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Effects of High-Intensity Anaerobic Training on Speed Performance With and Without the Ball in Youth Futsal Players

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ABSTRACT

Introduction: In futsal, strength, speed, and agility are essential for success due to the need for swift direction changes and rapid movements. Proficient dribbling is also crucial for maintaining possession and creating scoring opportunities. By incorporating strength training, plyometrics, agility drills, and dribbling exercises, athletes can improve their overall performance. This comprehensive training approach ensures athletes develop the skills and physical abilities necessary for the demands of futsal matches.

Methods: The sample consisted of 31 male youth futsal athletes, selected using systematic random sampling based on the known population size to estimate the average. The experimental intervention involved high-intensity anaerobic training sessions conducted three times a week over eight weeks, resulting in an index of item objective congruence of 1.00. To assess speed performance, the instruments used to collect data were the 20-meter and 40-meter speed tests, both with and without the ball. Descriptive statistics included percentages, means, and standard deviations. In contrast, inferential statistics entailed a one-way analysis of variance with repeated measures if the data was normally distributed and the Friedman test if the data was abnormally distributed, both at the 0.05 level.

Results: The results showed that a Friedman test found significant differences between before and after week 4, before and after week 8, and between week four and week 8 of training in the 20-meter speed test, the 20-meter speed with the ball test, the 40-meter speed test, and the 40-meter speed with the ball test.

Conclusion: High-intensity anaerobic training helps futsal players improve quick sprints, rapid direction changes, and explosive movements with and without the ball. This training enhances overall speed, enabling players to react swiftly and outmaneuver opponents effectively.

Keywords: High-intensity anaerobic training; Speed performance with and without the ball; Youth; Futsal player

Introduction

Futsal originated in Uruguay in 1930 and was created by Juan Carlos Ceriani [1]. Spyrou et al. [2] conclude that it was initially designed to be played in YMCAs and adapted for indoor play on basketball-sized courts. The sport quickly spread throughout South America, with Brazil becoming a major hub. In 1989, FIFA took over governance and held the first Futsal World Championship. Today, futsal is played globally and is known for its fast-paced and skillful play, influencing outdoor soccer significantly.

Futsal players demonstrate exceptional physical fitness, featuring high levels of cardiovascular endurance, which is essential for sustaining the high-intensity play that characterizes their matches [3]. Murr, Larkin & Höner [4] found that futsal players have high levels of cardiovascular endurance, which is essential for sustaining the continuous, high-intensity activity of the fast-paced game. The small court size requires

constant movement, with few opportunities for rest. This endurance allows players to maintain energy, reduce fatigue, and perform consistently throughout the match. It supports efficient oxygen delivery to muscles, is crucial for prolonged exertion, and aids quick recovery between intense bursts of activity [5]. Regular training, including interval running, circuit training, and continuous play drills, helps players build and maintain this vital fitness aspect, meeting the sport's demanding physiological requirements. Adami et al. [6] confirmed that futsal players rely on agility and speed for quick movements and rapid direction changes on the small court, ensuring precise navigation during matches. Their significant lower body strength enables powerful kicks, explosive sprints, and overall stability. Agile players swiftly execute directional changes, maintain balance, and intercept defensive and offensive passes [7]. Ehmann et al. [8] suggested that speed facilitates explosive acceleration and deceleration, which is crucial for offensive bursts and defensive recoveries. Regular training emphasizes complex training, agility drills, and sprint training to enhance agility and speed, ensuring rapid responses and competitive performance.

Futsal players exhibit highly developed anaerobic capacity, which is crucial for handling the frequent short bursts of intense activity demanded by the sport [9]. Their finely tuned balance and coordination ensure precise control and maneuverability in the confined spaces of futsal courts. Futsal players adhere to rigorous training regimes targeting these fitness aspects to sustain peak physical conditions, optimizing their performance and resilience [10]. Kunrath et al. [11] confirmed that anaerobic capacity is vital in futsal matches, supporting rapid sprints, jumps, and accelerations by providing immediate bursts of power from anaerobic energy systems. Quick recovery after each burst is essential to maintain performance levels, and anaerobic capacity enables rapid replenishment of energy stores, sustaining maximum effort throughout the game [2]. This capacity ensures that players can endure the fast pace and continuous action of futsal without significant fatigue.

