Physical Activity and Hormones (J Physic Act Horm)
Vol. 6 Spring 2025

The Effects of High-Intensity Interval Training (HIIT) on Dribbling Skills, Body Mass Index, Aerobic and Anaerobic Capacity, Fatigue Index, and Intermittent Endurance in 8–14-Year-Old Elite Futsal Players

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ABSTRACT

Introduction: This study aimed to evaluate the effects of a high-intensity interval training program on dribbling skills, body mass index (BMI), aerobic and anaerobic capacity, fatigue index, and intermittent endurance in futsal players aged 8 to 14.

Material & Methods: The research was semi-experimental, with data collected through field measurements. The sample consisted of 30 futsal players, with an average age of 11.73 years, weight of 41.2 kg, and height of 147 cm, who were randomly assigned to either an experimental group (15 players) or a control group (15 players). Measurements included height, weight, aerobic capacity (via the Queen's step test), anaerobic capacity and fatigue index (via the RAST test), and intermittent endurance (via the FIET test). Data analysis was conducted using descriptive statistics, including means and standard deviations, and inferential statistics, including the Shapiro-Wilk test for normality and t-tests for hypothesis testing.

Results: Results showed that high-intensity interval training had no significant impact on BMI. However, significant improvements were found in dribbling performance for the experimental group, and a significant difference between the experimental and control groups was observed in post-test dribbling scores. Significant changes in anaerobic capacity were found within both groups, with a significant difference between groups. Fatigue levels improved significantly within both groups, with a notable difference between groups.

Conclusion: In conclusion, high-intensity interval training is recommended for futsal players.

Keywords: HIIT, Futsal players, Youth athletes, Elite futsal training.

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Received: Mar 2025; **Revised:** June 2025; **Accepted:** Jul 2025.

DOI: https://doi.org/10.71878/jpah.2025.1204440

1. Introduction

Futsal has emerged as one of the most physically demanding team sports, requiring players to execute frequent explosive movements, rapid directional changes, and sustained high-intensity efforts throughout matches. The unique physiological demands of futsal are evidenced by players maintaining 80-90% of maximal heart rate for 85% of match time (1), with activity pattern analyses revealing changes in movement every 8-9 seconds (2). This intermittent nature places exceptional stress on both aerobic and anaerobic energy systems, making optimal conditioning programs essential for performance enhancement.

In recent years, High-Intensity Interval Training (HIIT) has gained considerable attention in sports science as an efficient training modality that elicits superior physiological adaptations compared to traditional continuous training methods. Characterized by repeated bouts of intense exercise (typically 30 seconds to 5 minutes at >85% of maximum heart rate) interspersed with active or passive recovery periods, HIIT has been shown to induce multiple beneficial adaptations including enhanced mitochondrial biogenesis (3), improved anaerobic threshold (4),increased muscle buffering capacity(5), and superior neuromuscular activation patterns (4). In other hand, Sedighian et al (6) found that HIIT interventions demonstrated no significant improvement in aerobic capacity) among elite futsal players. These adaptations are particularly relevant for futsal players who require both exceptional anaerobic power for explosive movements and well-developed aerobic capacity for recovery between high-intensity bouts.

Despite the growing body of research on HIIT across various sports, significant gaps remain in our understanding of its application to youth futsal development. Current literature has primarily focused on adult elite players (7), with limited examination of how HIIT simultaneously affects both physiological markers and technical skills in adolescent athletes during critical periods of development. Furthermore, while the importance of sport-specific endurance in futsal is well-established (8) few studies have investigated optimal training methods to enhance this quality in young players.

The technical demands of futsal, particularly dribbling proficiency, add another layer of complexity to training design. As a fundamental skill that distinguishes elite performers (9), dribbling requires not only technical precision but also the physiological capacity to execute it repeatedly under fatigue conditions. This intersection of technical and physical demands presents a unique challenge for coaches and trainers working with youth players, highlighting the need for training methods that can concurrently develop multiple aspects of performance.

