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EFFECTS OF TWO EXPLOSIVE STRENGTH CIRCUITS ON POWER, SPEED AND AGILITY IN U16 FOOTBALL PLAYERS

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Abstract. *The purpose of study was to examine the effect of two circuits, which consists in specific plyometric drills and football-specific sprints combined with technical elements (crosses and finishing from crosses, feint, dribble and shoot), on the performance level related to explosive strength, power, speed and agility in U-16 football players. Forty U16 junior football players were selected to participate in this study (20 in the experimental group and 20 in the control group). For the experimental group was applied a weekly training programme (the experimental intervention), which consisted in two specific explosive strength circuits with sprints on four and three pitch zones. The tests consisted of vertical jumps – squat jump, counter movement jump and 15" Bosco Repeated Jump Test, drop jump, 10 m, 20 m and 30 m linear sprints and the Illinois Agility Test. The experimental group showed performance improvements ($p < 0.05$) in all explosive strength and power tests, while the increases of the control group were not statistically significant. At speed and agility tests (10 m, 20 m and 30 m sprints and the Illinois test), the experimental group showed significant performance improvements for the 10 m, 20 m and 30 m sprints, and for Illinois Agility Test ($p < 0.05$). The observed differences between the experimental and the control group (at initial and final testing) were discussed, and recommendations regarding the effectiveness of the intervention programme were highlighted.*

Keywords: *explosive strength; power; speed; football U16.*

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Introduction

Football is a sport based on intermittent exercise, which involves different physiological components. Sprinting and jumping are essential abilities in achieving high-level standards in football, with physiological parameters becoming increasingly important for optimal performance in both adults and children. For example, high-speed sprints account for only up to 3% of the total distance covered during the game (Castagna et al., 2003), but the most important moments of the match such as gaining possession, scoring or conceding goals depend on them (Reilly et al., 2000). Standing starts, accelerations, jumps and agility elements are crucial explosive actions when the player is involved in a fast-paced game. Acceleration can be defined as a short sprint over the distance of 0-10 m (Kotzamanidis, 2006), and agility is the ability to change the direction of travel and accelerate and decelerate quickly (Little & Williams, 2005; Sheppard & Young, 2006).

However, soccer players are also required to perform short duration high-intensity activities such as accelerations, decelerations, and change of-direction (COD) that rely heavily on anaerobic pathways (Kargarfard et al., 2020). These high-intensity activities usually occur every 4-6 seconds interspersed with short recovery periods during a match (Mohr et al., 2003), maximal linear sprints typically occur every 90 s, each lasting from 2 to 4 s (Stolen et al., 2005).

Game analyses have demonstrated the importance of these qualities in football, from an average sprint time of 2-3 seconds (10-12 m sprint) (Castagna et al., 2003) to an average number of 50 sprints per match (Withers et al., 1982). Such explosive actions are essential elements for success in football and should be trained independently of aerobic endurance using an enhanced training programme (Helgerud et al., 2001). Some research suggests that, maximal strength training plays a major role in improving explosive actions, because of increased readiness to perform strength exercises. There are studies, which showed that the role of maximal strength during initial power production between concentric contraction activity and stretch-shortening cycle activity differs, and has significant implications for the training of athletes (Cronin et al., 2000). Instead, high-speed explosive training has demonstrated greater improvements in the rate of strength development and explosive actions compared to traditional heavyweight training methods for maximal power (Häkkinen et al., 1985). The controversy it has still debated in the literature addressing strength training in children and juniors. Some researches, has found that changes in the strength level has a significant effect on explosive actions (Christou et al., 2006), but other researcher has not found significant improvements in this regard (Nunes et al., 2021). The absence of several stimuli during strength training could explain this inconsistency: a) segmental coordination aimed at power transfer to multi-joint muscles and neural control mechanisms of optimal movement patterns (Schmidtbleicher, 1992) and b) specificity in relation to the joint angle and angular velocity and eccentric overload (Duchateau & Hainaut, 2003).

Sprints and jumps are extremely important components in achieving high standards of game. Over time, great efforts had made to identify anthropometric, biomechanical and physiological factors, in order to establish effectiveness-training methods, to improve motor skills necessary to reach top performance. The influence of muscle strength on these motor skills has been extensively studies; however, many of the previous findings are quite controversial (Dowson et al., 1998; Kukolj et al., 1999). Strength muscle was determined by the cross-sectional areas of the muscles. There are researches that has reported the existence of a correlation between the cross-sectional areas of psoas major and thigh muscles with the best results for the 100 m times in junior sprinters (Hoshikawa et al., 2006). In a study conducted by Hoshikawa et al. (2009), it was demonstrated that the predominant development of specific muscles partially influenced the short sprint and vertical jump performance of football players. Therefore, activating these muscles is essentially to developing explosive strength, power and speed capabilities.

The technical and tactical qualities of the elite players are undeniable; however, the physical ability and strength of the players make the difference. The ability to have starting strength and explosive strength are critical elements that any athlete must possess (Blejan et al., 2019).

