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Effects of Plyometric Training on Explosive Strength, Speed and Kicking Speed in Female Soccer Players

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KEYWORDS Leg Power. Jumping. Sprint. Kicking. Stretch-shortening Cycle

ABSTRACT The aim of the present study was to examine how to speed, explosive strength, and kicking speed are affected by a 10-week plyometric training (PT) program in elite female soccer players. Twenty adult players from Women First League (age=19.3±1.6year, height=163.3±4.7cm, body mass=56.6±6.1kg) were divided into plyometric group (PG) and control group (CG). Both the groups performed technical and tactical training and matches together. PG performed PT 2 times per week for 10 weeks. No significant difference was found between the groups at pretest variable ($p>0.05$). The significant improvement was found in the posttest of both groups ($p<0.05$), except for 10-20-m sprint test in the CG ($p>0.05$). Sprint, counter movement jump, standing broad jump, peak power and kicking speed test values were all significantly improved in the PG, as compared with the CG ($p<0.05$). The results indicated that safe and effective PT can be useful to strength and conditioning coaches for explosive strength.

INTRODUCTION

Women's soccer attracted many people in the world, therefore, it has become a subject to many researches. It has also reflected a rapid development in our country. This development projects into the content of training programs used in women's soccer. The observed performance increase of soccer players affected soccer viewing experience positively. Thus, trainings aiming to develop performance of women's soccer come into prominence. The purposeful PT has positive effects on soccer efficiency but especially on peak power, jumping and sprint performances (Ozbar et al. 2014).

During a soccer game, peak power, reversing running, jumping and sprints are applied to lower extremity. During the game, in a 4-6 second jumping, short-term movements, such as rotation and acceleration are repeated 1000 to 1400 times (Stolen et al. 2005). These movements are used frequently during the games; therefore, they are needed to be improved significantly with the trainings. The reason why PT is used is that they are more effective than other training programs.

PT contains fast and strong concentric contractions which are followed with eccentric loads. It's scientifically proved that a stretched muscle can produce more power than a non-stretched muscle (Malisoux 2006; Villareal et al. 2010). The PT methods applied to the lower extremities, particularly they provide an increase in vertical jump and leg muscle strength. The reason behind the strong effect of PT is stretching - contraction circle occurring simultaneously, instead of dynamic contraction (Markovic 2007; Markovic and Mikulic 2010; Micahilidis et al. 2013).

PT in female athletes; explosive strength, speed, jumping and kicking performance corresponds to these researches with positive effects, (Siegler et al. 2003; Villareal et al. 2008; Campo et al. 2009; Mohamed et al. 2014; Ozbar et al. 2014) and to a research with negative effect (Luebbers et al. 2003) or to one with no effect on jump performance (Chimera et al. 2004).

As a result, controversial and different results of the researches done on plyometric trainings in women's soccer revealed that more researches should be done. Further, the raising value of women's soccer makes these researches even more needed. The hypothesis was that this program would increase the jumping ability, peak power, running speed and kicking speed, and that these gains could be maintained by means of regular soccer training only.

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METHODOLOGY

Participants

A total of 20 female soccer players (19.3±1.6 years of age) from University Sports Club female soccer team that plays at Women 1st League voluntarily participated in the study. Anthropometrics and training characteristics of soccer players are presented (Table 1) by means ± *SD* and range table. Participants were chosen among the players who had at least 5 years of training history, and those who have no history of PT program or had an orthopedic injury within the past 8 months were excluded from the study.

The groups were divided into as plyometric (n = 10) and control (n = 10). The participants were homogeneous in terms of their training history and physical properties [height, weight, Body Mass Index (BMI)]. All players participated to all of the trainings except goalkeepers who were not included in this study. Approval from University Ethical Committee was received. All the participants and coach were informed of the purpose, benefits and potential risks of the participation. Written consent was obtained from all participants.

Training Protocols

All the athletes from both groups participating in the research have minimum 3 years of PT background. Both the groups continue their warm up, technical and tactical exercises (4 days a week) and preparation matches twice a week with same coach. Joint exercises take place on Mondays, Wednesdays, Fridays and Saturdays for between 100 - 120 minutes. On Tuesdays and Thursdays PG is applied 20 additional 40 minute training programs twice a week for 10 weeks. The control group did not participate to the PT. Players were not allowed to do any other physical activity during the research.