This study therefore aimed to investigate the effects of an 8-week HIIT program on both physiological and technical performance markers in elite youth futsal players aged 8-14 years. Specifically, we examined changes in: (1) dribbling performance as the primary technical outcome, (2) aerobic capacity and anaerobic power as key physiological indicators, and (3) sport-specific endurance and fatigue resistance as critical determinants of match performance. The findings provide novel insights into the adaptive responses of young futsal players to HIIT and offer practical guidance for designing developmentally appropriate training programs that address the sport's unique physiological and technical demands.

2. Methodology

2.1. Materials and methods

The present study employed a semi-experimental design to examine the effects of the independent variable (high-intensity interval training) in the experimental group on dependent variables (dribbling skills, body mass index, aerobic and anaerobic capacity, fatigue index, and intermittent endurance) using pre-test post-test measurements.

2.2. Participants

The study population consisted of all futsal players aged 8-14 years participating in the youth league of Guilan province who were actively training at Arya Novin Academy. From this population of 100 players, 30 volunteers were selected through convenience sampling and randomly assigned to either an experimental group (n=15) or a control group (n=15). Written informed consent was obtained from all participants and their parents/guardians, with clear communication that participants could withdraw from the study at any time without penalty.

2.3. Measurements

Anthopometry: Height was measured using a stadiometer. Weight was measured using a Sinocare digital scale. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

Aerobic Power Measurement: Aerobic capacity was assessed using the Queens College Step Test. In this test, participants performed step exercises on a 41 cm high bench for 3 minutes at a cadence of 24 steps per minute (96 beats/min). Immediately after completion, participants stood still while their pulse rate was measured between 5-20 seconds of recovery. VO_2max (ml/kg/min) was then estimated using the standard predictive equation (10).

Intermittent endurance: Intermittent endurance was measured using the Futsal-Specific Intermittent Endurance Test (FIET). Participants completed shuttle runs over 45m (3×15m) with progressive speed increases, starting at 9 km/h (increasing by 0.33 km/h for the first 9×45m, then 0.20 km/h every 45m). Between runs, they took 10-second active rests after each 45m and 30-second passive rests after every 8×45m. The test ended when participants failed twice consecutively to reach the turning line on time. The total distance covered was recorded as the test score (11).

Anaerobic power and fatigue index: Anaerobic power and fatigue index were assessed using the Running Anaerobic Sprint Test (RAST). Participants performed six 35m maximal sprints with 10-second rest intervals between repetitions. Sprint times were recorded using a stopwatch (Q&Q model), and heart rate was monitored via Polar heart rate monitors. The test was conducted twice: two days before and one hour after the training protocol. Anaerobic power (peak, mean, decline) and fatigue index were calculated from the recorded sprint times (12).

Dribbling skill: Dribbling skill was assessed using the slalom dribble test (13).

2.4. Intervention

2.4.1 Training program

The main training consisted of skill-based exercises including slalom dribbling, sprint running, agility (Pambudi et al., 2021), and shooting practice (Branquinho et al., 2022). Additionally, 10-minute small-sided games (playing area: 15×25m; number of players: 6 vs. 6) were conducted at maximum effort. Before starting the training program, performance factors (dribbling skill, aerobic capacity, anaerobic power, and intermittent endurance) were measured, and after completing the 8-week training period, the variables were measured again in the post-test phase and the results were recorded.

Table 1. *Skill-Based Training Program*

Total Activity Time (Three Stations per Player)	Recovery Between Stations	Recovery Between Reps	Repetition Duration	Repetitions	Weeks
33-35 minutes	4 minutes	30 seconds	20-25 seconds	4	1-2
33-35 minutes	4 minutes	30 seconds	20-25 seconds	5	3-4
35-37 minutes	5 minutes	30 seconds	20-25 seconds	6	5-6
35-37 minutes	5 minutes	30 seconds	25 seconds	7	7-8

2.5. Statistical Methods

The collected data were initially categorized and organized. Descriptive statistics were then used to summarize the results in the form of frequency tables and graphs. Subsequently, inferential statistics were employed to test the research hypotheses. First, the Shapiro-Wilk test was used to examine data normality. Then, paired t-tests were applied for within-group comparisons, while independent t-tests were used for between-group comparisons. All analyses were performed using SPSS software (version 22).

