The effects of speed endurance training on aerobic and anaerobic performance of young female soccer players

Efectos del entrenamiento de resistencia en velocidad sobre el rendimiento aeróbico y anaeróbico en jugadoras jóvenes

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Abstract

Introduction: This study examines the impact of speed endurance training on the aerobic and anaerobic capacities of young female soccer players. The research focuses on assessing the physiological adaptations resulting from structured high-intensity training, which is crucial for enhancing soccer performance.
Methodology: Thirty female soccer players, aged 14–18 years, were randomly assigned to either an experimental group or a control group. The experimental group participated in speed endurance training sessions twice per week for six weeks while continuing their regular soccer training regimen. In contrast, the control group followed their standard soccer training program without additional speed endurance exercises.
Results: The experimental group demonstrated significant physiological improvements compared to the control group. Specifically, aerobic capacity improved notably, with a 68.8% increase in Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) distance and a 10.2% increase in VO_2max, indicating enhanced cardiovascular endurance. Additionally, the reduction in resting heart rate suggested improved cardiovascular efficiency. In terms of anaerobic performance, the athletes who underwent speed endurance training exhibited a 35.6% improvement in anaerobic capacity and a 38.3% increase in anaerobic power. Furthermore, their fatigue index decreased, reflecting better sprinting ability and improved recovery. When compared to the control group, which showed minimal physiological progress, these results highlight the superior benefits of speed endurance training over regular soccer training alone.
Conclusion: The findings confirm that incorporating speed endurance training in soccer enhances both endurance and power production capabilities, leading to improved overall performance. Given these advantages, coaches and trainers should integrate structured speed endurance drills into training regimens.

Keywords

Speed endurance training; aerobic capacity; anaerobic power; VO_2max; soccer performance; fatigue resistance; high-intensity interval training.

Resumen

Introducción: Este estudio examina el impacto del entrenamiento de resistencia en velocidad sobre las capacidades aeróbicas y anaeróbicas de jugadoras jóvenes de fútbol, enfocándose en las adaptaciones fisiológicas resultantes de un entrenamiento estructurado de alta intensidad.
Metodología: Treinta jugadoras de 14 a 18 años fueron asignadas aleatoriamente a un grupo experimental o de control. El grupo experimental realizó sesiones de entrenamiento de resistencia en velocidad dos veces por semana durante seis semanas, mientras que el grupo de control siguió su programa habitual de fútbol.
Resultados: El grupo experimental mostró mejoras significativas en comparación con el grupo de control. La capacidad aeróbica aumentó un 68.8% en el Yo-Yo IR1 y un 10.2% en VO_2max. También se observó una reducción en la frecuencia cardíaca en reposo. En términos anaeróbicos, hubo un incremento del 35.6% en capacidad anaeróbica y un 38.3% en potencia anaeróbica. Además, su índice de fatiga disminuyó.
Conclusión: Los resultados confirman que el entrenamiento de resistencia en velocidad mejora tanto la resistencia como la potencia, lo que se traduce en un mejor rendimiento. Se recomienda su integración en los regímenes de entrenamiento.

Palabras clave

Entrenamiento de resistencia en velocidad; capacidad aeróbica; potencia anaeróbica; VO_2max; rendimiento en fútbol; resistencia a la fatiga; entrenamiento de intervalos de alta intensidad.

Introduction

Players who compete in soccer experience substantial physical demands which govern their match activities. Professional soccer athletes need to sustain performance levels that require endurance and simultaneously need speed and strength abilities and push their aerobic and anaerobic systems to their highest possible capacity (Bangsbo, 1994). Female soccer players need specialized training methods since research about their athletic performance has been historically restricted (Harkness-Armstrong et al., 2022) to enhance their athletic development and match performance outcomes. Speed endurance training from the high-intensity interval training (HIIT) category provides soccer athletes with an effective stimulus to enhance their aerobic capacity and anaerobic power (Bangsbo et al., 2008; Buchheit & Laursen, 2013). The results show that VO_2max determines how much aerobic fitness influences soccer performance. Players achieve longer durations at intensive activities through higher VO_2max levels which also improves their recovery speeds and maintains their speed performance during matches (Krustrup et al., 2005). The absolute VO_2max values of female athletes who participate in aerobic capacity training programs improve their endurance because their absolute VO_2max values tend to be lower than male values due to physiological differences (Randell et al., 2021). Many essential soccer situations depend on outstanding anaerobic ability because they involve brief high-intensity movements (Keir et al., 2013). Soccer players benefit from speed endurance training as an exclusive approach to simultaneously activate their aerobic and anaerobic energy systems (Iaia et al., 2009).

