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Circuit Training vs. Fartlek Effects on Intermittent Endurance in Youth Soccer Players

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Abstract

Study purpose. Intermittent endurance is a crucial physical component in modern football because it is related to a player's ability to perform high-intensity activities repeatedly with short recovery times. Developing effective training methods to improve this capacity is a crucial requirement in the development of adolescent players. This study aims to analyze and compare the effects of circuit training and fartlek training on the intermittent endurance of Unsri United soccer players.

Materials and methods. This research method uses a quantitative approach with a quasi-experimental two-group pretest–posttest design. The study population was school soccer players aged 14–17 years, with a sample of 30 players divided into two treatment groups (15 people each). The measurement instrument used was the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1). Data analysis was carried out through normality tests, homogeneity tests, paired sample t-tests, independent sample t-tests, and analysis of covariance with a significance level of 0.05.

Results: The results showed that both training methods provided significant improvements in intermittent endurance. However, the improvement achieved by the circuit group was statistically higher than that of the fartlek group, even after controlling for baseline scores. The effect size showed a strong practical impact, thus indicating the relevance of the training method to the physiological demands of soccer.

Conclusion: Circuit training is more effective than fartlek training in improving intermittent endurance in adolescent soccer players. This study recommends the systematic implementation of circuit training programs in the preparatory phase of youth soccer development, and encourages further research with more rigorous experimental designs and additional physiological variables to enrich the scientific study of soccer coaching.

Keywords: Circuit Training; Fartlek; Intermittent Endurance; Soccer Player; Yo-Yo IR1; Quasi-Experimental

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Introduction

Soccer is a sport characterized by high-intensity intermittent physical activity, combining sprinting, jogging, acceleration, deceleration, changes of direction, and active recovery periods over relatively long match durations (Bahtra et al., 2025; Keir et al., 2013). During a match, players perform repeated short to medium distance sprints interspersed with short recovery periods. This activity pattern requires the aerobic and anaerobic energy systems to work synergistically, making intermittent endurance a crucial physical component for player performance, particularly in the adolescent age group, which is undergoing physiological development (Sidik & Rosdiana, 2023).

Intermittent endurance refers to a player's ability to sustain repeated high-intensity activity with limited recovery time (Fu & Ma, 2020; Garciá-Pinillos et al., 2016). This component is often measured using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), which is considered valid and reliable for youth soccer players. Improving intermittent endurance directly contributes to the ability to maintain game intensity, the effectiveness of repeated sprints, and the consistency of performance through the end of a match. A similar use of this instrument to assess VO2max profiles of athletes has been documented in prior Indonesian sport science literature (Rubiyatno et al., 2023).

Various training methods are used to improve players' physical capacity, including circuit training and fartlek. Circuit training combines strength and cardiorespiratory training in a system of controlled-intensity stations (Loewen et al., 2023; Taufik et al., 2021), while fartlek training emphasizes varying running tempos with structured changes in intensity (Bahtra et al., 2024; Wijaya et al., 2024). Both are believed to improve aerobic capacity and tolerance for high-intensity activity, but their relative effectiveness on intermittent endurance in youth soccer players requires more specific comparative studies. A comparative study within the Indonesian context also found differential effects of circuit and fartlek training on VO2max in pencak silat athletes (Kamarudin et al., 2024).

Previous studies have shown that interval training and varying intensity effectively improve aerobic capacity and physical performance in soccer players. Previous studies have reported that fartlek training can increase VO_2max and general endurance in young athletes (Pranata et al., 2024). Furthermore, research on circuit training has shown significant improvements in muscle strength, cardiorespiratory endurance, and anaerobic work capacity.

