SINET: Ethiop. J. Sci., 47(3): 203-214, 2024 ISSN: 0379–2897 (PRINT)

eISSN: 2520–7997

Date received: October 30, 2023; Date revised: December 26, 2024; Date accepted: December 28, 2024
DOI: https://dx.doi.org/10.4314/sinet.v47i3.3

A Comparison of Training Method Effects on Strength and Power Development of Young Ethiopian Soccer Players

Belayneh Chekle Admasu[1] and **Tefera Tadesse**[2,3,*]

[1] Sport Academy, Bahir Dar University, Bahir Dar, Ethiopia, admbelaya@gmail.com
[2] Institute of Educational Research (IER), Addis Ababa University, Addis Ababa, Ethiopia, tefera.tadesse@aau.edu.et
[3] Educational Development and Quality Center, University of Global Health Equity, Kigali, Rwanda, ttadesse@ughe.org

ABSTRACT: This study aimed to assess the effects of three different training methods on the development of explosive power and strength of young Ethiopian soccer players: resistance training, plyometric training alone, and mixed training, combining both plyometric exercise and resistance training. Participants in the study were 36 male U20 soccer players enrolled in Bahir Dar University Sports Academy's youth soccer training program. The authors used a "randomized block design," with a player's playing position serving as the stratum, to assign research participants to one of the three training programs (12 players in each of the plyometric, resistance, and mixed groups). These training sessions were carried out with each group in accordance with the suggested exercises and training program for about four weeks in succession. The pre-test result showed that the dependent variables did not significantly differ between the groups. A post hoc MANOVA was employed to assess group differences, and partial eta-squared (ηp2) was utilized to compute the effect sizes. The result showed that there were significant main effects of the training method on ballistic strength $F(2, 33) = 5.13$, $p = .012$, ηp2 = 0.24 and explosive power, $F(2, 32) = 12.10$, $p < .001$, ηp2 = 0.44, but not on static strength, with the study participants in the plyometric training performing significantly better than those in the other two groups. Thus, it was concluded that plyometric training is better than resistance training and mixed training, which combined resistance training and plyometric training.

Keywords/phrases*:* Explosive power, strength, training method, U20 soccer, Ethiopia

INTRODUCTION

Soccer is regarded as the most complicated sport, as different factors and contexts will influence the relative importance of different aspects that can impact competitive performance or success (Rein & Memmert, 2016; Smith et al., 2018; Wilson et al., 2017). For instance, power training is beneficial in preparing soccer players' bodies for the demands of the game (Bedoya et al., 2015; Stojanović et al., 2017). However, anaerobic fitness may help athletes when most needed—during sprinting, acceleration, direction changes, and jumping. According to Granacher et al. (2016), plyometric exercises, in particular, are a useful physical conditioning method for developing certain skill-related metrics of sports performance.

Soccer and other multi-sprint team sports require players to be able to exert more force quickly to perform well. Thus, although various training programs are accessible, the ones with the highest event-specific adaptive stimuli (response) are crucial. Both aerobic and anaerobic physical fitness metrics are included in the general concept of physical fitness in soccer (Bujnovsky et al., 2019). The anaerobic segment of physical fitness, which comprises speed, strength, and power (Barnes et al., 2014; Faude et al., 2012), is the most crucial for successful soccer play, even though the aerobic segment is also important (Stølen et al., 2005).

The main distinction between strength and power training is that the former emphasizes overcoming resistance in terms of the ability to overcome resistance, while the

*Author to whom correspondence should be addressed.

latter emphasizes overcoming resistance in the shortest amount of time (Christian, 2016).

Strength training focuses on moving as much weight as possible for the prescribed number of repetitions, which develops the ability to overcome resistance. In contrast, Power Training emphasizes the capacity to overcome opposition and do so in the least amount of time.

Resistance training (RT), plyometric training (PT), and mixed training combining resistance training with plyometric training (CT) are well-established as safe and appropriate methods for increasing physical fitness in young soccer players (de Villarreal et al., 2015; Söhnlein et al., 2014). The RT is the most popular approach for increasing strength, speed, and power (Bedoya et al., 2015; Behringer et al., 2011; Stojanović et al., 2017). In RT, one muscle at a time is built up by repetitions using machines or large weights, such as hamstring curls or deadlifts (Schoenfeld, 2011). It increases muscle mass, develops full-body strength, and provides all the typical health advantages of exercise, such as elevating mood, speeding up metabolism and fat burning, and promoting bone health (Behm et al., 2017).

An exercise method called PT is used to improve strength and power (Meylan & Malatesta, 2009; Ozbar et al., 2014; Stojanović et al., 2017). It consists of physical activities designed to enhance dynamic performances by having muscles deliver their maximal force briefly. During this type of training, muscles quickly extend and then immediately contract (stretch-shortening contraction), using the elastic energy that was accumulated during the stretching phase (Wang & Zhang, 2016).

Scholars in the field of soccer agree that PT improves performance in vertical jumps, acceleration, muscle power, leg strength, joint awareness, and general sport-specific skills (Michailidis et al., 2013). The PT typically incorporates jumping movements (Faigenbaum & Chu, 2001), and is linked to exercises that emphasize the muscle stretch-shortening cycle (Taube et al., 2012). PT has been shown to improve sports performance and reduce the risk of injury (Rössler et al., 2014; Sáez de Villarreal et al., 2012; Stevenson et al., 2015). Over the years, it has become more and more common to mixed methods (CT) combining resistance training with plyometric training as it yields better results for muscular power measures than either method alone (Fatouros et al., 2000; Franco-Márquez et al., 2015; Martín-Moya et al., 2023; Zghal et al., 2019).