In a study by Meylan and Malatesta (2009), it was report that 8 weeks of plyometric work in football training induced positive effects on the explosive actions of football players in early puberty. Significant improvements were notice in the 10 m sprint, agility test and counter movement jump (CMJ) test. In most cases, there was not only an increase in the group average but also an increase at the individual level. No significant changes were observe in the control group for any test variable, which demonstrated the importance of specific strength training for improving the explosive actions of football players. Moreover, given that the baseline data showed a significant difference between the two groups in the CMJ and 10 m sprint tests; "the window" for improvement in these variables was smaller for the experimental group. However, the experimental group showed a statistically significant performance improvement in these two tests compared to the control group. This remark reinforces the value of a strength-training programme to improve the football player's explosive actions. Such improvement could have a positive influence on game performance, since the ability to win challenges and score goals is relate to this type of physical demand (Meylan & Malatesta, 2009). Similarly, Beato et al. (2018) also showed that combined speed and plyometric exercises improved sprinting performance with larger effects (range: -0.51 to -0.29 vs. -0.22 to -0.15, for 10 m, 20 m, and 40 m intervals) than isolated speed protocol in elite youth soccer players.

The Beato et al. (2018) study showed that short-term protocols (complex changes are important and able to give meaningful improvements on power and speed parameters in a specific soccer population. Changes of direction and plyometric group showed a larger effect in sprint and jump parameters compared with change of direction group after the training protocol.

The 10 m distance appears to be the most relevant to assess the specific quality of acceleration in football due to the increased frequency of high-intensity short sprints during a game (Castagna et al., 2003). A significant decrease in 10 m sprint times (22.1%) for the experimental group demonstrated the effectiveness of a plyometric programme aimed at improving the specific explosive actions of junior football players (Kotzamanidis, 2006). Initial acceleration has demonstrated to be more difficult to improve than maximum velocity, probably due to the smaller margin of increase and the different forces involved. Several studies (Cronin & Hansen, 2005; Murphy et al., 2003; Young et al., 1995) have been conduct to determine the most important factors for short-distance sprints and Murphy et al. (2003) have observed that the main factor differentiating fast and slow sprinters over distances longer than 15 m is ground contact time.

In physics, power it is defined as work divided by time. In applying this to athletic performance, it indicates how much the player can generate muscle force in such activities. The football game regards the ability to be fast and explosive (Blejan et al., 2019). So, the purpose of this research is to find out the effect of two circuits, which consists in specific plyometric drills and football-specific sprints combined with technical elements (crosses and finishing from crosses, feint, dribble and shoot), on performance level related to explosive strength, power, speed and agility in U-16 football players.

Research question

To which extent two physical circuits, one for explosive power, speed and change of direction with technical ability and the other one, for power agility with technical elements influence power, speed and agility, in U-16 football players?

Methodology

Participants

Forty participants (age: 15.49±0.61 years; height = 178.80±9.31m; body mass = 70.74±9.19 kg) were involved in this research and distributed as follows: 20 of them belong to the U16 Farul Football Club team and they were included in the experimental group, and 20 members of the U16 Kinder Sport Club Constanta team, were included in the control group. Both groups took part in the elite U16 National Championship, having six training sessions and one match per week. As stated, goalkeepers were excluded from this research due to dissimilar movement patterns when compared to field players (Chapman et al.,1998).

All testing procedures and risks were explained, and the tests were preceded by a pre-test during which players in the control group became familiar with these tests, given that they had not performed this type of testing before.

The study conformed to the recommendations of the Declaration of Helsinki, and all subjects received a clear explanation of the study, including the risks and benefits of participation. Each player had also completed the club-mandated physical examination, and read and signed the club consent and medical forms for participation in U16 championship.

During the study, the international ethical guidelines were respected: the participants' informed consent was obtained, and the anonymity and confidentiality of the data were ensured (Predoiu, 2020).

Procedure

Testing was incorporated, within the team's gym and field sessions that occured across 2 days in July 2022 and for final testing in September 2022. All subjects were familiar with the tests performed in this study, as they were consistently used by the team's training staff for general player monitoring.

The research spread over 8 weeks during the preparatory period. In the first week the initial test (pre test) was performed. Two weeks of accommodation followed. Starting with the third week, the proposed program for six weeks was applied. In the ninth week, the final test (post test) was performed.

The jump assessments were completed within one gym session, which took approximately 45 min to complete, with the Microgate OptoJump Next device. Jump testing consisted of the squat jump test, counter movement jump test, 45cm drop jump and 15" Bosco repeated jump test. The speed and agility assessments were completed prior to field training sessions following the team's usual warm-up, which incorporated the 10-m sprint, 20-m sprint, 30-sprint and Illinois agility test. Field-testing was conducted on a synthetic grass outdoor football pitch and subjects wore their own cleats they used in competition.

After the initial testing, the both groups (experimental and control) followed their own training programme.

Proposed training programme

From the third week of training, the experimental group performed the two proposed circuits for explosive strength, plyometrics, speed, agility and technical elements, twice a week. The first circuit consist in four series of four repetitions each set, and the second circuit 4 repetitions per set.

