HIGH INTENSITY INTERVAL TRAINING (HIIT) AND SPRINT INTERVAL TRAINING (SIT) FOR SOCCER-SPECIFIC SPRINTS IN YOUNG FEMALE PLAYERS: A RANDOMIZED CONTROLLED STUDY

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ABSTRACT
Introduction: High-intensity interval training (HIIT) and Sprint interval training (SIT) are effective training methods for soccer players. However, there is no clear indication which method is more effective to improve sprint performance, especially in young female soccer players. We hypothesized that a multi-component training model (HIIT+SIT) would improve soccer-specific sprint performance more effectively in young female soccer players. This study aims to investigate the effects of HIIT and SIT programs on soccer-specific sprint performance in young female soccer players. Methods: 30 trained female soccer players aged 14-16 from Çanakkale Youth and Sports Club's 3rd League women's soccer team were included in the study. Participants were randomly divided into two groups: the training group (n = 15) and the control group (n = 15). Anaerobic power was evaluated using the Wingate test. Soccer-specific sprint performance was evaluated with a sprint test and with a ball. The training group was included in HIIT and SIT programs in addition to soccer training. The control group was included in soccer training only. The program was applied for 6 weeks and 3 days a week. Tests and measurements were repeated after 6 weeks. The Shapiro-Wilk test was used to assess normal data distribution, and the Levene test was used to assess equality of variances. The Mann-Whitney U test was used to determine the significance level of the difference between the means of the groups. The Wilcoxon test was used to determine the significance of the difference between the means of two groups. Results: Significant differences were found between the training group and the control group in the 30 m sprint (p = .000), 30 m sprint with ball (p = 0.001), and 41 m sprint with change of direction with ball (p = .002) tests. No significant differences were found in mean and peak anaerobic power (p > .05). Conclusion: For young female soccer players, a combination of HIIT and SIT training is recommended to improve soccer-specific sprint performance.

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INTRODUCTION

Soccer is an intermittent, high-demand team sport that requires players to perform a combination of low-intensity aerobic movements and repeated high-intensity actions such as sprinting, jumping, tackling, and rapid directional changes (Davis et al., 1993; Stølen et al., 2005). During a competitive match, players typically cover an average distance of approximately 10 km, with 150-250 high-intensity actions (Mohr et al., 2005; Kobal et al., 2022). Although aerobic metabolism plays a dominant role in maintaining performance over 90 minutes, anaerobic capabilities are essential for executing explosive movements that can lead to outcomes (Elam et al., 2021; Buchheit, 2019).

Sprinting ability is a key determinant of soccer performance (Mohr et al., 2005; Iaia et al., 2009). Modern soccer demands rapid acceleration, deceleration, direction changes, and high-intensity efforts interspersed throughout the game (De Oliveira et al., 2023). These efforts are closely associated with both anaerobic power and neuromuscular efficiency, and thus their development is a primary objective in soccer training programs (Clemente et al., 2021). Recent meta-analytic findings also support the role of strength-based modalities in enhancing sprint performance in female team-sport athletes (Hughes et al.,2023). High-intensity interval training (HIIT) is an effective basic training strategy in soccer (Wisløff et al., 2007; Buchheit & Laursen, 2013). Sprint -interval training (SIT), which involves maximal or supramaximal sprints with longer intervals and is particularly effective in improving sprint time, anaerobic capacity, and metabolic adaptations (Gibala et al., 2006; Michal et al., 2023).

Numerous studies have explored the effects of HIIT and SIT across different populations, including both male and female soccer players (Akılveren et al., 2021; Boraczyński et al., 2023; Li & Xue, 2024; Liu et.al., 2024; Yang et al., 2024). In addition, multi-component programs integrating SIT with strength and plyometric training have demonstrated significant improvements in sprint performance, anaerobic power, and change-of-direction ability in adolescent soccer players (Ferley et al., 2020). Also, several studies have reported improvements in VO_2 max, sprint performance, and repeated sprint ability following structured HIIT or SIT protocols (Wright et al., 2016; Arazi et al., 2017; Nayıroglu et al., 2022; Lambright et al., 2024; Paprancova et al., 2024; Stankovic et al., 2024). However, findings across studies remain inconsistent, possibly due to differences in participant characteristics (such as training status, age, and sex), program duration, and training design.

Despite increasing interest in optimizing performance through targeted conditioning methods, there remains no consensus on whether HIIT or SIT is more effective for enhancing soccer-specific sprint performance, particularly in young female players. Consequently, evidence-based guidance for coaches and practitioners working with this population is limited. To address this gap, we designed a multi-component training intervention that combines soccer-specific technical work with both HIIT and SIT. This approach aims to stimulate the physical and technical demands of competitive match play more closely than a single method can.

