The Effects of Plyometric Training On the Running Speed in Soccer

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ABSTRACT

The plyometric method can be referred to as specific neuromuscular training, which may be used to optimize soccer players' functional status and physical fitness levels. The development of functional strength, which can be repeatedly used under game conditions, is decisive for success in the games themselves. The paper aims to extend knowledge about the effects of plyometric training on running speed among soccer players. Twelve U19 soccer players from the MFK Ružomberok soccer club participated in the experiment. The soccer players performed 10-m, 30-m, and 50-m running tests and an agility T-test. From the viewpoint of determining the efficiency of the plyometric method, the testing also included tests aimed to assess ankle mobility and jump tests with and without countermovement performed with the use of Optogait. The soccer players participated in a 9-week intervention program that included two 30-minute training sessions per week. As regards the effects of plyometric training on running speed, soccer players improved their running speed levels in both acceleration speed and running speed with changes of direction. The results show that these changes are determined by ankle mobility and lower-body explosive power levels..

Keywords: soccer; physical conditioning; running; speed; sports games

INTRODUCTION

Soccer performance requires a diversity of physical attributes and biomotor abilities. In-season training focus is often based on metabolic conditioning activities such as small-sided games, tactical and technical football drills and traditional running drills in order to further develop and maintain aerobic and anaerobic capacity. However, this often comes at the expense of strength training, which may be compromised for additional time on the pitch. Collectively, the literature suggests that strength and power maintenance can be achieved with one strength session per week for soccer players. However, it is important for strength and conditioning coaches to continue the development of strength and power characteristics during in season (Yu, Altieri, Bird, Corcoran & Jiuxiang, 2021). The incorporation of plyometrics into training is essential, and this principle is often referred to as jump training. Takeoff and especially landing (muscle lengthening), amortization transitional phase and subsequent transition into takeoff play a crucial role in learning and perfecting selected exercises (Baechle & Earle, 2000; Bompa & Buzzichelli, 2021). The primary purpose of this method is to create specific conditions for the fastest possible muscle contraction. These conditions include the toning (pretension) of the muscle, which precedes its own active movement. The pretension can be achieved by jumping from a certain height. In the landing phase, an eccentric contraction is activated, due to which muscle tension accumulates, and at the same time, the stretching reflex of the muscle is activated. From this state, the subsequent isokinetic contraction can occur much faster than without previous toning (Havel & Hnízdil, 2009). From the viewpoint of incorporating it into soccer training, the mechanical principle of the plyometric method appears to determine the transfer to specific game skills. Incorporating this method into the training process also depends on joint health and adequate muscle flexibility levels. From the viewpoint of practical application, the most frequent exercises include drop jumps and landings, horizontal and vertical jumps, thrusting and throwing with emphasis on countermovement (Boyle, 2016; Brewer, 2017). By performing these exercises, players may improve their ability to use the elastic energy of the stretch reflex and more effectively stimulate the nervous factors determining the speed of force production. Player performances can be distinguished according to the playing and the movements that can be considered performance-determining in terms of acceleration and deceleration. Acceleration from standing or running, usually associated with a sudden change of direction, is an extreme load on the player's musculoskeletal system, and without targeted intervention and adaptation to such an overload, players are more susceptible to injuries. Terje Ingebrigtsen, Ettema, Hjelde, & Wisløff (2016) found that accelerations contributed to 7–10% of the total player load for all player positions, whereas decelerations contributed to 5–7%. The mean total distance covered over the period of the whole match by all players independent of positional groups is approximately 11 km (Di Salvo et al., 2007; Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010). When making this statement, it is necessary to consider a significant variance, which depends on the playing style, the quality of the opponent, the current match score and other determining factors. It is also necessary to consider alternating low-intensity activities, such as walking, with high-intensity running and repeated sprints. Together with these activities, it is needed to focus on the game specifics, while placing emphasis on game skills. Hipp (2014) has found that as the quality level of the competition increases, players cover a greater total distance during the match at high to maximum speeds and perform a higher number of sprints. At the same time, players cover a smaller distance by walking and slow jogging. Eliáš and Ligday (2022) found that the higher the performance level of the players, the higher the demands on their preparation before the match during the warmup. The purpose of a specific warmup should be aimed at increasing neuromuscular activity along with the simulation of game skills and physical conditioning requirements during a soccer game (Eliáš, 2021). Boyle (2016) emphasizes the need to learn the proper landing and takeoff technique while considering the athlete's somatic parameters and stage of physical development. Plyometrics may be defined as jumping exercises that involve a rapid deceleration of body mass followed immediately by the rapid acceleration of that body mass in an opposing direction. As the transition phase should be as fast as possible, athletes should devote more training to landing and jumping acquisition exercises. The application of the stretch-shortening cycle requires a transition (amortization) phase from 150 to 200 milliseconds. A longer transition phase leads to elastic energy loss (Bílý, Cacek, Kalina, & Sunday, 2017).