The first circuit, called "Explosive strength circuit on four zones" (Figure 1), was conduct on the second day of each weekly training cycle. The training theme was synchronizations on compartments, where numerical superiority/inferiority was practiced by quick attacks with lateral and central combinations and finishing from crosses. Thus, we started this circuit from the tactical theme and we included four stations, two on the side and two in the central zone of the football field. The first part of the circuit, involved jumping over obstacles. The second part included sprinting with changes of direction and the third part included the technical elements: in the side zones, consisted of a low or high cross and, in the central zone, a headshot or volley shot if the cross was high and a finishing, if the cross was low.

On the side zone, the jumps were laterally performed to the right, on the right side and laterally to the left, on the left side, over hurdles with a height of 60 cm. After, a maximal sprint over the distance of 25 m was performed by changing the direction of travel in the middle of the distance as follows: to the left on the right side and to the right on the left side. In the third part of the exercise, the player received a one-two pass from the coach with a low cross or pass, a feint and a high cross.

In the central zone on the left side, two-leg jumps forward, laterally to the left/right and forward over hurdles with a height of 50 cm, 5 m forward sprint and 8 m sprint to the left, break on the left leg, 8 m backward sprint and 8 m sprint to the right, finishing.

The right side central zone, single-leg jumps over 30cm hurdles; 5 m forward sprint; changing the direction and 8 m sprint to the right, break on the right leg, 8 m sprint to return to starting position, 8 m sprint to the left, and finishing.

Each player performed four repetitions per position, so the total number was 16 repetitions consisting of 48 jumps and 358 m sprint.

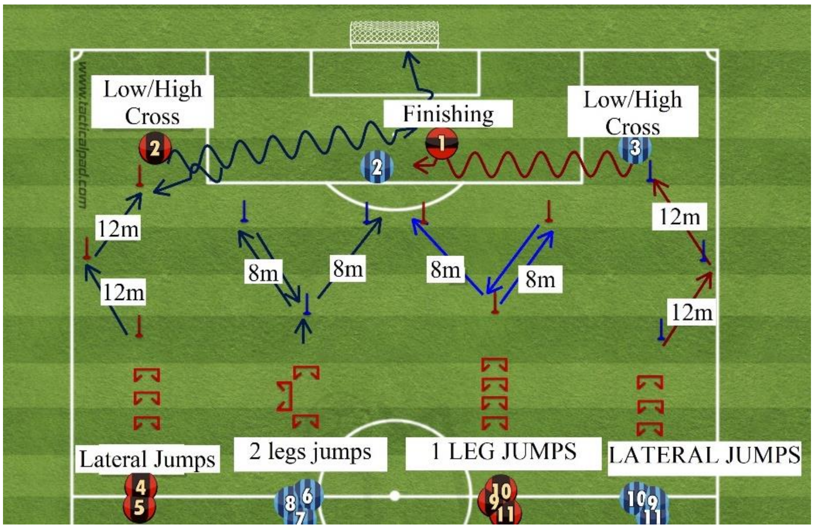

Figure 1. Explosive strength circuit with four finishing zones

The second circuit, called “Circuit on three finishing zones” (Figure 2), was conducted on the third day of each weekly training cycle, and the training theme was “duel” in conditions of numerical equality, small-sided games (1 vs. 1, 2 vs. 2, 3 vs. 3 and 4 vs. 4). As well as, offensive and defensive actions (1 vs. 1 and 2 vs. 2) was performed on finishing zone, where the strikers at the goal and the defenders at small goals placed 30 m, apart in three zones. The total distance of this circuit is in the right side 15m, centre 20m and left side 15m.

Thus, the circuit was built by respecting the “Duel” theme, namely individualisation, with a one-two or feint-dribble finish. The circuit consisted of three stations: two were located sideways in zone 1 and one was located centrally in zone 3. Two-legs forward jumps laterally, left side from delimitation of 16m box, 5 m sprint to the centre of the field, 5 m sprint with changing the direction backwards to the right, 5 m sprint, changing the direction, one-two ball takeover with the coach by feinting and shooting, and 30 m sprint to the field centre. On central zone, from the midfield, single-leg jumps over 30cm hurdles, 10 m - 5 m - 5 m shuttle sprints, ball takeover, feinting, dribbling and shooting, and then 30 m backward sprint to the centre of the field. Right side, from delimitation of 16m box with side jumps on both legs over 50cm hurdles, 5 m sprint, changing the direction to left, 5 m sprint, changing the direction, 5 m sprint, one-two with the coach, feinting, shooting and 30 m sprint to the field centre.

Four repetitions per station were performed, with each player going through all three stations. The total number of repetitions was 12 with 36 jumps and 560 m sprint.

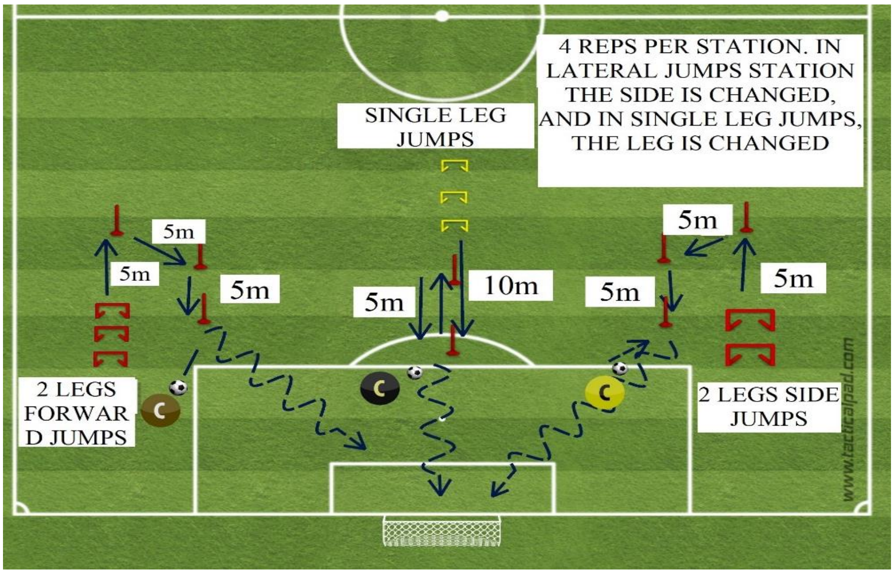

Figure 1. Circuit with three finishing zones

Starting with the third week of training, the control group performed a classic program for explosive strength, plyometrics and speed. For this group, the total number of jumps was 120 per week (two-legs jumps over hurdles with a height of 50 cm). For speed they practiced 10 m - 20 m - 30 m linear sprints in 4 series each, with a total volume of 240 m, and 10 m - 10 m - 20 m - 10 m - 20 m - 10 m - 10 m shuttle sprints with a total weekly volume of 360 m.

Results

Data collected from the initial and final tests were statistically processed using IBM SPSS Statistics 26.

The statistical analysis was done for the results obtained in the explosive strength and power tests, squat jump (SJ) test, counter movement jump (CMJ) test, drop jump (DJ) test and 15” Bosco Repeated Jump Test (RJT), as well as speed and agility tests, 10 m - 20 m - 30 m sprint tests and the Illinois Agility Test.

The initial and final tests were performed using similar facilities and under the same weather conditions, at a temperature of about 22^0 C in the initial testing and 20^0 C in the final testing, with a wind of about 8 km per hour. The sprint tests were performed with a tailwind.

Table 1. *Statistical analysis of strength and power parameters for dependent samples – experimental group*

Parameter	Testing	N	Mean ± SD	CV (%)	Median	Coefficient of asymmetry	*t* Dependent (p)
SJ (cm)	Initial	20	33.99 ± 3.46	10.18	33.20	0.227	7.176
	Final	20	36.53 ± 3.05	8.36	36.02	0.168	(p < 0.01)
CMJ (cm)	Initial	20	39.76 ± 3.06	7.69	39.00	0.250	6.620 (p < 0.01)
	Final	20	42.96 ± 3.56	8.28	42.25	0.200	
DJ (w/kg)	Initial	20	37.94 ± 8.26	21.76	35.91	0.245	5.164 (p < 0.01)
	Final	20	43.31 ± 9.39	21.69	43.11	0.020	
15” Bosco RJT (w/kg)	Initial	20	51.33 ± 9.38	18.28	50.28	0.112	5.959 (p < 0.01)
	Final	20	55.19 ± 8.53	15.45	54.97	0.025	

Note: p < 0.05 statistically significant

Table 1 shows the results obtained by the experimental group in the initial and final testing of explosive strength and power parameters. As it can be seen, there are statistically significant differences (p < 0.01) between the initial and final testing in the squat jump (SJ), counter movement jump (CMJ), drop jump (DJ), and 15” Bosco RJT. Thus, statistically significant improvements are noted for the experimental group in explosive strength tested by the squat jump and counter movement jump, as well as power in w/kg (body) tested by the drop jump and 15” Bosco RJT.

Table 2. *Statistical analysis of strength and power parameters for dependent samples – control group*

Parameter	Testing	N	Mean ± SD	CV (%)	Median	Coefficient of asymmetry	*t* Dependent (p)
SJ (cm)	Initial	20	33.93 ± 4.84	14.26	33.45	0.100	0.738
	Final	20	34.38 ± 4.55	13.24	32.90	0.327	(p > 0.05)
CMJ (cm)	Initial	20	40.17 ± 4.47	11.13	39.35	0.183	0.683
	Final	20	40.47 ± 4.33	10.71	39.70	0.178	(p > 0.05)
DJ (w/kg)	Initial	20	39.16 ± 6.40	16.36	39.60	- 0.068	0.561
	Final	20	39.57 ± 6.96	17.59	39.75	-0.027	(p > 0.05)
15” Bosco RJT (w/kg)	Initial	20	52.67 ± 8.81	16.72	52.14	0.060	1.036
	Final	20	53.31 ± 8.45	15.86	52.60	0.084	(p > 0.05)

Note: p < 0.05 statistically significant

Table 2 shows the results obtained by the control group for the initial and final testing of explosive strength and power parameters. It can be observed that, in terms of explosive strength tested by the squat jump and counter movement jump, there are no statistically significant differences between the initial and final testing. In the squat jump, the difference is statistically insignificant ($p > 0.05$), and in the counter movement jump, it is also statistically insignificant.