Since small margins often decide futsal matches, superior anaerobic capacity provides a competitive edge. Well-conditioned players can maintain speed, agility, and power during crucial moments, impacting game outcomes. Training methods like high-intensity interval training (HIIT), particularly complex training, enhance anaerobic capacity by improving the ability to generate and sustain power during intense game situations, ultimately contributing to success on the court [12]. Futsal training often includes high-intensity anaerobic training, blending strength, power, and plyometric exercises to enhance athletic performance [13]. Players target major muscle groups like the legs, core, and upper body with squats, lunges, deadlifts, and bench presses to build muscle mass and overall strength [14]. Power exercises, including plyometrics like box jumps, depth jumps, and medicine ball throws, focus on improving the explosive strength necessary for quick movements and rapid acceleration [15]. Sessions typically begin with heavy strength exercises like squats or deadlifts to activate muscle fibers, followed by plyometric drills like jump squats or bounding exercises, taking advantage of the potentiation effect from the prior strength work [16]. Psotta et al. [17] studied that complex training optimizes neuromuscular adaptations, enhancing speed, agility, and explosiveness while also improving coordination and motor skills crucial for executing precise movements during matches. Training programs employ periodization principles to vary the intensity and volume of complex training sessions over time, preventing overtraining and ensuring continual improvement. As players progress, exercises are adjusted to further challenge their physical capabilities [18].

The studies mentioned clearly show that high-intensity anaerobic training is crucial for futsal athletes, enhancing dribbling ability, lower limb muscle strength, speed, and agility with and without the ball. This comprehensive approach optimizes overall athletic performance by blending various physical fitness and skill development aspects. Given the importance of agility, speed, and strength in futsal, integrated training becomes indispensable. Dribbling skills, vital for possession and scoring opportunities, are also highlighted. Incorporating diverse methods like strength training, plyometrics, agility drills, and specific dribbling exercises significantly boosts athletes' on-court performance. However, despite the recognized significance of high-intensity anaerobic training, there's ongoing debate about the most effective complex training methods. This uncertainty stems from the varied factors that can positively or negatively impact athletes during competitive games. Only athletes equipped with well-honed technical skills can navigate these factors effectively. Therefore, the researcher is interested in studying the effects of high-intensity anaerobic training on speed performance with and without the ball in youth futsal players before and after the 4^{th} weeks and 8^{th} weeks in youth male futsal athletes. The hypothesis was that high-intensity anaerobic training results in speed performance with and without the ball of youth male futsal athletes in Nakhonpanom province before, after the 4^{th} week, and after the 8^{th} week, which was different.

Methods

Participants

This study received approval from the Institutional Review Board of Thailand National Sports University (No. 015/2567) in Thailand and adhered to the principles outlined in the Declaration of Helsinki.

Thirty-one youth futsal players aged between 17 and 18 who have been registered as Nakhonpanom Province Sports Association athletes for at least one year were selected for the study. This age range enables researchers to accurately explore the intersection of speed performance with and without the ball. Focusing on this age group allows the study to offer valuable insights for enhancing training strategies, mitigating injury risks, and optimizing the athletic potential of young male futsal players. Systematic random sampling from this formula = 10. Therefore, athletes with numbers 1, 11 (1+10), 21 (21+10), 31 (21+10), and 41 (31+10) will be sampled and drawn randomly systematically until the required number is reached. This method, derived from the calculation formula, is used to estimate the mean population size when the population size is known [Cohen, 1977, p. 99]. NZ2□/2 is the specified confidence (1.96), □2 is the variance (5.14) [19], d is the effect size value (2.54) [20] are incorporated, with an estimated influence size value (0.5) [21], and n is the population (305). To prevent dropout, the researcher increased the sample size by 30 percent, resulting in a new sample size of 31. The calculation formula for this adjustment is as follows:

$$n = \frac{NZ^2_{\alpha/2}\ \sigma^2}{d^2(N-1)+Z^2_{\alpha/2}\sigma^2}$$

$$n = \frac{305(1.96)^2(5.14)^2}{2.54(305-1)+(1.96)^2(5.14)^2} = 23.96$$

Intervention

The futsal high-intensity anaerobic training was conducted thrice a week for eight weeks (Mondays, Wednesdays, and Fridays). The total duration of each training session was approximately 60 minutes. Before commencing the high-intensity anaerobic training, subjects were instructed to exert maximum effort, with verbal encouragement provided every minute during the training phase. The training session was divided into three phases: a 15-minute warm-up, a training phase involving high-intensity anaerobic exercises, and a 15-minute cool-down period. During the training phase, exercises 1 and 2 were performed for 2 minutes per player, while exercise 3 was performed for 3 minutes per player. Exercise prescriptions are shown in Table 1 as follows:

Table 1 Exercise prescriptions

Program	Set	Rest between Set (second)	Times	Rest between time (min)	Recovery (min)	Intensity
Week 1-2						
Warm up			Jogging 15 min			
Exercise 1	2	45	2	1	2	Maximum
Exercise 2	2	45	2	1	2	effort
Exercise 3	2	45	2	1	2	
Cool down			Stretching 15 min			
Week 3-4						
Warm up			Jogging 15 min			
Exercise 1	3	45	2	1	2	Maximum
Exercise 2	3	45	2	1	2	effort
Exercise 3	3	45	2	1	2	
Cool down			Stretching 15 min			
Week 5-6						
Warm up			Jogging 15 min			
Exercise 1	4	45	3	1	2	Maximum
Exercise 2	4	45	3	1	2	effort
Exercise 3	4	45	3	1	2	
Cool down			Stretching 15 min			
Week 7-8						
Warm up			Jogging 15 min			
Exercise 1	5	45	4	1	2	Maximum
Exercise 2	5	45	4	1	2	effort
Exercise 3	5	45	4	1	2	
Cool down			Stretching 15 min			

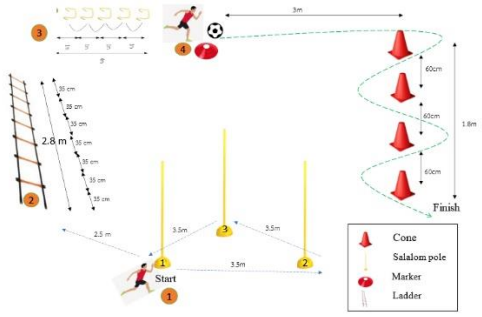

Figure 1 Exercise 1

Exercise 1: First, the athletes sprint from the first slalom pole to the second and 3rd slalom poles at maximum speed. Next, they sprint to number 2, sprint across the speed-agility ladder to number 3, then sprint over the hurdle to number 4 and touch the ball. Finally, the athletes dribble the ball toward number 5 at maximum speed and then dribble the ball in a zigzag sequence (Figure 1).

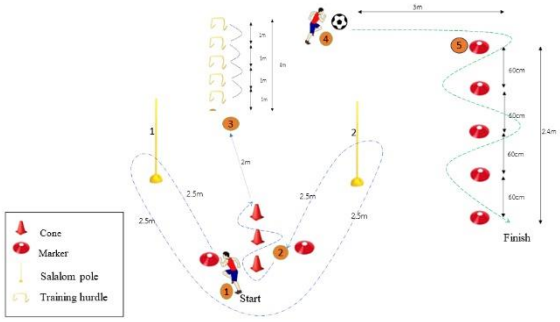

Figure 2 Exercise 2

Exercise 2: Firstly, the athletes sprint at maximum speed to the first slalom pole, then sprint back in a U shape to the second slalom pole, and continue to number two at maximum speed in a zigzag sequence through the cones to number 3. Next, they jump over the hurdle and sprint to number 4 to touch the ball. Finally, the athletes dribble the ball to number 5 (Figure 2).