Aim and Objectives

The aim of this study was to investigate the effects of multi-component training- including HIT and SIT and technical drills- on soccer-specific sprint performance in young female soccer players. We hypothesized that this combined approach would yield greater improvements in short sprint performance and repeated sprint ability over a short intervention period compared to traditional training methods.

METHODS

Participants

A total of 30 trained female soccer players, aged 14-16 years, from the Çanakkale Youth and Sports Club, competing in the Turkish Women's 3rd League, participated in the study. The sample included goalkeepers (*n = 2), defenders (n = 8), midfielders (n = 12), and forwards (n = 8*) players. All participants were divided into two groups: the Training group (TG, *n* = 15) and the Control group (CG, n = 15), using a simple randomization method based on a numbered list. For the TG, the mean height was 161.13 ± 4.65 cm, body weight was 52.53 ± 6.69 kg, and body mass index (BMI) was 20.25 ± 1.40 kg/m^2. For the CG group, the mean height was 162.53±4.12 cm, body weight 52.33±6.06 kg, and BMI 19.78±1.60 kg/m^2 ($p > .05$, Table 2).

Procedure

The research was conducted at the Çanakkale Youth and Sports 18 Mart Stadium in 2023. Participants and parents were informed about the purpose of the research and possible risks. Research data were collected both before the training program and the week following its completion. A certified football coach conducted all training sessions. The training group (TG) participated in interval training (HIIT) and sprint interval training (SIT) in addition to soccer training. The control group (CG) was included only in soccer training. The training program was carried out for six weeks and 3 days a week. Each training intensity was controlled by Borg's RPE. The research was approved by Çanakkale Onsekiz Mart University Clinical Research Ethics Committee (date: 11.11.2020, Number: 18920478-050.01.04-E. 2000177132). All players and their parents provided written consent.

Anaerobic Power Test

Anaerobic power was assessed with the Wingate anaerobic power test. The players were prepared for the test with a 5-minute warm-up at a 60-70 W workload and 60-70 rpm pedal speed. After the warm-up, they were asked to reach the highest pedal speed as quickly as possible without resistance. When the pedal speed reached 150 rpm, the scale was automatically lowered, and the test was started. The players were verbally supported to pedal at the highest speed for 30 seconds. An external resistance equivalent to 7.5% of their body weight was applied to the bicycle ergometer scale. At the end of the test, the players rested for 2-3 minutes at 25-100 W (Monark Ergomedic 834E model).

Sprint (30m) and sprint with a ball (30m)

To evaluate sprint performance, players completed two types of sprint tests: a 30-meter sprint without the ball and a 30-meter sprint with a ball. The electronic photocell timing gates were positioned at the

0m (start) and 30 m (finish) lines, set at a height of approximately 1 meter to detect torso passage. In the sprint with ball condition, players started with a ball placed at the start line and were instructed to dribble through a circular course formed by 12 cones arranged at 4.5-meter intervals, within a diameter of 18 meters. The course required continuous direction changes while maintaining control of the ball. In the sprint without a ball, the same cone layout was followed without a ball. Each player completed two valid trials per test type (with and without a ball), and the best time was recorded for analysis. A 3-minute passive recovery period was provided between trials.

Soccer training

Football training consisted of exercises that included passing, dribbling, and shooting development (Table 1). All training sessions included a warm-up (≈approximately 15 minutes) and a cool-down phase (≈approximately 5 minutes). Football training for all groups lasted ≈90 minutes. All high-intensity interval training sessions lasted ≈approximately 40 minutes.

Table 1. *Soccer training, HIT and SIT programs for six weeks*

Week		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
1	Soccer	Passing, dribbling ball control drills		Passing, dribbling ball control drills		Passing, dribbling ball control drills	
	HIIT		2-min run at 70-75% intensity, 1-min rest, 2 reps		2 -min run at 70-75% intensity, 1-min rest, 2 reps		2-min run at 70-75% intensity, 1-min rest, 2reps
	SIT		6-sprint 25m, 1-min rest, 3 reps		6-sprint 25m, 1-min rest, 3reps		6-sprint 30m, 1-min rest, 3reps
2	Soccer	Passing drills		Dribbling drills		Shooting drills	
	HIIT		3-min run at 80-90% intensity, 1-min rest, 3 reps		3-min run at 80-90% intensity, 1-min rest,3 reps		3-min run at 80-90% intensity, 1-min rest,4 reps
	SIT		8-sprint 30m 2-min rest, 3reps		8-sprint 30m 2-min rest, 3reps		8-sprint 30m 2-min rest, 3reps
3		Passing drills, ball control drills		Passing drills dribbling, turning drills		Shooting drills	
	HIIT		4-min run at 80-90% intensity, 2-min rest, 3 reps		4-min run at 80-90% intensity, 2-min rest, 3 reps		4-min run at 80-90% intensity, 2 reps
	SIT		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest,4reps		8-sprint 40m 2-min rest,4reps
4	Soccer	Technical development exercises; passing ball control drills		Technical development exercises; passing dribbling change of direction drills		Technical development exercises; dribbling shooting drills	
	HIIT		4-min run at 80-90% intensity, 2-min rest, 3 reps		4-min run at 80-90% intensity, 2-min-rest, 3reps		4-min run at 80-90% intensity, 2-min rest, 3reps
	SIT		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps
5	Soccer	Passing ball control dribbling drills exercises with changes of direction		Passing, ball control drills dribbling exercises with changes of direction		dribbling drills shooting drills	
	HIIT		4-min run at 80-90 % intensity, 2-min rest, 3reps		4 min run at 80-90% intensity, 2-min rest, 3reps		4-min at 80-90% intensity, 2-min rest, 3reps
	SIT		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps
6	Soccer	Passing, dribbling, and shooting drills		Passing, dribbling, and shooting drills		Passing, dribbling, and shooting drills	
	HIIT		4-min run at 80-90% intensity, 2-min rest, 3reps		4-min run at 80-90% intensity, 2-min rest, 3 reps		4-min rest at 80-90% intensity, 2-min rest, 4 reps
	SIT		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps		8-sprint 40m 2-min rest, 4reps