Statement of the problem

Soccer players are required to execute various explosive moves, such as jumping, sprinting, accelerating, and changing direction (Turner et al., 2013). Most of these moves come before the most crucial phases of the game, known as goal opportunities (Arnason et al., 2004; Datson et al., 2014; Faude et al., 2012). Consequently, it appears that a deeper understanding of how to enhance these vital physical fitness components—speed and strong movements—in soccer players is necessary, particularly for the more promising younger players with less data.

The optimum training program to enhance strength and power development is still subject to debate in the literature. Faster power-oriented RT, either alone or in combination with PT, is thought to provide a useful training stimulus to enhance jumping performance, provided the program is well-designed and carried out (Sáez de Villarreal et al., 2012). For example, despite its positive effect, Chtara et al. (2008) found that RT cannot produce significant strength and power performance. Another meta-analysis that assessed the effects of PT on female players' vertical jumps confirmed that PT was more effective in improving performance than RT (Ramirez-Campillo et al., 2020; Stojanović et al., 2017).

In terms of soccer, young players who underwent PT and CT outperformed those who only received standard soccer training in terms of increases in strength, countermovement jump height, and squat movement velocity (Franco-Márquez et al., 2015). However, youth soccer players aged 13 to 15 who just received PT have also demonstrated these advantages (de Villarreal et al., 2015; Marques et al., 2013).

Additional researchers have directly compared the effects of PT versus CT (traditional strength + plyometric training), but none of them included youth soccer players (Arabatzi et al., 2010; de Villarreal et al., 2015; Fatouros et al., 2000; Lyttle et al., 1996). Whether PT or CT yields the intended and best gains in sports performance in young soccer players can be questioned.

More precisely, it's unclear whether CT is better for young soccer players' strength and power development than PT alone. Nevertheless, one must know how to train efficiently to enhance performance, especially for young soccer players. Therefore, this study aims to determine whether RT alone, PT alone, or CT (mixed training combining both resistance and plyometric training) is more effective for the development of strength and power in young Ethiopian soccer players. More specifically, this study answered the following three research questions.

1. What is the most effective training method for enhancing static strength in young Ethiopian soccer players: resistance training (RT), plyometric training (PT), mixed or combined training (CT)?
2. What is the most effective training method for enhancing ballistic strength in young Ethiopian soccer players: resistance training (RT), plyometric training (PT), or combined training (CT)?
3. What is the most effective training method for enhancing explosive power in young Ethiopian soccer players: resistance training (RT), plyometric training (PT), or combined training (CT)?

Method

Design

In this study, the authors used a randomized-block design. Based on this design, young soccer players were initially divided into six groups according to their primary positions: fullbacks, center-backs, holding midfielders, outside midfielders, attacking midfielders, and strikers. As a result, the players were grouped according to their positions before being randomly assigned. Afterward, a player from each position was randomly allocated to one of the three groups. By using this selection process, we could equitably allocate players who shared playing positions among the three groups—fullbacks, center-backs, holding midfielders, outside midfielders, attacking midfielders, and strikers. This is due to the belief that athletes are physically distinct from other position players due to a certain fitness level.

Participants' profile

The study participants included U20 outfield soccer players (n= 36) with a mean age of 17±3.21 years and an average body weight of 55±3.580kg. The authors selected these participants purposely because they participated in a soccer development program for that age level. All the study participants were informed to have only their team-based normal soccer training, and the corresponding coaches guided the study intervention exercises in their respective groups. The soccer-specific training was the same for all the groups, as the players were from the same team.

Measures of strength, vertical jump, and power

A wall squat test (standardized squat test) was used for static strength, a ballistic strength test for elastic strength, and a vertical jump test for leg explosive power. Each participant had two trials to get the static strength test score, and we took the best. The same procedure was applied to measure elastic strength; however, we took the average of the two trials, one for the left leg and the other for the right leg. For leg explosive power, three trials of the jump-and-reach test were administered, and we took the average score.

Study Procedures

Three separate groups were used for different training treatments since the study's main objective was to compare how well three training programs increased the strength and explosive power of the lower extremities. The first group worked out with resistance. Resistance training (RT) was the name given to the group. The second group, called the Plyometric Training (PT) group, received plyometric training. The third group, referred to as the combined group (CT), underwent a combination of resistance and plyometric training. Specific training sessions were held three times a week for each group for four weeks.

Utilizing the same techniques as the post-test, each group's strength and explosive power were evaluated one week before the start of each training method (pre-test). Using the pre-test data, it was concluded that there was no significant difference in the groups' explosive power, dynamic strength, or static strength. Table 1 contains the training plans that were considered, as well as a thorough explanation of the suggested workouts.

Table 1. The detailed weekly plans for each of the three methods of training.