The training method of speed endurance consists of multiple intensive exercises followed by brief recovery periods. The training method that mimics soccer stop-start actions has been proven by scientists to yield significant advantages for participating athletes. Speed endurance training effectively increases VO_2max levels repeated sprint ability and fatigue resistance in male and female soccer players according to Nyberg et al. (2016) Castagna et al. (2020) and Jastrzębska (2023). The physical training responses of younger athletes make speed endurance training highly effective according to De Oliveira et al. (2023) and Komarudin et al. (2022).

Female soccer players experienced enhanced aerobic and anaerobic capacities through heart rate- and speed-based HIIT programs as described by Arazi et al. (2017). Programs developed by combining sport-specific movement patterns and high-intensity bursts serve to enhance performance during multiple high-intensity phases as well as repeated sprint movements observed in competitive play. The training method creates an effective solution for teams with short schedules because it generates fitness improvements during short time frames (Tønnessen et al., 2011; Vitale et al., 2018).

The evidence-based speed endurance training method produces effective results by enhancing both the aerobic and anaerobic abilities of young female soccer players. Speed endurance training brings two major benefits to soccer teams through its ability to develop multiple energy systems while remaining practical for team conditioning sessions so it stands as an important training method. The sustained research of coaches and trainers leads to enhanced athletic performance enabling them to provide young female soccer players with vital skills needed to succeed on the field (Mohr & Krustrup, 2016; Youcef et al., 2022).

Literature Review

This section examines research findings about speed endurance training's effects on both aerobic and anaerobic performance in soccer players while emphasizing young female athletes. The review is organized into three key themes: This section examines the physical requirements of soccer alongside speed endurance training benefits and physiological changes in female soccer players.

Physiological Demands of Soccer

The sport of soccer demands intermittent high-intensity performance characteristics of both aerobic endurance and anaerobic power. Throughout a soccer match players run between 10 and 13 kilometers and spend nearly 10% of this distance performing high-intensity movements like sprints and accelerations (Bangsbo 1994; Mohr et al. 2003). A player's capacity to maintain performance levels during matches and their recovery speed depends both on their aerobic capacity as measured by VO2 max and

their anaerobic ability to handle high-power activities of short duration. The 2003 Krustrup et al. study demonstrated how essential aerobic capacity becomes for soccer players because their performance and recovery rates improve with higher VO2 max ratings. The research demonstrated anaerobic power's critical role because explosive movements like sprinting and jumping drive both offensive and defensive actions. To optimize performance soccer training programs must address the requirement for both aerobic and anaerobic energy systems because players depend on both during a game.

Speed Endurance Training

Speed endurance training, a form of high-intensity interval training (HIIT), targets both aerobic and anaerobic systems. This exercise consists of intensive performance phases followed by brief rest intervals thereby simulating soccer movements which the human body perfectly emits during matches. The application of this training protocol to soccer-specific fitness represents a foundation of rigorous scientific investigation which demonstrates its powerful results. Elite soccer players showed significant improvements in Yo-YoIR1 performance along with VO2max and sprint ability following speed endurance training according to Bangsbo et al. (2008). The observed advancements resulted from better oxygen use alongside improved lactate tolerance and faster recovery during repeated high-intensity exercise intervals. The results from Iaia et al. (2009) demonstrate how speed endurance training strengthens aerobic and anaerobic energy systems so that players can perform high-intensity work for longer intervals. Professional soccer players who incorporated speed endurance training into their competitive-season programs experienced marked improvements in both endurance and match performance according to Dupont et al., 2004. The results demonstrate that speed endurance training improves physical fitness and produces better match-specific results.

Aerobic Training Adaptations

Maximizing aerobic fitness allows soccer players to perform consecutive high-intensity actions along with rapid recovery between sprints which supports overall soccer performance. Research consistently shows performance in terms of VO2 max rises alongside endurance capacity when speed endurance training is applied. The Yo-YoIR1 test which evaluates aerobic fitness matches soccer's intermittent demands and demonstrates performance gains from specialized training programs. According to research by Krustrup et al. (2005), soccer players demonstrated a strong relationship between Yo-YoIR1 test performance and their match performance which included total distance covered alongside high-intensity running distance. Yuan et al. (2024) determined that players needed improved aerobic capacity to achieve better game performance outcomes. A meta-analysis reinforced these results by demonstrating that HIIT methods together with speed endurance sessions outperformed traditional continuous training methods for enhancing soccer athletes' VO2 max.