3. Results

All variables demonstrated normal distribution per Shapiro-Wilk test results ($p > .05$) with homogeneity of variances confirmed by Levene's test, subsequently warranting the use of parametric analyses including both paired and independent samples t-tests to respectively evaluate within-group and between-group differences across the measured parameters, as supported by the descriptive statistics for all variables presented in Table 2 which summarizes the mean and standard deviation values for each experimental condition.

Table 2. *Descriptive Statistics of Research Variables in Pre-test and Post-test by Group*

Variable	Group	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD
Body Mass Index (BMI)	Experimental	18.70	1.13	18.62	1.05
	Control	18.32	1.39	18.43	1.24
Aerobic Power	Experimental	45.86	4.38	49.56	4.58
	Control	46.05	4.45	46.29	4.37
Anaerobic Power	Experimental	329.15	72.25	392.20	72.11
	Control	330.54	86.10	331.96	86.43
Fatigue Index	Experimental	8.71	1.10	7.01	0.41
	Control	8.63	2.12	8.21	1.96
Intermittent Endurance	Experimental	728.33	23.81	745.66	21.86
	Control	730.46	18.45	731.20	18.17
Dribbling	Experimental	29.93	2.86	27.73	2.63
	Control	30.20	2.95	30.06	2.68

Paired t-tests revealed significant post-intervention improvements in the experimental group across all measured parameters except BMI (anaerobic capacity: $t=61.84$, $p<0.001$; aerobic capacity: $t=14.58$, $p<0.001$;

endurance: t=-6.12, p<0.001; fatigue: t=7.67, p<0.001; dribble: t=12.60, p<0.001). Independent samples t-tests revealed statistically significant between-group differences in anaerobic capacity (t(28)=2.07, p=.048, Δ=60.24), dribble performance (t(28)=-2.40, p=.023, Δ=-2.33), and fatigue index (t(15.26)=-2.32, p=.034, Δ=-1.20). While aerobic capacity (p=.056) and intermittent endurance (p=.059) approached significance, BMI showed no group differences (p=.668). Levene's test confirmed homogeneity of variance for all measures except fatigue index (F=20.92, p<.001).

Table 3. *Paired t-test Results Comparing Pre-test and Post-test in Experimental and Control Groups*

Variable	Group	Pre-test (Mean)	Post-test (Mean)	t-value	p-value
BMI	Experimental	18.70	18.62	1.860	0.083
	Control	18.32	18.43	-1.860	0.084
	Experimental	29.93	27.73	12.602	0.000
Dribble	Control	30.20	30.06	1.000	0.334
Aerobic Capacity	Experimental	45.86	49.56	14.579	0.000
	Control	46.05	46.29	-3.104	0.008
Anaerobic Capacity	Experimental	329.15	392.20	61.836	0.000
	Control	330.54	331.96	-3.456	0.004
Fatigue Index	Experimental	8.71	7.01	7.671	0.000
	Control	8.63	8.21	4.607	0.000
Intermittent Endurance	Experimental	728.33	745.66	-6.119	0.000
	Control	730.46	731.20	-2.750	0.016

Table 4. *Independent t-test Results Comparing Experimental and Control Groups Across Key Variables*

Variable	Variance Sig	t-value	df	p-value	Mean Difference
BMI	0.362	0.434	28	0.668	0.1833
Dribble	0.904	-2.404	28	0.023	-2.333
Aerobic Capacity	0.870	1.998	28	0.056	3.269
Anaerobic Capacity	0.306	2.073	28	0.048	60.242
Fatigue Index	0.000	-2.324	15.26	0.034	-1.203
Intermittent Endurance	0.508	1.970	28	0.059	14.466

