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EFFECTS OF 10-WEEK IN-SEASON PLYOMETRIC TRAINING PROGRAM ON AGILITY PERFORMANCE IN MALE AMATEUR FOOTBALLERS

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Abstract:
This randomized controlled study aimed to investigate the effects of a 10-week in-season plyometric training program on agility performance. Thirty-one male soccer players (age = 28.8 ± 4.1 years; body mass = 73.7 ± 7.2 kg; height = 175.2 ± 6.0 cm) from an amateur soccer team were assigned into two groups, an experimental (EG; n=15) or a control (CG; n=16) group. The EG group performed a 10-week plyometric training program and the CG did not perform any plyometric training techniques. The program included one training session per week in place of a weekly usual soccer training session and lower limbs plyometric exercises at maximal intensity (total of 90 - 140-foot contacts/session) were executed. All subjects participated in two agility tests before and after the experiment: T-test and Illinois Agility Test. The EG group showed significantly ($p < 0.05$, $d = 0.7$) improvement than CG in the T-test (-0.5 vs. 0.5 sec., -4.3 vs. 4.4%, respectively) and Illinois Agility test (-0.6 vs. 0.5 sec., -3.7 vs. 3.1%, respectively) after 10-week. Results suggest that amateur adult male soccer players that are participating in a plyometric training program can enhance their agility performance by replacing a part of their standard regimen with an in-season 10-week one-weekly program of plyometric training for the lower limbs. This study provided the first objective demonstration of plyometric training value in amateur soccer players.

Keywords: soccer; periodization; changes of direction; foot contacts; stretch-shortening cycle

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1. Introduction

Plyometric training, that is jumping, bounding, and hopping exercises that use the stretch-shortening cycle of the muscle unit, have consistently been shown to improve the production of muscle force and power of subsequent movements using both natural elastic components of muscle and tendon and the stretch reflex (Komi, 2003; Nicol, Avela, & Komi, 2006; Meylan & Malatesta, 2009). According to Markovic and Mikulic (2010), the stretch-shortening cycle enhances the ability of the neural and musculotendinous systems to produce maximal force in the shortest amount of time, prompting the use of plyometric training as a bridge between strength and speed. These physiological adaptations have facilitated the increase in vertical jump height (Markovic, 2007; Wagner, & Kocak, 1997) and decrease in sprint and acceleration times (Kraemer, Ratamess, Volek, Mazzetti, & Gomez, 2000; Rimmer & Sleivert, 2000).

Plyometric training has frequently been used for improving human neuromuscular function and improving performance in both explosive and endurance athletic events (Fischetti, Vilardi, Cataldi, & Greco, 2018; Markovic & Mikulic, 2010). Various sports may benefit from plyometric training. Soccer is a sport in which the need for power is innate. The explosive movements of plyometric training are like the demands placed on athletes playing soccer. In effect, the potential improvements from plyometrics as measured by vertical jump and sprint performance would be beneficial to soccer (Bangsbo, 1994; Reilly, Bangsbo, & Franks, 2000). Soccer players use a combination of running, jumping, and changing directions. The basic movement patterns in soccer also require high levels of agility (Ellis et al., 2000; Reilly & Dorand, 2003). Agility requires rapid force development and high-power output, as well as the ability to efficiently utilize the stretch-shortening cycle in ballistic movements (Plisk, 2000). Plyometric training has been shown to improve these requirements (Anderson & Pandy, 1993; Bobbert, Gerritsen, Litjens, & Van Soest, 1996), and Besier, Lloyd, Ackland, and Cochrane (2001) have recommended the inclusion of plyometrics in soccer training to familiarize players with unanticipated changes in direction.

Plyometrics has been applied in numerous studies, and there is a consensus that it improves sport-specific skills such as agility (Miller, Herniman, Ricard, Cheatham, & Michael, 2006). In soccer rapid movements such as acceleration and deceleration of the body, changes of direction, as well as jumps are often performed, and high level of dynamic muscular performance is required at all levels of training status. Unfortunately, there is no universally accepted definition of agility, but it has more recently been defined as "*a rapid whole-body movement with change of velocity or direction in response to a stimulus*" (Sheppard & Young, 2006), and agility training is thought to be a reinforcement of motor programming through neuromuscular conditioning and neural adaptation of muscle spindles, Golgi-tendon organs, and joint proprioceptors (Craig, 2004).