The results obtained in the power, drop jump and 15” Bosco RJT tests, also show a statistically insignificant difference ($p > 0.05$) between the initial and final testing.

Table 3. *Statistical analysis of speed and agility parameters for dependent samples – experimental group*

Parameter	Testing	N	Mean ± SD	CV (%)	Median	Coefficient of asymmetry	*t* Dependent (p)
10 m (sec)	Initial	20	1.91 ± 0.08	4.28	1.89	0.232	10.855
	Final	20	1.79 ± 0.06	3.52	1.78	0.111	(p < 0.01)
20 m (sec)	Initial	20	3.17 ± 0.09	3.03	3.15	0.240	2.22
	Final	20	3.15 ± 0.12	3.81	3.13	0.175	(p < 0.05)
30 m (sec)	Initial	20	4.43 ± 0.20	4.52	4.40	0.145	2.470
	Final	20	4.37 ± 0.21	4.74	4.37	0.005	(p < 0.05)
Illinois (sec)	Initial	20	15.78 ± 0.48	3.07	15.80	-0.058	3.943
	Final	20	15.52 ± 0.41	2.67	15.35	0.400	(p < 0.01)

Note: p < 0.05 statistically significant.

Table 3 shows the results obtained by the experimental group in speed and agility tests, at initial and final tests. Statistically significant improvements can be seen in the 10 m speed ($p < 0.01$) and in the 20 m sprint ($p < 0.05$). The difference between the initial and final tests in the 30 m sprint is also statistically significant. Regarding agility, which was tested by the Illinois Agility Test, the differences are also statistically significant ($p < 0.01$). The coefficient of asymmetry is within the normal range for all parameters, and the coefficient of variation is within the range of a homogeneous population of values.

Table 4. *Statistical analysis of speed and agility parameters for dependent samples – control group*

Parameter	Testing	N	Mean ± SD	CV (%)	Median	Coefficient of asymmetry	*t* Dependent (p)
10 m (sec)	Initial	20	1.84 ± 0.12	6.79	1.84	0.016	5.553
	Final	20	1.76 ± 0.08	4.38	1.76	-0.104	(p < 0.01)
20 m (sec)	Initial	20	3.15 ± 0.21	6.77	3.09	0.270	4.266
	Final	20	3.05 ± 0.15	4.82	3.01	0.220	(p < 0.01)
30 m (sec)	Initial	20	4.28 ± 0.21	4.81	4.23	0.243	6.055
	Final	20	4.16 ± 0.17	4.16	4.11	0.272	(p < 0.01)
Illinois (sec)	Initial	20	15.71 ± 0.41	2.59	15.90	-0.464	2.775
	Final	20	15.65 ± 0.44	2.82	15.71	-0.133	(p < 0.01)

Note: p < 0.05 statistically significant.

Table 4 shows the differences between the results obtained by the control group in the initial and final tests. The results of the control group are statistically significantly better in the 10 m sprint, 20 m sprint, and 30 m sprint ($p < 0.01$). The Illinois Agility Test results are also significantly better ($p < 0.01$). The asymmetry of the results is normal for all parameters, and the coefficient of variation is within the range of a homogeneous population of values.

Table 5. *Statistical analysis of strength and power parameters for independent samples – experimental and control groups, initial testing*

Parameter	Group	N	Mean ± SD	CV (%)	Effect size (d)	*t* Independent (p)
SJ (cm)	Experimental	20	33.98 ± 3.46	10.18	0.012	0.038
	Control	20	33.93 ± 4.84	14.27		(p > 0.05)
CMJ (cm)	Experimental	20	39.76 ± 3.06	7.68	-0.106	0.335
	Control	20	40.17 ± 4.47	11.13		(p > 0.05)
DJ (w/kg)	Experimental	20	37.94 ± 8.26	21.76	-0.166	0.524
	Control	20	39.16 ± 6.41	16.36		(p > 0.05)
15” Bosco RJT (w/kg)	Experimental	20	51.33 ± 9.39	18.28	-0.147	0.466
	Control	20	52.67 ± 8.81	16.72		(p > 0.05)

Note: d = 0.8 – large effect size; d = 0.5 – medium effect size; d = 0.2 – small effect size.

Table 5 shows the statistical analysis of strength and power parameters for independent samples in the initial testing. Thus, in the squat jump (SJ), the mean performance score is 33.98 ± 3.46 cm for the experimental group with a homogeneous population of values (the coefficient of variation is 10.18%). The control group mean performance score is 33.93 ± 4.84 cm (the variation coefficient being 14.27%). The difference in mean performance scores between the two groups in the initial testing is insignificant ($p > 0.05$).