PT was prepared to develop the peak power in the lower extremity. five to ten minutes of warm up in the beginning of the exercises (jogging, multi directional movements, sprinting, dynamic stretching and drilling with balls), 20 - 30 minutes of plyometric exercise in the main part and 5 - 10 minutes of cooling down exercises were done. Exercise protocol was planned as 3 - 5 sets, 5 - 8 repeats and 6 - 8 exercises, minimum 120 maximum 250 foot contact. 1 minute of active resting between the repeats and 3- 5 minutes of active resting between the sets were given. Every practice in PT includes lateral and horizontal one foot or two feet jumps over barrier; forward, backward, sideways and diagonal 5 meter sprints and shoots which were added at the end of each parkour. Intensity of exercise set by barrier height and number of foot contact (Table 2).

Testing Protocols

The tests for detecting the effects of the exercise were applied before and after 10 weeks of exercise. Anthropometric, running speed and peak power tests were applied one after another in one session. 1 minute of resting was given between every test. Every participant was given a chance to practice before their actual performances. Participants were informed that they should stop physical activities 24 hours before and they should stop drinking and eating 3 hours before the test. The participants were given courage to perform well in the test. Tests were done on the synthetic turf field wearing crampon. Speed of the wind and temperature were calculated during the test and tests aren't performed in rainy weather. After anthropometric tests,

Table 1: Descriptive data for anthropometric features in plyometric group (n=10) and control group (n=10)

	Groups	*Mean ± SD (range)*	*P*
Age, y	PG	19.4± 1.6 (18-22)	0.684
	CG	19.1± 1.7 (18-22)	
Training age, y	PG	4.9± 0.73 (4-6)	0.535
	CG	4.7± 0.67 (4-6)	
Height, cm	PG	163.6± 4.7 (158.5-173)	0.824
	CG	163.1± 5.1 (155-170)	
Weight, kg	PG	58.0± 6.6 (49.5-70.5)	0.338
	CG	55.3± 5.5 (45.6-64.4)	
Body mass index, $kg.m^{-2}$	PG	21.7±2 .2 (19.7-26.9)	0.442
	CG	20.8± 2.4 (16.8-25.2)	

Table 2: Plyometric 10-week training protocol

Week	*Foot contacts*	*Drill*	*Sets x Reps*	*Intensity*	*Hurdle height, cm*
1. 2.	120-140	Standing long jump	4 x 8	Low	40
		Front cone hops	4 x 7	Low	
		Horizontal jumps over hurdle	3 x 5	Low	
		Single leg lateral jump	3 x 5	Low	
		Forward-backward run*	3 x 5	Low	
		Side-to-side skipping	3 x 5	Low	
3. 4.	140-160	Double leg horizontal jump	5 x 5	Low	40-50
		Lateral jump over hurdle	5 x 6	Low	
		Side-to-side sprint*	3 x 5	Medium	
		Jump over low hurdle	5 x 6	Medium	
		Vertical, lateral and horizontal jump	5 x 8	Medium	
		Skipping with change of direction sprint*	5 x 6	Medium	
5. 6.	160-180	Split squat jump	4 x 6	Medium	50-60
		Front cone hops and change of direction sprint*	4 x 6	Medium	
		Lateral jump over hurdle	4 x 6	Medium	
		Side-to-side slide and hops	4 x 6	Medium	
		Lateral and horizontal jump	4 x 6	Medium	
		Step, jump, down, up and sprint*	4 x 6	Medium	
7. 8.	180-200	Cone hops with 180? turn	4 x 8	Medium	50-60
		Vertical, lateral and horizontal jump	4 x 8	Medium	
		Lateral jump over hurdle	4 x 6	Medium	
		Diagonal jump over hurdle	5 x 8	Medium	
		Single leg lateral jump	4 x 7	High	
		Step, jump, down, up and sprint*	5 x 8	High	
		Slaloming*	4 x 6	High	
9. 10.	200-250	Diagonal jump	4 x 8	High	60
		Standing long jump and diagonal sprint*	4 x 8	High	
		Single leg vertical jump	4 x 8	High	
		Cone hops with 180? turn	4 x 8	High	
		Skipping over cone	4 x 8	High	
		Double leg diagonal jump over hurdle	5 x 6	High	
		Single leg lateral and horizontal jump	5 x 6	High	
		Cone hops with change of direction sprint *	5 x 6	High	

*The distance of sprint, 5m. Shot is added to the end of each parkour.

participants warm up for 10 minutes and then perform the tests.

