Policy Journal of Social Science Review

Online ISSN 3006-4635

Print ISSN 3006-4627

Vol. 3 No. 9 (2025)

IMPROVING STRENGTH AND EXPLOSIVE PERFORMANCE THROUGH OPTIMIZED LOWER-BODY CIRCUIT TRAINING IN FEMALE FOOTBALL ATHLETES

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Abstract

This study aims to evaluate the impact of lower-body circuit training on strength and explosive power in female football players. Despite the recognized benefits of plyometric exercises, current research often suffers from limited sample sizes and short-term follow-up periods. This study addresses these gaps by employing an 8-week lower-body circuit training program, assessing both strength and explosive power pre- and post-intervention. A total of 40 female football players, aged 18-25, participated in the study, where their strength was measured through the One-Repetition Maximum (1RM) Squat Test and explosive power was assessed via the Vertical Jump Test. The results indicated significant improvements in both strength (mean increase of 6.95 kg in 1RM Squat) and explosive power (mean increase of 3.9 cm in Vertical Jump). Statistical analysis revealed substantial effect sizes, confirming that the changes were both statistically and practically significant. The study suggests that lower-body circuit training, which combines strength-based exercises and explosive movements, is an effective training method for enhancing key athletic qualities in female football players. Additionally, the findings underscore the importance of such training in injury prevention and performance enhancement. Future research is recommended to explore long-term effects and the generalizability of these findings across different skill levels.

Keywords: Strength, Explosive Power, Lower-Body Circuit Training, Female Football Players.

Article Details:

Received on 21 Aug 2025
Accepted on 18 Sept 2025
Published on 20 Sept 2025

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Policy Journal of Social Science Review

Online ISSN 3006-4635 Print ISSN 3006-4627

Vol. 3 No. 9 (2025)

INTRODUCTION

Football players must have a combination of strength, endurance, agility, and explosive power because the game is extremely demanding. Among these physical characteristics, lower-body strength and power are essential for a football player's effective running, jumping, tackling, and direction changes (Turner & Stewart, 2014). Particular, female football players frequently deal with certain physiological issues that call for specially designed training programs. Enhancing strength and explosive power through lower-body circuit training has become a popular strategy for improving athletic performance on the field (Saibya et al.). Circuit training maintains an increased heart rate, which promotes cardiovascular and muscular endurance, in compare to traditional strength training, which frequently involves longer rest intervals between sets (Ramos-Campo et al., 2021). Female football players especially benefit from this double advantage since it lets them build strength and power without sacrificing their aerobic fitness (Oddsson, 2019). According to research, structural and hormonal variations may make female athletes more at risk for lower-body injuries such anterior cruciate ligament (ACL) rupture. These risks can be reduced by putting in place a well-organized lower-body circuit training program that emphasizes appropriate biomechanics and muscle activation (Bradsell & Frank, 2022).