Anaerobic Training Adaptations

Soccer athletes must have strong anaerobic strength alongside power capacity to perform their quick explosive running tasks and physical interruptions through tackles and jumps. Repetition of speed endurance workouts produces substantial improvements in these athletic attributes. Keir and colleagues (2013) demonstrated that soccer players who completed six weeks of speed endurance training showed improvements in both anaerobic power and sprint performance according to the Running-Based Anaerobic Sprint Test (RAST). The researchers found that the Fatigue Index decreased which suggested athletes experienced better recovery between repeated sprint sessions. According to Bangsbo et al. (2008), anaerobic power plays a crucial role in sustaining match performance during critical game situations. Through speed endurance training experimental results revealed enhanced muscular lactate tolerance and buffering potential and led to improved high-intensity exercise duration for players.

Training in Female Soccer Players

Research examining training adaptations for female soccer players remains scarce even though women's soccer has gained more popularity. Female soccer players encounter physiological difficulties because they typically have reduced absolute VO2max values combined with hormonal changes that affect their athletic performance (Lebrun, Joyce & Constantini, 2013). According to research results, well-designed exercise regimens successfully enhance the physical fitness of female athletes.

Through their 2005 research, Stølen and teammates reported positive results from soccer-specific workouts in female athletes who displayed enhancements in their aerobic output alongside their anaerobic capacity plus better muscle strength and endurance levels. The research team called for training plans that consider physiological gender differences between male and female athletes. Speed endurance training demonstrates potential effectiveness for surmounting these athletic challenges. Women soccer players under the guidance of Iaia et al. improved both their aerobic abilities with anaerobic performance following a speed endurance training program. As a result of these adaptations players demonstrated improved recovery times alongside decreased fatigue when playing. Research shows speed endurance training stands out as an optimal way to boost soccer players' aerobic and anaerobic capabilities. This training targets sport-specific physiological needs which leads to better VO2max performance together with enhanced endurance and anaerobic power and improved recovery function. The scientific community has extensively studied male soccer players yet research on female soccer athletes stays sparse which demonstrates a critical requirement for additional studies.

The review establishes essential knowledge about speed endurance training advantages for young female soccer players. The study demonstrates that high-intensity interval training should become an essential component of soccer programs to achieve peak physical fitness and superior match performance.

Method

This section explains how the research was done. The design of the same is described and it is explained how it was put into practice, justifying the choice of the methods used. This section should contain the type of quantitative research, the scope or depth of the research (exploratory, correlational and/or explanatory), population and sample, and the techniques used should be added. This section is fundamental, because it is the one that will allow the scientific community to reproduce the result. Most of this section should be written in the past tense, in a descriptive style.

Participants

Population

The research population included female soccer players at the youth level from Tessaban 1 “Burirat Darunwittaya” School in Buriram Province because they followed structured training programs and competed in matches which created a controlled setting to evaluate speed endurance training effects. Youth female soccer players from Tessaban 1 “Burirat Darunwittaya” School in Buriram Province form a representative research group that participates in systematic training at the regional level. Darunwittaya” School in Buriram Province during the 2021 academic year. The study participants ranged in age from 14 to 18 years.

Sample and Sample Size Calculation

A purposive sampling method was used to select 30 female soccer players who fulfilled the study requirements. The targeted participant recruitment method of purposive sampling enables researchers to select suitable candidates yet produces possible biased results that decrease study generalization. The research findings need to be viewed within the boundaries of purposive sampling because this method might restrict their universal application. The researchers determined the necessary sample size by running a power analysis through G Power 3.1 software (Faul et al., 2007). The independent t-test calculation used a 0.05 alpha level and 0.80 power with an effect size of 0.80 (Cohen, 1988) which is considered large. A total of 30 participants were needed to detect significant differences in the study with each group containing 15 participants. The sample size calculation through power analysis showed it would deliver enough statistical power to find meaningful results.