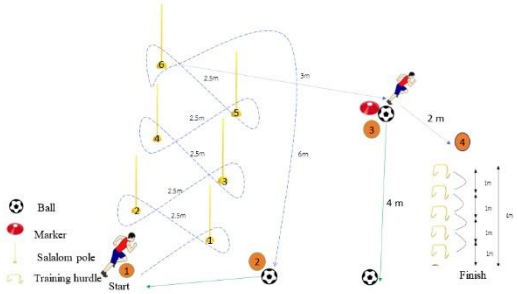

Figure 3 Exercise 3

Exercise 3: Firstly, the athletes sprint from the first slalom pole to the sixth slalom pole and then run at maximum speed to number 2 to touch the ball. Next, the athletes dribble the ball back to the starting point, from the 1st slalom pole to the 6th slalom pole again. Finally, they sprint at maximum speed to number 3, then pass the ball to number 5 and sprint to number 4 to jump over the hurdle (Figure 3).

Outcome measurement

Initially, the participants were evaluated for change of direction and reaction time before the experiment. Across all variables, the participants took measurements using a standardized protocol (pre-test) and re-evaluated all variables at the 4th and 8th weeks.

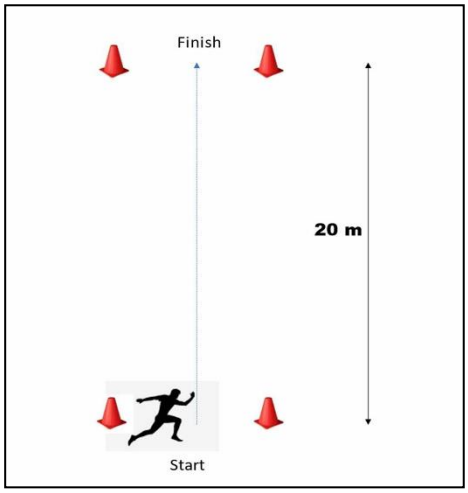

Figure 4a 20 meters speed test

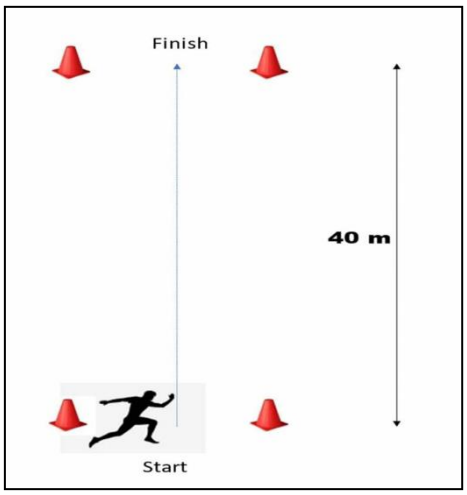

Figure 4b 40 meters speed test

The 20 and 40-meter speed test: The athletes stand at the starting point between the cones placed in the middle and prepare their body posture upon hearing the signal. When they hear the signal, the athletes sprint out at maximum speed towards the endpoint at a distance of 20 and 40 meters, recording the time using an infrared laser timer. The test was conducted twice with a 3-minute rest interval between each attempt, and the fastest time (second) was used for statistical analysis. The simple correlation coefficient of Pearson's correlation coefficient (r) with the 20 and 40-meter speed tests is 0.87 and 0.89, respectively (Figure 4a-4b).