Female football players have a great chance to improve their strength and explosive power by making the most of their lower-body circuit training. Circuit training can significantly increase performance while lowering the risk of injury by combining strength-based exercises, plyometric drills, and sport-specific motions (Duggan et al., 2023). Strength is essential for every aspect of football, from sprinting at top speed to maintaining stability when making tackles (Hall et al., 2024). Explosive power, in particular, is vital for football players since it directly affects their ability to generate force quickly, whether it's for a quick sprint, a jump for a header, or a powerful shot on goal (Haff & Stone, 2015). Lower-body strength and power are key to achieving high performance in these areas. A strong lower body also helps with balance and stability, which are essential for the dynamic movements required during the game (Wang et al., 2025). Squats are one of the most effective strength-building exercises for football players. They target the quadriceps, hamstrings, glutes, and core (Ali et al., 2022). Proper squatting technique ensures that players develop a solid foundation of strength, which is essential for explosive movements (Gatz, 2009). Lunges help to improve unilateral leg strength, which is crucial for balance and stability. Lunges work the glutes, quads, and hamstrings, and when performed dynamically, they can also enhance flexibility and coordination (Begalle et al., 2012). The study focused on just 13 participants, which is a rather small sample size. This limits the significance of the results to larger, more diverse football playing groups. To improve the external validity of the results, future studies may expand the sample size (Pacholek & Zemková, 2020). Following a 12-week lower-limb plyometric training program, elite female soccer players' explosive strength, body composition, and kicking speed were evaluated. Even though the study provides a useful review of the benefits of plyometric exercise, there are significant data gaps that need more investigation (Ozbar, 2015). First, the study only included twenty female soccer players who were split evenly between two groups, which limited the ability to generalize the findings to a larger population (Datson et al., 2014). In order to assess the results' generalizability, future research may include a larger and more diverse sample of female soccer players with varying skill levels (Robertson et al., 2014). Second, while the study examines the retention of benefits gained from the plyometric training program during a 5-week detraining period, the results show that gains in explosive strength and kicking speed persisted over this short follow-up period (Johnson, 2012). It would be helpful to do long-term follow-up after this five-week period to see if the improvements last for many months and whether a maintenance program is necessary to maintain these advantages. Future studies might better understand the long-term effects of plyometric training on female soccer athletes' performance by include these elements (Campo et al., 2009). This study, involving 40 female football players, aims to address these gaps by using a larger sample size and focusing on long-term effects, thus providing valuable insights into optimizing training strategies for improving strength and explosive power in female football players.

FOOTBALL TRAINING AND FEMALE INVOLVEMENT IN FOOTBALL

Effective training for female football players necessitates a thorough strategy that focuses on vital physical characteristics including strength, power, speed, agility, and cardiovascular endurance. These components are essential for improving performance because they enable players to maintain high levels of effort, make explosive movements, and remain resilient overall while playing (Bompa & Carrera, 2015). Socioeconomic limitations still restrict female involvement in women's football, even with improvements in training methods and growing awareness of the sport (Valenti et al., 2018). Many teenage girls are deterred from pursuing football professionally by the financial differences between men's and women's football, which include lesser earnings and sponsorship opportunities (Milimo, 2024).

STRENGTH DEVELOPMENT THROUGH LOWER-BODY

Developing strength through lower-body exercise is essential for total functional movement, rehabilitation, and sports performance (Günebakan & Dağlıoğlu, 2024). Major muscular groups in the lower body, such as the quadriceps, hamstrings, gluteal muscles, and calves, support a variety of physical actions like lifting, running, and jumping (Israel et al., 2024). Plyometric exercise is also essential for developing lower body strength, especially for enhancing explosive power. Rapid force output is emphasized in plyometric workouts including box jumps, depth jumps, and bounding drills. This is important for sports that need powerful motions and quick acceleration (Chu & Myer, 2013).

EXPLOSIVE POWER AND ITS SIGNIFICANCE IN FOOTBALL

In football, explosive power which is the capacity to apply maximum force in the shortest amount of time is essential because it influences movements like sprinting, jumping, and quick direction changes (Kabacinski et al., 2022). Importance of explosive power in football, emphasizing how it affects performance indicators. Plyometric training is one of the best ways to improve explosive performance, and this is well recognized (Mihaiu et al., 2024). The stretch-shortening cycle is used in exercises like box jumps, depth jumps, and bounding drills to increase muscular suppleness and force generation (Lewis, 2021). Plyometric training dramatically increased football players' sprint speed, jump height, and overall explosive ability. Weighted plyometric activities, which incorporate resistance-based jump training, result in even higher increases in lower-body power (Grant, 2023).