Week	Resistance Group (RT)			Plyometric Group (PT)			Combined Group (CT)		
Week	Exercise	Rep.	Sett	Exercise	Rep.	Set	Exercise	Rep.	Set
1	Leg extension	7	3	Jump to box	7	3	Jump t	7	3
	Squat rock	4	3	Tuck jumps	4	3	leg extension	4	3
	Lunge	6	3	Bounding with rings	6	3	Tuck jumps	6	3
	Seated calf raise	6	3	Lateral hurdle jump	6	3	Squat rock	6	3
	Calf raise	8	3	Single-leg lateral hops	8	3	Single-leg lateral hops	8	3
Week 2	Leg extension	6	3	Jump to box	6	3	Jump to box	6	3
	Squat rock	6	3	Tuck jumps	6	3	Leg extension	6	3
	Lunge	8	4	Bounding with rings	8	4	Bounding with rings	8	4
	Seated calf raise	8	4	Lateral hurdle jump	8	4	Lunge	8	4
	Calf raise	8	4	Single-leg lateral hops	8	4	Depth jumps	8	4
Week 3	Leg extension	10	3	Tuck jumps	10	3	Jump to box	10	3
	Squat rock	10	4	Bounding with rings	10	4	Squat rock	10	4
	Lunge	10-12	4	Lateral hurdle jump	10-12	4	Bounding with rings	10-12	4
	Seated calf raise	10-12	4	Single-leg lateral hops	10-12	4	Lunge	10-12	4
	Calf raise	10-12	4	Depth jumps	10-12	4	Depth jumps	10-12	4
Week 4	Leg extension	10-12	4	Tuck jumps	10-12	4	Jump to box	10-12	4
	Squat rock	10-12	4	Bounding with rings	10-12	4	Squat rock	10-12	4
	Lunge	10-12	4	Lateral hurdle jump	10-12	4	Single-leg lateral hops	10-12	4
	Seated calf raise	10-12	4	Single-leg lateral hops	10-12	4	Lunge	10-12	4
	Calf raise	10-12	4	Depth jump	10-12	4	Depth jumps	10-12	4

As shown in Table 1, each of the three training groups had a four-week training schedule. Maintaining progress during the training process requires adherence to the key training principles. Without using them, there won't be any progress, and plateaus will be inevitable. Table 2 summarizes the training protocols that direct the execution of the training workouts across the three methods compared.

Table 2. The specifications of the daily session plans for the three methods of training.

Day	Week 1	Week 2	Week 3	Week 4
Monday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Tuesday	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT
Wednesday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Thursday	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT
Friday	Normal soccer training	Normal soccer training	Normal soccer training	Normal soccer training
Saturday	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT	❖ Resistance training for the RT ❖ Plyometric training for the PT ❖ Combined training for the CT
Sunday	Rest	Rest	Rest	Rest

Note: Rep. = Repetition, RT = Resistance Training, PT = Plyometric Training, CT = Combined Training

As shown in Table 2, the usual soccer workouts were supplemented with the training programs of each group. Each training lasts 1.5–2 hours for three alternate days per week. For the duration of the training program, each group attended three sessions per week. Every measurement was done on the training field before and after the four weeks of training.

Data analysis methods

In this study, the authors used descriptive statistics to summarize the average performance of the young soccer players participating in the three training methods. We also used MANOVA with a post hoc test to determine which training method significantly impacts the assessed outcome variables. We preferred MANOVA over ANOVA because the former tests multiple dependent variables simultaneously. To determine the amount of the differences or effect sizes of the training methods, we also computed partial eta-squared (ηp2). The critical value for the whole analysis was established at.05. The Statistical Program for Social Science (SPSS) version 25 was used to perform these statistical analyses.

RESULTS

The findings of this study are presented in two sections. Section 1 presents a detailed profile of the study participants that are a part of this study. Section 2 presents the group difference analysis using a MANOVA summary for the three groups (RT, PT, and CT) across the three dependent variables compared (Static strength, ballistic strength, and explosive power).

Study participants' descriptive summary statistics

The data is summarized clearly and concisely in the descriptive statistics summary. The three measured dependent variables' descriptive summary results, which relate to the average achievement of the soccer players, contain statistics like mean and standard deviation. Table 3 presents the descriptive summary of the sample performances for young players.

Table 3. Descriptive statistics for the three measured outcomes for the young soccer players in the three training methods (post-test).

Performance		N	Mean	SD	Std. Error	95% CI for Mean Lower Bound	Upper Bound
Static Strength (in seconds)	RT	12	100.96	10.67	3.08	94.18	107.74
	PT	12	100.30	26.23	7.57	83.64	116.97
	CT	12	100.99	16.46	4.75	90.53	111.45
	Total	36	100.75	18.37	3.06	94.54	106.96
Ballistic Strength (in seconds)	RT	12	5.41	0.76	0.22	4.93	5.89
	PT	12	4.63	0.60	0.17	4.25	5.01
	CT	12	4.98	0.41	0.12	4.72	5.23
	Total	36	5.01	0.67	0.11	4.78	5.23
Explosive Power (in centimeter)	RT	12	40.69	4.03	1.16	38.13	43.25
	PT	12	48.44	4.33	1.25	45.69	51.19
	CT	12	47.89	4.11	1.19	45.28	50.51
	Total	36	45.68	5.40	0.90	43.85	47.50

Note: RT = Resistance Training, PT = Plyometric Training, CG = Combined Training, SD = Standard Deviation

As shown in Table 3, the descriptive statistics for the participants' mean performance scores on static strengths—which measure their ability to hold a wall squat range from 100.30 to 100.99 seconds. The scores for the RT, PT, and CT groups are 100.96±10.67, 100.30± 26.23, and 100.99± 16.46 seconds, respectively. The dynamic strength was tested in seconds to determine which training methods had different mean score values. The PT and CT mean values were 4.63±0.41 and 4.98±0.41 seconds, respectively, whilst the RT was 5.41±0.76 seconds. The explosive power gain for the RT and PT was 40.69±4.03cm and 48.44±4.33cm, respectively. The CT's explosive power reached 47.68±4.11 cm. Compared to the PT and CT; the RT could jump a lesser vertical distance.

Group differences in test results using a one-way MANOVA

After satisfying the assumption, a one-way MANOVA was used to investigate relationships between the training methods (CT, PT, and RT) as IVs and static strength, ballistic strength, and explosive power as dependent variables (DVs). The one-way MANOVA results showed significant main effects of the training method on ballistic strength and explosive power but not on static strength. The one-way MANOVA results are summarized in Table 4.