Anthropometric Measurements: The anthropometric variables (Body height and body mass) were measured according to the instructions of the Anthropometric Standardization Reference Manual (Lohman et al. 1988).

Sprint Test: Distance of 10-20-30-m distance was selected to evaluate running performance. The participants performed 2 maximal sprint efforts over the distance of 30 m on a grass tracks 3-minute interval between trials. Sprint times were recorded to 0.001 second accuracy by infrared photoelectric cells (Newtest 2000 Sprint Timing System, NewtestOy, Oulu, Finland) that were connected to 4 pairs of locations at the start and then at 10-m, 20-m, and 30-m marks of the 30-m distance. During the recovery period, the subjects walked back to the starting line and the best sprint time was used for statistical analysis (Flecther et al. 2004).

Countermovement Jump (CMJ): The players performed three countermovement jumps to realize maximal height on a vertical jumping mat (Newtest 2000 System, NewtestOy, Oulu, Finland). Three maximal jumps height (cm) were recorded. Further, between jumps, a break of 30 seconds was provided. The best trial was included into further analysis (Gonzales-rave et al. 2009).

Standing Broad Jump (SBJ): The test was performed according to Eurofit Test Battery (Oja et al. 1995). The participants were instructed to

jump forward as far as possible and land with the feet together and to stay upright. The test was repeated twice and the best trial was recorded.

Peak Power (PP): The countermovement jump height was then used to determine peak power by the formula Lara et al. (2006) and this equation was used for national female players.

PP = [53.6 x Jump Height (cm)] + [67.5 x Body Mass (kg)] – 2,624.1.

Kicking Speed (KS): Kicking performance was estimated from maximum ball speed during shooting. The speed, expressed in km/h, was measured with a Sports Radar Gun (SportsRadar 3600, Astro Products, Ontario, CA, USA) set up 5 m behind the player performing the kick and on the side of her leg. A ball with a standard size and inflation pressure following the rules of Federation International de Football Association was used. It was always placed at the 11 m distance (same point) from the goal line. To standardize, the researchers used a 2-step run-up. Participants were asked to kick the ball as fast as possible toward the radar gun, using the instep of the dominant and the non-dominant leg alternatively. They were told that kicks that missed the radar gun could be repeated and that they should not decrease the speed to improve accuracy. Each woman performed 3 trials with each leg, and the best result was used for statistical analysis. The rest between trials was 40 seconds.

Statistical Analyses

The descriptive statistics were expressed as mean values, *SDs*, and value ranges. The tests of normal distribution (Shapiro-Wilk) were conducted on all data before analysis. Statistical analyses of data were performed using Mann-Whitney U-test to compare differences between PG and CG. The Wilcoxon signed rank test was used to analyze pre and post-test difference of the players within their group in all test variables. Significant was established at $p \leq 0.05$. Data analysis was performed using SPSS (version 14.0, SPSS Inc., Chicago, III).

RESULTS

The Shapiro-Wilk test suggested that all variables were distributed normally ($p>0.05$). Twenty adult players were divided into PG (age=19.4 ±1.6 year, height=163.6±4.7 cm, weight=58.0±6.6 kg, body mass index=21.7±2.2 kg.m^{-2}) and CG (age=19.1±1.7 year, height= 163.1±5.1 cm, weight =55.3±5.5 kg, body mass index=20.8±2.4 kg.m^{-2}). Results of comparative analysis between PG and CG in all the variables at baseline revealed that there were no statistically differences before the start of the PT program ($p>0.05$).