Although plyometric training has been shown to increase performance variables, little scientific information is available to determine if plyometric training actually enhances agility. Again, studies were all carried out by analysing the professional soccer players, while nothing is known about the effects that plyometric training can cause on agility in amateur soccer players. Therefore, our objective in the present study was to determine whether the substitution of a one-weekly plyometric program for some existing drills within a regular in-season soccer training program would enhance agility in male amateur footballers. Given existing information on the efficacy of plyometric training (Meylan & Malatesta, 2009; Miller et al., 2006), we designed a 10-week training program consisting of a variety of plyometric exercises for the lower extremity added to the normal in-season regimen, performed by the experimental group in place of a weekly usual soccer training session. We hypothesized that one session per week of plyometric exercises at increasing intensity would improve agility decreasing the run times in the experimental group compared to the control group players who continued to follow their customary in-season training regimen.

2. Material and Methods

2.1 Study design

This study examined whether a 10-week one weekly in-season plyometric program would enhance selected aspects of agility performance in amateur footballers relative to that of their peers who continued to follow their customary in-season training regimen. A group of 23 male amateur soccer players volunteered to be assigned randomly between a plyometric training group (EG; n = 15) or a control group (standard in-season regimen) (CG; n = 16). Two weeks before definitive testing, 2 familiarizations sessions were held. Definitive measurements began when all participants were 2 months into the competitive season. Data were collected before modification of training and after completing the 10-week trial. The test protocol included the T-test and Illinois agility test, and the run time in seconds was used as a dependent variable.

2.2 Participants

Thirty-one males were recruited and randomly assigned to a plyometric training (EG, n = 15) (age = 28.2 ± 5.4 years; body mass = 73.1 ± 6.4 kg; height = 174.7 ± 5.5 cm) or control (CG, n = 16) group (age = 29.4 ± 2.4 years; body mass = 74.4 ± 8.1 kg; height = 175.7 ± 6.6 cm). An a priori power analysis (Faul, Erdfelder, Lang, & Buchner, 2007) with an assumed type I error of 0.05 and a type II error rate of 0.20 (80% statistical power) was calculated for dependent measures and revealed that 8 participants per group would be sufficient to observe medium 'Time x Group' interaction effects. However, to avoid the experimental mortality, i.e. the loss of subjects, that could threaten the validity of the research design, more subjects were recruited. For randomization, we used the method of randomly permuted blocks using Research Randomizer, a program published on a publicly accessible official website (www.randomizer.org).

Participants were selected from a local amateur soccer club. During the experiment participants from both groups were involved in 3 regular soccer training sessions per week, on Tuesday, Thursday and Friday, and participated in one game on the weekends.

EG performed plyometric training on Tuesday instead of the usual football training that the CG continued to perform.

All participants have previously done unilateral or bilateral plyometric exercises although without respect for the principles of training as often happens in amateur footballers. Before any training and testing, an oral explanation of the experimental procedures was given to all participants. After this, a written informed consent form was signed by the subjects according to the Declaration of Helsinki. None of the participants reported current injuries of the spine or the lower extremities and no injuries occurred during the experiment.

2.3 Procedures

The experiment consisted of two test sessions (pre- and post-exercise test) and plyometric training intervention. Pre-exercise tests were performed three days before the beginning of training and included field tests to evaluate agility. A ten-week-long periodized plyometric training program was applied, followed by post-exercise tests, three days after the last training session. The study was carried out from January to March 2019 in the middle of the playing season. During the experiment all participants continued their regular soccer training routine, that was identical for every participant, except that the EG that participated in a plyometric training program on Tuesday, in place of the usual soccer training.