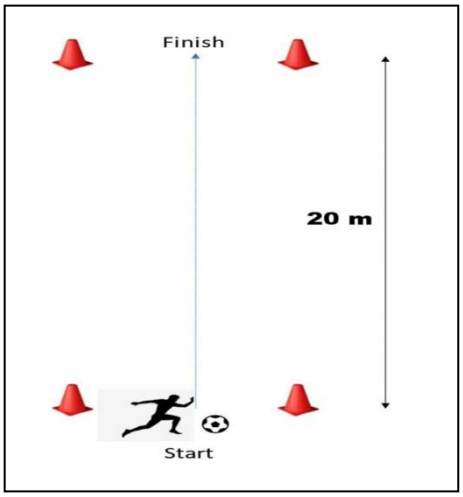

Figure 5a 20 meters speed with the ball test

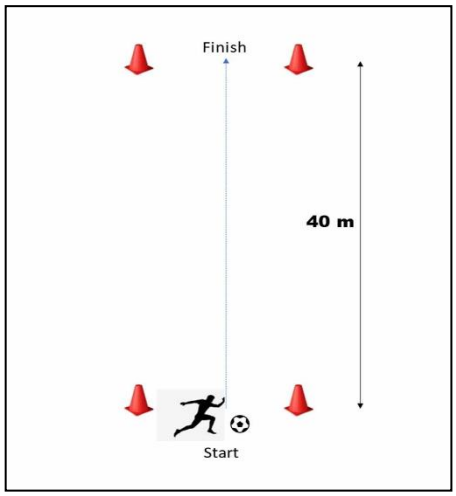

Figure 5b 40 meters speed with the ball test

The 20 and 40-meter speed with the ball test: The athletes stand at the starting point between the cones placed in the middle and prepare their body posture upon hearing the signal. When they hear the signal, the athletes sprint out with the ball at maximum speed towards the endpoint at a distance of 20 and 40 meters, recording the time using an infrared laser timer. The test was conducted twice with a 3-minute rest interval between each attempt, and the fastest time (second) was used for statistical analysis. The simple correlation coefficient of Pearson's correlation coefficient (r) with the 20 and 40 meters speed with the ball test is 0.91 and 0.90, respectively (Figure 5a-5b).

Statistical analysis

Statistical analysis was conducted using STATA 13 (Texas, USA, 2007). The Shapiro-Wilk test assessed the normal distribution of values. Descriptive statistics included frequency, percentage, mean, and standard deviation for age, body mass index (BMI), and futsal experience. Inferential statistics utilized a one-way analysis of variance with repeated measures if the data was normally distributed and the Friedman test if the data was abnormally distributed to compare changes in the 20-meter speed with and without the ball test and the 40-meter speed with and without the ball test before training, after the 4th week, and after the 8th week of training (post-test) at a 95% confidence interval. A significance level of $\alpha = 0.05$ was employed.

Results

The results of the assumption test revealed that the data for the 20-meter speed with and without the ball test and the 40-meter speed with and without the ball test had an abnormal distribution. This contradicts the assumption required for the use of parametric statistics. Therefore, we switched to the Friedman, non-parametric statistical test (Table 2).

Table 2 Shapiro-wilk test (n=31)

Variables	n	Shapiro-wilk test		
		Statistic	df	p-value
The 20 meters speed test	31	0.97	31	0.04
The 20 meters speed with the ball test	31	0.96	31	0.00
The 40 meters speed test	31	0.61	31	0.00
The 40 meters speed with the ball test	31	0.97	31	0.03

Characteristics

The players had an average age of 17.42 years (SD=0.50), an average weight of 62.42 kilograms (SD=5.36), an average height of 168.35 centimeters (SD=8.51), an average body mass index of 22.09 (SD=2.07), and experience playing futsal was 1.48 years (SD=0.77) (Table 3)

Table 3 Characteristics (n=31)

Measure	Mean (SD)
Age (year)	17.42 (0.50)
Height (kg)	168.35 (8.51)
Weight (kg)	62.42 (5.36)
BMI	22.09 (2.07)
Futsal experience	1.48 (0.77)

The 20 meters speed test

The average 20-meter speed test before training was 4.16 (±0.26) s; after the 4th week, it was 4.11 (±0.22) s; and after the 8th week, it was 4.06 (±0.31) s. A one-way repeated-measures analysis of variance (ANOVA) found that the 20-meter speed test before training, after training week 4, and after training week 8 were significantly different (Table 3). Therefore, the means had to be compared for each pair using the Friedman test (Table 3).