Players who incorporated the plyometric exercise were able to significantly increase their CMJ from 40.1±1.9 cm to 48.6±1.6 cm, SBJ from 182.5±12.4 cm to 193.5±12.6 cm, PP from 3438.9±497.3 W to 3894.5±470.7 W, kicking speed from 83.2±5.9 km/h to 91.4 ±7.7 km/h and 10 m sprint time from 2.3±0.7 s to 2.0±0.1 s, 20 m sprint time from 3.8±0.3 s to 3.4±0.2 s, 30 m sprint time from 5.3±0.4 s to 4.8±0.2 s, compared to the control group.

Significant differences ($p<0.05$) were observed between all pre and posttest measurements of both groups. However, no significant differences ($p>0.05$) were observed in the speed time decrease in 10-m and 20-m sprint test between pre and posttest for the CG. In addition, differences between pretest and posttest within each group were found in the order of significant increase in PG's and CG's CMJ, SBJ, dominant leg KS, non-dominant leg KS and PP values ($p<0.05$). The PG's showed significant decrease in ($p<0.05$) 10-m, 20-m and 30-m sprint time from pretest to posttest. The CG's showed significant decrease in ($p<0.05$) 30-m sprint time from pretest to posttest (Table 3).

There were significant differences between the groups for pretest and posttest results of CMJ, SBJ, dominant leg KS, non-dominant leg KS, PP and 10-m, 20-m, 30-m sprint (s) parameters in favor of PG (Table 3).

DISCUSSION

The prime findings of the present study was that the supplementary 10 weeks of PT on 2 days per week significantly increased CMJ, SBJ, PP, KS and 10-20-30m sprint performance in female soccer players. The players who incorporated the plyometric exercise were able to significantly increase their CMJ from 40.1±1.9 cm to 48.6±1.6 cm, SBJ from 182.5±12.4 cm to 193.5±12.6 cm, PP from 3438.9±497.3 W to 3894.5±470.7 W, kicking speed from 83.2±5.9 km/h to 91.4 ±7.7 km/h and 10 m sprint time from 2.3±0.7 s to 2.0±0.1 s, 20 m sprint time from 3.8±0.3 s to 3.4±0.2 s, 30 m sprint time from 5.3±0.4 s to 4.8±0.2 s, compared to the control group.

Table 3: Performance variables of pretest and posttests for plyometric group (n=10) and control group (n=10).

Test	*Group*	*Pretest*	*Posttest*	*Differences*	*Within group, p*	*Between group, p*
10-m Sprint, s	PG	2.3± 0.7	2.0± 0.1	-0.3± 0.2	0.005*	0.011*
	CG	2.2± 0.3	2.2± 0.2	-0.1± 0.2	0.674	
20-m Sprint, s	PG	3.8± 0.3	3.4± 0.2	-0.3± 0.2	0.005*	0.002*
	CG	3.8± 0.4	3.8± 0.4	-0.0± 0.2	0.721	
30-m Sprint, s	PG	5.3± 0.4	4.8± 0.2	-0.5± 0.3	0.005*	0.011*
	CG	5.4± 0.4	5.3± 0.4	-0.1± 0.1	0.005*	
Countermovement jump, cm	PG	40.1± 1.9	48.6± 1.6	8.5± 2.2	0.005*	0.000*
	CG	39.7± 1.8	42.3± 1.9	2.6± 0.5	0.004*	
Standing broad jump, cm	PG	182.5± 12.4	193.5± 12.6	11.0± 2.8	0.005*	0.000*
	CG	174.9± 3.7	179.2± 3.6	4.2± 0.9	0.004*	
Dominant leg kicking speed km/h	PG	83.2± 5.9	91.4 ± 7.7	8.2± 3.2	0.005*	0.000*
	CG	79.2± 3.6	82.9± 4.6	3.7± 1.1	0.003*	
Nandominant leg kicking speed km/h	PG	71.0± 4.2	79.5± 5.3	8.5± 2.1	0.005*	0.000*
	CG	71.1± 4.0	74.7± 3.5	3.5± 1.3	0.004*	
Peak power, W	PG	3438.9± 497.3	3894.5± 470.7	455.6±119.2	0.005*	0.000*
	CG	3236.6± 388.8	3375.9± 382.9	139.4± 27.7	0.004*	