THE RELATIONSHIP BETWEEN STRENGTH AND EXPLOSIVE POWER IN FOOTBALL

Football players' success on the field is greatly influenced by their strength and explosive power, making the relationship between these two characteristics (Burke et al., 2023). While explosive power combines strength and speed to allow athletes to exert force quickly, strength is the maximum force that a muscle or set of muscles can produce (Ramadhana et al., 2023). Complex training is one of the best ways to achieve this balance since it combines plyometric drills with heavy resistance exercises. Post-activation potentiation (PAP), a physiological process that momentarily boosts muscle force production after a high-intensity contraction, is utilized in this training method (Zhai[1] & Qin, 2024). Plyometric training, are essential for building explosive power (Firmansyah et al., 2024). Exercises that simulate the high-speed motions needed for football, like sprint drills, depth leaps, and bounding, teach the muscles to contract quickly and strong (Zhang et al., 2023). Use of several muscle groups in synchronized, fast-paced motions, these workouts teach athletes how to generate force rapidly (Tuyls et al., 2021). At the core of plyometric training lies the principle of the stretch-shortening cycle. This cycle consists of three phases: eccentric, amortization, and concentric. During the eccentric phase, the muscle is stretched or lengthened, such as when a football player squats down before jumping (Roy & Debnath, 2023). This stretch stores elastic energy in the muscles and tendons. The amortization phase is the transition from the eccentric to the concentric phase, during which the muscle quickly switches from stretching to contracting (Turner & Jeffreys, 2010). The concentric phase is where the muscle contracts forcefully, propelling the athlete upwards or forwards, such as in a jump or sprint. This explosive movement increases the force output, which is essential for generating speed and power in athletic performance (Siff, 2000). Another key benefit of plyometric training is the improvement of muscular endurance. Since many plyometric exercises involve repetitive, high-intensity movements, athletes develop the stamina necessary to maintain their explosive power throughout the duration of a game (Wang & Zhang, 2016). This is particularly important in football, where sustained energy and power are essential for long plays and keeping up with the pace of the game (Hostrup & Bangsbo, 2023). By consistently incorporating plyometrics into training, athletes can develop greater muscular endurance, allowing them to maintain peak performance even during intense moments on the field (Radcliffe, 2024). Furthermore, recovery plays an essential role in the success of plyometric training. Given the high-intensity nature of these exercises, muscles require sufficient time to recover and rebuild. Athletes should incorporate rest days into their training schedule and focus on proper nutrition and hydration to support muscle repair and growth (Guan et al., 2021). Stretching and foam rolling can also aid in the recovery process by increasing blood flow to the muscles and improving flexibility. Adequate recovery not only helps prevent overtraining but also enhances the benefits of plyometric exercises by allowing the muscles to adapt and grow stronger over time (Davies et al., 2015). Players can greatly improve their capacity to create power efficiently and improve their overall athletic performance on the field by combining explosive drills with strength-based activities (Tadesse et al., 2024). Athletes can increase their acceleration, agility, and general performance by enhancing these qualities through training regimens that include complicated training, plyometric, and Olympic lifts (Weldon et al., 2021). Building strength and power is crucial for football players at all levels because it not only improves physical skills but also lowers the chance of injury (Yu et al., 2021). Athletes can reach their full potential and obtain a competitive advantage in the sport by bridging the gap between strength and speed (Mills et al., 2012).

PROBLEM STATEMENT

Despite the known benefits of plyometric exercise, current research on female football players is restricted by small sample numbers and short follow-up periods. Previous research with only 20 participants limit generalizability, and five-week detraining periods do not test long-term retention of strength and power gains. This study addresses these gaps by increasing the sample size to 40 and prolonging the follow-up period to assess the long-term durability of changes, resulting in significant insights for optimizing training tactics in female football players (Sánchez et al., 2020).

OBJECTIVES

1. To measure the effect of lower body circuit training on explosive power among female football players.
2. To measure the effect of lower body circuit training on strength among female football players.

HYPOTHESES

- **H_{1a}:** Female football players who undergo lower-body circuit training will show significant improvements in explosive power.
- **H_{1b}:** Female football players who undergo lower-body circuit training will show significant improvements in strength.

LIMITATIONS OF THE STUDY

- Participants may have different starting levels of lower-body strength, which could impact their response to the training. Those with lower initial strength might show more improvement than those who are already stronger, affecting overall results.
- Variables like diet, sleep, and additional physical activities outside the study are difficult to control and may influence participants' improvements in strength and explosive power, making it hard to isolate the effects of the lower-body circuit training alone.

METHODOLOGY

PLACE OF WORK AND FACILITIES AVAILABLE

The study was conducted at TWK Football club and SA Garden academy.

