Research Paper

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The Effectiveness of Isolated and Combined Plyometric and Sprint Exercises During an 8-Week Regimen in Young Soccer Players

Physical Education

KEYWORDS : soccer, training load, height jump, speed running.

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ABSTRACT

The purpose of this study was to determine the effect of plyometric and strength drills, both in isolation and combined, on improvements in explosive power and running speed in young soccer players. Twenty six soccer players were divided into two homogenous groups: IG (the Isolated Group, 18.17 ± 0.48 yrs) and CG (the Combined Group, 17.95 ± 0.32 yrs). The experimental program of exercises was applied twice per week, for 8 weeks. The players split into two groups (IG and CG) and performed the experimental programs (including plyometric drills – jump over hurdles and sprints 5-10-15m), which differed for each group. The results show significant interactions with time for the following jumping height indices: Hfmax ($p = 0.004$, $\eta 2 = 0.29$), Pmax ($p = 0.039$, $\eta 2 = 0.16$), Hfmean ($p = 0.000$, $\eta 2 = 0.47$), and Pmean ($p = 0.000$, $\eta 2 = 0.43$). However, post-hoc analysis revealed a considerable improvement in these indices only for the CG. For the running speed results, significant interactions with time for these indices were found for both the IG and CG for all of the distances. The results of the current study demonstrate that 8-week programs including plyometric and speed regimes in both isolated and combined forms can considerably improve the power and running speed of soccer players. However, the effectiveness of the combined intervention proved to be greater than that of the isolated regimen.

INTRODUCTION

Soccer training processes aim to systematically increase the performance level of players. Because motor abilities determine the effectiveness of players, the development of these abilities plays a crucial role in the training process. Previous studies have reported that effective players are distinguished by their speed and strength, particularly their explosive power (velocity of generating strength) and short-distance running speed [1, 2, 3, 4, 5]. Therefore, research from various scientific centers has sought to analyze the characteristics of strong performance during elite level soccer matches, as well as determine the optimal methods for developing strength and running speed in players [6, 7].

Previous studies examining the effectiveness of methods for developing speed and strength in soccer players have suggested implementing 6- to 12-week-long training programs. These programs involve drills (strength and plyometric), sprints, overspeed training, and sprints with resistance [8, 9, 10, 11, 12, 13]. Plyometric training, which mainly involves dynamic movements of the lower limbs, requires rapid eccentric and concentric muscle contractions. Therefore, muscles must be well prepared to perform these exercises because using incorrect technique during these exercises may cause micro-injuries that could lead to serious injuries [14]. Speed training involves repeated sprints of various distances with various recovery breaks between the runs [15]. During such drills, explosive power is also developed as a result of frequently repeated starts from a stationary position [6].

Both plyometric training and speed training develop speed and strength. However, the effects of combining these two programs on soccer performance remain unknown. To determine this influence, the effectiveness of a combined regimen (plyometric and speed) should be compared to the effectiveness of programs in which these exercises (plyometric or speed) are practiced separately.

Monitoring the performance level of players is one of the basic tasks of coaches. However, doing so requires reliable and accurate tests [16]. Procedures that assess explosive power in soccer include the Sargent jump test and tests performed on a force platform (SJ – squat jump, VJ – vertical jump, and CMJ – countermovement jump) [17, 18]. For running speed assessments, players run for short distances (5-30 m) either from a stationary position or with a running start of 2-3 m [19, 20].

In available literature there is plenty studies analyzing effects of sprint and plyometric training in adult soccer players [10, 13, 14, 21, 22]. However, there is a lack of researches involving the combination of plyometric and sprint training. Many coaches claim that combination of these exercises is effective in developing strength and speed abilities of young players. Therefore, we decided to apply the 8-week combined sprint and plyometric training to young soccer players during the competitive season, when these drills are crucial.

The purpose of this study was to determine the effect of plyometric and strength drills, both in isolation and combined, on improvements in explosive power and running speed in young soccer players. It was hypothesized that improvements in explosive power and running speed would be greater for players subjected to combined exercises than isolated drills. Moreover, we assumed that the experimental training load volumes chosen for both types of training (plyometric and speed) should be similar.