METHOD

The purpose of the study was to determine the effects of a 9-week plyometric training on running speed and lower-body explosive power among soccer players. The sample consisted of U19 soccer players included 4 defenders, 4 midfielders, 4 attackers and 1 goalkeeper from the MFK Ružomberok soccer club, which is in the 1st league for the U19 age category. Sample characteristics are presented in Table 1.

Table 1. Sample characteristics

MFK Ružomberok	n	**Age** *(years)*		**BH** *(cm)*		**BW** *(kg)*		**Muscle mass** *(kg)*		**Fat mass** *(kg)*	
		M	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
	12	17.3	0.6	179	6.2	71.1	6.1	36.3	3.2	7.9	1.9

Note. n – sample size; BH – body height; BW – body weight; *M* – arithmetic mean; *SD* – standard deviation

Players participated in the experimental study during the fall part of the season between September 2022 and December 2022. The assessment included body composition analysis with the use of InBody 230. We analyzed body composition using the direct segmental multi-frequency bioelectrical impedance analysis. The parameters measured and assessed included body weight (BW), 2. body fat mass (BFM), 3. skeletal muscle mass (SMM). Players performed physical fitness tests that assessed: 1. ankle mobility (dorsiflexion against a wall), 2. lower-body explosive power using the Optogait device. The Optogait tests included the countermovement jump (CMJ), squat jump (SJ), and 10-second vertical jump test requiring plantar flexion. The parameters recorded during the jump tests included the ground contact time (GCT), flight time (FT), jump height (JH) and jump power (P), 3. running speed tested by 10-m, 30-m, and 50-m dash and agility T-test, which included running forward, rearward, and sideward. The players covered a running distance of 9.14 m (distance between the start line and first cone when sprinting forwards) and 4.57 m (distance between the middle cone and lateral cones when shuffling to the left or right). The Witty Kit 4 photocells were used to measure time.

The intervention program consisted of three parts: 1. 3-week mesocycle consisting of preparatory and landing exercises, 2. 3-week mesocycle consisting of follow-up jump exercises, 3. 3-week mesocycle consisting of combined landing and jump exercises with accessory unilateral and rotational movements. The intervention program scheme is displayed in Figure 1.