In the counter movement jump (CMJ), the mean value obtained by the experimental group in the initial testing is 39.76 ± 3.06 cm with a homogeneous value. The control group achieves a slightly better mean performance score of 40.17 ± 4.47 cm in the initial testing. The performance difference between the two groups is statistically insignificant ($p > 0.05$).

In the drop jump test (DJ), the mean value of the experimental group is 37.94 ± 8.26 w/kg, while the mean performance score of the control group is slightly better than experimental group, 39.16 ± 6.41 w/kg. The difference between the two groups in the initial testing is statistically insignificant at $p > 0.05$.

In the 15” Bosco RJT, the differences in mean values between the two groups are, also, statistically insignificant at $p > 0.05$.

In conclusion, there are no statistically significant differences in mean performance scores between the two groups as regards the results achieved for explosive strength and power in the initial testing. Nominally, the performance of the control group is better in CMJ, DJ and 15” Bosco RJT, but the differences are insignificant.

Table 6. *Statistical analysis of strength and power parameters for independent samples – experimental and control groups, final testing*

Parameter	Group	N	CV (%)	ɯ^{2}	Effect size (d)	*t* Independent (p)
SJ (cm)	Experimental	20	8.36	0.049	0.554	1.750
	Control	20	13.24	(4.9%)		($p < 0.05$)
CMJ (cm)	Experimental	20	8.28	0.069	0.628	1.986
	Control	20	10.71	(6.9%)		($p < 0.05$)
DJ (w/kg)	Experimental	20	21.69	0.026	0.452	1.431
	Control	20	17.59	(2.6%)		($p > 0.05$)
15” Bosco RJT (w/kg)	Experimental	20	15.45	-0.013	0.221	0.699
	Control	20	15.85	(-1.3%)		($p > 0.05$)

Note: d = 0.8 – large effect size; d = 0.5 – medium effect size; d = 0.2 – small effect size.

Table 6 shows the statistical analysis of strength and power parameters for independent samples in the final testing. Thus, in the squat jump (SJ), there is an increase in the difference between the mean values of the two groups, with a significant increase for the experimental group. The mean difference is statistically significant ($p < 0.05$) and the size effect is medium, which reveals that the proposed training method has a moderate influence on performance (the difference between means is 4.9%).

At the counter movement jump (CMJ), the difference is also statistically significant ($p < 0.05$) with better values for the experimental group, and the effect size is medium (the difference between means is 6.9%).

Regarding the drop jump power test (DJ), although the control group has significantly better results in the final testing, the difference between the two groups is statistically insignificant ($p > 0.05$).

After analysing the 15” Bosco RJT results obtained in the final testing, a significant improvement ($p < 0.05$) can be noted at the experimental group compared to the initial testing. However, compared to the results of the control group in the final testing, the difference is statistically insignificant ($p > 0.05$).

Table 7. *Statistical analysis of speed and agility parameters for independent samples – Experimental and control groups, initial testing*

Parameter	Group	N	Mean ± SD	CV (%)	Effect size (d)	*t* Independent (p)
10 m (sec)	Experimental	20	1.91 ± 0.08	4.28	0.679	2.154
	Control	20	1.84 ± 0.12	6.79		($p < 0.05$)
20 m (sec)	Experimental	20	3.17 ± 0.10	3.03	0.158	0.507
	Control	20	3.15 ± 0.21	6.77		($p > 0.05$)
30 m (sec)	Experimental	20	4.43 ± 0.20	4.52	0.734	2.321
	Control	20	4.28 ± 0.21	4.81		($p < 0.05$)
Illinois (sec)	Experimental	20	15.78 ± 0.48	3.07	0.148	0.467
	Control	20	15.71 ± 0.41	2.59		($p > 0.05$)

Note: d = 0.8 – large effect size; d = 0.5 – medium effect size; d = 0.2 – small effect size.

Table 7 shows the statistical analysis of travel speed (10 m, 20 m and 30 m sprint) and agility (Illinois Agility Test) parameters for independent samples in the initial testing.

In the 10 m sprint test, the experimental group achieves a mean performance score of 1.91 ± 0.08 sec, which is significantly lower in statistical terms ($p < 0.05$) compared to the control group whose mean value is 1.84 ± 0.12 sec.

In the 20 m sprint test, the situation is similar to the one encountered in the 10 m sprint test, the experimental group achieving lower performance than that of the control group, but the difference between the two groups is statistically insignificant ($p > 0.05$).

In the 30 m sprint test, the mean performance in the initial testing is 4.43 ± 0.20 sec for the experimental group and 4.28 ± 0.21 sec for the control group. In this case, the difference between the two groups is statistically significant ($p < 0.05$).

In the Illinois Agility Test, the experimental group achieves a mean performance score of 15.78 ± 0.48 sec in the initial testing, which is lower than that of the control group whose mean value is 15.71±0.41 sec. However, the difference between the two groups is not statistically significant ($p > 0.05$).