Table 4 Speed performance with and without the ball test (n=31)

Source	SS	df	MS	F	p-value
The 20 meters speed test					
Within group	0.14	2	0.07	31.69	0.0000*
Error	0.14	60	0.00		
Total	6.42				
The 20 meters speed with the ball test					
Within group	0.77	2	0.04	94.72	0.0000*
Error	0.02	60	0.00		
Total	11.19				
The 40 meters speed test	0.06	2	0.03	310.10	0.0000*
Within group	0.01	60	0.00		
Error	30.18				
Total					
The 40 meters speed with the ball test					
Within group	0.06	2	0.03	223.56	0.0000*
Error	0.00	60	0.00		
Total	19.92				

The 20-meter speed with the ball test

The average 20-meter speed with the ball test before training was 4.51 (±0.45) s. After the 4th week, it was 4.47 (±0.51) s, and after the 8th week, it was 4.43 (±0.38) s. A one-way repeated-measures analysis of variance (ANOVA) found that the 20-meter speed with the ball test between before training, after training week 4, and after training week 8 were significantly different (Table 4). Therefore, the means had to be compared for each pair using the Friedman test (Table 5).

Table 5 The Friedman test (n=31)

Time	Mean	Before	Week 4	Week 8
The 20 meters speed test				
Before	4.16 (±0.26)	-	-0.04	-0.09
Week 4	4.11 (±0.22)		-	-0.06
Week 8	4.06 (±0.31)			-
The 20 meters speed with the ball test				
Before	4.51 (±0.45)	-	-0.04	-0.07
Week 4	4.47 (±0.51)		-	-0.03
Week 8	4.43 (±0.38)			-
The 40 meters speed test				
Before	6.52 (±0.37)	-	-0.03	-0.06
Week 4	6.44 (±0.33)		-	-0.03
Week 8	6.40 (±0.35)			-
The 40 meters speed with the ball test				
Before	7.51 (±0.52)	-	-0.03	-0.06
Week 4	7.43 (±0.57)		-	-0.03
Week 8	7.40 (±0.49)			-

The 40 meters speed test

The average 40-meter speed test before training was 6.52 (±0.37) s after the 4th week was 6.44 (±0.33) s, and after the 8th week was 6.40 (±0.35) s. A one-way repeated-measures analysis of variance (ANOVA) found that only the 40-meter speed test before training, after training week 4, and after training week 8 were significantly different (Table 4). Therefore, the means had to be compared for each pair using the Friedman test (Table 5).

The 40-meter speed with the ball test

The average 40-meter speed with the ball test before training was 7.51 (±0.52) s. After the 4th week, it was 7.43 (±0.57) s, and after the 8th week, it was 7.40 (±0.49) s. A one-way repeated-measures analysis of variance (ANOVA) found that only the 40-meter speed with the ball test before training, after training week 4, and after training week 8 were significantly different (Table 4). Therefore, the means had to be compared for each pair using the Friedman test (Table 5).

The Friedman tests

Comparing the mean pairs using the Friedman test found that both the pre-test and after week 4, pre-test and after week 8, and after week four and after week 8, the 20 meters speed test, the 20 meters speed with the ball test, the 40 meters speed test, and the 40 meters speed with the ball test decreased non-significantly (Table 5).

Discussion

The one-way repeated-measures analysis of variance (ANOVA) for both the 20 and 40-meter speed with and without the ball tests before, after four weeks, and after eight weeks of training showed statistically significant differences. Therefore, pairwise comparisons of the means were conducted using the Friedman test. Upon comparing the mean pairs, it was found that both the 20 and 40-meter speed tests, with and without the ball, between before and after four weeks, before and after eight weeks, and after four weeks and after 8, decreased non-significant. The high-intensity anaerobic futsal training is a blended training program designed to improve both straight-line sprints over short distances and ball handling skills. It incorporates training for speed change, acceleration, and overall agility, specifically tailored for futsal players. One notable feature of this training is its emphasis on rapid movements over short distances at maximum intensity, particularly sprinting speed. This training helps enhance the ability to accelerate and maintain maximum speed over short periods, develops strength in the leg and core muscles used in running, and promotes improvements in running efficiency [22]. While dribbling training enhances ball control skills while running at high speeds, it also improves eye and foot movement coordination, confidence, and ability to dribble past opponents [23]. Additionally, agility training helps improve agility and responsiveness to changes in gameplay, enhances balance maintenance and body control during directional changes, and develops strength in joints and muscles used for agility [24]. Additionally, acceleration training enables athletes to initiate movements more quickly and increase muscle power, particularly in the leg muscles, promoting a faster transition from stationary to high-speed running [25]. The high-intensity anaerobic futsal training covering all four aspects positively affects athletes, enabling them to develop essential skills for sports more efficiently. Clear outcomes include enhanced playing performance, such as increased running speed, improved ball control, and greater agility. Physical readiness is also improved through diverse training, increasing strength and endurance, thus reducing the risk of injuries. Furthermore, there's development in responsiveness and reaction, enabling athletes to respond more quickly to game situations and make more accurate decisions [26]. Therefore, the high-intensity anaerobic futsal training program results in significant changes in advanced physiological adaptations that are relatively complex [27]. This leads to initiating non-oxygen-dependent energy expenditure mechanisms during training sessions and competitions. The high-intensity anaerobic futsal training, comprising elements to enhance short-distance running speed, dribbling, agility, and acceleration, significantly impacts the anaerobic metabolism system in athletes' physiology. This is particularly evident in developing high-intensity work capacity over short durations and at maximal effort levels [28]. These training methods impact various physiological systems of the body, such as anaerobic metabolism, the anaerobic alactic system (phosphagen system), and the anaerobic lactic system, also known as glycolysis. The anaerobic alactic system primarily utilizes stored ATP and CP (creatine phosphate) for rapid energy production. Training aimed at high-speed acceleration and short-distance sprinting enhances the ability to generate and utilize energy from ATP and CP more rapidly [27]. Moreover, the anaerobic lactic system, which involves glycolysis to produce energy without oxygen, is also influenced by intense and short-duration training activities, such as agility drills and dribbling. These activities contribute to the development of energy utilization from glycolytic processes and improve tolerance to lactic acid buildup [29].

Furthermore, these training methods also affect the physiological adaptations of the muscular system, particularly by increasing the number and size of mitochondria. Although mitochondria are primarily associated with oxygen-dependent metabolism, anaerobic training can increase the size and quantity of mitochondria, allowing muscles to produce more energy even in anaerobic conditions. Additionally, high-intensity anaerobic futsal training contributes to muscle glycogen accumulation, a significant energy source in anaerobic processes. Training emphasizing speed and maximal effort also enhances the activity of enzymes involved in glycolysis, such as phosphorylase and lactate dehydrogenase, enabling muscles to produce energy more rapidly and tolerate lactic acid accumulation more effectively [23]. Additionally, high-speed acceleration and short-distance sprinting training can increase athletes' pulmonary and cardiovascular capacity. While anaerobic training primarily focuses on oxygen-independent energy utilization, adaptations in the heart and blood vessels aid in faster post-training recovery. Intense training contributes to increased muscle capillary density, facilitating better nutrient and

oxygen delivery to muscle tissues [27]. Furthermore, these training methods enhance neuromuscular coordination, improving the synchronization between the nervous system and muscles. Rapid responsiveness and directional changes strengthen the collaboration between the nervous system and muscles, resulting in more precise and swift movements. Speed-focused training also enhances neural drive to muscles, increasing movement power and efficiency [30].

The high-intensity anaerobic futsal training approach combining short-distance sprinting, dribbling, agility, and acceleration exercises positively impacts the athlete's anaerobic energy system, promoting muscle development, cardiovascular fitness, and nervous system function. This enhances the athlete's ability to perform high-intensity activities in short durations, increasing overall strength and endurance. Additionally, it improves resilience to fatigue and facilitates quicker recovery from intense workouts.

Conclusion

High-intensity anaerobic training significantly enhances speed performance, both with and without the ball, in youth futsal players. By improving sprinting ability and ball control at high speeds, such training ensures that players can meet the fast-paced and physically demanding nature of futsal. Incorporating varied high-intensity drills into training routines can maximize these benefits and contribute to better overall performance on the court. Future studies should include a larger sample size, a control group, and a comparison group to evaluate the effectiveness of the high-intensity anaerobic training program.

This study's limitations include the absence of a control group, preventing comparison of the impacts of futsal-specific training on neuromuscular coordination. Addressing these constraints and employing a rigorous study design with suitable control measures can enhance future research, offering more robust evidence on the effects of high-intensity anaerobic training on speed performance with and without the ball in youth futsal players.

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