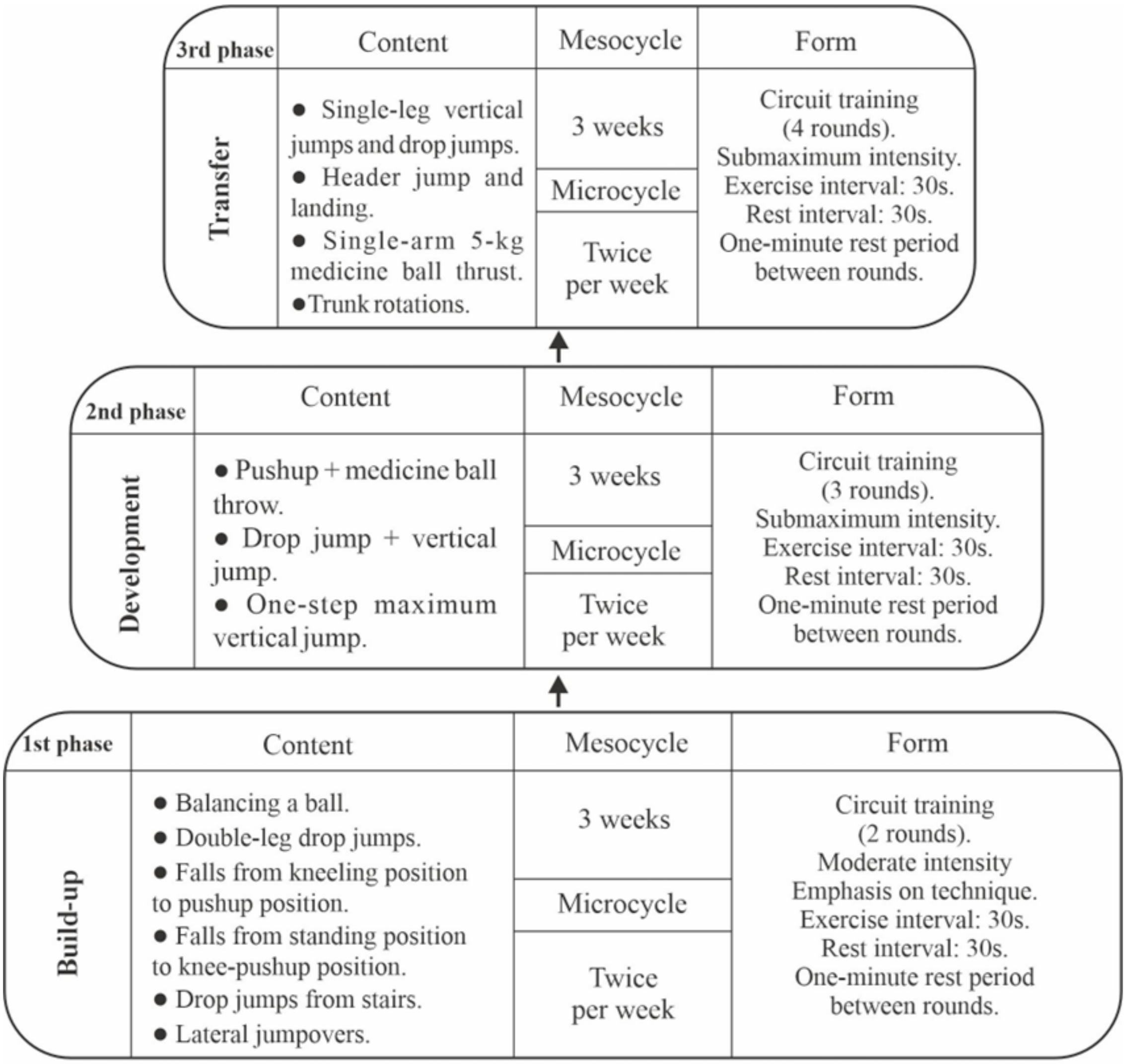


Figure 1. Intervention program

RESULTS

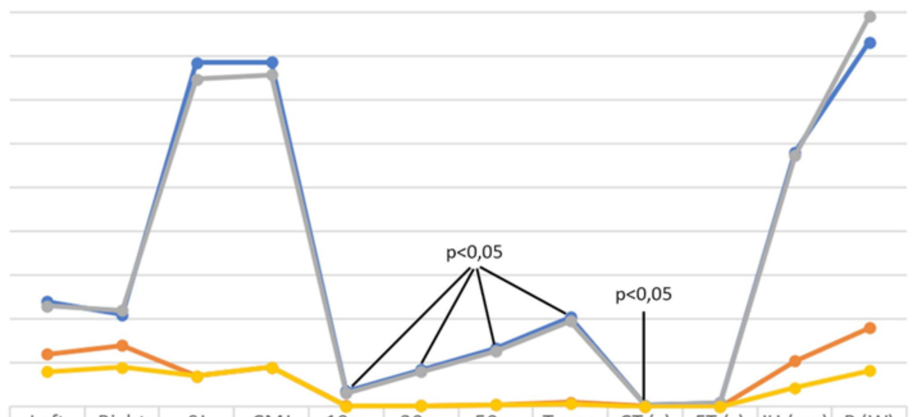
Correlation analysis was applied for the used test items to identify factors that probably have an influence on running speed. Table 2 shows the degrees of relationships between the variables that comprised the content of the test battery. Only statistically significant correlations at $p < 0.05$ are presented. Test battery variables can be divided into three groups with emphasis to ankle mobility, lower-body explosive power, and running speed.

Table 2. Correlation coefficients

	1	2	3	4	5	6	7	9	10	11
1. Left ankle mobility *(cm)*	1.00									
2. Right ankle mobility *(cm)*	**.88**	1.00								
3. Squat jump *(cm)*			1.00							
4. CMJ *(cm)*			**.81**	1.00						
5. 10-m dash *(s)*				**-.66**	1.00					
6. 30-m dash *(s)*					**.71**	1.00				
7. 50-m dash *(s)*				**-.63**		**.88**	1.00			
9. VJ 10 second *(Contact time)*		**.63**					**.65**	1.00		
10. VJ 10 second *(Flight time)*									1.00	
11. VJ 10 second *(Jump height)*									**.99**	1.00
12. VJ 10 second Power *(W)*							**-.73**	**-.80**	**.65**	**.70**

Note. CMJ – countermovement jump; VJ – vertical jump; s – seconds; W - watts

A very strong relationship between the left and right ankle mobility, or repeated jumps, squat jump and countermovement jump, or 30 and 50 meters running speed is logically expected. On the other hand, ankle mobility seems to contribute to take off and running speed optimization. There was a relationship between the time interval for fast takeoffs during the repeated vertical jumps relying on plantar flexion and right ankle mobility and 50-meter running speed. Fast repeated takeoffs also determine the 50-meter dash performance. As for the acceleration during the 10-meter dash, its relationship with the countermovement jump may be considered a factor underlying the gradual acceleration up to 50 meters. The 50-meter distance may be viewed as borderline, which the players are able to cover during the game. On the other hand, correlational analysis has not shown any relationships between the agility T-test and other presented variables. The test scores achieved by the players at the pretest and posttest have shown statistically significant improvements ($p < .05$) in running speed tests (figure 2). Players most significantly improved in the agility T-test with changes of direction, as confirmed by the median decrease by 0.45 s. The speed of repeated takeoffs with the shortest ground contact time (GCT) possible should be one of the basic factors underlying the acquisition of plyometric movements. The results showed that the intervention program had an effect on this factor because there were significant changes in the GCT. Even though the ground contact time decreased only by 0.01 s, and the GCT median at the pretest was 0.18 s, it is highly demanding to optimize such a time interval. On the other hand, the graph in Figure 2 shows the jump height. When comparing pretest and posttest measurements after the end of the intervention, we see a decrease in the squat jump by 1.9 cm and in the countermovement test by 1.45 cm.



	Ankle mobility (cm)		Opto gait (cm)		Running tests (s)				Opto gait (VJ)			
	Left	Right	SJ	CMJ	10m	30m	50m	T-run	CT (s)	FT (s)	JH (cm)	P (W)
Pretest Median	12.00	10.50	39.30	39.35	1.82	4.25	6.71	10.25	0.18	0.49	29.10	41.65
Pretest Quartile deviation	6.00	7.00	3.55	4.50	0.12	0.13	0.23	0.53	0.07	0.05	5.25	9.05
Posttest Median	11.50	11.00	37.40	37.90	1.60	4.02	6.35	9.80	0.17	0.50	28.70	44.60
Posttest Quartile deviation	4.00	4.50	3.50	4.55	0.10	0.16	0.26	0.36	0.01	0.02	2.20	4.15

Note. SJ – squat jump; CMJ – countermovement jump; VJ – vertical jump; CT- contact time; FT – flight time; JH – jump height; P – power; W – watts; cm – centimeters; s – seconds; m – meters.

Figure 2. Comparison of pretest and posttest in experimental group

The results showed that the acceleration of the ground contact time reduced the jump height. In more extensive research, it will be necessary to find out whether it is possible to eliminate the decreasing level of jump height by strength training. The present study points to that the intervention program is designed to drill and improve plyometric movements divided into 3 phases (build-up, development and transfer) which are a determining factor in relation to periodization of training process. In the preparation of soccer players, it is important to apply resistance training, which in combination with plyometric exercises can be classified as contrasting methods of developing strength ability.

