Original Article

doi: 10.16926/par.2023.11.23

The comparison of plyometric and speed training effect on speed abilities of soccer players: pilot study

Marian Skorik ABCDE **David Brunn** AB, **Roman Svantner** AB, **Pavol Pivovarniček** CDF

Department of Physical Education and Sports, Faculty of Arts, Matej Bel University, Banská Bystrica, Slovakia

Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract: *Introduction:* The aim of the study was to compare the impact of 6 weeks plyometric intervention training (PIT) and speed intervention training (SIT) on the stimulation of speed abilities (indicators) of soccer players. *Methods:* Research group was uniformly divided to experimental sample 1 (n=7, graduated PIT) and experimental sample 2 (n=7, graduated SIT). The indicators of linear running speed were measured by 5m, 10m, 30m sprinting. 5-10-5 test was used to measure indicators of running speed with changes of direction, where the following have been recorded: (5-0-5L) 5m left side sprint from the start, change of direction, 5m sprint (5-0-5L); 5m sprint from the start, change of direction, 10m sprint, change of direction and 5m left side sprint to the finish (5-10-5L); 5m right side sprint from the start, change of direction, 5m sprint (5-0-5R); 5m sprint from the start, change of direction, 10m sprint, change of direction and 5m right side sprint to the finish (5-10-5R). *Results:* Intergroup comparisons of pretest-posttest (PRE-POST) differences between PIT and SIT have not revealed significant difference ($p>0.05$) in any of the speed indicators tests. In two indicators of linear speed, we observed PRE-POST differences with a medium effect in favour of SIT (5m; 10m) in one indicator (30m) in favour of PIT. In two indicators of speed with changes of direction PRE-POST differences with a large effect (5-10-5L; 5-0-5R) have been noted in favour of SIT. In two other indicators (5-0-5L; 5-10-5R) PRE-POST differences between PIT and SIT have been noted without any difference effect. *Conclusion*: The results of the pilot study revealed a positive effect of both PIT and SIT on the stimulation of the speed abilities of soccer players and indicate tendencies in favour of SIT, which is needed to be verified with larger research samples.

Keywords: soccer players, plyometric intervention training, speed intervention training, speed abilities, speed indicators

Corresponding author: Pavol Pivovarnicek, e-mail: palopivo@gmail.com

Recevied: 10.04.2023; Accepted: 6.05.2023; Published online: 17.05.2023

Citation: Skorik M, Brunn D, Svantner R, Pivovarniček P. The comparison of plyometric and speed training effect on speed abilities of soccer players: pilot study. Phys Act Rev 2023; 11(2): 75-85. doi: 10.16926/par.2023.11.23

INTRODUCTION

Soccer is a team sport dominated by acyclic movement activities of explosive nature. It is typical for soccer to feature repeated intensive activities, placing high demands on both the anaerobic and aerobic energy systems [1,2,3] such as acceleration, deceleration, change of direction, jumps, and bound. The key abilities during accelerating and decelerating are to move quickly, to change the direction and speed of movement. [4]. The main physiological factors are the combination of endurance and speed, like repeated short sprints; moreover, current soccer increases strength and power requirements [5]. The development of speed, agility, strength with combination of aerobic and anaerobic (even maximal) abilities is important for successful, competitive football careers [6,7]. These high-intensity activities appear at irregular intervals and at unequal volume indicators (distance covered) during different types of physical activity, e.g., running sideways, backwards, with and without a ball, accelerating and decelerating [8]. The current trend points to the acceleration of the pace of the game, which may cause a further increase in energy demands presented in the collected comparison data from the 2006/2007 and 2012/2013 seasons in the English Premier League. The authors [9] note a ~2% increase in the total match distance and a ~30% increase in high intensity runs. The challenge for strength and conditioning specialists remains to stimulate the players' strength and condition skills so that they can withstand the demands of the match and simultaneously develop the speed abilities crucial for soccer. A soccer player sprints between 17 and 81 times during a match, with an average duration of 2-4 seconds, while many sprints are shorter than 20 meters [10]. At first sight the distance covered by a sprint may seem insignificant which is 2-3% of the total distance at a pace faster than 25 km/h [3]. However, in the study [11], the authors, analysing 360 goal-scoring situations of the German Bundesliga in the 2007/2008 season, evaluated a linear sprint as the most frequent action (45%) preceding the goal, followed by a jump (16%) and a sprint with a change of direction or rotation (6% each). The speed difference is easily observable even in defensive activity. In practice, 30-50 cm (~0.04-0.06 s at 20 meters) is a sufficient difference for a player in a one-on-one situation so he can move his shoulder in front of the opponent and thus make it impossible for him to handle the ball [10]. HSR (high-speed running) and sprint training play an important role not only in the development of physical abilities and sports performance in soccer, but also in the prevention of injuries [12]. A study [13] reported that up to 57% of hamstring injuries occur because of sprinting, Hamstring injuries are the most common injury in soccer. "Sprinter-type" injuries are most likely to occur during eccentric muscle contraction in the late swing phase of the running stride cycle [14]. The chronic inclusion of sprints to the training process in an adequate amount can have a beneficial effect on the prevention of injuries [15]. To be a faster player is a proven advantage, leading to further research focused on speed development using different methods, such as standard speed training, sprint drills, resistance sprinting, resistance strength training and plyometric training [16].