METHODS

SUBJECTS

Our research was conducted using a sample of 26 soccer players, who were all members of The School of Sports Mastering. The subjects were divided into two homogenous groups: IG (the Isolated Group; calendar age: 18.17 ± 0.48 yrs, biological age: 17.16 ± 0.91 yrs, body mass: 70.00 ± 4.32 kg, Height: 178.85 ± 3.21 cm, lower limb length: 94.62 ± 3.66 cm) and CG (the Combined Group; calendar age: 17.95 ± 0.32 yrs, biological age: 17.99 ± 1.26 yrs, body mass: 75.32 ± 7.46 kg, height: 180.54 ± 4,93 cm, lower limb length: 94.31 ± 4.87 cm), according to basic anthropometric characteristics. The biological age was calculated according to age and body mass of the players using the centile ranks [23]. The lower limbs length were measured using anthropometer from the base to the pubic symphysis.

The subjects played at the national level, and in the year prior to the study, they participated in the final game of the Championships of Poland. The average soccer experience was 8 years, and 26 subjects (13 in each group) completed the entire program. The other players were excluded from further analyses due to injuries (sustained during league matches) or temporary absences (junior national representative matches). The players in each group underwent the same training program apart from the experimental drills. Moreover, the subjects played macro-regional league matches in two separate teams corresponding to their experimental groups. All of the players and their parents or guardians were fully informed, and they signed consent forms. The study protocol was approved by the Local Ethical Committee in Gdańsk.

METHODOLOGY
All of the participants were subjected to control tests before and after the 8-week experiment, which was conducted during the competitive season (September and October). The tests were conducted on Mondays and Tuesdays between 10:00 am and 12:00 noon before the experimental intervention and during the first week after completion of the 8-week regimen (on Tuesday of the first week of the experiment, the experimental drills and the routine training session were performed in the afternoon).

Day 1
The power test was conducted in the laboratory for sports testing (the air temperature was 22°C before the experiment and 23°C after the experiment, and the corresponding air pressures were 995 mmHg and 1010 mmHg). First, the anthropometric variables of the participants were measured using a stadiometer and an electronic scale (Tanita BC428, Tanita Corporation, Tokyo, Japan). Next, the coach administered a 20-min warm-up in a sports hall. The warm-up involved low-intensity running for 5 min, coordination and jumping drills for 7 min, stretching for 5 min, and general fitness exercises for 3 min.

The test comprised 10 maximal vertical jumps that were performed in the shortest possible time on a force platform (Quattro Jump, Kistler Instrumentation Corp., Winterhur, Switzerland). The following variables were tested: maximal jumping height, mean value of the 10 jumping heights (Hf), power generated during the jumps (P), time of the contact with the platform between the jumps (Tcont), and force against the platform during the jumps (K). After completing the power test, there was a recovery break for 5 min, followed by 7 min of preparation (administered by the coach) for the shuttle run.

The shuttle run test was performed for a total distance of 150 m on a synthetic surface (outdoor). The subjects started the run from the starting line, covered a distance of 5 m, and ran back to the starting line. Then, the run was repeated for distances of 10, 15, 20, and 25 m continuously, without any break.

Day 2
The running speed tests were performed on a synthetic surface (outdoor). The air temperature was 20°C and 18°C, the air pressure was 1005 mmHg and 1020 mmHg, and the humidity was 55% and 67% before and after the experiment, respectively. The wind speed did not exceed 2 m/s. The coach administered a 25-min warm-up to prepare the subjects for the speed and explosive power drills. The warm-up involved 6 min of running at 55% of HR_{max}, 5 min of stretching (static and dynamic), and 12 min of specific drills. The specific drills combined either single jumps or ground bounces with sprints (15 m, 20 m, and 30 m); the sprints were performed twice and separated by a 60 s recovery break. After the specific drills, the subjects ran for 2 min at low intensity and then performed the tests. The running speed was measured for the following runs: 5, 10, and 15 m runs (both from a stationary position and with a 2 m run-up) and 20 and 30 m runs (from the standing position only). The times were measured using the Smart Speed electronic system (Fusion Sport, Cooper Plains, Australia) which was fixed at a height of 85 cm.

STUDY DESIGN
The experimental program of exercises was applied twice per week, on Tuesday and Thursday mornings, for 8 weeks. A warm-up preceded the 25-min experimental program. The players in each group underwent the same warm-up, which included the following: running at 30-40% of HR_{max} (5 min), static and dynamic stretching (5 min), and specific drills to prepare the subjects for the experimental practice. The specific warm-up drills consisted of stabilization exercises for the knee and ankle joints, one-leg leaps, two-legged jumps over low hurdles (5 min), and sprints for 15 and 20 m (repeated 3 times, 5 min total). Next, the players split into two groups (IG and CG) and performed the experimental programs (including plyometric drills and sprints), which differed for each group. The subjects practiced on a pitch with a synthetic surface. Concerning the weather conditions during the experiment, the air temperature was 17-22°C, the air pressure was 995-1010 hPa, the air humidity was 45-70%, and the wind speed was 1.5-3.2 m/s. During the 16 experimental training sessions, a light shower was registered twice, and a wind speed of 5 m/s was detected once; however, those conditions did not affect the performance of the players. All the training sessions were conducted in the mornings between 10:00 and 12:00 noon. The participants from both groups were subdivided into two sections based on the length of their legs to provide individualization for the plyometric hurdle exercises (Polanik, Polska, Piotrków Trybunalski, 2008). As a result, one group jumped over 0.68 m high hurdles, and the other jumped over 0.75 m high hurdles. The hurdles were lined up with 0.75 m between each hurdle, and the distances (5, 10, and 15 m) were measured from the last hurdle. Considering the number of jumps and sprints and recovery periods, the similar intensity of exercises in both groups was observed. It was confirmed by the players' evaluation of the exercise intensity. In 10 point scale the evaluation in IG was 8.25±0.15 and in CG 8.32±0.19.

Table 1. The experimental exercise program for the IG and CG.

Exercise	Recovery break between the exercises (s)	Number of repetitions	Recovery break after the series (s)
IG			
Single jump over a hurdle	30	3	60
Jumps over two hurdles	60	3	120
Jumps over three hurdles	90	3	300
Sprint of 15 m	90	3	150
Sprint of 10 m	60	3	90
Sprint of 5 m	30	3	-
CG			
Single jump over a hurdle + 15 m sprint	120	3	210
Jumps over two hurdles + 10 m sprint	120	3	210
Jumps over three hurdles + 5 m sprint	120	3	-

The recovery between the repetitions and the series was passive (any stretching was static). The times for the performances and breaks were deliberately determined so that the two groups completed the experimental programs simultaneously. Therefore, these regimens were integrated parts of the training for each player. After finishing the experimental program, the players performed technique and tactic drills, which were common to all of the participants. In total, the subjects participated in 5 training sessions each week, and each session lasted 90 min. Moreover, the subjects played league matches on Saturdays and rested on Sundays. Due to the number of subjects who participated in the experiment, the training sessions were conducted by two coaches, who alternately ran the groups.

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Table 2. An example of training load applied during one microcycle of the 8-week experiment (only including the effective time of performance).

	AE (min)	AAnE (min)	ALE (s)	AAE (s)
Monday	29	35		
Tuesday	34	30		60
Wednesday	27	30	540	
Thursday	34	30		60
Friday	22	30		
Saturday	20	95		
Sunday	-	-	-	-
AE – aerobic exercises; AAnE – mixed aerobic-anaerobic exercises; ALE – anaerobic lactacid exercises; AAE – anaerobic alactacid exercises				

STATISTICAL ANALYSES

The results are presented as the mean and standard deviation (M ± SD). All of the statistical analyses were performed using the StatSoft, Inc. STATISTICA version 10.0 software (StatSoft, Tulsa, OK). The level of significance was set at $p < 0.05$. All of the data sets were assessed using the Shapiro-Wilk test for normal distributions. Levene's test was used to evaluate the homogeneity of the variances. A two-way repeated measures ANOVA was applied to analyze the between-group (IG and CG) and within-group (pre- and post-training) effects. The effect size (eta squared, η^2) for the analysis of the variance was calculated to estimate the significance of the comparisons between the groups. Post-hoc analyses using the HSD Tukey test were performed when the interaction effects were significant.