*p<0.005

PT was suggested as an alternative to strength training oriented at lower extremity for female athletes (Myer et al. 2005). A major component of power activities is the PT. Plyometric is a viable training for development of power output and can be performed on the sports field. Campo et al. (2009) investigated the effects of plyometric training on elite female soccer players that consisted of hurdle jumps, drop jumps, and horizontal jumps for 12 weeks, 3 times a week. Both vertical jump height and kicking distance significantly increased after the plyometric training as compared with a control group. Although, the several authors have reported significant improvements in vertical jump using plyometric training in male and female athletes (Diallo et al. 2001; Polman et al. 2004; Martel et al. 2005; Myer et al. 2005; Mohamed et al. 2014; Ramírez-Campillo et al. 2014). The meta-analysis of De Villarreal et al. (2009) concluded that subjects with the most sport experience showed the greatest increases in vertical jump height. The increase in the PP performance of legs of PG is bigger in proportion to the CG and this can be explained with neuromuscular adaptation. Although, the effect of neural adaptation was not studied in our study, positive effect of PT on, especially, speed and jump performance shows similarity to the study of Wilkerson et al. (2004).

Markovic (2007) suggested in a meta-analytical study that there may be a positive transfer of the effects of PT on vertical jump ability to other athletic performance, which could include kicking. Several authors have emphasized that kicking is one of the most important skills in soccer (Barfield et al. 2002; Masuda et al. 2005; Myer et al. 2005). Although, some authors identified a relationship between the strength of the lower limbs and ball speed in both male and female players (Kalapotharakos et al. 2006; Manolopoulos et al. 2006; Vucetic et al.2007; Campo et al. 2009; Rubley et al. 2011; Sedano et al. 2011; Micahilidis et al. 2013; Ramírez-Campillo et al. 2014). Also, general running speed and jumping ability increased in kicking-related sports with plyometric training (Ronnestad et al. 2008; Meylan et al. 2009). Results of the present study are in agreement with this statement because it was shown that the PT program caused significant difference in jump ability, speed and kicking speed between pre-training and post-training values for PG as compared with a control group.

Previous researches have demonstrated that the velocity over distances of 0-30, 10-20, and 20-30-m increased significantly ($p < 0.05$) after 10 weeks of plyometric training (Kotzamanidis 2006). A 12-week period of non-depth jump plyometric exercise also improved the 25-m sprint performance of entry-level collegiate athletes by 9% (Moore et al. 2005). Several previous studies have suggested an the increase (Rimmer et al. 2000; De Villarreal et al. 2008; Chelly et al. 2010; De

Villarreal et al. 2012; Micahilidis et al. 2013; Brito et al. 2014; Müller et al. 2014) or no change (Herrero et al. 2006; Markovic 2007) in sprint performance after PT. De Villarreal et al. (2012) suggested in a meta-analytical study that PT is an effective training method for improving sprint performance and, thus, the hypothesis of this study is supported. Plyometric training increases sprint performance, especially, between 10- and 40-m distances (De Villarreal et al. 2012). This could also be true of sprint performance, explaining some of the discrepant results. Differences in the training protocol may also be a factor. As a result, the current study indicated plyometric training significantly improved the performance of female soccer players.

CONCLUSION

As a result, the present study was found to support the view that PT increases speed, kicking speed, horizontal and vertical jumping performance and peak power of female soccer players significantly. This study showed that, in addition to traditional training, well-conceived PT with duration of 10 weeks, 2 day per week, influences multidimensional development of muscular performance.

RECOMMENDATIONS

PT has gained popularity in soccer training, and its use by strength and conditioning coaches is increasing, because they can be applied on the field. However, explosive strength is important in most sports including soccer. Thus, the women's soccer must notice that the PT is beneficial in increasing the ability to use explosive strength effectively in a specific task. These results provide strength and conditioning coaches with a safe and effective PT. Strength and conditioning coaches must also take into account that PT should be combined with regular soccer training to transfer the gains in explosive strength to the kicking movement.

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