The study divided its participants into two groups of 15 participants who underwent maximum oxygen uptake (VO_2max) testing through the Yo-YoIR1 assessment. The researchers used VO_2max test results as a basis to assign participants into groups because they wanted to maintain similar initial aerobic capacity levels. The grouping procedure accounted for physical conditioning and training history to reduce selection bias while using Yo-Yo Intermittent Recovery Level 1 (Yo-YoIR1) test to measure VO_2max. The VO_2max measurement required the use of this calculation formula:

- Experimental Group (n = 15): Underwent a speed endurance training (SET) program combined with regular soccer practice.
- Control Group (n = 15): Participated only in regular soccer training, with training volume and time matched to the experimental group to ensure comparable physical workloads.

Variables

Independent Variables

- Speed endurance training program
- Regular soccer training program

Dependent Variables

- Distance covered in the Yo-YoIR1 test
- VO_2max
- Resting heart rate (HR) after 10 minutes of rest
- Anaerobic capacity
- Anaerobic power
- Fatigue index

The dependent variables were selected based on their relevance in assessing the effects of speed endurance training on soccer performance. VO_2max and Yo-YoIR1 test performance are critical indicators of aerobic fitness, while anaerobic power and fatigue index are essential for evaluating sprint performance and endurance.

Inclusion and Exclusion Criteria

Inclusion Criteria Participants were eligible if they:

- Had at least three years of soccer playing and competitive experience.
- Had no history of musculoskeletal injuries or conditions that could hinder training. • Were willing to participate and provided informed consent.
- Had regular and mild menstrual cycles to control for hormonal variability (assessed through participant self-reporting and medical history).
- Were not at risk for COVID-19 based on local health regulations.

Exclusion Criteria Participants were excluded if they:

Experienced illness, injury, or COVID-19 infection during the study.

Participated in less than 90% of the training sessions.

• Voluntarily withdrew from the study.

Data Collection Procedure Preparation

- Testing facilities, equipment, and training schedules were arranged in advance.
- Participants received detailed instructions and demonstrations of testing procedures.
- Informed consent was obtained from each participant and their guardians.

Baseline Measurements General participant data, including age, weight, height, and resting heart rate, were recorded. Baseline performance tests included:

- Sprint Tests (10m, 20m, and 30m)
- Agility T-Test

- RAST Test (Running Anaerobic Sprint Test): Participants sprinted 35m at maximum speed, rested for 10 seconds, and repeated the sprint six times. Time was recorded for each sprint (Keir et al., 2013).
- Yo-YoIR1 Test: Participants performed a 20m shuttle run with increasing speed, synchronized with auditory cues, until exhaustion (Krustrup et al., 2003).

Environmental and Standardization Controls

- Time of Day for Testing: All tests were conducted between 8:00 AM and 10:00 AM to minimize circadian rhythm effects.
- Environmental Conditions: The study took place in an indoor sports facility, maintaining consistent temperature (22-24°C) and humidity (50-60%). Temperature and humidity levels were monitored using a digital hygrometer and adjusted as needed to ensure stable conditions throughout the study period. And humidity (50-60%).
- Pre-Test Standardization: Participants were instructed to: o Avoid caffeine and heavy meals at least two hours before testing.
- Maintain normal hydration levels (monitored through self-reporting and urine color assessment).
- Refrain from intense exercise 24 hours before testing.
- Warm-Up Protocol: All participants underwent a standardized 15-minute dynamic warm-up, including jogging, mobility drills, and sprint activation exercises before testing.
- Training Protocol Experimental Group (Speed Endurance Training + Regular Soccer Practice)
- Warm-up: 15 minutes (dynamic stretching, mobility drills, and short sprints).
- Speed Endurance Training:
- 20m maximal sprint efforts
- Six sprints per session (each lasting <30 sec)
- 3-minute rest between each sprint
- Conducted twice per week (Monday and Thursday) for six weeks.
- Regular soccer training followed the same structure as the control group.

Control Group (Regular Soccer Training Only, Volume Matched)

- Warm-up: 15 minutes (dynamic stretching, mobility drills).
- Technical drills: 40 minutes (passing, dribbling, ball control).
- Small-sided games: 40 minutes.
- Shooting and set-piece drills: 20 minutes.
- Cool-down: 10 minutes.
- Sessions lasted 140 minutes per day, six days per week, ensuring equal training volume as the experimental group.