Note: Min: minute, Rest: resting, Reps: repetition, S: set,

HIIT

The first week began with 2 sets and 2 minutes of work at 70% of maximum heart rate. The second week continued with 3 sets and 3 minutes of work at 80-90% of maximum heart rate. From the third week until the end of the sixth week, the athletes continued to work at 80-90% of maximum heart rate for 3 sets and 4 minutes. Passive rest was given between sets. A Polar chest band monitored the heart rate.

SIT

Soccer players performed 20 m sprints with 3 sets and 6 repetitions, 25 m sprints with 3 sets and 6 repetitions, and 30 m sprints with 3 sets and 6 repetitions in the first week. In the second week, they performed 30 m with 3 sets and 8 repetitions. From the third week to the end of the sixth week, the players performed a 40 m sprint and a 40m sprint with a change of direction, with 4 sets and 8 repetitions. A 1-minute passive rest was given between repetitions, and a 2-minute active rest was given between sets (Akılveren et al., 2021). HIIT and SIT sessions were conducted three times a week for six weeks. RPE was recorded for each set and each session.

Statistical analysis

The Shapiro-Wilk test was used to check the normality of data distribution, and the Levene's test was used to assess the homogeneity of variances between groups. Since these assumptions were violated for all measured parameters, non-parametric statistical analyses were applied. The Mann-Whitney U test was used to compare differences between the training group (TG) and control group (CG) at the pre- and post-training time points. The Wilcoxon Signed-Rank Test was used to assess within-group changes from pre to post-training. In all analyses, the significance level was set at $p < .05$ with a 95% confidence level. The SPSS 26.00 program was used for data analysis.

RESULTS

Table 2. *Physical characteristics of soccer players*

	Group	*n*	*Mean*	*SD*	Min	Max	Z	*p*	*F* (Levene's)
Age (years)	TG	15	15.26	0.96	14.00	16.00	-0.823	.411	0.63
	CG	15	15.60	0.63	14.00	16.00			
Height (cm)	TG	15	161.13	4.65	150.00	168.00	-0.669	.504	0.45
	CG	15	162.53	4.12	153.00	170.00			
Body weight (kg)	TG	15	52.53	6.69	43.00	64.00	-0.104	.917	0.02
	CG	15	52.33	6.06	45.00	69.00			
BMI (kg/m²)	TG	15	20.25	1.4	15.23	21.44	-0.548	.584	0.27
	CG	15	19.78	1.6	15.57	22.49			

Participants' age, height, and body weight are given in Table 2 (p > .05).

Table 3. *Between-Group Comparisons (Mann-Whitney U Test)*

	Pre-training			Post training		
	TG *Mean ± SD*	CG *Mean ± SD*	*p*	TG *Mean ± SD*	CG *Mean ± SD*	*p*
Sprint with a ball (30m)	6.37±0.37	6.51±0.39	.206	6.25±0.40	7.51±1.07	.000*
Sprint (30m)	4.98±0.30	4.99±0.47	.709	4.92±0.31	5.39±0.31	.001*
Peak power (W/kg)	8.54±2.64	8.29±1.41	.852	8.70±1.47	8.77±1.46	.619
Mean power (W/kg)	6.08±1.60	6.22±1.09	.431	6.45±1.02	6.54±0.81	.575
Peak power (W)	461.37±175.03	440.24±91.62	.852	465.16±102.27	468.23±103.51	.787
Mean power (W)	328.14±109.79	329.65±69.71	.663	344.94±73.22	349.16±67.87	.724

*Note: TG: Training group, CG: Control group, SCD-with ball: sprint with a change of direction with the ball, *p<.05*

No significant difference was found between the groups before training ($p > 0.05$). Post-training, significant differences were found between the groups in sprint with ball-30m and sprint-30m ($p < .05$). No significant differences were found in anaerobic peak power and average power (Table 3, $p > .05$). Levene's homogeneity test results showed that the variances of the dependent variables were homogeneous between groups ($p > .05$ for all variables), thus meeting the assumptions for group comparisons.