Table 8. *Statistical analysis of travel speed and agility parameters for independent samples – experimental and control groups, final testing*

Parameter	Group	N	Mean ± SD	CV (%)	Effect size (d)	*t* Independent (p)
10 m (sec)	Experimental	20	1.79 ± 0.06	3.52	0.429	1.349
	Control	20	1.76 ± 0.08	4.38		(p > 0.05)
20 m (sec)	Experimental	20	3.15 ± 0.12	3.81	0.776	2.451
	Control	20	3.05 ± 0.15	4.82		(p < 0.05)
30 m (sec)	Experimental	20	4.37 ± 0.21	4.74	1.094	3.465
	Control	20	4.16 ± 0.17	4.16		(p < 0.01)
Illinois (sec)	Experimental	20	15.52 ± 0.41	2.67	-0.303	0.959
	Control	20	15.65 ± 0.44	2.82		(p > 0.05)

Note: d = 0.8 – large effect size; d = 0.5 – medium effect size; d = 0.2 – small effect size.

Table 8 shows the statistical analysis of travel speed (10 m, 20 m and 30 m sprint) and agility (Illinois Agility Test) parameters for independent samples in the final testing.

In the 10 m sprint test, the experimental group achieves a mean performance score of 1.79 ± 0.06 sec, while the control group achieves a mean performance score of 1.76 ± 0.08 sec. The performance difference between the two groups is in favour of the control group, although the experimental group manages to obtain better results in terms of the difference value compared to the initial testing; the difference between the two groups is not statistically significant ($p > 0.05$).

In the 20 m sprint test, the experimental group achieves a mean performance score of 3.15 ± 0.12 sec, while the mean performance of the control group is 3.05 ± 0.15 sec. The effect size is medium ($d = 0.77$); the performance of the control group is 0.10 sec better than that of the experimental group and is statistically significant ($p < 0.05$).

In the 30 m sprint, the experimental group achieves a mean performance score of 4.37 ± 0.21 sec, while the mean performance of the control group is better than that of the experimental group, namely 4.16 ± 0.17 sec. The difference of 0.21 sec between the mean performance scores obtained by the two groups is statistically significant at $p < 0.01$; the effect size is very large ($d = 1.094$).

In the Illinois Agility Test, the experimental group achieves a mean performance score of 15.52 ± 0.41 sec, while the control group achieves a mean performance score of 15.65 ± 0.44 sec. The difference between the two groups is 0.13 sec, being statistically insignificant ($p > 0.05$).

Discussions

This research has determined the efficiency of two circuits of explosive force, speed and technical ability, compared to a traditional speed and jumping training, in the development of U16 junior footballer's speed, agility and power.

Football is a sport based on intermittent exercise, which is why different physiological components are needed, to achieve the best performance. In modern football, physiological considerations are increasingly important to achieve optimal performance in both adults and children (Meylan & Malatesta, 2009). The football players' ability to perform various high-intensity explosive actions, such as sprinting, jumping, tackling, turning and changing the running pace, greatly influences performance during football matches (Reilly et al., 2000), as well as psychological variables, such as anxiety (trait anxiety impact on intersegmental coordination of football players being emphasized - Cojocaru et al., 2015; Mitrache et al., 2014). Researchers underlined the essential role of coaches (generally), which must perform a functional analysis of athletes' behaviour in order to improve performance (Pelin et al., 2018). Forster et al. (2022) examined the effect of specific and non-specific training methods on pro-agility performance, by analysing the intervention type and resulting magnitude of training effects (on pro-agility shuttle performance). Data from 638 subjects and 29 intervention groups involving seven different training methods, were extracted and analysed to make a classification of training methods. It was noticed that interventions involving speed, plyometric and resistance training and combined resistance, plyometric and sprint training were observed to produce a statistically significant improvement in speed and agility performance per training session. Sprint training (0.108 ES), plyometric training (0.092 ES), resistance training (0.087 ES), and combined resistance, plyometric, and sprint training (0.078 ES) methods were found to have the highest per session training effect (Forster et al., 2022).

Falch et al. (2019) identified a clear link between the implementation of specific and non-specific training methods for change of direction ability. Specificity of training is a fundamental principle in optimising transference of training to physiological performance. Whether specific training exercises are better for increasing the performance of the change-of-direction skill and is the main concern of the work of Forster et al. (2022). The findings of the analysis provide important insight into the selection of training methods and exercises to develop speed and agility. The authors aimed to examine the training effects of different non-specific and specific training methods on agility performance; and details limitations and future research directions in this field of work (Forster et al. 2022).

According to the statistical analysis in the current study, the experimental group has a significant increase in explosive strength: in the squat jump and counter movement jump, the increase is, 7.47% and 8.05%, respectively, being statistically significant. In the power tests, the results are also statistically significantly better with the following differences between the initial and final testing: in the drop jump by 14.13%, and in the 15" Bosco RJT, with 7.52%.