Table 4. Summary results of the between-subjects effects of the three groups in terms of static strength, dynamic strength, and explosive power gains.

Performance		Sum of Squares	df	Mean Square	F	Sig.	partial eta-squared (ηp2)
Static Strength	Between Groups	3.62	2.00	1.81	0.01	1.00	0.00
	Within Groups	11802.47	33.00	357.65			
	Total	11806.09	35.00				
Ballistic Strength	Between Groups	3.73	2.00	1.86	5.13	.012*	0.24
	Within Groups	12.00	33.00	0.36			
	Total	15.73	35.00				
Explosive Power	Between Groups	448.89	2.00	224.44	13.00	.000**	0.44
	Within Groups	569.89	33.00	17.27			
	Total	1018.77	35.00				

**The mean difference is significant at the 0.05 level.*

As shown in Table 4, the test results for static strength showed no statistically significant difference according to training methods, with $F(2, 33) = 1.81$, $p = 1.00$, and partial eta squared = 0.00. However, the ballistic strength test results show that the training method had a statistically significant impact on ballistic strength test scores: $F(2, 33) = 5.13$, $p = .012$, partial eta squared = 0.24. Additionally, the training method had a statistically significant impact on explosive power test scores $F(1, 75) = 0.195$, $p< .000$, partial eta squared = 0.44. To put it simply, when converted into Cohen's d, the partial eta squared values yielded score values of 1.12 and 1.77 effect sizes, respectively (Lenhard & Lenhard, 2016), which were interpreted as large-value effects (Cohen, 1988).

There was no statistically significant difference between the PT and CT groups regarding the gain in static strength. However, there is a statistically significant difference in the ballistic strength gain between the three groups (RT, PT, and CT). Also, for explosive power, a significant difference in young soccer players' scores accounted for the effect of the training method. As a result, hypotheses 2 and 3 were verified. The training method identified a greater effect value of 1.12 and 1.77 effect size differences, accepting the alternative hypothesis (H2 and H3) that there were variations in the means of the three groups. The univariate main effects were examined, given the significance of the overall MANOVA test for ballistic strength and explosive power. The descriptive statistics related to the three groups' mean performance scores are shown in Table 5.

Table 5: Multiple comparisons of the three groups' mean performances across static strength, ballistic strength, and explosive power.

Performance	Treatment group	Treatment group	Mean Difference	Std. Error	Sig.	95% CI	
						Lower Bound	Upper Bound
Ballistic Strength	RT	PT	.79*	.25	.008	.18	1.39
		CT	.44	.25	.194	-.17	1.04
	PT	RT	-.79*	.25	.008	-1.39	-.18
		CT	-.35	.25	.342	-.95	.25
	CT	RT	-.44	.25	.194	-1.04	.17
		PT	.35	.25	.342	-.25	.95
Explosive Power	RT	PT	-7.75*	1.70	.000	-11.91	-3.59
		CT	-7.20*	1.70	.000	-11.37	-3.04
	PT	RT	7.75*	1.70	.000	3.59	11.91
		CT	.55	1.70	.945	-3.62	4.71
	CT	RT	7.20*	1.70	.000	3.04	11.37
		PT	-.55	1.70	.945	-4.71	3.62

**The mean difference is significant at the .05 level.*

As shown in Table 5, the PT significantly achieved a better dynamic strength gain than the RT, p = .008 (4.67±0.60 versus 5.41±0.76 seconds), as they covered the 25m hop sprinting with 0.79 seconds faster than the RT (table 3 and 5). However, the difference between the RT and the CT was not statistically significant. In the same way, the PT does not have a significant difference with the CT in the performance gain of dynamic strength. Univariate testing revealed that the PT group outperformed the RT group in terms of explosive power and ballistic strength. Based on the multiple comparisons, the RT achieved statistically smaller explosive power development/gain than both PT and CT in the p<.001 (40.69±4.03 versus 48.44±4.33 and 40.69±4.03 versus 47.89±4.109cm) (Table 3 & 5). The PT and CT achieved 7.75 and 7.20cm vertical jump performance gains than that of the RT respectively. However, the explosive power gain was not significantly different between the PT and CT (48.44±4.33 versus 47.89±4.109cm).

However, there isn't a significant difference between the RT and CT groups' ballistic strength results. Furthermore, the results of the univariate testing for explosive power show that the PT and CT groups outperformed the RT group in terms of both explosive power and ballistic strength. This is clear from the information in Table 5.

DISCUSSION

This study aims to compare the impacts of three distinct training methods—RT, PT, and CT—on the development of young Ethiopian soccer players' static strength, ballistic strength, and explosive power. As predicted, the PT and CT demonstrated a higher performance gain in dynamic strength and explosive power than the RT group, indicating that the two training methods increase strength and power differentially. PT and CT, rather than RT, can be beneficial for physiological reasons. Greater muscle size and morphology, better intermuscular coordination, enhanced neuromuscular activation, and increased excitability of the stretch reflex are potential explanations of the muscle power gain seen here for the PT and CT (Markovic & Mikulic, 2010; Slimani et al., 2017).

A total of twelve PT or CT sessions (3 sessions per week, for 4 weeks), compared to RT (as a control group), found significantly more improvement in explosive power performance of 7-8cm. This superior improvement may be attributed to adaptations like increases in the thickness, fascicle length, and pennation angle of knee flexor and extensor muscles (Ullrich et al., 2018). Several study findings go in line with this study as plyometric or plyometric plus resistance training can positively affect the power performance of lower limbs (Ozbar et al., 2014; Ramírez-Campillo, González-Jurado, et al., 2016; Ramirez-Campillo et al., 2020; Ramírez-Campillo, Vergara-Pedreros, et al., 2016; Ullrich et al., 2018). The same thing is true with the effect of plyometric training on the upper limbs. Plyometric training was effective in developing the upper limb power development of Golf players (Fletcher & Hartwell, 2004).