Table 4. *Within-Group Changes (Wilcoxon Signed-Rank Test)*

Variable	TG pre *Mean ± SD*	TG post *Mean ± SD*	P (TG)	ES (TG)	CG pre *Mean ± SD*	CG post *Mean ± SD*	*P* (CG)
Sprint with a ball (30m)	6.37±0.37	6.25±0.40	0.041*	0.61	6.51±0.39	7.51±1.07	0.057
Sprint (30m)	4.98±0.30	4.92±0.31	0.053	0.60	4.99±0.47	5.39±0.31	0.211
Peak power (W/kg)	8.54±2.64	8.70±1.47	0.691	0.02	8.29±1.41	8.77±1.46	0.570
Mean power (W/kg)	6.08±1.60	6.45±1.02	0.191	0.04	6.22±1.09	6.54±0.81	0.932
Peak power (W)	461.37 ±175.03	465.16±102.27	0.650	0.01	440.24±91.62	468.23±103.51	0.532
Mean power (W)	328.14±109.79	344.94±73.22	0.363	0.02	329.65±69.71	349.16±67.87	0.955

*Note: TG: Training group, CG: Control group, SCD-with ball: sprint with a change of direction with the ball,*p<.05*

The significance of the differences between the pre-training and six-week test averages within the groups was analyzed using the Wilcoxon test. According to this analysis, a significant improvement in sprinting with a ball for 30m was found in the training group ($p < .05$, Table 4)

DISCUSSION

According to the results of this study, HIIT and SIT training, in addition to soccer training, improved soccer-specific sprint performance in female soccer players. In the control group, which did not participate in HIIT or SIT training, some performances remained unchanged, and some deteriorated.

According to the results of this study, significant improvements were observed in the training group's sprint-with-ball-30m and sprint-30m performances (Table 3, $p < 0.05$). An increase was also observed in the mean anaerobic peak power and mean power; however, this increase was not statistically significant ($p > .05$). The results of our study highlight that HIIT and SIT training significantly improve sprint performance, but do not make a statistically significant contribution to anaerobic performance. Arazi et al (2017), similarly, Paprancova et al. (2024) found improvement in sprint performances in soccer players. Also, Nayıroğlu et al. (2022) reported a significant improvement with speed-based HIIT in female soccer players.

HIIT and SIT forms in male soccer players (Akılveren et al., 2021; Michal et al., 2023; Li & Xue, 2024; Liu, Wang, & Shu, 2024; Yang et al., 2024) have been emphasized to be specific to football and effective in improving VO_2max in studies including female and male soccer players (Ferley et al., 2020). The improvement in soccer-specific sprint performance in the group that combined HIIT and SIT exercises is similar to other previous research (Wright et al., 2016; Lambright et al., 2024; Stankovic et al., 2024).

The difference between pre- and post-training test averages within the groups was analyzed. Accordingly, a significant improvement was found in the training group in the sprint-with-ball 30m (ES=0.61, $p < .05$). Although there was an increase in average anaerobic power, this increase was not statistically significant. The lack of a significant increase in anaerobic power is thought to be due to several reasons. First, the combined training sessions used were not sufficient to increase anaerobic power in 6 weeks. Second, this may be due to the testing method used to determine anaerobic power. The Wingate test is applied to intermittent sports such as football. However, some authors have stated that the Wingate test is not very valid for reflecting anaerobic power, and that a repetitive activity type test that mimics the activity pattern during a football match would likely be more appropriate for football (Meckel et al., 2009). Arazi et al. (2017) reported improvements in anaerobic power with a six-week, speed-based HIIT exercise. However, this study involved older athletes, and the anaerobic power test was different.

CONCLUSION

In conclusion, this study demonstrated that the addition of HIIT and SIT to regular soccer training significantly improves soccer-specific sprint performance in female soccer players. While improvements were observed in sprint-with-ball-30m and sprint-30m performances, no statistically significant changes were found in anaerobic power. These findings suggest that although combined HIIT and SIT training effectively enhances sprint-based performance, it may not be sufficient alone to improve anaerobic power within a six-week period. Limitations such as training duration and the anaerobic power assessment method (Wingate test) may have influenced these results. Future research with longer training periods and sport-specific anaerobic testing methods is recommended to better understand the effects of HIIT and SIT on anaerobic capacity in female soccer players.

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