Post-Training Measurements After six weeks, the same performance tests were conducted to measure changes in:

- VO_2max and Yo-YoIR1 performance
- Sprint and agility performance
- Anaerobic power and fatigue index (RAST Test)
-

Research Instruments and Reliability Equipment

- Stopwatch (±0.01s accuracy)
- Computer for data recording
- Weighing scale (precision ±0.1kg) and height measurement tools
- Polar H10 Wireless Heart Rate Monitor (validated for high-accuracy HR measurement)
- RAST and Yo-YoIR1 testing software

Reliability and Quality Control Measures

- Yo-YoIR1 test reliability: ICC = 0.89 (Krustrup et al., 2003)
- RAST test reliability: ICC = 0.86 (Keir et al., 2013)
- Sprint tests: ICC = 0.91 (Dupont et al., 2004)

All tests were conducted by the same researcher to ensure consistency.

Data Analysis

- Descriptive statistics (mean ± standard deviation) were used to summarize dependent variables.
- Normality was assessed using the Shapiro-Wilk test.
- Levene's test was conducted to check the homogeneity of variances.
- Paired sample t-tests were conducted to analyze within-group differences before and after training.
- Independent sample t-tests compared post-training differences between the experimental and control groups.
- Effect sizes (Cohen's d) were reported to quantify meaningful differences.

Statistical analyses were conducted using SPSS (version 28.0), chosen for its robust statistical analysis capabilities, user-friendly interface, and wide acceptance in sports science research. with significance set at $p < 0.05$.

Results

Symbols Used in Data Analysis

- N: Number of samples
- $\bar{x}$: Mean
- S.D.: Standard deviation
- NS: No significant difference
- S: Significant difference

This study evaluated the effects of a speed endurance training program on the aerobic and anaerobic performance of young female soccer players in Buriram Province. The collected data before and after training for both the experimental and control groups are detailed below.

Part 1: Basic Information of the Experimental and Control Groups

Table 1 presents the demographic data for 30 participants, including 15 in the experimental group and 15 in the control group. All participants were aged 14–18 years, had 3–5 years of soccer experience, had no history of injury, were not at risk for COVID-19, and attended at least 90% of training sessions.

Table 1. Demographic Data of Participants

Demographic Variable	Category	Frequency (n)
Age	14-16 years	18
	17-18 years	12
Total		30
Group	Experimental	15
	Control	15
Experience in Soccer	3-5 years	18
	6+ years	12
Menstrual Cycle	Regular	30
Health Condition	No history of injury	30
	History of injury	0
Risk for COVID-19	Not at risk	30
	At risk	0
Informed Consent	Provided	30
Training Participation	≥ 90% sessions attended	30
	< 90% sessions attended	0

The pre-training characteristics of both groups were statistically similar, ensuring comparability before the intervention.

Part 2: Comparison of Aerobic Performance

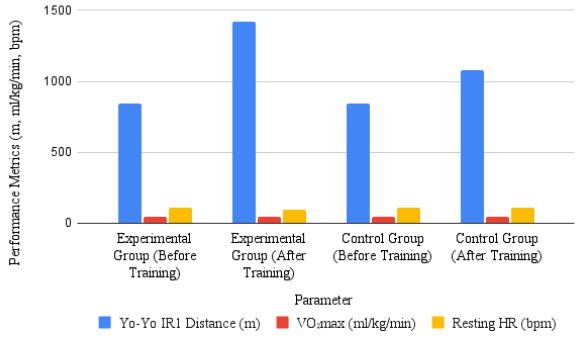
The aerobic performance improvements for the experimental and control groups before and after training are shown in Tables 2 and 3. The experimental group demonstrated significant improvements in Yo-Yo IR1 distance (+68.8%), VO2 max (+10.2%), and a significant reduction in resting heart rate (-9.07 bpm), all with p-values < 0.05.

Table 2. Aerobic Performance of the Experimental Group (Pre- and Post-Training)

Parameter	Before Training x̄ ± S.D.	After Training x̄ ± S.D.	p-value	Sig.
Distance Yo-YoIR1 (m)	844 ± 281.65	1424 ± 332.45	0.000	S
VO2max (ml/kg/min)	43.48 ± 2.36	47.92 ± 2.71	0.000	S
HRrest10 min (bpm)	108.20 ± 7.32	99.13 ± 8.65	0.003	S

Figure 1 illustrates these improvements in aerobic performance metrics for the experimental and control groups before and after training.

Figure 1. Comparative Analysis of Aerobic Performance Metrics



Part 3: Comparison of Anaerobic Performance

Significant performance gains were observed in the experimental group for anaerobic performance metrics. Anaerobic capacity increased by 35.6%, anaerobic power improved by 38.3%, and fatigue index improved significantly.