Regarding the frequency of the intervention training, less than three sessions per week have even been shown to produce substantial improvement (Ozbar et al., 2014; Ramirez-Campillo et al., 2018; Rosas et al., 2017) after plyometric training. In the current study, the effect size ranges between ES= 0.8-1.47, which represents moderate to high effect sizes (Lenhard & Lenhard, 2016).

A systematic review with a meta-analysis was conducted to assess the effects of plyometric jump training on female soccer players' vertical jump height (Ramirez-Campillo et al., 2020). The magnitude of the main effect was moderate (ES = 1.01, p = 0.002). The current study's findings align with the findings reported in the literature on this field that recommend that plyometric exercises are effective in players for the improvement of vertical jump height. Thus, plyometric exercises are the best stimulus to cause the most possible adaptive response regarding explosive power. And it is also clear that the potent effect of plyometric training can be identified after 4 weeks. Also, power training consists of a combination of resistance training and strength-based plyometric exercises, which can have a significant adaptive effect on strength-based speed (dynamic/ballistic) and power(Franco-Márquez et al., 2015). In the same way, 4-week plyometric training and as well 8 weeks of plyometric training can significantly improve the explosive power of lower limbs (Voisin & Scohier, 2019). From a training frequency perspective, two weekly strength training sessions are sufficient to increase a player’s force production (Silva et al., 2015).

No matter what level of load is assigned to resistance exercise, it is far more important to exert as much effort (fastest concentric speed) as possible per repetition; otherwise, the training effects are reduced (Sakamoto et al., 2016). This is the reason that can be taken for the RT (resistance training alone) not to have an effect as big as that of the PT or CT. Thus, using stretch-shortening cycle effects with increased power may give a further training edge. Coaches need to understand that force generation in soccer players is not just about quantity but also about explosiveness (Michailidis et al., 2013). The adaptation that can be expected is also a function of the force generation speed or explosiveness (Sakamoto et al., 2016). Thus, speed of action or force generation and displacement for every repetition, rather than smooth repetitiveness, is too critical (Sakamoto et al., 2017). Generally, force exertion at a faster rate and speed is the key to accomplishing desired functional needs (Lyttle et al., 1996).

Thus, training methods aimed to improve the power and speed of a specific muscle are advised to focus on both the speed of contraction and power (Kraemer et al., 1996; Lyttle et al., 1996). Exaggerating the effect of speed of movement (effort) over that of intensity (load), recent studies confirm that effort rather than intensity has a greater effect on training effectiveness when the concern is power and dynamic strength (González-Badillo et al., 2014; Pareja-Blanco et al., 2014). Thus, maximum effort in every repetition is crucial, no matter what intensity, for optimizing training outcomes (Sakamoto et al., 2016). Another study found that improving change-of-direction performance and counter-movement jump can be significantly enhanced by a CT intervention that consists of strength training, plyometrics, and running tactics (Markovic & Mikulic, 2010). This study's findings demonstrate that, with no apparent difference between the two training approaches, PT and CT can help young soccer players' explosive power.

CONCLUSIONS AND IMPLICATIONS

Conclusions

This training intervention design, in particular the application of Plyometric training (PT) and combined training (CT) in the actual training of young soccer players, offers clear examples of how to use PT and CT to improve strength and explosive power. The study's conclusions show that the hypothesis about explosive power gains is correct, and sufficient data supports the hypothesis. Similarly, the study hypothesis may be partially correct in the ballistic strength improvements. However, this study doesn't have enough data to support the hypothesis that predicts a difference between the RT and CT groups.

Results suggest that PT is the best stimulus to cause the most possible adaptive response regarding strength and explosive power. And it is also clear that the potent effect of PT can be identified after 4 weeks. Also, a CT can have a significant adaptive effect on ballistic strength and explosive power. PT, which involves a stretch-shortening cycle, enhances force, power output, work done, and thus overall sports performance. PT is better by far than RT alone in improving soccer-specific anaerobic fitness, including strength and explosive power. If RT is to be part of the preparation or maintenance of anaerobic fitness, it is too important to combine it with PT for better sport-specific preparation.

Implications

When the preparation is short for a soccer season, the training programs introduced in this study can be valuable to keep soccer players fit for sport-specific anaerobic physical fitness demands like strength and power. Short preparation periods of three to five weeks in contemporary soccer are familiar challenges. Thus, this study might contribute information regarding improving soccer-specific finesses such as static strength, ballistic strength, and explosive power.

The current study's findings demonstrated that when compared to RT alone, PT or CT significantly increased the strength and explosive power of young soccer players. Thus, this research may have important implications for coaches looking to maximize the development of strength and power of young soccer players, especially U20 players. Given the brief four-week duration of the strength training used in this study, it can be readily combined with other training elements before the start of regular technical-tactical field soccer training.

ACKNOWLEDGEMENTS

The Bahir Dar University male youth soccer team members are highly praised for their enduring participation in the study protocol and full commitment to the testing procedures. Bahir Dar University is highly acknowledged for covering the entire budget for the study. Dr. Dawit Amogne (associate professor) and Professor Alemayehu Bishaw provided critical comments and corrections when developing the study proposal and writing the manuscript before submission. Therefore, they are highly acknowledged for their immense professional help.