All testing sessions began with a standardized warm-up: 5 minutes aerobic warm-up (jogging) followed by stretching of the lower extremity muscles. One familiarization trial of each of the exercise tests was executed with submaximal intensity before the actual measurement. For training, the participants warmed up with their usual routine. This comprised of 10 min. jogging, stretching, performing 8 to10 running drills into different directions, and 4 to 6 submaximal running strides. The plyometric drills in the experimental group were always executed immediately after the warm-up before any other training tasks were performed on the given day. Each training session ended with ~ 20 min. of the friendly match and 5 min. of cool-down activities (i.e., stretching). The daily training duration for both study groups was ~90 minutes.

2.4 Measures

It has been previously suggested that plyometric training improves sport-specific agility in sports where sudden movements (accelerations, stops and direction changes) are required (Yap & Brown, 2000). Two specific agility tests were performed in the present investigation.

The *T agility test* was applied to measure agility during direction changes such as forward sprints, left and right shuffles, and backpedalling. In this test, three cones were set five meters apart on a straight line and a fourth cone was placed ten meters from the middle cone, forming a T shape. The test-retest reliability reported high reliability for the T-test (ICC = 0.94).

The *Illinois agility test* was used to measure agility during sprints including direction changes without stopping and running at different angles. The test-retest reliability reported a high reliability for the Illinois agility test (ICC = 0.92).

These tests were selected based upon established criteria data for males and females and because of their reported validity and reproducibility of the tests (Pauole, Madole, Garhammer, Lacourse, & Rozenek, 2000; Roozen, 2004). Additional information about these tests has been reported by Miller et al. (2006). Participants performed two trials of each of the agility tests with five minutes recovery between trials, and ten minutes recovery between test types. The best time of the two trials was recorded for statistical analysis. Times to complete the agility tests were measured every time by the same two assisting people using a stop-watch. The average of the times measured by the two assistants was used for statistics. Until the end of the experiment, the experimental status of the participants (EG or CG) was unknown for both assistants.

2.5 Plyometric training

The plyometric training group participated in a 10-week training program performing a variety of plyometric exercises designed for the lower extremity (see Table 1), while the control group did not participate in any plyometric exercises. The training program was based on recommendations of intensity and volume from Piper and Erdmann (1998), using similar drills, sets, and repetitions. However, in this study, the training frequency of the experimental protocol was modified compared to previous studies which examined the effects of the plyometric training on agility (Meylan & Malatesta, 2009; Miller et al., 2006; Váczi, Tollár, Meszler, Juhász, & Karsai, 2013). It was performed one plyometric training session per week because amateur footballers have been involved who perform fewer training sessions per week than professional footballers.

Training volume ranged from 90-foot contacts to 140-foot contacts per session while the intensity of the exercises increased for 9 weeks before tapering off during last week as recommended by Piper and Erdmann (1998). The intensity of training was tapered so that fatigue would not be a factor during post-testing. The plyometric training group trained at the same time of day, one day a week (on Tuesday), throughout the study. The duration of the plyometric exercises' session was gradual, ranging from a minimum of 30 minutes of the first session up to a maximum of 60 minutes. During the training, all subjects were under a sports science graduate direct supervision and were instructed on how to perform each exercise.

Table 1: Details of the plyometric training program for lower limbs performed by the experimental group over the 10-week trial*