Our study primarily deals with the plyometric method of stimulating speed indicators and its effectiveness in comparison with a specific speed training program. Plyometrics is a training method consisting of exercises in which the muscles produce a high level of force in the shortest possible time. Such exercises are various types of jumps characterized by a sudden stretching of the muscle (eccentric phase), energy accumulation and subsequent sharp shortening (concentric phase) of the same muscle, resulting in explosive movement in the take-off. This mechanism is called stretch-shortening cycle – SSC. The advantage of SSC compared to the slower concentric contractions typical for strength training is the storage of elastic energy in the muscle-tendon apparatus after rapid deceleration of the mass (e.g., body weight, medicine ball). The stored energy in the stiff tendon creates a spring effect resulting in an explosive movement in the opposite vertical direction from the surface [17]. Conditioning activities such as resistance training can cause excitation of central nervous system resulting in Post-activation Potentiation phenomenon. Plyometric exercise also has an important role in developing Post-activation Potentiation following a resistance stimulus [18]. Several studies have indicated a positive effect of plyometric exercises on the development of speed skills [17,19,20,21]. However, most authors agree that the principle of specificity must be preserved for a favourable transfer [22,23]. For example, "bounds" are a suitable exercise for the development of horizontal force production typical for the initial phase of sprinting, while vertical jumps are aimed primarily for the development of vertical force, often observed during jumps in volleyball or basketball [16,23]. The exact mechanism and effectiveness of specific transfer is still under research, so plyometric exercises in multiple levels are generally preferred. Some research suggests even greater effect of a plyometric program during the first 20 meters of a sprint compared to standard sprint training [17]. The ground contact time during sprinting and plyometrics is comparable in the initial phases of sprinting, but the ground reaction force (GRF) is higher in plyometrics [17].

We assume that both PIT and SIT will produce adaptations that increase performance in both linear speed and speed with change of directions. The results of a study [20] comparing a plyometric and sprinting 6-week program have showed that the sample implementing the sprinting program managed to achieve greater improvements. However, the study was dealing with linear speed. In our study, in addition to indicators of linear running speed, we aim to focus on indicators of running speed with changes of direction. For these reasons, the aim of our pilot study is to compare the effect of 6-week plyometric intervention training (PIT) and speed intervention training (SIT) on the stimulation of indicators of linear speed and speed with changes of direction. Based on the results of the study [20], we assume SIT to have a greater effect on linear speed indicators compared to PIT. In terms of comparing the effect of PIT and SIT for speed indicators with changes of directions we have left the question open.

MATERIAL AND METHODS

Participant

After performing the speed indicators pretest, the sample of soccer players (n=14, age = 22.5±3.7 years, height = 180.2±6.4 cm, weight = 75.2±5.0 kg) was deliberately divided into two performance-homogeneous, mutually referential experimental samples. Experimental sample 1 (ES1, n=7, age = 23.7±4.4 years, height = 179.7±6.2 cm, weight = 76.0±5.1 kg) implemented plyometric intervention training (PIT) with the participation of 79.8±10.6% of completed PIT content. Experimental sample 2 (ES2, n=7, age = 21.3±1.6 years, height = 180.7±6.0 cm, weight = 75.2±3.4 kg) implemented speed intervention training (SIT) with the participation 77.4±7.9% of completed SIT content. The criteria for research inclusion evaluations for each soccer player: completion of pretest and posttest in a satisfactory state of health; participation in at least 8 out of 12 training units (2/3 intervention = 66.7%) within PIT (ES1) and SIT (ES2). Due to the failure to meet some inclusion criteria, five soccer players have not been included in the research evaluations. The players signed an informed consent to the anonymous publication of the results for research purposes. Measurements were carried out in accordance with the ethical standards of the Declaration of Helsinki and the ethical standards in sport and exercise science research [24].

Organization of research

The pretest (PRE) was carried out on Wednesday, June 22, 2022, at 6:00 p.m. on a surface with synthetic grass. The posttest (POST) was carried out on Wednesday, August 31, 2022, at 6:00 p.m. in an identical environment and similar climatic conditions. According to the RAMP = Raise-Activation-Mobilization-Potentiation protocol [25], a 15-minute warm-up took place before both PRE and POST testing. Due to the objectification of the measurements, the soccer players had a day off before both the PRE and POST with instructions not to perform any physically intense activities.