REFERENCES

1. Arabatzi, F., Kellis, E., & De Villarreal, E. S.-S. (2010). Vertical jump biomechanics after plyometric, weight lifting, and combined (weight lifting+ plyometric) training. *The Journal of Strength & Conditioning Research*, *24*(9), 2440-2448.
2. Arnason, A., Sigurdsson, S. B., Gudmundsson, A., Holme, I., Engebretsen, L., & Bahr, R. (2004). Physical fitness, injuries, and team performance in soccer. *Medicine & Science in Sports & Exercise*, *36*(2), 278-285. https://doi.org/10.1249/01.MSS.0000113478.92945.CA
3. Barnes, C., Archer, D., Hogg, B., Bush, M., & Bradley, P. (2014). The evolution of physical and technical performance parameters in the English Premier League. *International journal of sports medicine*, 1095-1100. https://doi.org/https://doi.org/10.1055/s-0034-1375695
4. Bedoya, A. A., Miltenberger, M. R., & Lopez, R. M. (2015). Plyometric Training Effects on Athletic Performance in Youth Soccer Athletes: A Systematic Review. *The Journal of Strength & Conditioning Research*, *29*(8), 2351-2360. https://doi.org/10.1519/jsc.0000000000000877
5. Behm, D. G., Young, J. D., Whitten, J. H. D., Reid, J. C., Quigley, P. J., Low, J., . . . Granacher, U. (2017). Effectiveness of Traditional Strength vs. Power Training on Muscle Strength, Power and Speed with Youth: A Systematic Review and Meta-Analysis [Review]. *Frontiers in Physiology*, *8*. https://doi.org/10.3389/fphys.2017.00423
6. Behringer, M., Heede, A. v., Matthews, M., & Mester, J. (2011). Effects of Strength Training on Motor Performance Skills in Children and Adolescents: A Meta-Analysis. *Pediatric Exercise Science*, *23*(2), 186-206. https://doi.org/10.1123/pes.23.2.186
7. Bujnovsky, D., Maly, T., Ford, K. R., Sugimoto, D., Kunzmann, E., Hank, M., & Zahalka, F. (2019). Physical Fitness Characteristics of High-level Youth Football Players: Influence of Playing Position. *Sports*, *7*(2), 46. https://www.mdpi.com/2075-4663/7/2/46
8. Christian, B. (2016). *Power Training vs Strength Training – what is the difference between Strength Training and Power Training?* https://doi.org/https://christianbosse.com/power-training-vs-strength-training-what-is-the-difference/
9. Chtara, M., Chaouachi, A., Levin, G. T., Chaouachi, M., Chamari, K., Amri, M., & Laursen, P. B. (2008). Effect of Concurrent Endurance and Circuit Resistance Training Sequence on Muscular Strength and Power Development. *The Journal of Strength & Conditioning Research*, *22*(4), 1037-1045. https://doi.org/10.1519/JSC.0b013e31816a4419
10. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (Second ed.). L. Erlbaum Associates.
11. Datson, N., Hulton, A., Andersson, H., Lewis, T., Weston, M., Drust, B., & Gregson, W. (2014). Applied Physiology of Female Soccer: An Update. *Sports Medicine*, *44*(9), 1225-1240. https://doi.org/10.1007/s40279-014-0199-1
12. de Villarreal, E. S., Suarez-Arrones, L., Requena, B., Haff, G. G., & Ferrete, C. (2015). Effects of plyometric and sprint training on physical and technical skill performance in adolescent soccer players. *The Journal of Strength & Conditioning Research*, *29*(7), 1894-1903.
13. Faigenbaum, A., & Chu, D. (2001). Plyometric training for children and adolescents. *American College of Sports Medicine*, 1-2.
14. Fatouros, I. G., Jamurtas, A. Z., Leontsini, D., Taxildaris, K., Aggelousis, N., Kostopoulos, N., & Buckenmeyer, P. (2000). Evaluation of Plyometric Exercise Training, Weight Training, and Their Combination on Vertical Jumping Performance and Leg Strength. *The Journal of Strength & Conditioning Research*, *14*(4), 470-476. https://journals.lww.com/nsca-jscr/fulltext/2000/11000/evaluation_of_plyometric_exercise_training,_weight.16.aspx

15. Faude, O., Koch, T., & Meyer, T. (2012). Straight sprinting is the most frequent action in goal situations in professional football. *Journal of sports sciences*, *30*(7), 625-631. https://doi.org/10.1080/02640414.2012.665940

16. Fletcher, I. M., & Hartwell, M. (2004). Effect Of An 8-Week Combined Weights And Plyometrics Training Program On Golf Drive Performance. *The Journal of Strength & Conditioning Research*, *18*(1), 59-62. https://journals.lww.com/nsca-jscr/fulltext/2004/02000/effect_of_an_8_week_combined_weights_and.8.aspx

17. Franco-Márquez, F., Rodríguez-Rosell, D., González-Suárez, J. M., Pareja-Blanco, F., Mora-Custodio, R., Yañez-García, J. M., & González-Badillo, J. J. (2015). Effects of combined resistance training and plyometrics on physical performance in young soccer players. *International journal of sports medicine*, 906-914.