Training week	Training Volume (foot contacts)	Plyometric Drill	Set x Reps	Training Intensity
Week 1	90	Side to side ankle hops	2 x 12	Low
		Standing jump and reach	2 x 12	Low
		Front cone hops	6 x 7	Low
Week 2	90	Side to side ankle hops	2 x 12	Low
		Standing jump and reach	2 x 12	Low
		Standing long jumps	6 x 7	Low
Week 3	90	Side to side ankle hops	2 x 12	Low
		Standing long jump	6 x 7	Low
		Lateral jump over barrier	2 x 12	Low/Medium
Week 4	120	Side to side ankle hops	2 x 12	Low
		Double leg hops	2 x 12	Low
		Lateral cone hops	2 x 12	Low/Medium
		Diagonal cone hops	6 x 8	Medium
Week 5	120	Side to side ankle hops	2 x 12	Low
		Lateral jump over barrier	2 x 12	Low
		Lateral cone hops	2 x 12	Low/Medium
		Standing long jump	6 x 8	Medium
Week 6	120	Side to side ankle hops	2 x 12	Low
		Lateral jump over barrier	2 x 12	Low
		Standing jump and reach	2 x 12	Medium
		Diagonal cone hops	5 x 6	Medium/High
		Plyo box jump 30 cm	4 x 5	High
Week 7	120	Diagonal cone hops	5 x 6	Low
		Standing long jump with lateral sprint	4 x 6	Medium
		Lateral cone hops	4 x 6	Medium
		Cone hops with 180-degree turn	4 x 6	Medium
		Plyo box jump 30 cm	5 x 5	High
Week 8	140	Side to side ankle hops	2 x 12	Low
		Standing jump and reach	2 x 12	Low
		Lateral cone hops	6 x 6	Medium
		Diagonal cone hops	6 x 6	Medium
		Plyo box jump 30 cm	6 x 4	High
Week 9	140	Side to side ankle hops	2 x 12	Low
		Lateral jump over barrier	2 x 12	Low
		Diagonal cone hops	6 x 6	Medium/High
		Lateral jump single leg	2 x 7	High
		Plyo box jump 50 cm	6 x 6	High
Week 10	120	Side to side ankle hops	2 x 12	Low
		Hexagon drill	5 x 4	Low
		Double leg hops	4 x 5	Low
		Cone hops with change of direction sprint	4 x 5	Low/Medium
		Plyo Box jump 50 cm	6 x 6	High

Note: *Gradual duration from 30 to 60 min.; recovery between set: 2 min. The intensity of training was tapered during the last week so that fatigue would not be a factor during post-testing.

2.6 Statistical Analyses

All analyses were performed using SAS Jmp Statistics (v. 14.1, Cary, NC, USA) and the data are presented as group mean values and standard deviations. Normality of all variables was tested using the Shapiro-Wilk test procedure. Levene's test was used to determine the homogeneity of variance. A multivariate analysis of variance (MANOVA) was used to detect differences between the study groups in all baseline variables. Training-related effects were assessed by 2-way analyses of variance (ANOVA) with repeated measures (group x time). When 'Time x Group' interactions reached the level of significance, group-specific post hoc tests (i.e., paired t-tests) were conducted to identify the significant comparisons. Percentage changes were calculated as [(post training value – pretraining value)/pretraining value] x 100.

The reliabilities of T-test and Illinois agility test measurements were assessed using intraclass correlation coefficients; scores from 0.8 to 0.9 were considered as good, while values above > 0.9 were considered as high (Vincent & Weir, 2012). The effect size was identified to provide a more qualitative interpretation of the extent to which changes observed were meaningful. Cohen's *d* was calculated as a ratio of the difference between the mean change value for each group and the pooled SD at baseline for all participants, and was interpreted as small, moderate and large effects defined as 0.20, 0.50, and 0.80, respectively (Cohen, 1988). Partial eta squared (η^2_P) was used to estimate the magnitude of the difference within each group and interpreted using the following criteria (Cohen, 1988): small ($\eta^2_P < 0.06$), medium ($0.06 \le \eta^2_P < 0.14$), large ($\eta^2_P \ge 0.14$).We accepted $p < 0.05$ as our criterion of statistical significance, whether a positive or a negative difference was seen (i.e., a 2-tailed test was adopted).

3. Results

All participants attended all training sessions (100% compliance) and no injuries were resulting from either training program. The EG and CG groups did not differ significantly at baseline in anthropometric characteristics and agility performance measures ($p > 0.05$). Pre- and post-intervention results for all outcome variables are presented in Table 2.

A. T-Test

A significant 'Time x Group' interaction was found ($F_{1,29} = 33.03$, $p < 0.001$, $\eta^2_P = 0.53$). However, no significant main effects of 'Group' and 'Time' were detected. The post hoc analysis revealed a significant decrease in the run time from pre- to post-test in the EG ($p = 0.001$, $d = 0.70$) and a significant increase in the run time in the CG ($p = 0.006$; $d = 0.80$).

B. Illinois Agility Test

The statistical analysis revealed a significant 'Time x Group' interaction ($F_{1,29} = 29.55$, $p < 0.001$, $\eta^2_P = 0.50$). However, we could not detect a significant main effect of 'Group' or 'Time'. The post hoc analysis revealed a significant decrease in the run time from pre- to post-test in the EG ($p < 0.001$, $d = 0.70$) and a significant increase in the run time in the CG ($p = 0.006$, $d = 0.60$).