DISCUSSION

In soccer players, a positive correlation is reported between strength, power and acceleration. Multijoint dynamic tests of strength (squat 1RM and power clean 1RM), expressed relative to body mass, are most closely correlated with countermovement jump performance. These results suggest that increasing maximal strength relative to body mass can improve performance in explosive lower body movements. The squat and power clean, used in a concurrent strength and power training program, are recommended for optimizing lower body power (Nuzzo, McBride, Cormie, & McCaulley, 2008). A performance attribute for players is to perform sprints repeatedly, therefore it is important to optimize the content of strength training during the season. Through plyometric training, it is possible to develop high forces and maintain high levels of stiffness in muscles. Higher stiffness levels of lower limb muscles during plyometric exercises increase the amount of stored and reused elastic energy. According to Turner and Jeffreys (2010), the primary and key places of storage and subsequent release of elastic energy are tendons. While the stiffness of a tendon is constant, the stiffness of a muscle is variable and depends on the forces exerted. The relevance of plyometric training is determined by two basic requirements, i.e. eccentric strength development necessary to tolerate high demands during fast movement deceleration and accumulation of potential elastic energy with the intention of reactive strength improvement as a faster response to the stretch during the muscle shortening phase (Vanderka, 2006). It can be concluded that during the season, it is necessary to include strength resistance exercises in addition to plyometric training, with which we can eliminate the decrease in the performance of the explosive power of the lower limbs, with emphasis on squat jump and countermovement jump. According to Čaprić et al. (2022), the intervention duration, which plays a key role, should last 2 to 4 weeks. The optimal intervention duration is 6 weeks two to three times per week. An intervention longer than 10 weeks is suitable for improving agility and specific fitness among soccer players. The best results are achieved when plyometric exercises with weights equaling 20% to 30% of the one-repetition maximum are used (Grasgruber & Cacek, 2008). The amount of weight depends on athletes' physical fitness levels. The increasing weight causes longer contact time while exerting a significant load on joints and tendons. Also, plyometric training is to be combined with strength exercises with weights equaling 90% of the one-repetition maximum. Studies have shown that this type of strength exercise is enough to include in a training microcycle once a week during the season. Boyle (2016) has found that the optimum number of jumps during a training session varies from 25 to 100 performed two to four times a week. When performed four times a week, it is necessary to distinguish between linear and multidirectional jumping exercises. The usability of plyometric exercises in soccer training is important from the viewpoint of movement stereotypes optimization in relation to the functional status of the musculoskeletal system. According to Shamshuddin, Hasan, Azli, Mohamed, and Razak (2020), an intervention consisting of plyometric training significantly prevents injury among soccer players. This may be optimized through blood flow restriction training, which improves the rate of strength gains with positive effects on explosive power development (Cook, Kilduff, & Beaven, 2014). Also previous research of authors Abe et al. (2005) point to improvements in acceleration and sprinting characteristics due to blood flow restriction training in team sport athletes. Another option is the application of contrast strength training to the process of football players. According to Hammami, Gaamouri, Shephard, and Chelly (2019), in summary, most athletic performance measures in male soccer players were enhanced after contrast strength training and plyometric training. However, the improvement of physical performance was better with 8 weeks of contrast strength training than with plyometric training. Storen, Helgerud, Stoa, and Hoff (2008) established that maximal strength training has a positive effect on running economy as well as maintaining maximal oxygen uptake (VO2max). The results demonstrated that well-trained athletes significantly improved their one repetition maximum by 33.2%, rate of force development by 26.0%, running economy by 5.0%, and time to exhaustion at maximal aerobic speed 21.3%, following eight weeks of strength training.

CONCLUSION

Incorporating intervention program into training has to meet the criteria based on the schedule and specific requirements of the in-season. As the plyometric method aims to improve the relationship between maximum and explosive power, it is necessary to incorporate these interventions during the winter pre-season period after the strength training period, followed by transfer to fast and explosive movements. The transitional - amortization phase of the movement seems to have a decisive effect on the running speed determined by ankle mobility. Following the intervention, players showed significantly improved levels of running speed in all tests. The results highlight the importance of the transition phase during fast takeoff movements, which was a determining factor during the intervention program. At this age, the development of lower-body explosive power relies heavily on the maximum strength potential, which may be enhanced by targeted intervention during the pre-season. In practice, this development need not be based on demanding exercises with emphasis on resistance training approaching 90% of the repetition maximum. Blood flow restriction training is one of the alternatives that significantly save a player's musculoskeletal system during resistance training with 20 to 40% of the repetition maximum. Strength training is part of in-season soccer training. Its methodological sophistication determines the importance of transfer to specific running activities and is an important factor in injury prevention.

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