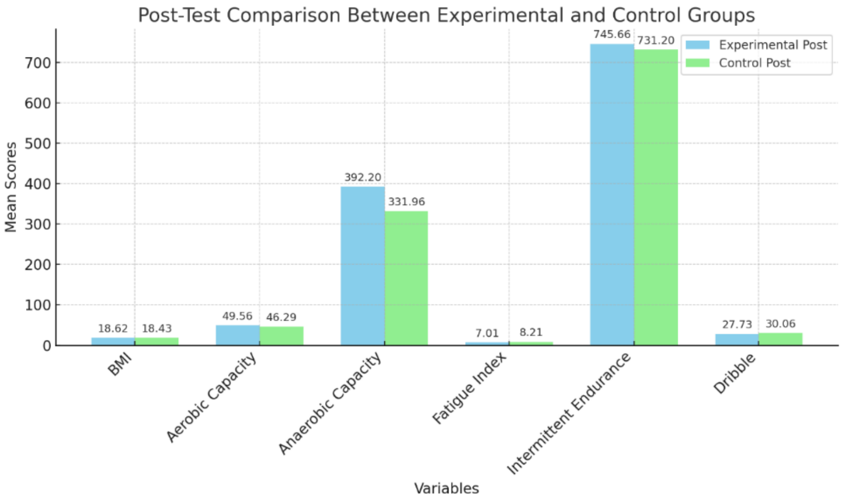

Fig 1. *Post-Test Comparison Between Experimental and Control Groups*

4. Discussion

This study examining high-intensity interval training (HIIT) in youth futsal players reveals notable physiological and performance adaptations, while contributing both confirmation and nuance to the existing literature. The results largely align with previous findings regarding anaerobic and neuromuscular benefits of HIIT in adults but also highlight age-specific considerations that merit further exploration in youth populations.

Improvements in anaerobic capacity and dribbling performance are consistent with established HIIT outcomes. For example, Gibala et al.(14) demonstrated that HIIT enhances glycolytic enzyme activity and muscle buffering capacity, both of which are crucial for short-duration, high-intensity performance. Our findings echo these results, suggesting enhanced phosphofructokinase (PFK) and lactate dehydrogenase (LDH) activity, facilitating more efficient anaerobic ATP resynthesis and lactate clearance. These metabolic shifts likely increase in anaerobic power.

In addition, the significant improvements in dribbling performance may be explained by neuromuscular adaptations commonly elicited by high-intensity training. Prior work by Hammami et al. (15) and Folland et al. (16) suggests that HIIT enhances motor unit recruitment, rate coding, and intermuscular coordination—factors that improve movement efficiency and technical execution, particularly under fatigue. These neural mechanisms are especially relevant in sports like futsal, where rapid, multidirectional movements are critical.

The absence of meaningful changes in body composition contrasts with studies conducted on sedentary youth, but is consistent with findings from Gómez-Campos et al. (17),who concluded that trained adolescents may experience limited BMI shifts due to already optimized metabolic profiles. Furthermore, the relatively short duration of our intervention may have been insufficient to provoke detectable morphological changes, despite performance gains.

Importantly, while improvements in performance were evident, the physiological mechanisms may also involve mitochondrial and capillary adaptations not directly assessed in this study. HIIT is known to stimulate mitochondrial biogenesis through PGC-1α signaling and increase capillary density, potentially enhancing oxygen delivery and recovery between efforts. In adolescent populations, these responses may be amplified or moderated by maturational hormones such as growth hormone and testosterone—factors that could shape individual responsiveness to HIIT but remain underexplored.

Our results, showing anaerobic performance increases in line with Tabata et al. (18)and Buchheit & Laursen (4) ,exceed the 7–12% range reported by García-Hermoso et al. (19). This discrepancy could be attributed to our participants' higher baseline aerobic fitness (VO_2max >45 ml/kg/min), which may enable more rapid or pronounced adaptations.

Despite these promising outcomes, this study has several limitations. The intervention duration was relatively short, and no hormonal or maturation status markers were included—factors that may have offered deeper insights into age-related training effects. Additionally, the sample included only male players, limiting the generalizability of findings across sexes.

Future research should address these limitations by incorporating longer-term protocols, biological maturity assessments (e.g., Tanner staging), and sex-specific analyses. Moreover, the integration of nutritional strategies and individualized periodization frameworks may help optimize HIIT's efficacy across different maturation stages in youth futsal players.

5. Conclusion

HIIT appears to be a valuable, time-efficient training method for improving anaerobic power and skill performance in youth futsal players. These findings support its integration into youth training programs, though future work should consider biological maturation and individual responsiveness for optimal outcomes.

6. Acknowledgment

The researchers hereby thank and appreciate all those who contributed to this research.

Conflict of interests: The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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