Table 2: Changes in Agility measures in the EG and CG. Data are mean (±SD)

Variables	EG (n = 15)				CG (n = 16)			
	Pre-test	Post-test	Difference		Pre-test	Post-test	Difference	
			Absolute	%			Absolute	%
Agility test								
T - Test (sec)	11.5 (0.7)	11.0 (0.7)*†	-0.5	-4.3	11.4 (0.7)	11.9 (0.5)*	0.5	4.4
Illinois Agility Test (sec)	16.3 (0.9)	15.7 (0.8)*†	-0.6	-3.7	16.3 (1.0)	16.8 (0.7)*	0.5	3.1

EG = Experimental (Plyometric training) group; CG = Control (standard in-season regimen) group; *Significantly different from baseline ($p < 0.05$). †Significant 'Time x Group' interaction = significant effect of the training program.

4. Discussion

Plyometric programs are often implemented during the preseason to bring players to an appropriate initial level of fitness. Such a preseason regimen may serve to reduce injuries and improve the athletic performance of footballers, both by strengthening ligaments, tendons, and bones and by enhancing muscular strength, endurance, and power. However, this happens mainly in professional football clubs but not among amateur footballers where the athletic preparation is not supported by solid scientific bases. Previous authors (Bangsbo, 1994; Reilly, Bangsbo, & Franks, 2000; Markovic & Mikulic, 2010; Meylan & Malatesta, 2009; Miller et al., 2006) have recommended continuation of a plyometric training program into the soccer season to maintain and increase explosive ability. The aims of our study were thus to determine whether amateur male soccer players could enhance agility by a 10-week in-season plyometric program. The answer to both of these questions is strongly positive. Our results substantiate the hypothesis that substitution of one session per week of plyometric training enhanced the agility performance of the lower limbs whether assessed by run times of the T-test and Illinois Agility test (see Table 2). In contrast, the control group who continued with the standard training program showed a worsening of the performance in these variables.

In plyometric training group, significant improvements were observed both in the T agility (4.3%) and in the Illinois agility (3.7%) tests. Fewer studies examined the effects of plyometric training on specific agility, but the greatest improvement in agility (10%) was found in children soccer players after 8 weeks of plyometric training (Meylan & Malatesta, 2009) and in semi-professional adolescent soccer players after six weeks (9%) (Thomas, French, & Hayes, 2009). Instead, Miller et al. (2006) found 5 and 3% improvements in the T agility and Illinois agility tests, respectively, after 6 weeks of plyometric training. Some improvements are greater than those obtained in the present study, while they are similar to those of Miller et al. (2006) although making a comparison is difficult because the training status of the participants is not reported. From these research data, in agreement with our results, a conclusion can be made that a 10-week plyometric training program is effective for improving soccer-specific agility in amateur adults. The magnitude of improvement in agility, on one hand, may be influenced by the training status or age of the participants, demonstrating greater agility enhancement in younger individuals versus adults. Overall, improvements in agility after plyometric training can be attributed to neural adaptation, specifically to increased intermuscular coordination. Previous research also demonstrated increased proprioception after plyometric training (Myer, Ford, Brent, & Hewett, 2006).

In our study, subjects who underwent plyometric training were able to improve their times significantly on both the T-test and Illinois agility test, in agreement with previous studies (Meylan & Malatesta, 2009; Miller et al., 2006; Thomas et al., 2009) Therefore, we found a positive relationship between plyometric training and improvements of both agility tests. After ten weeks, the experimental group performed the T agility and Illinois agility tests in 11 and 15.7 seconds, respectively, showing good results despite being amateur footballers. Therefore, the present research provides novel findings in the field of advanced training methodologies in the amateur footballers' field. Although the experimental group performed plyometric exercises only once a week, it achieved equally good results compared to the control, demonstrating the effectiveness of the intervention protocol used in this study. This occurred because the plyometric training was individualized to each athlete with regard to sets/reps and progressions, and we tried to provide useful advice such as not using mobile devices (e.g., smartphones or tablets) before testing and training sessions to avoid a decline in fitness performance (Greco, Tambolini, Ambruosi, & Fischetti, 2017). Also, it should be noted that performance gains were achieved without any occurrence of musculoskeletal injury. This demonstrates the importance of being trained by graduates in the Sport Sciences and experts on plyometric training in order to prevent musculoskeletal injuries which are very common among athletes who participate in conditioning programs (Greco, Settimo, & Fischetti, 2018).