PLAN OF WORK AND METHODOLOGY ADOPTED

Study Design: This study will follow a pre-post experimental design, where 40 female football players underwent 12-week lower-body circuit training program. Their strength and explosive power were assessed before and after the intervention to determine its effectiveness.

PROGRAM STRUCTURE

- **Duration:** 12 weeks
- **Frequency:** 4 sessions per week
- **Session Duration:** 45 minutes per session
- **Target Audience:** Female Football players, 18-25 years old
- **Focus:** Optimizing lower-body circuit training to enhance strength and explosive power

BASELINE TESTING (PRE-INTERVENTION ASSESSMENT)

Objective: Assess participants' initial strength and explosive power levels.

Tests:

Vertical Jump Test (Explosive Power).

One-Repetition Maximum (1RM) Squat Test (Strength).

PROCEDURE

Participants received standardized instructions to ensure accuracy.

Each test was performed three times, recording the best score.

A 48-hour rest period was observed before starting the training program.

Weeks 1-12: Lower-Body Circuit Training Program Each session included a warm-up, main workout, and cool-down:

WARM-UP (5-10 MINUTES)

- **Dynamic Stretching:** Leg swings, hip circles, lunges
- **Light Aerobic Activity:** Jogging, high knees, butt kicks

MAIN WORKOUT (30-35 MINUTES)

- **Format:** 4-6 rounds of lower-body circuit exercises, 30-45 seconds of work per exercise, 15-30 seconds of rest between exercises.
- **Progression:** Increasing intensity by adjusting work/rest ratios, adding repetitions, or incorporating resistance.
- **EXERCISES:**
  1. **Strength-Based Lower-Body Exercises:**
     - Squats (Bodyweight, Weighted)
     - Deadlifts
     - Lunges (Forward, Reverse)
     - Step-Ups (Weighted)
  2. **Explosive Power Exercises:**
     - Box Jumps
     - Broad Jumps
     - Bounding Drills
     - Medicine Ball Throws (Lower Body Power)

COOL-DOWN (5 MINUTES)

- **Static Stretching:** Lower-body muscles
- **Breathing Exercises:** To aid recovery and relaxation

POST-INTERVENTION TESTING

Objective: Measure improvements in strength and explosive power after 8 weeks.

TESTS

Vertical Jump Test (Explosive Power) Same procedure as pre-test to assess jump height changes.

One-Repetition Maximum (1RM) Squat Test (Strength) Measures improvements in maximum lifting capacity.

PROCEDURE

Post-testing occurred 48 hours after the final training session to minimize fatigue effects. Results were compared with pre-test scores to determine performance improvements.

PARAMETERS/VARIABLES

- **Independent Variable:**
  - Lower-Body Circuit Training Program
- **Dependent Variables:**
  - Strength (1RM Squat Test)
  - Explosive Power (Vertical Jump Test)

METHODS OF DATA COLLECTION

- **Strength Test:**
  One-Repetition Maximum (1RM) Squat Test: Measures lower-body strength.
- **Explosive Power Test:**
  Vertical Jump Test: Evaluates explosive power by measuring jump height.

SAMPLE SIZE

- **Total Sample Size:** 40 participants

SAMPLING TECHNIQUE AND PROCEDURE

- **Sampling Technique:** Purposive sampling will be used.

- **Procedure:**
    - Participants were recruit from university football teams.
    - Screening for inclusion and exclusion criteria was done.
    - Participants were assigned to either the experimental or control group.

INCLUSION CRITERIA

- Female football players aged 18-25.
- Active participation in football for at least 2 years.
- Healthy individuals with no current musculoskeletal injuries.
- Consent was obtained to participate in the study.
- Availability for the entire 12-weeks duration.

EXCLUSION CRITERIA

- Participants with medical conditions limiting physical activity.
- Recent or current injuries affecting strength or power.