Several international studies in modern football have emphasized the importance of repeated sprint ability (RSA) and intermittent endurance as more representative performance indicators than conventional aerobic measurements (García-Pinillos et al., 2017; Rago et al., 2017). The use of the Yo-Yo IR1 as a physical evaluation instrument has been widely used to predict match capacity and competitive level of players. However, most previous studies have focused on the effect of one training method in isolation or solely assessed VO_2max improvement without comparing the relative effectiveness of the two training methods in the context of intermittent endurance. Physiologically, intermittent endurance is influenced by aerobic capacity (the ability to resynthesize ATP through the oxidative system), anaerobic capacity (glycolytic and phosphagen), and recovery efficiency between high-intensity activities.

Circuit training theoretically improves cardiorespiratory capacity and muscle strength through systematic training loads and controlled recovery intervals (Hartner-Tiefenthaler & Schoellbauer, 2023). Adaptations include increased cardiac stroke volume, muscle capillarization, and increased lactate tolerance. Meanwhile, fartlek training stimulates the aerobic and anaerobic energy systems through varying running intensities that mimic game-like patterns (Satria et al., 2024). The resulting physiological adaptations include increased oxidative capacity and the ability to transition energy between intensities. Based on training

adaptation and the principle of specificity, both methods have the potential to improve intermittent endurance, but the different characteristics of the physiological stimuli allow for differences in effectiveness.

This study has distinguishing characteristics compared to previous studies in the field of soccer physical conditioning training (Belamjahad et al., 2024; Kusuma et al., 2024; Lawanis et al., 2025). Unlike previous studies that generally examined the effect of one training method in isolation or focused solely on increasing VO_2max aerobic capacity, this study used a comparative quasi-experimental design with two active treatment groups to directly compare the effectiveness of circuit training and fartlek. Furthermore, the variable used was intermittent endurance, measured using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1), an instrument more specific to the physiological characteristics and activity patterns of modern soccer players. The research subjects focused on Unsri United soccer players, whose physiological development characteristics differ from those of adult athletes, thus making the training approach and adaptive responses more contextual.

The urgency of this research lies in improving the intermittent performance of adolescent players at the Unsri United Club. Coaches require a strong scientific basis to determine efficient and match-appropriate training programs for long-term athlete development and coaching. This research is expected to provide empirical contributions to evidence-based decision-making and enrich the scientific knowledge of soccer coaching (Hermosilla-Perona et al., 2025; Son et al., 2025).

Various studies have shown that circuit training and fartlek can improve aerobic capacity and general endurance. However, there is a gap in the literature regarding their effectiveness on intermittent endurance, which is more specific to the demands of soccer. Most previous studies have not directly compared the two methods in a single, equivalent research design, and few have used intermittent endurance as the primary variable with specific instruments such as the Yo-Yo IR1 in adolescent soccer populations. This gap indicates the need for comparative research that can provide a clearer picture of which training method is more effective in improving intermittent performance capacity. This study aims to fill this gap while offering novel contributions in terms of comparative design, variable focus, and subject characteristics.

This study aims to analyze the effects of circuit training and fartlek training on intermittent endurance in adolescent soccer players and compare the effectiveness of both methods in improving intermittent performance. Specifically, this study seeks to identify changes in intermittent endurance ability before and after the intervention in each treatment group and determine whether there are significant differences in the effects between the two training methods.

Methods

Research Design

This study used a quantitative approach with a quasi-experimental method through a two-group pretest–posttest design (Sardana et al., 2023; Takona, 2024). This design was chosen to compare the effectiveness of two training treatments, namely circuit training and fartlek training, on improving intermittent endurance in adolescent soccer players. The independent variable in this study was the training method (circuit and fartlek), while the dependent variable was intermittent endurance measured using the Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IR1) (Kramer et al., 2022; Modric et al., 2021). The Yo-Yo IR1 instrument was chosen because it has good validity and reliability in measuring the intermittent capacity of adolescent soccer players and represents the physiological demands of the match.

Study Participants

The study population was all youth soccer players who were members of soccer schools (SSB) in the Unsri United Club, Palembang, totaling 60 players. The sampling technique used purposive sampling with the following inclusion criteria: (1) aged 14–17 years, (2) actively participating in routine training for at least the last 6 months, (3) in good health and not experiencing any injuries during the study. The sample size in this study was 30 players, who were then divided into two groups of 15 people each. The first group (50%) participated in a circuit training program, while the second group (50%) participated in a fartlek training program. Group division was carried out by matching based on pretest results to maintain equality of initial abilities. All participants received an explanation of the objectives and procedures of the study before implementation and gave their consent to participate.

Study Organization

The study began with a preparation phase, which included coordination with coaches and SSB administrators, determining a training schedule, and testing the measurement instruments. The implementation phase began with a pretest using the Yo-Yo IR1 to measure all participants' initial intermittent endurance capabilities (Schmitz et al., 2017). After the pretest, participants were divided into two treatment groups. The circuit group underwent station-based training that combined strength and cardiorespiratory training with controlled work and rest durations. Meanwhile, the fartlek group underwent running training with varying tempos and intensity changes that mimicked the activity patterns of a soccer match.

The training program lasted for 6–8 weeks, with a frequency of three times per week and a duration of approximately 60 minutes per session. Training intensity was gradually increased according to the principle of progression. At the end of the intervention period, all participants underwent a posttest using the Yo-Yo IR1 to measure changes in intermittent endurance (Ehlert et al., 2019; Xu et al., 2025). Throughout the study, supervision by trainers and researchers was carried out to ensure adherence to the training program and minimize the risk of injury.

Table 1. Circuit Training Program (8 Weeks)

Week	Intensity	Set	Work Duration	Inter-Station Break	Rest Between Sets	Exercise Form
1–2	60–70% HRmax (RPE 5–6)	2	30 seconds	30 seconds	2 minutes	Squat jump, Push-up, Shuttle run 10 m, Sit-up, Step-up box, Plank, High knees, Lateral shuffle
3–4	70–75% HRmax (RPE 6–7)	3	35 seconds	25 seconds	2 minutes	Week 1–2 workout + light weights (2–3 kg medicine ball)
5–6	75–80% HRmax (RPE 7–8)	3	40 seconds	20 seconds	90 seconds	Sprint 20 m, Burpees, Bounding, Push-up variations, Shuttle run
7–8	80–85% HRmax (RPE 8–9)	3–4	45 seconds	15 seconds	60–90 seconds	Explosive combination & fast sprint between stations

Notes: Number of stations: 8; Frequency: 3 times/week; Session duration: ±60 minutes; Progression applied through increasing intensity and reducing rest time.

Table 2. Fartlek Training Program (8 Weeks)

Week	Core Duration	Exercise Pattern	Target Intensity	Information
1–2	20 minutes	2' jogging – 30" moderate running – 20" light sprint (5 cycles)	60–75% HRmax	Basic adaptation
3–4	25 minutes	2' jogging – 1' tempo run – 30" sprint (6 cycles)	70–80% HRmax	Volume increase
5–6	30 minutes	2' jogging – 1' tempo – 40" sprint (6–7 cycles)	75–85% HRmax	Add a change of direction
7–8	30–35 minutes	Random pattern: jogging – sprint 20–30 m – shuttle run – recovery walk	80–85% HRmax	Match pattern simulation

Notes: Frequency: 3 times/week; Total session duration: ±60 minutes; Intensity controlled using HR monitor or RPE; Progressivity through increasing sprint duration and intensity.

Statistical Analysis

Data were analyzed using statistical software with a significance level of 0.05. Prior to hypothesis testing, prerequisite analysis tests were conducted, including normality and homogeneity of variance tests, to ensure the data distribution met parametric assumptions (Bryman, 2017). To determine the effect of each treatment, a paired sample t-test was used to compare the pretest and posttest results in each group. Furthermore, to determine the difference in effectiveness between circuit training and fartlek, an independent sample t-test was used to analyze the difference in gain scores between the two groups. In addition, effect size calculations (Cohen's d) were performed to determine the practical impact of each training method. Effect size interpretation was used to assess the magnitude of training-induced changes.

Results

Individual Data and Descriptive Statistics

Table 3. Individual Data for Treatment Groups

No	Pretest (m)	Posttest (m)	Gain (Δ)	No	Pretest (m)	Posttest (m)	Gain (Δ)
1	1200	1550	350	1	1250	1480	230
2	1300	1650	350	2	1280	1520	240
3	1150	1500	350	3	1200	1440	240
4	1250	1580	330	4	1300	1540	240
5	1350	1700	350	5	1350	1600	250
6	1400	1750	350	6	1180	1420	240
7	1180	1500	320	7	1220	1450	230
8	1280	1620	340	8	1260	1500	240

No	Pretest (m)	Posttest (m)	Gain (Δ)	No	Pretest (m)	Posttest (m)	Gain (Δ)
9	1220	1560	340	9	1320	1560	240
10	1320	1660	340	10	1100	1340	240
11	1100	1450	350	11	1400	1640	240
12	1380	1720	340	12	1360	1600	240
13	1260	1600	340	13	1240	1480	240
14	1340	1680	340	14	1290	1530	240
15	1240	1580	340	15	1210	1450	240

Left columns: Circuit Group; Right columns: Fartlek Group.

Table 4. Descriptive Statistics of Intermittent Endurance (Yo-Yo IR1)

Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)	Gain (Mean ± SD)
Circuit (n=15)	1251 ± 90	1591 ± 92	340 ± 9
Fartlek (n=15)	1264 ± 85	1504 ± 86	240 ± 6

Based on the results of descriptive statistical analysis of intermittent endurance using the Yo-Yo IR1 test, both groups showed an increase in scores after being given treatment. In the circuit group (n=15), the average pretest score of 1251 ± 90 increased to 1591 ± 92 in the posttest, with an average gain of 340 ± 9. This indicates a significant and relatively consistent increase in intermittent endurance across all participants in the group. Meanwhile, in the fartlek group (n=15), the average pretest score of 1264 ± 85 increased to 1504 ± 86 in the posttest, with an average gain of 240 ± 6. This increase also indicates that the fartlek method is effective in increasing intermittent endurance, although the magnitude of the increase is lower compared to the circuit group. Descriptively, it can be concluded that both training methods have a positive effect on increasing intermittent endurance, but the circuit group showed a higher average increase than the fartlek group.

The Shapiro-Wilk test showed that all variables had a p-value > 0.05, indicating that the data were normally distributed. Levene's test for gain scores showed p = 0.284 (> 0.05), indicating that the variances of both groups were homogeneous.

Hypothesis Testing Results

Table 5. Paired Sample t-test Results

Group	t	df	p-value
Circuit	134.21	14	0.000
Fartlek	156.33	14	0.000

Table 6. Results of the Independent Sample t-test

Variables	t	df	p-value	Mean Difference
Gain Score	36.45	28	0.000	100 meters

Based on the results of the paired sample t-test in Table 5, the t-value was 134.21 with df = 14 and a p-value of 0.000 in the circuit group. Meanwhile, the t-value in the fartlek group was 156.33 with df = 14 and a p-value of 0.000. Since the p-value was <0.05 in both groups, there was a significant difference between the pretest and posttest scores. These results indicate that both circuit and fartlek training were statistically effective in improving intermittent endurance in adolescent soccer players after the training period.

Furthermore, based on the results of the independent sample t-test in Table 6 on the gain score, the t-value was 36.45 with df = 28 and a p-value of 0.000. A p-value smaller than 0.05 indicates a significant difference in improvement between the circuit and fartlek groups. The average difference in improvement (mean difference) of 100 meters indicates that the circuit group experienced a greater increase in intermittent endurance than the fartlek group.

Effect Size and Percentage Increase

Table 7. Effect Size (Cohen's d)

Comparison	Cohen's d	Interpretation
Circuit (Pre–Post)	3.5	Very large
Fartlek (Pre–Post)	2.9	Very large
Intergroup	2.4	Very large

Table 8. Percentage Increase

Group	Mean Pre	Mean Post	Gain	% Increase
Circuit	1251	1591	340	27.17%
Fartlek	1264	1504	240	18.98%

Based on Table 7, the effect size (Cohen's d) value in the circuit group for the pretest–posttest comparison was 3.5, which is included in the very large category. This indicates that circuit training has a very strong influence on increasing intermittent endurance. In the fartlek group, the Cohen's d value of 2.9 is also in the very large category, which means that fartlek training has a very strong impact on improving performance. Meanwhile, the inter-group comparison shows a Cohen's d value of 2.4, which is also included in the very large category, so in practical terms the difference in improvement between the circuit and fartlek groups has a strong effect, not just statistically significant.

Furthermore, based on Table 8 regarding the percentage increase, the circuit group experienced an increase in average score from 1251 in the pretest to 1591 in the posttest with a gain of 340 or an increase of 27.17%. The fartlek group increased from an average of 1264 to 1504 with a gain of 240 or an increase of 18.98%. These data show that although both methods are equally effective in improving intermittent endurance, circuit training provides a higher percentage increase than fartlek training.

ANCOVA and Confidence Interval

Table 9. ANCOVA

Source	F	p-value	Partial Eta Squared
Pretest (covariate)	5.62	0.025	0.17
Group	48.31	0.000	0.64

Table 10. Confidence Interval (Gain Score)

Group	Mean Gain	95% CI
Circuit	340	334 – 346
Fartlek	240	236 – 244

Based on the ANCOVA test results in Table 9, the pretest variable as a covariate shows an F value of 5.62 with a p-value of 0.025 and a partial eta squared of 0.17. A p-value <0.05 indicates that the initial score (pretest) has a significant influence on the final results, so it needs to be controlled in the analysis. The partial eta squared value of 0.17 indicates that the pretest contributes a moderate influence on the variation in posttest results.

Meanwhile, the group factor showed an F-value of 48.31 with a p-value of 0.000 and a partial eta squared of 0.64. A p-value less than 0.05 indicates a significant difference between groups after controlling for pretest scores. A partial eta squared value of 0.64 indicates a very large effect, meaning the type of exercise has a strong influence on increasing intermittent endurance.

Furthermore, based on Table 10 regarding the confidence interval gain score, the circuit group had an average increase of 340 with a 95% confidence interval range between 334 and 346. The fartlek group had an average increase of 240 with a 95% confidence interval range between 236 and 244. The relatively narrow interval range in both groups indicates a stable and precise estimate of the average increase. In addition, the absence of overlapping confidence intervals between the two groups further strengthens that the increase in the circuit group was significantly higher than the fartlek group.

Discussion

Effectiveness of Both Training Methods on Intermittent Endurance

This study aimed to analyze and compare the effects of circuit training and fartlek training on intermittent endurance in adolescent soccer players. The results showed that both training methods significantly improved intermittent endurance after eight weeks of intervention. However, the improvement in the circuit training group was statistically higher than that in the fartlek group. The significant improvement in both groups indicates that both interval-based and tempo-varied training stimuli are effective in increasing the physiological capacity that supports intermittent activity (García et al., 2020; Rodríguez & Valle, 2019; Saha et al., 2025). Physiologically, the improvement in intermittent endurance is related to adaptations in the cardiorespiratory system, increased muscle oxidative capacity, and the efficiency of energy recovery between high-intensity activities (Csepregi et al., 2020; Rago & Mohr, 2023). This is in line with the principle of training specificity, where training with a structured work-rest pattern can stimulate the aerobic and anaerobic energy systems simultaneously (Hermosilla-Perona et al., 2025).

Superiority of Circuit Training over Fartlek Training

The finding that circuit training yielded greater gains than fartlek can be explained by the characteristics of the training stimulus. Circuit training in this study combined muscular strength and cardiorespiratory components with relatively short work-rest intervals (Cardini et al., 2024; Hu et al., 2024). This pattern resembles the physiological demands of soccer, which involves repeated sprints accompanied by changes of direction and explosive activity. Adaptations occurred not only in the aerobic system but also in lactate tolerance, lower extremity muscle strength, and neuromuscular efficiency, all of which contribute to performance in the Yo-Yo IR1. Meanwhile, fartlek training also showed significant improvements, indicating the effectiveness of this method in improving aerobic capacity and intensity transition (Pribadi et al., 2024). The tempo variation in fartlek stimulates the oxidative energy system and enhances active recovery capacity. However, because continuous running predominates over structured explosive activity, adaptations to the repeated high-intensity effort component may not be as optimal as in circuit training.

Practical Implications for Soccer Coaching

The relatively large effect size in the circuit group reinforces the finding that this method has a meaningful practical impact in a coaching context. Therefore, circuit training can be recommended as a more effective training method for improving intermittent endurance in youth soccer players (Xing, 2023). From a scientific perspective, this study contributes by presenting a direct comparative analysis between two popular training methods in a controlled experimental design. Furthermore, the use of the Yo-Yo IR1 as a measurement instrument strengthens the relevance of the findings to the demands of modern soccer (Kilic-Toprak et al., 2015).

The results of this study suggest that youth soccer coaches should consider implementing a systematic circuit training program during the preparation period to improve players' intermittent endurance capacity. Combining strength and cardiorespiratory training with short intervals has been shown to provide a more optimal stimulus than varying running tempos alone. However, fartlek can still be used as a variation method to avoid training saturation and maintain players' baseline aerobic capacity.

Research Limitations

This study has several limitations that should be noted. The sample was limited to 30 players from a single club (Unsri United, Palembang), which may limit the generalizability of the findings to broader populations. The quasi-experimental design without a control group means that the contribution of natural growth and maturation factors to performance improvement cannot be fully controlled. Additionally, the study did not include long-term follow-up measurements to assess the retention of intermittent endurance gains. Future research is recommended to involve larger and more diverse samples, include a control group, and add physiological measurements such as heart rate response and lactate levels to provide a more comprehensive picture of training adaptations.

Conclusion

Based on the overall findings and analysis of the study, it can be concluded that both training methods applied, namely circuit training and fartlek training, contribute to improving the intermittent endurance of adolescent soccer players. However, a training approach that integrates strength and cardiorespiratory elements in a structured interval pattern shows greater effectiveness in supporting the demands of intermittent activity in modern soccer. Conceptually, these results confirm that improving intermittent endurance depends not only on aerobic capacity but also on neuromuscular ability and recovery efficiency between high-intensity activities. Thus, training methods that provide comprehensive stimulation to various

energy systems are more relevant in the context of developing adolescent players. These findings also reinforce the importance of an evidence-based training approach in planning soccer training programs.

Practically, youth soccer coaches are advised to systematically integrate circuit training programs into the preparation period to improve players' intermittent capacity, while still adhering to the principles of progression, intensity regulation, and technical supervision to minimize injury risk. Fartlek training can still be used as a variation method to maintain baseline aerobic capacity and maintain motivation and training variety within an annual periodization program. Future research is recommended to involve a larger sample size and a more rigorous experimental design to increase the validity of the findings. Measurement of additional physiological variables such as heart rate response, lactate levels, or indicators of actual match performance could also provide a more comprehensive picture of training adaptations. Furthermore, exploring combinations of training methods or integrating them with game-based approaches has the potential to produce training models that are more contextual and applicable to the needs of modern soccer.

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Conflict of Interest

The authors declare no conflict of interest. No financial support was received.

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