Our findings were limited to one particular category of soccer players, amateur adult males. Future studies should extend these observations to women, to other age groups, and other levels of competition. Furthermore, observations are also needed with differing intensities and volumes of plyometric training to determine their optimum dosage for this form of preparation.

5. Conclusion

In summary, this controlled study shows that amateur adult male soccer players that are participating in a plyometric training program can enhance their agility performance by replacing a part of their standard regimen with an in-season 10-week one-weekly program of plyometric training for the lower limbs. Besides, it has proven quite easy and practical to incorporate the proposed regimen into the traditional routine of technical and tactical training. The gains that we have observed should be of great interest for soccer coaches because the performance of this sport relies greatly on specific abilities like sprint, jump and change of velocity or direction, all of which were enhanced by the plyometric training regimen. Previous authors have found a similar need for deliberate plyometric training in other sports, but this is the first objective demonstration of its value in amateur soccer players. For this reason, we strongly recommend that soccer coaches implement in-season plyometric training to enhance the performance of their players.

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Authors' contribution
Claudio Damasco designed the study, collected data and wrote the manuscript. Gianpiero Greco carried out the statistical analysis, interpreted the data, wrote and revised the manuscript. Both authors contributed intellectually to the manuscript and have read the manuscript and approved the submission.

References

Anderson, F. C., & Pandy, M. G. (1993). Storage and utilization of elastic strain energy during jumping. *Journal of biomechanics*, *26*(12), 1413-1427.

Bangsbo, J. (1994). The physiology of soccer--with special reference to intense intermittent exercise. *Acta Physiologica Scandinavica. Supplementum*, *619*, 1-155.

Besier, T. F., Lloyd, D. G., Ackland, T. R., & Cochrane, J. L. (2001). Anticipatory effects on knee joint loading during running and cutting maneuvers. *Medicine and science in sports and exercise*, *33*(7), 1176-1181.

Bobbert, M. F., Gerritsen, K. G., Litjens, M. C., & Van Soest, A. J. (1996). Why is countermovement jump height greater than squat jump height? *Medicine and science in sports and exercise*, *28*, 1402-1412.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. 2nd edition. Hillsdale, NJ: L. Lawrence Earlbaum Associates.

Craig, B. W. (2004). What is the scientific basis of speed and agility? *Strength & Conditioning Journal*, *26*(3), 13-14.

Ellis, L., Gastin, P., Lawrence, S., Savage, B., Buckeridge, A., Stapff, A., Tumilty, D., Quinn, A., Woolford, S., & Young, W. (2000). Protocols for the physiological assessment of team sports players. In: *Physiological Tests for Elite Athletes.* C.J. Gore. Champaign, IL: Human Kinetics. pp. 128–144.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191. doi:10.3758/BF03193146.

Fischetti, F., Vilardi, A., Cataldi, S., & Greco, G. (2018). Effects of Plyometric Training Program on Speed and Explosive Strength of the Lower Limbs in Young Athletes. *Journal of Physical Education and Sport, 18*(4), 2476-2482.

Greco, G., Settimo, M., & Fischetti, F. (2018). Relationship between the correct running technique and lower back well-being perceived by the practitioner. *Journal of Physical Education and Sport, 18*(3), 1796-1800.

Greco, G., Tambolini, R., Ambruosi, P., & Fischetti, F. (2017). Negative effects of smartphone use on physical and technical performance of young footballers. *Journal of Physical Education and Sport, 17*(4), 2495-2501.

Komi, P. V. (2003). Stretch-shortening cycle. *Strength and power in sport, 2*, 184-202.

Kraemer, W. J., Ratamess, N. A., Volek, J. S., