JIAS
Journal of Indonesian Active in Sports
Vol. 2 (2) July 2025

Article

Evaluating Plyometric Circuit Training for Enhancing Explosive Power and Sprint Times

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History Article

Received:
January 2025

Accepted:
April 2025

Published:
July 2025

Keywords:
circuit training, leg muscle power, sprinting speed, 200-meter sprint, athletic performance, plyometric exercises.

Abstract

This study investigates the impact of circuit training on enhancing leg muscle power and 200-meter sprinting speed among athletes of PASI Mandailing Natal, addressing prevalent deficiencies in these performance metrics. Employing a one-group pretest-posttest experimental design, six male athletes were subjected to a six-week training program, conducted three times weekly. The intervention comprised eight structured stations targeting strength, power, and speed through exercises such as squat jumps and box jumps, progressively increasing in intensity. Performance was assessed using standing broad jump tests for leg muscle power and stopwatch measurements for 200-meter sprint times. Statistical analyses, including paired t-tests and ANOVA, revealed significant improvements: mean leg muscle power increased by 32.83 cm, while sprinting times decreased by 2.98 seconds. These findings underscore the efficacy of circuit training in stimulating neuromuscular coordination and anaerobic adaptations, crucial for sprint performance. The reduction in performance variability further highlights the program's adaptability to diverse fitness levels. This study provides evidence-based validation of circuit training as a practical and efficient approach for athletic development, with implications for optimizing competitive readiness. Future research should explore individual exercise contributions within the protocol to refine training strategies. The results contribute to sports science literature, offering actionable insights for coaches seeking targeted interventions to enhance sprint performance.

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INTRODUCTION

Athletics is one of the most fundamental sports disciplines, encompassing various physical activities such as running, jumping, and throwing, which serve as the foundation for many other sports. The 200-meter sprint is a discipline that combines speed, strength, endurance, and technique in a highly synchronized manner. However, athletes' performance in this event often faces significant challenges, particularly during critical phases such as the start and the final 60 meters approaching the finish line. These challenges are often attributed to insufficient leg muscle power and inadequate sprinting speed. Previous research has highlighted the crucial role of these physical components in determining a sprinter's success in achieving optimal race times (Pandy, Lai, Schache, & Lin, 2021). Further empirical evidence underscores that enhanced lower limb power is significantly associated with increased stride length and reduced sprint time over 200 meters, indicating a direct and meaningful relationship between muscular explosiveness and sprinting performance (Ali, Hussain, & Jasim, 2022; Maćkała, Michalski, & Ćoh, 2010). Thus, improving leg muscle power and sprinting speed has become an urgent necessity in athletic training programs.

The PASI (Indonesian Athletics Federation) Mandailing Natal has demonstrated a consistent commitment to enhancing its operational effectiveness and fostering the development of its athletes. This commitment has been particularly evident in the 200-meter running category, where the association has been working to ensure the success of its athletes in both domestic and international competitions. Nevertheless, despite these efforts, numerous challenges persist, and the current state of affairs is not yet optimal. In the initial standing broad jump test, 33.3% of the athletes were classified as "poor," while 66.7% were categorized as "very poor." Similarly, in the 200-meter sprint test, 83.3% of the athletes fell into the "below average" category. These findings underscore significant weaknesses in leg muscle power and sprinting speed, directly impacting athletes' competitive performance (Lockie, Jalilvand, Callaghan, Jeffriess, & Murphy, 2015; Pandy et al., 2021).

To address these issues, an effective and evidence-based training approach is required. One highly recommended method is circuit training. This training program consists of a series of stations designed to systematically target various physical components, including strength, endurance, agility, and speed (Annasai, Sumaryanti, Nugroho, Hartanto, & Arianto, 2023; Mola & Bayısa, 2020). Previous studies have demonstrated that circuit training effectively enhances leg muscle power and endurance while providing a variety of exercises to mitigate athlete fatigue (Annasai et al., 2023; Mola & Bayısa, 2020). Moreover, this method has been shown to significantly improve speed, a critical component of sprint performance (Pandy et al., 2021). Circuit training has also been found to significantly enhance the sprinting abilities of young athletes, including high school sprinters, by improving their overall performance in track and field events (Babu & Kumar, 2013; Deshmukh & Dhokrat, 2025).