Prior to the initial testing, we conducted a single training session, which served to practice jumping techniques and landing mechanisms. Despite this, in the first part of the program, we opted for less intense exercises to prepare the tendons and muscles for the stimulus from short-contact plyometric exercises. The aim was to prevent potential injuries due to improper execution, particularly considering that the exercises were a new experience for some of the participants. The short-contact exercises included in the second phase were specific for speed development.

Research of experimental design took place between PRE and POST in the pre-season period and at the beginning of the in-season 2022/2023. Duration of interventions in both ES1 and ES2 was 6 weeks. ES1 performed plyometric intervention training (PIT) and ES2 performed speed intervention training (SIT). Both PIT and SIT were divided into two 3-week phases. In ES1, we kept the volume of take offs (n=108) per training unit throughout the 6 weeks constant, but in the second half of the program we replaced the exercises with more intense ones (with shorter ground contact time). Compared to the first phase, the second phase of the SIT cycle was different in the increase of the volume of sprint distance covered. Rest intervals were set to be approximately 1 minute before every sprint and every plyometric set.

Exercises implemented in weeks 1-3 for ES1:

- Vertical non countermovement jump (bilateral) – 4 x 6,
- Broad jump with countermovement (unilateral) – 3 x 6 + 6,
- Lateral bounds (unilateral) – 4 x 6 + 6,

Exercises implemented in weeks 4-6 for ES1:

- Depth jump (bilateral) – 4 x 6,
- Linear bounds – 3 x 6 + 6,
- Lateral continuous hurdle hops (unilateral) – 2 x 6 + 6,
- Medial continuous hurdle hops (unilateral) – 2 x 6 + 6.

Exercises implemented in weeks 1-3 for ES2:

- Straight-line sprint for 10 meters – 1 x 6,
- Change of direction speed "5-0-5" – 1 x 3+3,
- Curved sprint for 10 meters – 1 x 3 + 3.

Exercises implemented in weeks 4-6 for ES2:

- Straight-line sprint for 15 meters – 1 x 6,
- Change of direction speed "L-drill" – 1 x 3 + 3,
- Curved sprint (sharper angle) for 10 meters – 1 x 3 + 3.

Under our guidance, the players performed two training units per week in accordance with the research objectives, focusing on PIT in ES1 and SIT in ES2. The first half of the training unit was intended for warm-up and completing of our program (PIT in ES1/SIT in ES2). The second half of training session was focused on game drills under the guidance of the head coach. In the intervention period, in addition to the PIT/SIT training units, 1-2 training units per week were performed under the leadership of the head coach, focusing on technical and tactical activities not related to the aim of the study. During each training session, the researchers provided verbal instructions and encouragement to ensure that the exercises were performed correctly with maximum effort. The exercises included in the intervention period are presented in Table 1 with a detailed description of the load.

Measurement

In the pretest (PRE) and posttest (POST) in Experimental Sample 1 (ES1) and Experimental Sample 2 (ES2), we evaluated speed indicators divided into linear speed indicators and speed indicators with changes of direction. Linear speed indicators were measured by linear 5m, 10m, 30m 2 - point autonomous sprint start without external stimuli. 5-10-5 test was used to measure speed indicators with changes of direction and

Table 1. Load indicators during the intervention in Experimental Sample 1 and Experimental Sample 2.

Week	Experimental Sample 1 (n=7)			Experimental Sample 2 (n=7)		
	Exercise	Sets x Reps	Contacts (per week)	Exercise	Sets x Reps	Distance (per week)
1	Vertical NCM jump	4x6	24	10m sprint	1x6	60m
	Broad jump	3x6+6	36	CoD 5-0-5	1x3+3	60m
	Lateral bound	4x6+6	48 (2x108)	Curve sprint	1x3+3	60m (2x180m)
2	Vertical NCM jump	4x6	24	10 m sprint	1x6	60m
	Broad jump	3x6+6	36	CoD 5-0-5	1x3+3	60m
	Lateral bound	4x6+6	48 (2x108)	Curve sprint	1x3+3	60m (2x180m)
3	Vertical NCM jump	4x6	24	10 m sprint	1x6	60m
	Broad jump	3x6+6	36	CoD 5-0-5	1x3+3	60 m
	Lateral bound	4x6+6	48 (2x108)	Curve sprint	1x3+3	60m (2x180m)
4	Depth jump	4x6	24	15 m sprint	1x6	90m
	Linear bounding	3x6+6	36	CoD L- drill	1x3+3	90m
	Medial hurdle hops	2x6+6	24	Curve sprint	1x3+3	60m (2x240m)
	Lateral hurdle hops	2x6+6	24 (2x108)	-	-	--
5	Depth jump	4x6	24	15m sprint	1x6	90m
	Linear bounding	3x6+6	36	CoD L- drill	1x3+3	90m
	Medial hurdle hops	2x6+6	24	Curve sprint	1x3+3	60m (2x240m)
	Lateral hurdle hops	2x6+6	24 (2x108)	-	-	-
6	Depth jump	4x6	24	15m sprint	1x6	90m
	Linear bounding	3x6+6	36	CoD L-drill	1x3+3	90m
	Medial hurdle hops	2x6+6	24	Curve sprint	1x3+3	60m (2x240m)
	Lateral hurdle hops	2x6+6	24 (2x108)	-	-	-