RESULTS

There were no statistically significant differences in the anthropometric variables between the groups before the experiment. The results presented in Table 5 show significant interactions with time for the following jumping height indices: Hf_{max} (p = 0.004, η^2 = 0.29), P_{max} (p = 0.039, η^2 = 0.16), Hf_{mean} (p = 0.000, η^2 = 0.47), and P_{mean} (p = 0.000, η^2 = 0.43). However, post-hoc analysis revealed a considerable improvement in these indices only for the CG. For the running speed results, significant interactions with time for these indices were found for both the IG and CG for all of the distances except the 20 m sprint. Moreover, for the 10 m run, there were significant interactions of these indices for each group with time and between the groups. The HSD Tukey test results for the running speed tests and the shuttle run revealed a substantial ($p < 0.01$) improvement in the running times for all of the analyzed distances (Fig. 1).

Table 3. Changes in the mean explosive power and strength values in young soccer players (IG – isolated training, CG – combined training).

	IG		CG		ES	differences
	pre	post	pre	post		
Jumps Hf_{max} [cm]	53.41± 5.09	55.10± 4.83	53.74± 7.41	56.97± 7.78**	0.29	Time
P_{max} [W/kg]	57.16± 7.59	57.96± 8.55	50.50± 12.70	53.89± 13.08*	0.16	Time
Hf_{mean} [cm]	47.31± 4.00	48.77± 3.52	45.46± 7.33	49.20± 6.79**	0.47	Time
P_{mean} [W/kg]	48.79± 7.10	51.31± 7.23	42.92± 12.14	46.61± 11.36**	0.43	Time
T_{cont} [ms]	259.55± 49.96	247.71± 34.84	300.39± 79.71	285.36± 69.23	-	-
K [kN/m]	16.43± 4.90	17.20± 5.60	14.41± 7.40	12.88± 6,11	-	-
Sprints [s]						
5 m	1.14± 0.05	1.09± 0.06**	1.18± 0.04	1.11± 0.06**	0.60	Time
2+5 m	0.87± 0.02	0.83± 0.04**	0.89± 0.03	0.85± 0.03**	0.62	Time
10 m	1.91± 0.07	1.81± 0.06**	1.94± 0.07	1.90± 0.06**	0.22 0.62 0.17	Group Time Time x group
2+10 m	1.63± 0.11	1.53± 0.06**	1.63± 0.06	1.57± 0.05**	0.52	Time
15 m	2.57± 0.08	2.46± 0.11**	2.64± 0.13	2.55± 0.15**	0.51	Time
2+15 m	2.23± 0.08	2.19± 0.08**	2.30± 0.10	2.23± 0.08**	0.60	Time
20m	3,19 ± 0,11	3,17 ± 0,13	3,23 ± 0,16	3,21 ± 0,18	-	-
30m	4,38 ± 0,12	4,31 ± 0,12	4,48 ± 0,19	4,45 ± 0,20	0.19	time

Significant differences between pre to post changes at *$p < 0.05$, **$p < 0.01$

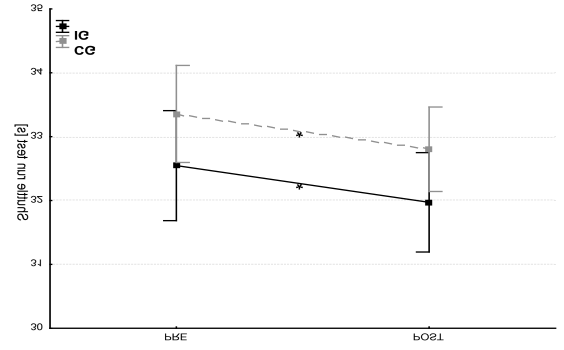

Figure 1. Changes in the mean shuttle run test results for the IG and the CG. * significant ($p < 0.01$) changes between pre- and post-experiment values.

DISCUSSION

The purpose of this experiment was to determine which of two programs (the isolated plyometric and sprint exercises or the combined set of such drills) more effectively developed the strength and speed abilities in young soccer players. There was a significant improvement in running speed in both groups after the 8-week training program. However, a significant increase in the values of the power indices for jumping height (maximal vertical jumping height and the mean value for 10 jumps) and power (maximal and mean value for 10 jumps) was only found in CG, who performed the combined drills.

The level of dynamic components of physical capacity is one of the most important elements of soccer players' fitness. This study showed that proper training can significantly improve the level of speed and strength during competitive season.

The time and manner of the performance, i.e., the number of repetitions, the number of series, and the time of recovery breaks between the exercises, represent key factors determining the effectiveness of the program. Literature search was performed before the experiment to assess the methodology of plyometric and sprint training [24, 25, 26, 27, 28, 29, 30, 31]. According to previous findings, our methods, forms, and means of training were appropriate for the effective development of explosive strength and running speed in young soccer players. Wong et al. [9] subjected 14-year-old soccer players to a similar 12-week strength intervention and found considerable effects (statistically significant differences in the values for the vertical jump and the 10 m and 30 m runs). In contrast, Rimmer et al. [14] applied different study procedures. These researchers divided the subjects into three groups that underwent either plyometric, speed, or control interventions. The results revealed that improvements in running speed (for 5-10 m) were greater for individuals who received plyometric training in comparison to standard speed training ($p < 0.01$ for the pre-post test, $p < 0.05$ for the plyometric and control groups); however, for the 20-40 m runs, the regimens were found to have a similar influence on running speed improvement. In contrast, the findings of Kotzamanidis et al. [8] dispute these results. In their studies comparing soccer players with control subjects, plyometric training proved to be effective in developing VJ height, although the intervention did not enhance the players' running speed for 5-10 m runs. Furthermore, Markovic et al. [6] found that the improvement in the performance of soccer players was greater for sprint training over short distances than for standard plyometric training. Therefore, several studies have evaluated plyometric and speed training, but no consensus has been reached regarding the effectiveness of these regimes. Because plyometric and sprint training require high performance precision, these discrepancies could, in our opinion, be caused by differences in the quality of the performance or the sports experience or sport level of the subjects. For example, Cherif et al. [27] studied young handball players and reached a similar conclusion, and Wisløff et al. [31] studied soccer players and reported strong correlations between explosive strength and the running speeds for the 10 m run, 30 m run.

The results of the current study demonstrate that 8-week programs including plyometric and speed regimes in both isolated and combined forms can considerably improve the power and running speed of soccer players. However, the effectiveness of the combined intervention proved to be greater than that of the isolated regimen.

PRACTICAL APPLICATION

The present study was inspired by previous practical experience with soccer players from different age groups and sports levels. Using the observations of coaches, we concluded that greater improvements in soccer performance occur for exercises that combine strength and explosive power (e.g., jumps over hurdles or jumps for heading followed by sprints to the ball or the opponent) than for the same exercises performed in isolation. The manner of the performance was also a significant factor, and the effectiveness of the drills was dependent on the precision, strength, speed, and motivation of the players during the drills. Neglecting any of these factors, even to a minor extent, may have a detrimental effect on the performance enhancement that could be attained from training. Apart from these factors, which are specific to each player, appropriate choices for exercises and the duration of drills and recovery breaks also play a critical role. The most serious mistakes made by coaches involve the running distances and the duration of breaks between exercises. Using these observations, we concluded that short sprints (5-15 m) and long sprints (20-40 m) should not be included in the same training session; furthermore, single jumps (1-3 jumps; for example, over a hurdle) should not be practiced along with repeated jumps (4-10 jumps). However, combining a short distance run with a short sprint, as applied in the present study, is advisable. These training principles are based on physiological demands, as previous findings have reported that anaerobic alactacid capacity can only be developed when a player is fully recovered and the time of the exertion does not exceed 5 seconds. Another significant factor for training effectiveness is the duration of the recovery breaks between the exercises, which should not be shorter than 30 s for a single exercise that lasts approximately 1 second or shorter than 90 seconds for an exercise that lasts for several seconds. Moreover, another neglected aspect of strength and explosive power training is individualization. When performing exercises in the gym (weight lifting), participants are divided into groups according to, for example, their maximal strength results. However, athletes are not separated during drills on the field that involve hurdles or other obstacles (e.g., gymnastic box), and the height or leg length of players should definitely be considered for these exercises. Otherwise, players with significant variations in these parameters will experience different training loads and therefore different fatigue levels. The present study considered this requirement, and the results confirmed our assumptions. However, in our opinion, sports training is such a complex process that research on this topic should be continued.

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