This study aims to evaluate the effect of circuit training on improving leg muscle power and 200-meter sprinting speed among male athletes from PASI Mandailing Natal. The research employs a one-group pretest-posttest experimental design, with athletes undergoing a six-week circuit training program at a frequency of three sessions per week (Ando et al., 2024; Bijarga, 2023). Circuit-based training significantly enhances strength and speed due to its focus on explosive and resistance-driven exercises (Kahraman & Hocalar, 2024; Ramos-Campo, Andreu Caravaca, Martínez-Rodríguez, & Rubio-Arias, 2021). This provides a robust scientific foundation for implementing this training method in the context of sprint athletes.

The urgency of this study lies not only in enhancing the individual performance of athletes but also in its broader impact, such as improving the reputation of the club and the region in national and international competitions. Furthermore, the findings of this research are expected to make a significant contribution to the sports training literature, particularly regarding the effectiveness of circuit training in enhancing sprint performance. By optimizing strength and speed components through a scientifically grounded training method, this study seeks to address the pressing need for a more effective, efficient, and relevant approach to modern competitive sports training.

METHODS

This study employed an experimental design using a one-group pretest-posttest model. This approach is widely used to evaluate the effectiveness of interventions by comparing outcomes before and after treatment within the same group, as recommended in sports experimental research (Creswell & Creswell, 2017). The study was conducted at H. Adam Malik Stadium, Mandailing Natal, North Sumatra, which serves as the training center for PASI (Persatuan Atletik Seluruh Indonesia) athletes. The study period lasted six weeks, with a training frequency of three sessions per week, starting from January to February 2024. The independent variable in this study was the circuit training program, while the dependent variables included leg muscle power and 200-meter running speed.

Table 1. Research Implementation Procedure

Station	Type of Exercise	Execution Description	Duration/ Repetitions	Rest between Stations & Sets / Total Sets
1	Squat jump	Jump from a squat position with both hands behind the head, return to the squat position, and repeat	20-30 seconds / 10-15 repetitions	30 seconds & 5 minutes / 3 sets
2	Step up	Step up and down on an elevated surface (box or stairs) alternately with each leg	20-30 seconds / 10-15 repetitions	
3	Lunges	Take a long forward step, ensuring the front knee forms a 90-degree angle while the back leg remains stable.	20-30 seconds / 10-12 repetitions per leg	
4	Lateral bound	Perform side-to-side jumps as far as possible, landing on one foot, then alternate legs	20-30 seconds / 10-12 repetitions per leg	
5	Knee tuck jump	Jump as high as possible while tucking knees toward the chest, land softly, and repeat	20-30 seconds / 10-15 repetitions	
6	Box jump	Jump onto a plyo box with both feet, then step or jump back down to the starting position	20-30 seconds / 10-12 repetitions per leg	
7	Split squat jump	Perform explosive jumps from a squat position, alternating the front and back legs mid-air	20-30 seconds / 10-12 repetitions per leg	
8	Squat thrust	From a squat position, kick both feet back into a push-up position, return to squat, and jump up	20-30 seconds / 10-15 repetitions	

Table 1 illustrates the procedure for implementing the circuit training program aimed at enhancing leg muscle power and 200-meter running speed. The training consists of eight stations, each designed to target specific components of physical fitness, such as strength, power, and endurance. Athletes progress through these stations in sequential order, performing exercises like squat jump, step up, and lateral bound, with each exercise lasting 20-30 seconds or 10-15 repetitions. Between stations, a 30-second rest is provided to maintain workout intensity while allowing partial recovery. The training session is structured into 3 sets, with a 5-minute rest between circuits. Intensity is progressively increased over time by adding repetitions, extending duration, or reducing rest intervals. This structured approach ensures a balanced workload that optimizes physiological adaptations, aligning with evidence-based practices in circuit training. The program is overseen by trainers to ensure proper technique and minimize the risk of injury, making it a practical and effective method for athletic performance improvement.

The study population consisted of 8 male PASI athletes specializing in the 200-meter sprint. The sampling technique applied was purposive sampling, selecting 6 athletes who met the inclusion criteria, such as active participation in training during the study period and no history of injuries affecting performance. Data were collected through pretest and posttest measurements for each variable, using the standing broad jump test to assess leg muscle power and a stopwatch to measure 200-meter running speed. Data analysis involved three main stages. First, normality testing was conducted using the Shapiro-Wilk test, a commonly employed method for verifying normal data distribution in small samples (Ghasemi & Zahediasl, 2012). Second, homogeneity of variance across groups was tested using Levene's test to ensure equal variances (Field, 2013). Lastly, hypothesis testing was performed using both a paired sample t-test and a one-way ANOVA. The hypothesis was statistically tested regarding the effect of circuit training on increasing leg muscle power and 200-meter running speed of PASI Mandailing Natal male athletes. The paired sample t-test was employed to identify significant differences between pretest and posttest results for each variable, while the one-way ANOVA was used to analyze variations across multiple measurements and further validate the consistency of the training effects across athlete (Pallant, 2020). All statistical analyses were conducted using SPSS software version 25, with a significance level set at 0.05.

RESULTS & DISCUSSION

Descriptive Statistics

Table 2 and Table 3 provide the descriptive statistics of the study variables, focusing on leg muscle power and 200-meter running speed, respectively. Table 2 summarizes the pretest and post-test results for leg muscle power. The mean value increased significantly from 209.83 in the pretest to 242.67 in the post-test, reflecting notable improvements in leg muscle power after the circuit training intervention. Additionally, the minimum and maximum values improved, from a range of 200.00 to 219.00 in the pretest to 230.00 to 249.00 in the post-test, indicating performance gains across all participants. The standard deviation decreased slightly from 7.41 to

7.06, suggesting reduced variability in individual performance following the training program.

Table 2. Descriptive Statistics of Leg Muscle Power

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test	6	200.00	219.00	209.8333	7.41395
Post Test	6	230.00	249.00	242.6667	7.06163
Valid N (listwise)	6				

Table 3 presents the descriptive statistics for 200-meter running speed. The mean sprint time decreased from 56.79 seconds in the pretest to 53.82 seconds in the post-test, indicating faster running performance as a result of the intervention. Improvements were also observed in the minimum and maximum sprint times, which decreased from 55.00 to 52.10 seconds and from 59.07 to 56.36 seconds, respectively. These results demonstrate consistent enhancements across the group. The standard deviation values remained stable, at 1.60 in the pretest and 1.67 in the post-test, reflecting a consistent performance range among participants.

Overall, the data presented in both tables strongly support the conclusion that the circuit training program was effective in enhancing both leg muscle power and 200-meter running speed. These improvements were evident across all participants, as indicated by the statistical measures, reinforcing the program's applicability and impact on athletic performance.

Table 3. Descriptive Statistics of 200-Meter Running Speed

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test	6	55.00	59.07	56.7950	1.60267
Post Test	6	52.10	56.36	53.8183	1.67139
Valid N (listwise)	6				

Pre-Conditional Test

Table 4 displays the results of the Shapiro-Wilk normality tests performed on the pretest and post-test data for the standing broad jump (SBJ) and 200-meter running speed (RS). The purpose of the normality test is to determine whether the data follow a normal distribution, which is a fundamental requirement for conducting parametric statistical analyses. For the standing broad jump, the Shapiro-Wilk test produced p-values of 0.699 for the pretest and 0.155 for the post-test. Similarly, the 200-meter running speed data showed p-values of 0.686 for the pretest and 0.424 for the post-test. Since all p-values exceed the 0.05 significance threshold, the results confirm that the data for both the SBJ and RS variables meet the normality assumption for both pretest and post-test phases. This validation ensures the appropriateness of using parametric statistical methods for further analyses, thereby reinforcing the robustness and reliability of the study's findings.

Table 4. Normality Test of Standing Broad Jump and 200-Meter Running Speed

	Saphiro-Wilk		
	Statistic	**df**	**Sig.**
Pre-Test of SBJ*	0.945	6	0.699
Post Test of SBJ*	0.849	6	0.155
Pre-Test of RS**	0.943	6	0.686
Post Test of RS**	0.908	6	0.424

*SBJ: Standing Broad Jump; **RS: Running Speed

Table 5 shows the results of Levene's test for homogeneity of variance applied to the pretest and post-test data for the standing broad jump (SBJ) and 200-meter running speed (RS). The purpose of the homogeneity test is to assess whether the variances of the data are equal across the pretest and post-test phases, which is a critical assumption for conducting parametric statistical analyses. For the standing broad jump, Levene's test yielded a p-value of 0.723, and for the 200-meter running speed, the p-value was 0.981. As both p-values are greater than the significance level of 0.05, the results confirm that the variances of the data are homogeneous across the pretest and post-test phases for both variables. These findings validate the use of parametric statistical methods in subsequent analyses, ensuring the reliability and validity of the study's conclusions.

Table 5. Homogeneity Test of Standing Broad Jump and 200-Meter Running Speed

	Lavene			
	Statistic	**df1**	**df2**	**Sig.**
Pre- and Post Test of SBJ*	0.132	1	10	0.723
Pre- and Post Test of RS**	0.001	1	10	0.981

*SBJ: Standing Broad Jump; **RS: Running Speed

Hypothesis Test

Table 6. ANOVA Linearity Test of Standing Broad Jump and 200-Meter Running Speed

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Standing Broad Jump					
Beetween Groups (Combined)	3234.083	1	3234.083	61.700	0.000
Within Groups	524.167	10	52.417		
Total	3758.250	11			
200-Meter Running Speed					
Beetween Groups (Combined)	26.582	1	26.582	9.915	0.010
Within Groups	26.810	10	2.681		
Total	53.392	11			

Table 6 presents the results of the ANOVA linearity test for the standing broad jump and 200-meter running speed. This test assesses whether there is a significant linear relationship between the pretest and post-test scores for both variables. For the standing broad jump, the test produced an F-value of 61.700 with a p-value of 0.000, indicating a highly significant linear relationship. Similarly, for the 200-meter running speed, the F-value was 9.915 with a p-value of 0.010, also confirming a statistically significant linear relationship. These results suggest that the changes observed between the pretest and post-test phases for both variables follow a consistent and predictable linear pattern. This finding supports the conclusion that the circuit training intervention had a direct and systematic effect on improving both leg muscle power and running speed. The statistical significance of these results underscores the reliability of the data and the effectiveness of the training program in achieving its intended outcomes.

Table 7. Paired Sample T-Test of Standing Broad Jump and 200-Meter Running Speed

	Paired Differences							
	Mean	**Std. Deviation**	**Std. Error Mean**	**95% Confidence Interval of the Difference**		**t**	**df**	**Sig. (2-tailed)**
				Lower	**Upper**			
Pre- and Post Test of SBJ*	-32.83333	10.26483	4.19060	-43.60561	-22.06106	-7.835	5	0.001
Pre- and Post Test of RS**	2.97667	1.64408	0.67119	1.25131	4.70202	4.435	5	0.007

*SBJ: Standing Broad Jump; **RS: Running Speed

Table 7 provides the results of the paired sample t-test, which was conducted to analyze the differences between the pretest and post-test scores for the standing broad jump (SBJ) and 200-meter running speed (RS). The analysis indicates statistically significant improvements in both variables following the circuit training intervention. For the standing broad jump, the mean difference between the pretest and post-test scores was -32.83 with a standard deviation of 10.26, resulting in a t-value of -7.835 (p = 0.001). This demonstrates a significant enhancement in leg muscle power. Similarly, for the 200-meter running speed, the mean difference was 2.98 with a standard deviation of 1.64, yielding a t-value of 4.435 (p = 0.007), which confirms a significant improvement in sprinting performance. The 95% confidence intervals for both variables further reinforce the reliability of these findings. These results provide robust evidence that the circuit training program effectively improved both leg muscle power and running speed, highlighting its efficacy in enhancing athletic performance.

Discussion

The results of this study demonstrate the significant impact of circuit training on improving both leg muscle power and 200-meter sprinting speed among PASI Mandailing Natal athletes. Plyometric circuit training has been shown to significantly improve maximal strength and sprint performance, with a 6% reduction in sprint times attributed to improvements in movement power and speed (Sáez de Villarreal, Requena, Izquierdo, & Gonzalez-Badillo, 2013). These findings align with existing literature emphasizing the role of structured and progressive training programs in enhancing physical performance metrics (Pandy et al., 2021). The observed increase in leg muscle power, as indicated by the standing broad jump test, and the reduction in 200-meter sprint times highlight the effectiveness of circuit training in addressing specific performance deficiencies identified during the pretest phase. Consistent with established theories in exercise physiology, circuit training induces neuromuscular and metabolic adaptations through high-intensity, multi-component exercises, resulting in enhanced motor unit recruitment, muscle-tendon stiffness, and anaerobic energy production—critical elements for sprinters aiming to maximize force output and minimize ground contact time (Mackala & Fostiak, 2015; Mahalingam et al., 2024; Sonchan, Moungmee, & Sootmongkol, 2017).

The improvement in leg muscle power, with a mean increase of 32.83 cm in the standing broad jump, corroborates previous findings on the benefits of plyometric and resistance-based circuit training programs for developing explosive power. According to Annasai et al. (2023), lower-body plyometric exercises, such as squat jumps and box jumps, effectively enhance the stretch-shortening cycle, which is essential for maximizing force generation during propulsion. Enhanced leg muscle power is particularly beneficial during the acceleration phase of sprinting, where efficient force transfer directly impacts running velocity (Lockie et al., 2015). Additionally, the reduced variability in individual performance, as indicated by decreased standard deviation values, suggests that the training protocol effectively mitigated differences in baseline fitness levels, promoting uniform improvements across participants (Voisin, Jacques, Lucia, Bishop, & Eynon, 2019).

Similarly, the improvement in sprinting speed, with a mean reduction of 2.98 seconds in 200-meter sprint times, aligns with research demonstrating that circuit training enhances speed by improving neuromuscular coordination and anaerobic energy system efficiency (Mola & Bayısa, 2020). High-intensity, short-duration circuit training stimulates adaptations in the glycolytic energy pathway, enabling athletes to sustain higher power outputs during sprinting (Haff & Triplett, 2015). Additionally, high-intensity plyometric interventions in the short term have been shown to improve sprint performance by reducing ground contact time and increasing stride frequency, which contributes to faster running speeds (Mackala & Fostiak, 2015). The structured progression in training intensity, achieved through incremental increases in repetitions, exercise duration, and reductions in rest intervals, adheres to the principle of progressive overload, a cornerstone of performance improvement in sports training (Kasper, 2019). These findings underscore the efficiency of circuit training in producing significant performance enhancements within a relatively short timeframe of six weeks.

A 12-week circuit training program was found to increase explosive power by 8.2%, while ladder training improved sprint performance by 5.3%, indicating that both methods are effective in enhancing anaerobic performance and explosive power, though their impacts on speed and strength differ (Ravi & Kalimuthu, 2023). While the study confirms the efficacy of circuit training, it raises important questions regarding the contributions of individual exercises within the protocol. Plyometric exercises, such as box jumps and split squat jumps, may have had a disproportionately positive impact on explosive power and sprint mechanics due to their emphasis on rapid transitions between eccentric and concentric muscle actions (Bastholm & Olsen, 2024). Future research could investigate the differential effects of these exercises through isolated interventions, providing a more granular understanding of their roles in overall performance improvement.

In conclusion, this study highlights the efficacy of circuit training as a practical, efficient, and scientifically validated approach to improving sprint performance. By demonstrating significant gains in both leg muscle power and sprinting speed, the research contributes to the growing body of evidence supporting circuit training as a foundational method in athletic development. These findings not only address critical performance deficits but also provide actionable insights for sports practitioners seeking to enhance the competitive readiness of sprint athletes.

CONCLUSION

This study demonstrates the significant effectiveness of circuit training in enhancing leg muscle power and 200-meter sprinting speed among athletes, showing improvements in both performance metrics with leg muscle power increasing by an average of 32.83 cm and sprint times decreasing by 2.98 seconds. These improvements are attributed to the high-intensity, multi-component exercises that foster neuromuscular and metabolic adaptations, particularly in the anaerobic energy system, which are essential for optimizing sprint performance. The progressive structure of the training program, incorporating plyometric and resistance exercises, allowed for improved explosive power and sprint mechanics, aligning with established exercise physiology principles. However, this study did not isolate the effects of individual exercises within the circuit training protocol, which limits the understanding of how specific exercises contribute to overall performance improvement. Future research should consider investigating the differential effects of individual exercises, such as plyometric and resistance-based movements, to gain a more granular understanding of their specific impact on sprinting performance and explosive power.

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