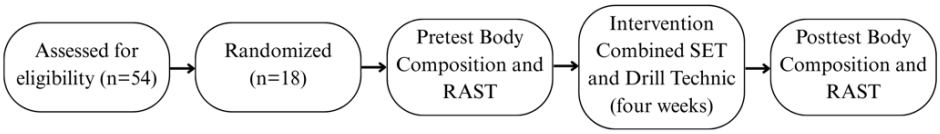
In addition to physical aspects, improving players' technical and tactical skills is equally important, mainly through technical drill training. Passing and dribbling are fundamental skills every soccer player must master. A team's success in winning matches relies heavily on individual skills and teamwork in executing passes or dribbles to teammates (Syahrastani & Kamal, 2020). Technical drill training offers an effective method to enhance players' passing and dribbling abilities (Supriatna & Juni, 2023). Furthermore, this method allows players to automate key movements in specific match situations (Clemente, 2016; Hakim & Ulpi, 2023).

Based on this background, the present study examines the effects of SET and technical drill training on players' anaerobic capacity. The results are expected to significantly contribute to soccer coaching, particularly in meeting the demands of modern gameplay.

Method

This study employed a pre-experimental method with a one-group pretest-posttest design. The objective was to analyze the effects of Speed Endurance Training (SET) and technical drills on anaerobic capacity, measured through peak power, average power, and fatigue index. We conducted the testing using the Running-based Anaerobic Sprint Test (RAST). The study lasted six weeks, with one week for pretest measurements, four weeks of intervention, and one week for posttest measurements.

Figure 1. Flowchart the experimental design



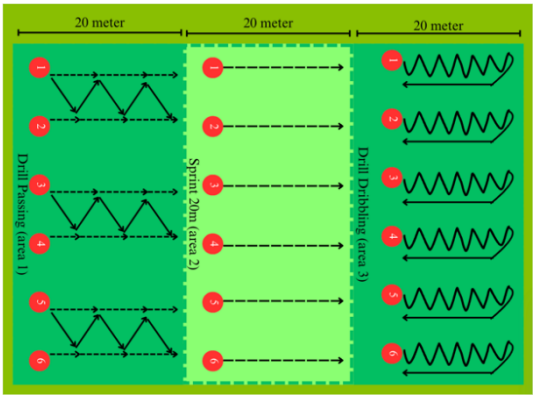
Participants

The study population consisted of 54 amateur male soccer players. A total of 18 participants were selected using a random sampling technique. The sample size was determined based on the specific requirements and feasibility of implementing the designed training program, which involved detailed supervision and controlled training sessions. Before random sampling, participants had to meet specific eligibility criteria, including being male, aged 19–21 years, actively involved in an amateur soccer team for at least one year, in good health without any serious injuries in the past three months, training at least three times per week, and willing to participate in all stages of the study. Participants were excluded if they had active injuries, could not complete the study, had not played regularly in the past six months, or used medications or supplements that could affect physical performance.

Training Program

The training program design is illustrated in Figure 2, showing the combination of SET and technical passing and dribbling drills, including player positions, sprint distances, and repetition patterns. The SET and drill combination begins with all players performing paired passing drills in Area 1 for 18 seconds, followed by a 20-meter sprint to Area 3. In Area 3, players perform zig-zag dribbling drills for 18 seconds. Afterward, they sprint 20 meters back to Area 1 to repeat the passing drill for another 18 seconds. Players then sprint 20 meters back to Area 3 and repeat the pattern. Each repetition involves a total of 4 sprints, covering a distance of 20 meters, resulting in a total sprint distance of 80 meters per repetition and a total drill time of 72 seconds (18 seconds x 4). In one training session, players complete 8 repetitions, covering a total sprint distance of 640 meters (80 meters x 8 repetitions) and a total drill time of 576 seconds (72 seconds x 8 repetitions). The interval between activities is set at 1:2, ensuring a balance between work intensity and rest (Bharlaman et al., 2024).

Figure 2. Training area



Data analysis

Data were analyzed using mean values and standard deviations. We performed statistical tests using the paired sample test and checked normality using the Shapiro-Wilk method. We also calculated the percentage change between the pretest and posttest results to illustrate trends of improvement or decline. The percentage change (Δ%) was calculated using the formula: Δ% = ((Post - Pre) / Pre) * 100.

Results

This section presents the findings of the study on the effects of Speed Endurance Training (SET) combined with technical drills on anaerobic performance in amateur male soccer players. The analysis focuses on changes in peak power, average power, and fatigue index between pretest and posttest.

Table 1. Sample characteristics

Variable	Mean ± SD
Age (years)	20.28±0.89
Soccer experience (years)	5.06±0.86
Height (cm)	170.94±4.71
Body mass (kg)	61.07±5.52
BMI (kg/m2)	20.89±1.72
Peak Power (watt)	460.83±54.79
Average power (watt))	355.22±61.91
Fatigue Index	42.54±9.98

Note: The values shown refer to the pretest results for all variables

Table 1 presents the characteristics of the sample in this study. The average age of the participants falls within the young adult range, with a diverse range of soccer experience. The participants' height shows relatively standard variation, while their body weight and body mass index indicate a generally healthy range. Regarding physical performance, participants demonstrate fairly good peak power and average power levels, and their fatigue index values reflect the degree of fatigue following physical activity.

Figure 3. Normality test graph

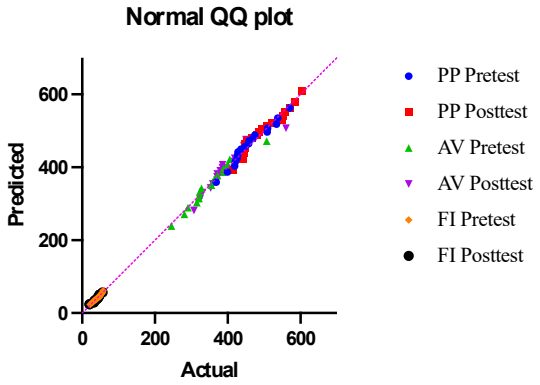
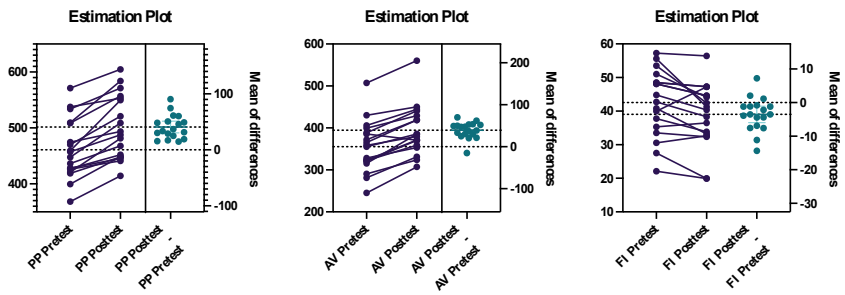


Figure 3 displays the normality test results, showing that all variables' data follow a normal distribution. The Shapiro-Wilk test results support this, with significance values >0.05: Pretest PP (0.5655), Posttest PP (0.3187), Pretest AV (0.7909), Posttest AV (0.1153), Pretest FI (0.7216), and Posttest FI (0.2690). Therefore, the data met the normality assumption and were subsequently analyzed using the paired sample test.

Figure 4. Pretest and posttest comparison for PP, AV, and FI variables



Based on Figure 4, the paired sample test results indicate significant differences in all analyzed variables. The PP variable's p-value was <0.0001, with an average difference of 40.77±21.24 watts. The AV variable's p-value was <0.0001, with an average difference of 39.14±19.42 watts. Meanwhile, the FI variable's p-value was 0.0077, with an average difference of -3.521±4.944. These results demonstrate significant changes in all three variables following the intervention.

Figure 5. The magnitude of improvement in PP, AV, and FI variables

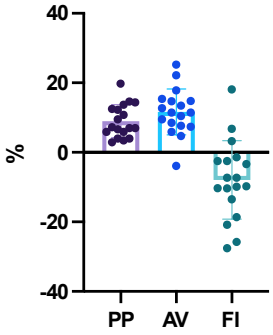


Figure 5 shows the pretest and posttest differences in the PP, AV, and FI variables, reflecting the effects of the intervention on anaerobic capacity. PP showed significant fluctuations, with differences ranging from 2.91% to 19.74%, while AV varied from -3.87% to 25.23%, mainly indicating performance improvement despite some declines in certain subjects. FI was predominantly negative, with the lowest value of -27.54%, indicating reduced fatigue, although some positive values suggest the opposite. These results demonstrate improvements in anaerobic performance with varying responses across individuals.

Discussion

The analysis results show a significant improvement in the anaerobic capacity of amateur male soccer players after participating in the SET and technical drill training program. This improvement was demonstrated by increases in peak power and average power and a decrease in fatigue index during the posttest, indicating that the training successfully enhanced the players' overall anaerobic capacity. The primary indicator of this improvement is the players' ability to maintain high intensity during repeated activities, a key component of soccer performance (Kusuma, Kusnanik, Lumintuarso, et al., 2024).

SET training increases muscle fatigue tolerance by triggering physiological adaptations, including improving muscle buffering against lactic acid accumulation (Bharlaman et al., 2024; Kusuma, Kusnanik, Pramono, et al., 2024). In this study, the SET used was maintenance type, which has been shown in previous research to enhance fatigue tolerance and performance (Vitale et al., 2018). Physiologically, this training promotes more efficient glycolytic activation, improves energy production through anaerobic pathways, and minimizes hydrogen ion accumulation, contributing to muscle fatigue, this is in line with previous studies that suggest training targeting glycolytic capacity enhances anaerobic endurance in soccer players (Polczyk & Zatoń, 2015).

The energy system involved in SET training is the anaerobic lactate system. Adaptations from this training include increased PCr storage capacity and improved lactate metabolism efficiency, which are crucial for soccer performance. Previous studies have shown that SET training improves muscle oxidative capacity and performance during training (Fransson et al., 2018). Enhanced muscle oxidative capacity enables more efficient energy production, improving endurance, accelerating recovery, and delaying fatigue. Other studies also support the positive impact of SET training on soccer performance (Rago et al., 2022).

Moreover, Fahrudin et al. (2024) indicates that high-intensity training methods, such as High-Intensity Interval Training (HIIT), significantly enhance anaerobic endurance and are relevant to the results of this study, where players showed significant improvements in repeated sprint performance after the

training program. These findings are consistent with previous research by Stöggl & Björklund (2017), which suggests that high-intensity training can enhance muscle glycolytic activity quickly, providing additional energy needed for anaerobic activities. This study also supports the findings of Luesopa & Yimlamai (2019), which indicate that speed and endurance training improves anaerobic and aerobic capacity in university soccer players. Furthermore, four-week training durations have shown significant effectiveness, as demonstrated by Mohr & Krustrup (2016), where two training sessions per week for four weeks enhanced intermittent training capacity and anaerobic ability. In this context, the frequency of the three times per week used in this study yielded even more optimal results.

The main advantage of combining SET training with technical drills is the integrative approach that improves physical capacity and develops essential technical skills in soccer. The coach designed the technical drill sessions to hone passing and dribbling abilities (Aquino et al., 2017; Pizarro et al., 2017; Rello Pambudi & Widiyanto, 2019). This combination provides synergistic benefits, where enhanced anaerobic capacity supports the stability of technical skills even under fatigue. Previous research also found that ball drills positively impact soccer player performance (Sridadi et al., 2021), which further reinforces the approach used in this study. Additionally, Clemente et al. (2022) supports that training three times a week, as applied in this study, positively impacts anaerobic capacity. This approach also optimizes physiological and neuromuscular adaptations through repeated high-intensity training.

The findings of this study offer valuable insights for soccer coaches, particularly in designing effective training programs. Combining physical training like SET with technical drills provides a holistic approach that improves physical performance and develops players' technical skills (Castillo et al., 2021; Karahan, 2020; Moran et al., 2019). This program can be applied at various competition levels, from university to professional levels, to prepare players for the increasing demands of modern, dynamic soccer. This training model can also be used to develop young players, helping them achieve their full physical and technical potential. However, this study has some limitations. First, there was no control group for comparison. Second, the training duration of just four weeks may not be enough to uncover the long-term effects of this program.

Conclusions

This study shows that the combination of SET training and technical drills significantly improves the anaerobic capacity of male amateur soccer players. These results indicate that this training is effective in enhancing anaerobic endurance and helping players maintain high intensity during repeated activities, which is crucial for soccer performance. However, this study's limitations include the lack of a control group and the short training duration of only four weeks, which may not be sufficient to reveal the long-term effects of this program. We expect further research with a longer duration and a control group to provide a more comprehensive understanding of the long-term impact of this training.

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