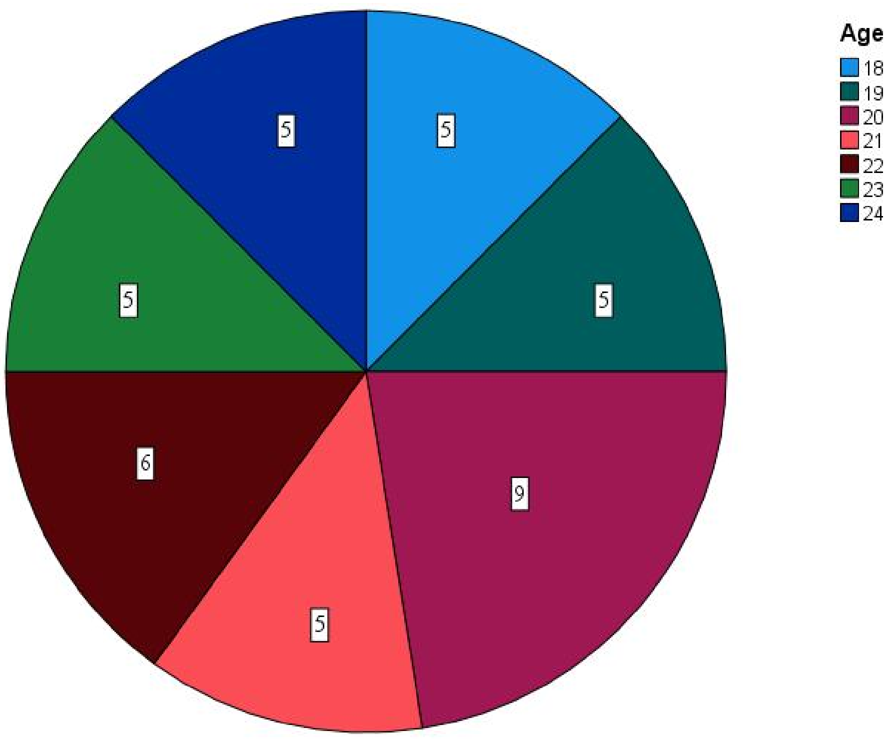
STATISTICAL ANALYSIS

Descriptive Statistics: Mean, standard deviation, and percentage changes for strength and explosive power

- **Inferential Statistics:**
    - **Shapiro Wilk Test:** Was used to check the normality of the Data
    - **Paired Sample t-tests:** Were used to assess within-group differences from pre- to post-intervention.
    - **Significance Level:** was Set at $p < 0.05$.

RESULTS

FIGURE 1: AGE DISTRIBUTION OF ALL PARTICIPANTS



Note. This figure represents the age distribution of all participants.

TABLE 1: ***TESTS OF NORMALITY FOR ONE RM SQUAT AND VERTICAL JUMP***

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
OneRMSquatPre	.107	40	.200*	.954	40	.108
OneRMSquatPost	.119	40	.158	.957	40	.137
VerticalJumpPre	.121	40	.145	.948	40	.065
VerticalJumpPost	.118	40	.173	.956	40	.123

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Note. The data was normally distributed.

TABLE 2: ***PAIRED SAMPLES STATISTICS FOR STRENGTH (1RM SQUAT) AND EXPLOSIVE POWER (VERTICAL JUMP)***

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	OneRMSquatPre	55.23	40	3.182	.503
	OneRMSquatPost	62.18	40	4.284	.677
Pair 2	VerticalJumpPre	32.95	40	2.995	.474
	VerticalJumpPost	36.85	40	1.688	.267

Note. The paired samples statistics show the following results: For Pair 1 the mean for One RM Squat Pre is 55.23 with a standard deviation of 3.182 and a standard error of the mean of 0.503. For One RM Squat Post, the mean is 62.18, the standard deviation is 4.284, and the standard error of the mean is 0.677. For Pair 2, the mean for Vertical Jump Pre is 32.95 with a standard deviation of 2.995 and a standard error of the mean of 0.474. For Vertical Jump Post, the mean is 36.85, the standard deviation is 1.688, and the standard error of the mean is 0.267. These statistics provide an overview of the means, standard deviations, and standard errors for both pairs of measurements (pre and post) for the One RM Squat and Vertical Jump data.