18. González-Badillo, J. J., Rodríguez-Rosell, D., Sánchez-Medina, L., Gorostiaga, E. M., & Pareja-Blanco, F. (2014). Maximal intended velocity training induces greater gains in bench press performance than deliberately slower half-velocity training. *European journal of sport science*, *14*(8), 772-781. https://doi.org/10.1080/17461391.2014.905987

19. Granacher, U., Lesinski, M., Büsch, D., Muehlbauer, T., Prieske, O., Puta, C., . . . Behm, D. G. (2016). Effects of Resistance Training in Youth Athletes on Muscular Fitness and Athletic Performance: A Conceptual Model for Long-Term Athlete Development [Review]. *Frontiers in Physiology*, *7*. https://doi.org/10.3389/fphys.2016.00164

20. Kraemer, W. J., Fleck, S. J., & Evans, W. J. (1996). Strength and Power Training: Physiological Mechanisms of Adaptation. *Exercise and Sport Sciences Reviews*, *24*(1), 363-398. https://journals.lww.com/acsm-essr/fulltext/1996/00240/strength_and_power_training__physiological.14.aspx

21. Lenhard, W., & Lenhard, A. (2016). Calculation of Effect Sizes. *Dettelbach (Germany): Psychometrica*. https://www.psychometrica.de/effect_size.html

22. Lyttle, A. D., Wilson, G. J., & Ostrowski, K. J. (1996). Enhancing Performance: Maximal Power Versus Combined Weights and Plyometrics Training. *The Journal of Strength & Conditioning Research*, *10*(3), 173-179. https://journals.lww.com/nsca-jscr/fulltext/1996/08000/enhancing_performance__maximal_power_versus.8.aspx

23. Markovic, G., & Mikulic, P. (2010). Neuro-Musculoskeletal and Performance Adaptations to Lower-Extremity Plyometric Training. *Sports Medicine*, *40*(10), 859-895. https://doi.org/10.2165/11318370-000000000-00000

24. Marques, M. C., Pereira, A., Reis, I. G., & van den Tillaar, R. (2013). Does an in-season 6-week combined sprint and jump training program improve strength-speed abilities and kicking performance in young soccer players? *Journal of human kinetics*, *39*, 157.

25. Martín-Moya, R., Silva, A. F., Clemente, F. M., & González-Fernández, F. T. (2023). Effects of combined plyometric, strength and running technique training program on change-of-direction and countermovement jump: A two-armed parallel study design on young soccer players. *Gait & Posture*, *105*, 27-34. https://doi.org/https://doi.org/10.1016/j.gaitpost.2023.06.025

26. Meylan, C., & Malatesta, D. (2009). Effects of In-Season Plyometric Training Within Soccer Practice on Explosive Actions of Young Players. *The Journal of Strength & Conditioning Research*, *23*(9), 2605-2613. https://doi.org/10.1519/JSC.0b013e3181b1f330

27. Michailidis, Y., Fatouros, I. G., Primpa, E., Michailidis, C., Avloniti, A., Chatzinikolaou, A., . . . Kambas, A. (2013). Plyometrics' Trainability in Preadolescent Soccer Athletes. *The Journal of Strength & Conditioning Research*, *27*(1), 38-49. https://doi.org/10.1519/JSC.0b013e3182541ec6

28. Ozbar, N., Ates, S., & Agopyan, A. (2014). The Effect of 8-Week Plyometric Training on Leg Power, Jump and Sprint Performance in Female Soccer Players. *The Journal of Strength & Conditioning Research*, *28*(10), 2888-2894. https://doi.org/10.1519/jsc.0000000000000541

29. Pareja-Blanco, F., Rodríguez-Rosell, D., Sánchez-Medina, L., Gorostiaga, E., & González-Badillo, J. (2014). Effect of movement velocity during resistance training on neuromuscular performance. *International journal of sports medicine*, 916-924.

30. Ramirez-Campillo, R., García-Pinillos, F., García-Ramos, A., Yanci, J., Gentil, P., Chaabene, H., & Granacher, U. (2018). Effects of Different Plyometric Training Frequencies on Components of Physical Fitness in Amateur Female Soccer Players [Original Research]. *Frontiers in Physiology*, *9*. https://doi.org/10.3389/fphys.2018.00934

31. Ramírez-Campillo, R., González-Jurado, J. A., Martínez, C., Nakamura, F. Y., Peñailillo, L., Meylan, C. M. P., . . . Izquierdo, M. (2016). Effects of plyometric training and creatine supplementation on maximal-intensity exercise and endurance in female soccer players. *Journal of Science and Medicine in Sport*, *19*(8), 682-687. https://doi.org/https://doi.org/10.1016/j.jsams.2015.10.005

32. Ramirez-Campillo, R., Sanchez-Sanchez, J., Romero-Moraleda, B., Yanci, J., García-Hermoso, A., & Manuel Clemente, F. (2020). Effects of plyometric jump training in female soccer player's vertical jump height: A systematic review with meta-analysis. *Journal of sports sciences*, *38*(13), 1475-1487. https://doi.org/10.1080/02640414.2020.1745503

33. Ramírez-Campillo, R., Vergara-Pedreros, M., Henríquez-Olguín, C., Martínez-Salazar, C., Alvarez, C., Nakamura, F. Y., . . . Izquierdo, M. (2016). Effects of plyometric training on maximal-intensity exercise and endurance in male and female soccer players. *Journal of sports sciences*, *34*(8), 687-693. https://doi.org/10.1080/02640414.2015.1068439

34. Rein, R., & Memmert, D. (2016). Big data and tactical analysis in elite soccer: future challenges and opportunities for sports science. *SpringerPlus*, *5*(1), 1410. https://doi.org/10.1186/s40064-016-3108-2

35. Rosas, F., Ramírez-Campillo, R., Martínez, C., Caniuqueo, A., Cañas-Jamet, R., McCrudden, E., . . . Pereira, L. A. (2017). Effects of plyometric training and beta-alanine supplementation on maximal-intensity exercise and endurance in female soccer players. *Journal of human kinetics*, *58*, 99. https://doi.org/https://doi.org/10.1515/hukin-2017-0072

36. Rössler, R., Donath, L., Verhagen, E., Junge, A., Schweizer, T., & Faude, O. (2014). Exercise-Based Injury Prevention in Child and Adolescent Sport: A Systematic Review and Meta-Analysis. *Sports Medicine*, *44*(12), 1733-1748. https://doi.org/10.1007/s40279-014-0234-2

37. Sáez de Villarreal, E., Requena, B., & Cronin, J. B. (2012). The Effects of Plyometric Training on Sprint Performance: A Meta-Analysis. *The Journal of Strength & Conditioning Research*, *26*(2), 575-584. https://doi.org/10.1519/JSC.0b013e318220fd03

38. Sakamoto, A., Kuroda, A., & Sakuma, K. (2017). Ballistic projectile motion is essential during power training to enhance shot-put performance. *Journal of Science and Medicine in Sport*, *20*, e52. https://doi.org/https://doi.org/10.1016/j.jsams.2017.01.140

39. Sakamoto, A., Sinclair, P. J., & Naito, H. (2016). Strategies for maximizing power and strength gains in isoinertial resistance training: Implications for competitive athletes. *The Journal of Physical Fitness and Sports Medicine*, *5*(2), 153-166.

40. Schoenfeld, B. (2011). The Use of Specialized Training Techniques to Maximize Muscle Hypertrophy. *Strength & Conditioning Journal*, *33*(4), 60-65. https://doi.org/10.1519/SSC.0b013e3182221ec2

41. Silva, J. R., Nassis, G. P., & Rebelo, A. (2015). Strength training in soccer with a specific focus on highly trained players. *Sports Medicine - Open*, *1*(1), 17. https://doi.org/10.1186/s40798-015-0006-z

42. Slimani, M., Paravlić, A., & Bragazzi, Nicola L. (2017). Data concerning the effect of plyometric training on jump performance in soccer players: A meta-analysis. *Data in Brief*, *15*, 324-334. https://doi.org/https://doi.org/10.1016/j.dib.2017.09.054

43. Smith, M. R., Thompson, C., Marcora, S. M., Skorski, S., Meyer, T., & Coutts, A. J. (2018). Mental Fatigue and Soccer: Current Knowledge and Future Directions. *Sports Medicine*, *48*(7), 1525-1532. https://doi.org/10.1007/s40279-018-0908-2

44. Söhnlein, Q., Müller, E., & Stöggl, T. L. (2014). The Effect of 16-Week Plyometric Training on Explosive Actions in Early to Mid-Puberty Elite Soccer Players. *The Journal of Strength & Conditioning Research*, *28*(8), 2105-2114. https://doi.org/10.1519/jsc.0000000000000387

45. Stevenson, J. H., Beattie, C. S., Schwartz, J. B., & Busconi, B. D. (2015). Assessing the Effectiveness of Neuromuscular Training Programs in Reducing the Incidence of Anterior Cruciate Ligament Injuries in Female Athletes:A Systematic Review. *The American Journal of Sports Medicine*, *43*(2), 482-490. https://doi.org/10.1177/0363546514523388

46. Stojanović, E., Ristić, V., McMaster, D. T., & Milanović, Z. (2017). Effect of Plyometric Training on Vertical Jump Performance in Female Athletes: A Systematic Review and Meta-Analysis. *Sports Medicine*, *47*(5), 975-986. https://doi.org/10.1007/s40279-016-0634-6

47. Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of Soccer. *Sports Medicine*, *35*(6), 501-536. https://doi.org/10.2165/00007256-200535060-00004

48. Taube, W., Leukel, C., & Gollhofer, A. (2012). How Neurons Make Us Jump: The Neural Control of Stretch-Shortening Cycle Movements. *Exercise and Sport Sciences Reviews*, *40*(2), 106-115. https://doi.org/10.1097/JES.0b013e31824138da

49. Turner, E., Munro, A. G., & Comfort, P. (2013). Female Soccer: Part 1—A Needs Analysis. *Strength & Conditioning Journal*, *35*(1), 51-57. https://doi.org/10.1519/SSC.0b013e318281f689

50. Ullrich, B., Pelzer, T., & Pfeiffer, M. (2018). Neuromuscular Effects to 6 Weeks of Loaded Countermovement Jumping With Traditional and Daily Undulating Periodization. *The Journal of Strength & Conditioning Research*, *32*(3), 660-674. https://doi.org/10.1519/jsc.0000000000002290

51. Voisin, M. P. J., & Scohier, M. (2019). Effect of an 8-Week Plyometric Training Program with Raised Forefoot Platforms on Agility and Vertical Jump Performance. *Int J Exerc Sci*, *12*(6), 491-504.

52. Wang, Y.-C., & Zhang, N. (2016). Effects of plyometric training on soccer players. *Experimental and therapeutic medicine*, *12*(2), 550-554.

53. Wilson, R. S., David, G. K., Murphy, S. C., Angilletta Jr, M. J., Niehaus, A. C., Hunter, A. H., & Smith, M. D. (2017). Skill not athleticism predicts individual variation in match performance of soccer players. *Proceedings of the Royal Society B: Biological Sciences*, *284*(1868), 20170953. https://doi.org/http://doi.org/10.1098/rspb.2017.0953

54. Zghal, F., Colson, S. S., Blain, G., Behm, D. G., Granacher, U., & Chaouachi, A. (2019). Combined Resistance and Plyometric Training Is More Effective Than Plyometric Training Alone for Improving Physical Fitness of Pubertal Soccer Players [Original Research]. *Frontiers in Physiology*, *10*. https://doi.org/10.3389/fphys.2019.01026