CoD – Change of direction

the following were recorded: (5-0-5L) 5m left side sprint from the start, change of direction, 5m sprint (5-0-5L); split time 5-10-5 L; 5m sprint from the start, change of direction, 10m sprint, change of direction and 5m left side sprint to the finish (5-10-5L); 5 m right side sprint from the start, change of direction, 5m sprint (5-0-5R); - split time 5-10-5R; 5m sprint from the start, change of direction, 10m sprint, change of direction and 5m right side sprint to the finish.

In 5-10-5 test, players started with the hand placed on surface. Autonomous sprint started without external stimuli in the direction of the hand that was on the surface. Players were instructed to touch the surface with their chosen hand and foot beyond the tape marked boundary (5 meters from the center line/start).

All speed indicators were measured with Fitro Light Gates photocells (Fitronic, Slovak republic) with an accuracy of 0.001 seconds. Two attempts were made in all measurements of speed indicators. For the evaluation, the best of the attempts was noted.

Data analysis

A Paired Samples T Test was used to determine the significance of the differences between the pretest (PRE) and posttest (POST) measurements in the examined speed indicators in Experimental Sample 1 (ES1) and Experimental Sample 2 (ES2). Between-group comparisons of PRE-POST differences between ES1 and ES2 were performed using the Independent Samples T Test, in case of rejection of the normality of data distribution, the Mann-Whitney U test was used. The effect size within the Paired Samples T Test and Independent Samples T Test procedure was evaluated by the Cohen coefficient d, which was interpreted using the cut-off values as follows: d = 0.20 - small effect, d = 0.50 -

medium effect, *d* = 0.80 - large effect [26]. The coefficient *r* [27] was used to evaluate the effect size within the Mann-Whitney U test procedure, which was interpreted using the cut-off values as follows: *r* = 0.10 - small effect, *r* = 0.30 - medium effect, *r* = 0.50 - large effect [26]. The normality of the data distribution in the examined speed indicators was verified by the Shapiro-Wilk test. The probability of error type I. was set to the conventional value α = 0.05 in all analyses. Statistical analysis was performed using computer software IBM® SPSS® Statistics V28 and Microsoft® Office Excel 2016.

RESULTS

In ES1 (Table 1) are presented improvements between the pretest (PRE) and the posttest (POST with a medium effect in linear speed indicators) (5m: *d* = 0.55; 10m: *d* = 0.50; 30m: *d* = 0.70), although statistical significance of these improvements has not been recorded (p>0.05). Statistically significant improvement (p<0.05) has been noted between PRE-POST in speed indicators with changes of direction, with a large effect in two indicators (5-0-5L: *d* = 1.53; 5-10-5L: *d* = 2.43), in one case, a PRE-POST improvement has been noted with a large effect (5-10-5R: *d* = 0.81), but without statistical significance of the change (p>0.05). In the 5-0-5R indicator, we can see an improvement between PRE-POST with a medium effect (*d* = 0.75), which has not been statistically significant (p>0.05).

In ES2 (Table 2), are presented statistically significant improvements (p<0.05) in linear speed indicators PRE-POST with a large effect (5m: *d* = 1.24; 10m: *d* = 1.68), while in the 30m indicator no statistically significant PRE-POST difference has been recorded (p>0.05) and the improvement effect was small (*d* = 0.25). A statistically significant improvement (p<0.05) with a large effect has been noted between PRE-POST in all speed indicators with changes of direction.

Intergroup comparisons of PRE-POST differences between ES1 and ES2 (Table 4) did not show a statistically significant difference (p>0.05) in any of the speed indicator tests. In two indicators of linear speed, PRE-POST improvements (p>0.05) are presented with a medium effect in favour of ES2 (5m: *d* = 0.58; 10m: *r* = 0.40), one in favour of ES1 (30m: *d* = 0.78). In two indicators of speed with changes of direction, PRE-POST differences with a large effect (5-10-5L: *d* = 0.84; 5-0-5R: *d* = 1.14) are presented in favour of ES2, while in two others are PRE-POST differences in ES1 and ES2 almost identical with no difference effect (5-0-5L: *d* = 0; 5-10-5R: *d* = 0.11).

Table 2. Values of speed indicators and statistical analysis between pretest and posttest in Experimental Sample 1 (ES1, n=7).

Speed indicator	Pretest (PRE)	Posttest (POST)	t-test	Effect size (ES)		PRE-POST improvement
	M (*SD*)	*M* (*SD*)		ES value	ES level	
5m [s]	1.016 (0.063)	1.010 (0.058)	t = 1.441	*d* = 0.55	medium	0.8%
10m [s]	1.740 (0.072)	1.727 (0.072)	t = 1.333	*d* = 0.50	medium	0.6%
30m [s]	4.117 (0.133)	4.037 (0.192)	t = 1.838	*d* = 0.70	medium	2.0%
5-0-5L [s]	2.714 (0.050)	2.577 (0.121)	t = 4.034*	*d* = 1.53	large	5.1%
5-10-5L [s]	5.200 (0.073)	5.081 (0.109)	t = 6.429*	*d* = 2.43	large	2.3%
5-0-5R [s]	2.711 (0.919)	2.624 (0.057)	t = 1.975	*d* = 0.75	medium	3.1%
5-10-5R [s]	5.219 (0.177)	5.073 (0.056)	t = 2.130	*d* = 0.81	large	2.7%

5m = 5m sprint; 10m = 10m sprint; 30m = 30m sprint; 5-0-5L = split time in 5-10-5L test; 5-10-5L = left side sprint; 5-0-5L = split time in 5-10-5R test; 5-10-5R = right side sprint; s = seconds; *M* = Mean; *SD* = standard deviation; t = the value of the test criterion of Paired Samples T Test; * = statistical significance α = 0.05 (p<0.05); *d* = Cohen's coefficient.

Table 3. Values of speed indicators and statistical analysis between pretest and posttest in Experimental Sample 2 (ES2, n=7).

Speed indicator [s]	Pretest (PRE)	Posttest (POST)	t-test	Effect size (ES)		PRE-POST improvement
	M (*SD*)	*M* (*SD*)		ES value	ES level	
5m	1.014 (0.061)	0.997 (0.058)	t = 3.286*	*d* = 1.24	large	1.7%
10m	1.766 (0.046)	1.729 (0.043)	t = 4.437*	*d* = 1.68	large	2.1%
30m	4.214 (0.125)	4.203 (0.101)	t = 0.658	*d* = 0.25	small	0.3%
5-0-5L	2.749 (0.073)	2.611 (0.076)	t = 3.827*	*d* = 1.45	large	4.9%
5-10-5L	5.237 (0.106)	5.023 (0.160)	t = 3.701*	*d* = 1.40	large	4.1%
5-0-5R	2.847 (0.072)	2.629 (0.061)	t = 5.031*	*d* = 1.90	large	7.6%
5-10-5R	5.249 (0.049)	5.112 (0.070)	t = 7.446*	*d* = 2.81	large	2.5%

5m = 5m sprint; 10m = 10m sprint; 30m = 30m sprint; 5-0-5L = split time in 5-10-5L test; 5-10-5L = left side sprint; 5-0-5L = split time 5-10-5R test; 5-10-5R = right side sprint; s = seconds; *M* = Mean; *SD* = standard deviation; t = the value of the test criterion of Paired Samples T Test; * = statistical significance α = 0.05 (p<0.05); *d* = Cohen's coefficient.

Table 4. Statistical evaluation of differences in examined speed indicators between Experimental Sample 1 (ES1, n=7) and Experimental Sample 2 (ES2, n=7).

Speed indicator [s]	PRE-POST improvement (ES1)	PRE-POST improvement (ES2)	t-test; Mann-Whitney test	Effect size (ES)		DifferencesPRE-POST ES1 vs ES2
	M (*SD*)	*M* (*SD*)		ES value	ES level	
5m	0.009 (0.016)	0.017 (0.014)	t = -1.083	*d* = 0.58	medium	0.9% ES2
10m	0.011 (0.023)	0.037 (0.022)	Z = -1.503	*r* = 0.40	medium	1.5% ES2
30m	0.080 (0.115)	0.011 (0.046)	t = 1.463	*d* = 0.78	medium	1.7% ES1
5-0-5L	0.137 (0.090)	0.137 (0.095)	t = 0	*d* = 0	no effect	0.2% ES1
5-10-5L	0.119 (0.049)	0.214 (0.153)	t = -1.575	*d* = 0.84	large	1.8% ES2
5-0-5R	0.087 (0.117)	0.219 (0.115)	t = -2.123	*d* = 1.14	large	4.5% ES2
5-10-5R	0.146 (0.181)	0.131 (0.047)	t = 0.202	*d* = 0.11	no effect	0.2% ES1

5m = 5m sprint; 10m = 10m sprint; 30m = 30m sprint; 5-0-5L = split time in 5-10-5L test; 5-10-5L = left side sprint; 5-0-5L = split time in 5-10-5R test; 5-10-5R = right side sprint; s = seconds; *M* = Mean; *SD* = standard deviation; t = the value of the test criterion of Independent Samples T Test; Z = the value of the test criterion of Mann-Whitney U test; *d* = Cohen's coefficient; *r* = coefficient of effect size of Mann-Whitney U test. Note: The values in the "PRE-POST improvement" columns are presented in positive numbers, even though there was a decrease in sprinting times between PRE-POST, which means an increase in performance in speed indicator tests.