Performance improvements are much smaller for the control group, with the explosive strength tests showing an increase of 1.33%, which is statistically insignificant at $p > 0.05$, in the case of both the squat jump and counter movement jump, where the increase is by 0.75%. In the power tests, the differences between the initial and final testing are as follows: in the drop jump - 1.05% (statistically insignificant), while in the case of 15" Bosco RJT the situation is the same, the difference being 1.21%.

Therefore, during the 6 weeks of using the two explosive strength circuits in four and three finishing zones, a statistically significant development occurred in the explosive strength and power of the experimental group.

Regarding speed, the performance increase is 6.28% in the 10 m sprint test for the experimental group, while the increase is 4.35% for the control group, with both percentages being statistically significant at $p < 0.05$. In this test, the experimental group has a greater performance increase than the control group, although the control group has better results in terms of performance.

In the 20 m sprint test, the experimental group has a 0.63% increase, which is statistically significant, while the increase is 3.17% (also, statistical significance). In this test, the control group has a significantly better performance improvement compared to the experimental group.

In the 30 m sprint test, the experimental group has a 1.35% (0.06 sec) increase, which is statistically significant, while the increase is 2.80% (0.12 sec) for the control group, being, also, statistically significant. In this test, performance improvement is clearly in favour of the control group. Both the experimental and control groups have improved their performance, but the increase is greater for the control group. Analysing these data we can say that the two proposed circuits are not very suitable for a significant increase in speed.

Performance improvement in agility was assigned, as in other dynamic tasks, to neurological adaptations. However, because of the complex and different manifestations, other factors appear to contribute to agility (Blejan et al., 2019). A recent study confirmed that agility is significantly correlated with speed in both genders, with power in women and with balance in men (Sekulic et al., 2013).

The study of González-Fernández et al. (2021) purpose to examine the effects of a ten-week coordination training program applied to soccer on different tests that evaluate speed (30 m speed test), agility (Illinois Agility Test (IAT)) and lower body strength (countermovement jump (CMJ). Forty U16 male soccer players participated, from two nonprofessional teams (twenty in the control group – CG, aged = 14.70 ± 0.47, body weight = 60.15 ± 8.07 kg, height = 1.71 ± 0.06 m) and twenty in the experimental group – EG, aged = 14.50 ± 0.51, body weight = 58.08 ± 9.78 kg, height = 1.69 ± 0.06 m). They performed a combined coordination and agility program during 10 min every training day (3 days a week) for 10 weeks. The results of this study showed that coordination training produced adaptations in the power (CMJ of EG - $p = 0.001$) and agility capacities (IAT of EG - $p = 0.002$) of young soccer players, but not on speed performance at longer distances (CG, $p = 0.20$ and EG, $p = 0.09$). Despite the benefits of the training program, a combination of training methods that includes power, agility, speed, and strength can enhance such improvements (González-Fernández et al., 2021).

In the Illinois Agility Test, the experimental group has a 1.65% increase, which is statistically significant, while the increase is 0.38% for the control group (being, also, statistically significant). As regards the agility parameter, there is a clear significant increase in performance for the experimental group.

Conclusions

Following the research, some conclusions could be drawn. In terms of explosive strength and power parameters, there are no statistically significant differences between the two groups in the initial testing. However, in the final testing, the situation changed, the difference between groups being statistically significant in explosive strength tests, while the differences in power tests, although they still remain insignificant, indicate improvements in favour of the experimental group despite the fact that it was behind the control group in the initial testing. Therefore, the application of this training programme over a longer period can lead to significant performance gains in explosive strength and power.

Concerning travel speed there is an improvement in performance after the experimental intervention. However, for 20 m and 30 m sprints other integrated training methods should be found (the two proposed circuits have more limitations in these situations, after comparing the results of the experimental group with the values obtained by the control group, at the initial and final testing).

For the Illinois Agility Test, the results are clearly in favour of the experimental group, and thus we can assimilate these two circuits into training themes for the development of agility, which, together with the technical gesture, can provide an effective means for the training of coordination skills.

It can be stated that the two proposed circuits are effective in training lessons with themes addressing the development of combined speed-strength and power-strength motor skills, as well as the development of coordination skills such as agility and spatiotemporal orientation. For the development of travel speed in conditions of maximum speed and endurance, these circuits are not necessarily recommended in terms of improving athletes’ results.

The utility of this research is to demonstrate that plyometric training integrated with sprints and technical gesture can bring greater improvements in explosive actions performance, compared with dedicated technical individualization training without the physical component or vice versa.

In practical terms, the current research aims to demonstrate that plyometric training combined with football training can lead to an increase in the number of very high-intensity actions compared to classic training where the physical factor is separated from the technical one. Combined speed-strength and power-strength motor skills, such as vertical jumps involving the stretch-shortening cycle (SJ, CMJ), acceleration speed (10 m) and agility, significantly improved for the experimental group. These gains can be essential for winning duels during match play because can be transferred into in-game performance.

No injuries were reported during this type of training; however, coaches should consider progressive increases in training load and ensure that exercises are performed on soft landing surfaces to reduce player injury. Further research should use video analysis and the OptoJump Next multi-modular system to determine possible decreases in ground contact time after a plyometric training programme.

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