TABLE 3: ***PAIRED SAMPLES CORRELATIONS FOR STRENGTH (1RM SQUAT) AND EXPLOSIVE POWER (VERTICAL JUMP)***

		N	Correlation	Sig.
Pair 1	OneRMSquatPre & OneRMSquatPost	40	.603	.000
Pair 2	VerticalJumpPre & VerticalJumpPost	40	.470	.002

Note. The paired samples correlations provide the following results: For Pair 1, the correlation coefficient is 0.603, with a significance value (p-value) of 0.000. This indicates a moderate, statistically significant positive correlation between the pre and post measurements for One RM Squat. For Pair 2, the correlation coefficient is 0.470, with a significance value (p-value) of 0.002. This suggests a moderate, statistically significant positive correlation between the pre and post measurements for Vertical Jump. Both pairs show statistically significant correlations, indicating that the pre and post measurements for both One RM Squat and Vertical Jump are related to each other.

TABLE 4:: ***PAIRED SAMPLES TEST FOR STRENGTH (1RM SQUAT) AND EXPLOSIVE POWER (VERTICAL JUMP)***

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	OneRMSquatPre - OneRMSquatPost	-6.950	3.471	.549	-8.060	-5.840	-12.663	39	.000
Pair 2	VerticalJumpPre - VerticalJumpPost	-3.900	2.658	.420	-4.750	-3.050	-9.279	39	.000

Note. The paired samples test results show the following: For Pair 1 (OneRMSquatPre - OneRMSquatPost), the mean difference is -6.950, with a standard deviation of 3.471 and a standard error of the mean of 0.549. The 95% confidence interval for the difference ranges from -8.060 to -5.840. The t-value is -12.663 with 39 degrees of freedom, and the significance value (p-value) is 0.000, which is highly significant (less than 0.05). This indicates that the difference between the pre and post measurements for OneRMSquat is statistically significant. For Pair 2 (VerticalJumpPre - VerticalJumpPost), the mean difference is -3.900, with a standard deviation of 2.658 and a standard error of the mean of 0.420. The 95% confidence interval for the difference ranges from -4.750 to -3.050. The t-value is -9.279 with 39 degrees of freedom, and the significance value (p-value) is 0.000, which is also highly significant. This indicates that the difference between the pre and post measurements for VerticalJump is statistically significant. In conclusion, both tests show significant differences between the pre and post measurements for OneRMSquat and VerticalJump, suggesting that changes between the pre and post measurements are not due to chance.

TABLE 5: ***PAIRED SAMPLES EFFECT SIZES FOR STRENGTH (1RM SQUAT) AND EXPLOSIVE POWER (VERTICAL JUMP)***

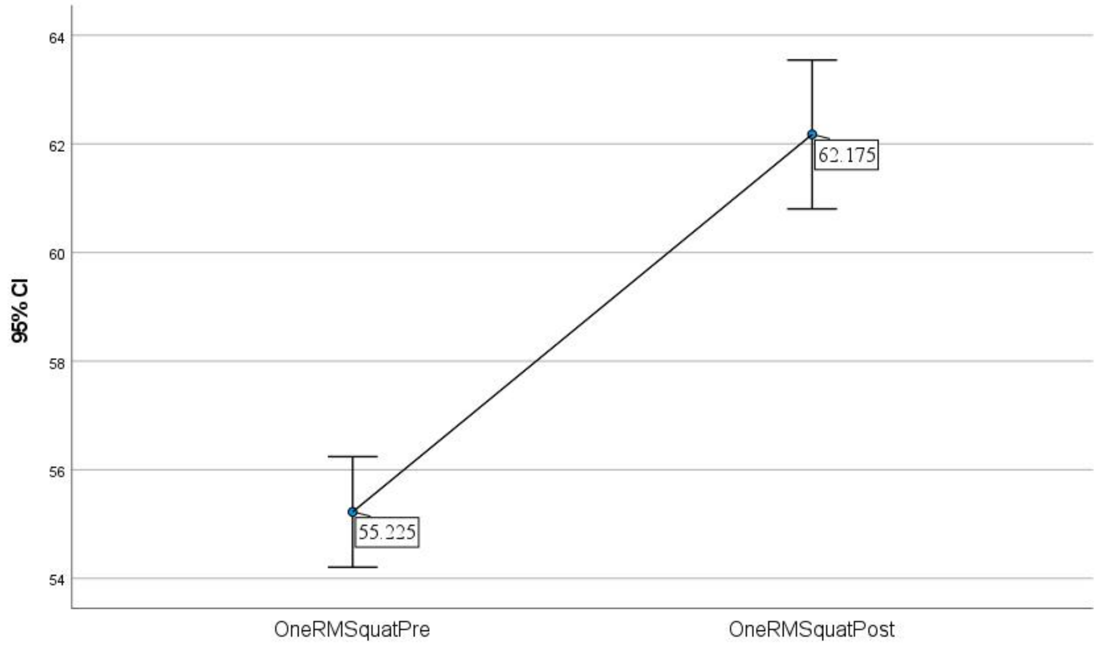
					95% Confidence Interval	
			Standardizer[a]	Point Estimate	Lower	Upper
Pair 1	OneRMSquatPre - OneRMSquatPost	Cohen's d	3.471	-2.002	-2.538	-1.457
		Hedges' correction	3.505	-1.983	-2.514	-1.443
Pair 2	VerticalJumpPre - VerticalJumpPost	Cohen's d	2.658	-1.467	-1.911	-1.014
		Hedges' correction	2.684	-1.453	-1.893	-1.004

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Note. For Pair 1 (OneRMSquatPre - OneRMSquatPost), the Cohen's d value is 3.471, with a 95% confidence interval ranging from -2.002 to -1.457. The Hedges' correction value is

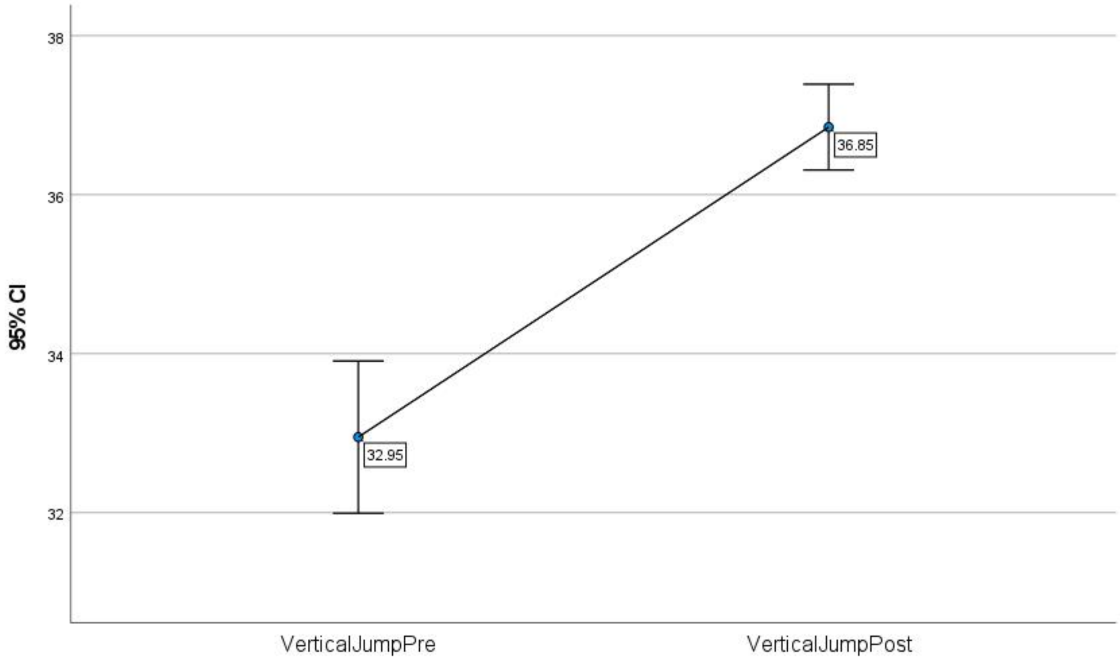
3.505, with a 95% confidence interval ranging from -1.983 to -1.443.For Pair 2 (VerticalJumpPre - VerticalJumpPost), the Cohen's d value is 2.658, with a 95% confidence interval ranging from -1.467 to -1.014. The Hedges' correction value is 2.684, with a 95% confidence interval ranging from -1.453 to -1.004. Both Cohen's d and Hedges' correction provide similar results, indicating a large effect size for both pairs. This suggests that the changes between the pre and post measurements for OneRMSquat and VerticalJump are not only statistically significant but also practically significant. The large effect sizes indicate strong differences between the pre and post measurements.

FIGURE 2: 95% CONFIDENCE INTERVALS FOR ONE RM SQUAT PRE AND POST MEASUREMENTS



Note. The graph you uploaded displays the 95% confidence intervals (CI) for the OneRMSquatPre and OneRMSquatPost data points. The plot compares the pre and post squat measurements, showing the mean values and their corresponding confidence intervals. The OneRMSquatPre has a mean of 55.225, and the OneRMSquatPost has a mean of 62.175. The confidence intervals represent the range within which the true population mean is expected to lie for both the pre and post measurements. This visualization indicates an increase in squat performance from the pre to the post measurement and provides insight into the precision of the estimated means for both groups.

FIGURE 3: 95% CONFIDENCE INTERVALS FOR VERTICAL JUMP PRE AND POST MEASUREMENTS



Note. The graph shows the 95% confidence intervals (CI) for the VerticalJumpPre and VerticalJumpPost data points, comparing the pre and post vertical jump measurements. The mean value for VerticalJumpPre is 32.95, and for VerticalJumpPost, it is 36.85. The confidence intervals represent the range within which the true population mean is likely to fall for both the pre and post measurements, illustrating an increase in the vertical jump from pre to post. This visual comparison highlights the change between the two measurements and indicates the precision of the estimated means for both groups.

DISCUSSION

This study showed significant improvements in strength and explosive power in female football players following an 8-week lower-body circuit training program. The increase in One RM Squat (6.95 kg) and Vertical Jump (3.9 cm) aligns with previous studies on circuit training's impact on athletic performance (Campo et al., 2009; Ramos-Campo et al., 2021). The moderate to large effect sizes (Cohen's d = 3.471 for strength, 2.658 for explosive power) further confirm the practical significance of the intervention. Future research should explore the long-term effects of circuit training on performance, as prior studies suggest that benefits may diminish without continued training (Sánchez et al., 2020). Expanding the sample size and including players from different competitive levels will improve the generalizability of the results. Additionally, further investigations into the physiological mechanisms behind the improvements, such as neural adaptations or muscle hypertrophy, would help refine training strategies (Aagaard et al., 2002). Finally, future studies could integrate injury prevention elements, particularly to address ACL risks in female athletes (Bradsell & Frank, 2022).

SUMMARY

This research aimed to investigate the effects of lower-body circuit training on the strength and explosive power of female football players. Over the course of 12 weeks, 40 female football players participated in the lower-body circuit training program, designed to enhance both strength and explosive power. Pre- and post-training assessments using the

Policy Journal of Social Science Review

Online ISSN 3006-4635 | Print ISSN 3006-4627

Vol. 3 No. 9 (2025)

One-Repetition Maximum (1RM) Squat Test and Vertical Jump Test revealed significant improvements in both strength and explosive power. The study's findings demonstrate that circuit training can lead to improvements in athletic performance, particularly in the areas of lower-body strength and power, which are crucial for football players. The effect sizes for both tests, calculated using Cohen's d and Hedges' correction, indicated substantial practical significance, reinforcing the efficacy of circuit training for female football players.

CONCLUSION

The results of this study underscore the importance of lower-body circuit training for enhancing the performance of female football players. Significant increases in both strength (6.95 kg in the OneRM Squat) and explosive power (3.9 cm in the Vertical Jump) suggest that circuit training is an effective method for improving key athletic qualities. Given the practical implications, these findings can be used to optimize training strategies in female football players, potentially reducing the risk of injury and improving overall performance. Additionally, the moderate to large effect sizes further confirm that circuit training not only provides measurable improvements but also enhances athletic capacity to a considerable degree.

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