DISCUSSION

In connection with the formulated assumptions, the most significant finding of the implemented pilot study is the fact that both training programs, plyometric intervention training (PIT) and speed intervention training (SIT) had a positive effect on the stimulation of the speed abilities (speed indicators) of soccer players in the 6 weeks intervention period which is consistent with findings [17,20,28], although the improvements are at the level of 0.3% to 7.6%. We consider the 6-week duration of the intervention period to be long enough for new adaptations and improvements in speed abilities [19,29].

Concerning plyometrics, the authors [17] have been observing the most significant improvement after plyometric intervention in the initial phase of the sprint (0-10m) which does not comply with our findings, where in terms of linear running speed, presented improvements are at 5m of 0.8%, at 10m by 0.6% and at 30m by 2.0%, which is an improvement with a medium effect in all indicators. Surprisingly, the most significant improvement has been noted in the 10-30m. For a clear justification the data of stride length and ground reaction force produced in individual phases of sprint and running technique would be needed. We consider insufficient strength training of the players to be the reason for slower take off (0-5m). In a maximal back squat, it is possible to produce a GRF exceeding 5000N [30], while in a countermovement jump or depth jump - 2500N [31]**.** We assume that the reason for more significant improvement in the later part of the sprint in ES1 could have been affected by GRF development of the plyometric program (PIT). An increase in GRF results in a running stride lengthening, which is not demonstrated sufficiently at shorter distances if an adequate amount of force is not produced in the first running steps. Compared to the results of [17,20], the level of improvement in ES1 after completing PIT is lower despite the little experience our players have with plyometrics. We justify the insufficiency of the effect by the complexity of the chosen PIT (exercises for horizontal, vertical, lateral, medial force production). When including plyometrics in the training process, it is important to consider several factors, such as the biological age, training age and player 's experience. The effectiveness of the intervention depends on variables related to the volume, intensity, duration of the intervention program, the chosen in-season/preparation period and above all the choice of specific exercises. . In the running speed indicators test with changes of direction after completing the PIT, improvements from 2.3% to 5.1% are presented, meaning that except for one case an improvement with a large effect is presented, in two cases we deal with statistically significant ($p<0.05$).

In terms of linear speed indicators, after performing SIT the opposite effect occurred in ES2 than in ES1 after performing PIT. In 30m sprint an improvement only at the level of a small effect (0.3%) is noted. On the other hand, statistically significant improvements ($p<0.05$) with a large effect (5m: 1.7%; 10m: 2.1%) are noted in 5m and 10m sprints. Even in speed indicators with changes of directions, the improvements were statistically significant ($p<0.05$) with a large effect in the range of 2.5% to 7.6%.

In the context of the aim of the study, which was to compare the effect of 6-week PIT and SIT on the stimulation of speed indicators of soccer players, it can be concluded that in two of the three indicators of linear speed (5m and 10m), SIT was more effective compared to PIT, whereas the opposite situation occurred in 30m sprint. A higher efficiency of SIT was recorded in the indicators of running speed with changes of direction, in the other two the efficiency of PIT and SIT was practically identical. Our study addressed the stimulation of speed indicators. Measurements of change of direction (COD) performance and agility consider the total time to complete various agility tests, or the mean speed achieved over a specific distance used in the test. Unfortunately, most tests involve linear sprinting. It is hard to assess whether a player is agile or just fast [32]. Based on the statement, we carried out measurements with tests of linear speed and speed with changes of direction.

The most studied tests were classified as linear-sprint tests and change-of-direction sprint tests. In terms of construct validity, the majority of studies report faster sprint times in favour of the higher-level players compared to the lower-level players. Linear-sprint tests over various distances (5 to 40m) can be used to determine acceleration and maximal speed. Thereby, such tests have shown ability to distinguish between playing levels, to correlate with sprint-related parameters during matches, and to possess high levels of reliability. It might be concluded that all distances investigated (from 5 to 30m) seem to be equally important in soccer, even though short sprints and accelerations (e.g., 10m) occur more frequently than longer sprints (e.g., 30m) during matches [33]. Maximal speed testing protocols are generally underrepresented in soccer compared to acceleration tests and changes of direction speed tests. However, the selection of tests is closely related to the player's position and can serve as an adequate tool for the coach. Although tests for speed with change of direction, including the 5-0-5 test do not imply match demands, their confirmed construct validity and reliability through several studies allow their usage as long specific tests for match demands are thoroughly evaluated.

As one of the research limits we consider the absence of a control sample, which could be another reference to the experimental sample. On the other hand, our study was conducted on soccer players in the training process. A control sample would require taking only the pretest and posttest without any intervention, which in competitive soccer during the duration of our interventions (a period of 6 weeks) is not possible. The influence of body weight on speed abilities is crucial. Our study does not include changes in somatic indicators of body weight or muscle mass in soccer players during the experimental period. Therefore, it is not possible to determine how any potential change may have affected the outcome of speed tests. Additionally, the size of the sample is not sufficiently large. We attempted to compensate for this by ensuring homogeneity within the sample and by conducting the training sessions at the same time and location to provide the most similar conditions for both groups. In our study, we focused on speed abilities, and the tests were chosen to evaluate speed performance. The research does not include strength tests, even though strength significantly correlates with speed capabilities.

Contribution to a more accurate comparison of the effects of PIT and SIT would be 100% participation and performance of all training units in PIT and SIT. Our groups completed interventions with similar participation (ES1 = PIT = 79.8±10.6%; ES2 = SIT = 77.4±7.9%). In further research, we recommend increasing the number of soccer players in the experimental samples, specifying the exercises for the chosen direction of movement, where the adaptation should occur (linear speed or the speed with the changes of direction) and identifying the adaptation mechanism, for example, using the GRF variables, the length of the running step and the ground contact time.

CONCLUSION

In modern soccer, we deal with effort to improve all processes in sport's preparation and training as much as possible. Speed abilities (indicators) are among the key components of a player's performance which consequently limits the team's performance. The aim of the pilot study was to compare the effect of 6-week plyometric intervention training (PIT) and speed intervention training (SIT) on stimulating the speed abilities (speed indicators) of soccer players in terms of linear running speed and speed with changes of direction. The results of the pilot study showed a positive effect on the stimulation of speed indicators of soccer players in both 6-week PIT and SIT and indicate tendencies in favour of SIT in terms of both linear speed and speed with changes of direction. These results are affected by the pilot study limitations thus verification of larger samples is needed. The results of the pilot study are suitable for meta-analyses and indicate the importance of further investigation of the subject.

Acknowledgment: This work was supported by the Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banska Bystrica..

Conflicts of Interest: The authors declare that they have no conflict of interest. Each of the authors has read and concurs with the contact in the final manuscript. This study did not receive financial support. All authors read and approved the final version of the manuscript.

REFERENCES

1. Stølen T, Chamari K, Castagna C, Wisløff U. Physiology of soccer: an update. Sports Med. 2005; 35: 501-536. doi: 10.2165/00007256-200535060-00004
2. Bangsbo J. Physiological demands of football. Sports Sci Exchange. 2014; 27: 1-6.