Table 3. Anaerobic Performance of the Experimental Group (Pre- and Post-Training)

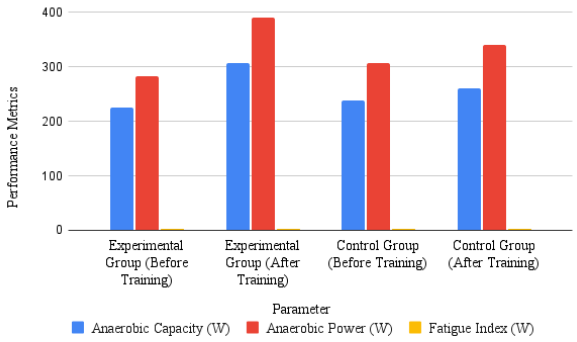
Parameter	Before Training x̄ ± S.D.	After Training x̄ ± S.D.	p-value	Sig.
Anaerobic Capacity (W)	226.22 ± 199.92	306.73 ± 241.45	0.000	S
Anaerobic Power (W)	282.34 ± 276.87	390.63 ± 306.63	0.049	S
Fatigue Index (W)	2.91 ± 1.12	2.78 ± 1.13	0.000	S

The control group showed only minor improvements in anaerobic capacity, with no significant changes in anaerobic power or fatigue index.

Table 4. Anaerobic Performance of the Control Group (Pre- and Post-Training)

Parameter	Before Training x̄ ± S.D.	After Training x̄ ± S.D.	p-value	Sig.
Anaerobic Capacity (W)	238.43 ± 218.07	260.68 ± 234.17	0.000	S
Anaerobic Power (W)	306.67 ± 287.19	339.74 ± 303.55	0.265	NS
Fatigue Index (W)	3.06 ± 0.95	3.01 ± 1.02	0.811	NS

Figure 2. Comparative Analysis of Anaerobic Performance Metrics



Part 4: Overall Performance Comparison

The experimental group demonstrated significantly greater improvements in aerobic and anaerobic performance compared to the control group, confirming the effectiveness of the speed endurance training program.

Table 5. Performance Comparison of Experimental and Control Groups (Pre- and Post-Training)

Parameter	Experimental Group (Before)	Experimental Group (After)	Control Group (Before)	Control Group (After)	p-value	Sig.
Distance Yo-YoIR1 (m)	844 ± 281.65	1424 ± 332.45	842.67 ± 249.67	1080 ± 252.24	0.003	S
VO2max (ml/kg/min)	43.48 ± 2.36	47.92 ± 2.71	43.48 ± 2.10	45.47 ± 2.11	0.004	S
HRrest10 min (bpm)	108.20 ± 7.32	99.13 ± 8.65	112.27 ± 5.62	108.20 ± 6.89	0.003	S
Anaerobic Capacity (W)	226.22 ± 199.92	306.73 ± 241.45	238.43 ± 218.07	260.68 ± 234.17	0.000	S
Anaerobic Power (W)	282.34 ± 276.87	390.63 ± 306.63	306.67 ± 287.19	339.74 ± 303.55	0.049	S
Fatigue Index (W)	2.91 ± 1.12	2.78 ± 1.13	3.06 ± 0.95	3.01 ± 1.02	0.000	S

The speed endurance training program demonstrated substantial improvements in both aerobic and anaerobic performance metrics in the experimental group, underscoring its effectiveness for young female soccer players.

Discussion

This study evaluated the effects of a speed endurance training program on the aerobic and anaerobic performance of young female soccer players. The findings demonstrated that the experimental group, which underwent speed endurance training, experienced significantly greater improvements in both aerobic and anaerobic performance compared to the control group. These results highlight the efficacy of structured speed endurance training in enhancing key physiological markers related to soccer performance.

The experimental group exhibited a 68.8% increase in Yo-Yo IR1 distance, a 10.2% increase in VO2max, and a significant reduction in resting heart rate compared to the control group. These improvements align with previous research indicating that high-intensity interval training (HIIT) and speed endurance training enhance cardiovascular efficiency, oxygen utilization, and overall aerobic capacity in athletes (Buchheit & Laursen, 2013; Dupont et al., 2004). The increase in Yo-Yo IR1 distance suggests better

endurance, allowing players to sustain higher work rates during matches, while the increase in VO2 max indicates improved oxygen delivery and utilization, which is critical for prolonged performance (Krustrup et al., 2003).

The control group also demonstrated improvements in aerobic parameters; however, the magnitude of change was significantly lower. These findings support the notion that while regular soccer training contributes to aerobic development, structured endurance-specific training provides superior benefits (Iaia et al., 2009). The reduction in resting heart rate in the experimental group suggests enhanced cardiovascular efficiency and faster recovery times, both of which are crucial for performance in intermittent high-intensity sports like soccer (Helgerud et al., 2001).

The anaerobic performance metrics of the experimental group also showed significant enhancements. Anaerobic capacity increased by 35.6%, anaerobic power improved by 38.3%, and the fatigue index decreased significantly. These results are consistent with research suggesting that repeated sprint and speed endurance training enhance muscular power, sprint performance, and fatigue resistance in soccer players (Bangsbo et al., 2008). The significant increase in anaerobic power is particularly noteworthy, as explosive sprinting ability is critical for competitive soccer performance (Rampinini et al., 2007).

Conversely, the control group exhibited only minor improvements in anaerobic parameters, reinforcing the conclusion that soccer training alone is insufficient for maximizing anaerobic power development. The limited changes in fatigue index within the control group suggest that endurance-based metabolic adaptations require a more targeted training approach, further supporting the role of speed endurance training in anaerobic conditioning (Glaister, 2005).

The results of this study align with the extensive body of literature advocating for speed endurance training as an effective intervention for improving both aerobic and anaerobic performance in team sports (Buchheit & Laursen, 2013; Iaia & Bangsbo, 2010). Previous studies have shown that elite soccer players benefit from structured speed endurance drills, which induce greater physiological adaptations compared to traditional endurance training (Iaia et al., 2009). Additionally, the significant gains in anaerobic power observed in the experimental group support findings by Krustrup et al. (2006), who noted that high-intensity training improves explosive actions and repeated sprint ability in soccer.

Research findings from this study generate useful applications for soccer coaches together with trainers and sports scientists. Athletic coaches must implement structured speed endurance training drills twice per week to achieve the best possible aerobic and anaerobic transformations for improved results. Heart rate monitoring should be used regularly to assess cardiovascular changes and training outcomes because of the notable resting heart rate improvements found in this research. Speed endurance training programs that match specific soccer positions enhance performance outcomes by helping players fulfill their field requirements (Reilly et al., 2000).

The research findings were robust but the study contained certain limitations. The research used a small participant number (N = 30) that could affect how widely the findings can be applied. Future research needs to utilize bigger participant numbers to enhance the statistical validity of future research projects. Future research must study speed endurance training effects on female soccer players from various age groups and competition levels because this study only included youth-level participants. A complete evaluation of speed endurance training's effects on soccer performance requires the addition of biomechanical and neuromuscular assessments. The research demonstrates that speed endurance training leads to significant performance improvements for aerobic and anaerobic aspects in young female soccer athletes. The experimental group achieved better results than the control group in Yo-Yo IR1 distance measurement VO2 max and resting heart rate and anaerobic capacity and power tests. The research underlines how speed endurance training protocols should be included in soccer conditioning programs because they enhance athletic performance.

Conclusions

This study confirms that speed endurance training significantly enhances both aerobic and anaerobic performance in young female soccer players. The experimental group showed substantial improvements in Yo-Yo IR1 distance (+68.8%), VO_2max (+10.2%), and resting heart rate reduction, indicating enhanced cardiovascular efficiency. Additionally, significant gains in anaerobic capacity (+35.6%), anaerobic power (+38.3%), and fatigue index reduction highlight the effectiveness of speed endurance training in boosting sprint performance and recovery. The findings reinforce that traditional soccer training alone is insufficient for maximizing endurance and anaerobic adaptations. Implementing structured speed endurance training twice a week can optimize both aerobic and anaerobic conditioning, leading to better match performance. Coaches should integrate high-intensity interval sprint drills tailored to game demands, ensuring improved speed, endurance, and recovery. While this study provides valuable insights, its small sample size (N=30) limits generalizability. Future research should include larger, diverse cohorts and assess neuromuscular and biomechanical adaptations to understand the long-term effects of speed endurance training. In conclusion, speed endurance training is a crucial conditioning method that enhances aerobic endurance, sprint ability, and fatigue resistance in female soccer players. Integrating this training into conditioning programs will provide a competitive edge, improving overall performance in soccer and other high-intensity sports.

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