3. Dolci F, Hart NH, Kilding AE, Chivers P, Piggott B, Spiteri T. Physical and Energetic Demand of Soccer: A Brief Review. Strength Cond J. 2020; 42: 70-77. doi: 10.1519/SSC.0000000000000533
4. Horicka P, Simonek J. Age-related changes of reactive agility in football. Phys Act Rev 2021; 9: 16-23. doi: 10.16926/par.2021.09.03
5. Petr M, Thiel D, Kvapilová K, Brož P, Malý T, Zahálka F, Vostatková P, Wilk M, Chycki J, Stastny P. Speed and power-related gene polymorphisms associated with playing position in elite soccer players. Biol Sport. 2022; 39: 355-366. doi: 10.5114/biolsport.2022.105333
6. Bangsbo J. Fitness training in football: a scientific approach. August Krogh Inst., University of Copenhagen; 1994
7. Bujnovsky D, Maly T, Ford KR, Sugimoto D, Kunzmann E, Hank M, Zahalka F. Physical Fitness Characteristics of High-level Youth Football Players: Influence of Playing Position. Sports (Basel). 2019; 7: 46. doi: 10.3390/sports7020046. Erratum in: Sports (Basel). 2019; 7
8. Malý T, Zahálka F, Malá L, Teplan J. Profile, correlation and structure of speed in youth elite soccer players. J Hum Kinet. 2014; 40: 149-159. doi: 10.2478/hukin-2014-0017.
9. Bush M, Barnes C, Archer DT, Hogg B, Bradley PS. Evolution of match performance parameters for various playing positions in the English Premier League. Hum Mov Sci. 2015; 39: 1-11. doi: 10.1016/j.humov.2014.10.003
10. Haugen T, Tønnessen E, Hisdal J, Seiler S. The role and development of sprinting speed in soccer. Int J Sports Physiol Perform. 2014; 9: 432-441. doi: 10.1123/ijspp.2013-0121
11. Faude O, Koch T, Meyer T. Straight sprinting is the most frequent action in goal situations in professional football. J Sports Sci. 2012; 30: 625-631. doi: 10.1080/02640414.2012.665940
12. Beato M, Drust B, Iacono AD. Implementing High-speed Running and Sprinting Training in Professional Soccer. Int J Sports Med. 2021; 42:295-299. doi: 10.1055/a-1302-7968
13. Woods C, Hawkins RD, Maltby S, Hulse M, Thomas A, Hodson A; Football Association Medical Research Programme. The Football Association Medical Research Programme: an audit of injuries in professional football--analysis of hamstring injuries. Br J Sports Med. 2004; 38: 36-41. doi: 10.1136/bjsm.2002 .002352
14. Gronwald T, Klein C, Hoenig T, Pietzonka M, Bloch H, Edouard P, Hollander K. Hamstring injury patterns in professional male football (soccer): a systematic video analysis of 52 cases. Br J Sports Med. 2022; 56: 165-171. doi: 10.1136/bjsports-2021-104769
15. Malone S, Owen A, Mendes B, Hughes B, Collins K, Gabbett TJ. High-speed running and sprinting as an injury risk factor in soccer: Can well-developed physical qualities reduce the risk? J Sci Med Sport. 2018; 21: 257-262. doi: 10.1016/j.jsams.2017.05.016
16. Sáez de Villarreal E, Requena B, Cronin JB. The effects of plyometric training on sprint performance: a meta-analysis. J Strength Cond Res. 2012; 26: 575-584. doi: 10.1519/JSC.0b013e318220fd03
17. Rimmer E, Sleivert G. Effects of a Plyometrics Intervention Program on Sprint Performance. J. Strength Cond Res. 2000; 14: 295-301
18. Haris MH, Moazzam HK, Tarushi T, Nida I, Shibili N. Acute effects of weighted plyometric exercise on sprint, agility and jump performance in university football players. Phys Act Rev 2021; 9: 1-8. doi: 10.16926/par.2021.09.01
19. Lockie RG, Murphy AJ, Schultz AB, Knight TJ, Janse de Jonge XA. The effects of different speed training protocols on sprint acceleration kinematics and muscle strength and power in field sport athletes. J Strength Cond Res. 2012; 26: 1539-1550. doi: 10.1519/JSC.0b013e318234e8a0
20. Lockie RG, Murphy AJ, Callaghan SJ, Jeffriess MD. Effects of sprint and plyometrics training on field sport acceleration technique. J Strength Cond Res. 2014; 28: 1790-1801. doi: 10.1519/JSC.0000000000000297
21. Davies G, Riemann BL, Manske R. Current concepts of plyometric exercise. Int J Sports Phys Ther. 2015; 10: 760-786.
22. Sale D, MacDougall D. Specificity in strength training: a review for the coach and athlete. Can J Appl Sport Sci. 1981; 6: 87-92
23. Young W. Plyometrics: Sprint bounding and the sprint bound index. Strength Cond J. 1992; 14: 18-22.
24. Harriss DJ, Atkinson G. Ethical Standards in Sport and Exercise Science Research: 2016 Update. Int J Sports Med. 2015; 36: 1121-1124. doi: 10.1055/s-0035-1565186
25. Jeffreys I. The warm-up: Maximize performance and improve long-term athletic development. Human Kinetics; 2019
26. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum Associates; 1988
27. Corder GW, Foreman DI. Nonparametric Statistics for Non-Statisticians: A Step-by-Step Approach. 2nd ed. Hoboken (NJ): Wiley; 2009
28. Kotzamanidis C. Effect of plyometric training on running performance and vertical jumping in prepubertal boys. J Strength Cond Res. 2006; 20: 441-445. doi: 10.1519/R-16194.1

29. Kristensen GO, van den Tillaar R, Ettema GJ. Velocity specificity in early-phase sprint training. J Strength Cond Res. 2006; 20: 833-837. doi: 10.1519/R-17805.1
30. Zink AJ, Perry AC, Robertson BL, Roach KE, Signorile JF. Peak power, ground reaction forces, and velocity during the squat exercise performed at different loads. J Strength Cond Res. 2006; 20: 658-664. doi: 10.1519/R-16264.1
31. Jensen RL, Ebben WP. Quantifying plyometric intensity via rate of force development, knee joint, and ground reaction forces. J Strength Cond Res. 2007; 21: 763-767. doi: 10.1519/R-18735.1
32. Fischerova P, Krosta R, Gołaś A, Terbalyan A,Nitychoruk M, Maszczyk A. Effect of power on agility, linear speed and change of direction deficit in female soccer players. Phys Act Rev 2021; 9: 109-116. doi: 10.16926/par.2021.09.13
33. Altmann S, Ringhof S, Neumann R, Woll A, Rumpf MC. Validity and reliability of speed tests used in soccer: A systematic review. PLoS One 2019; 14: e0220982. doi: 10.1371/journal.pone.0220982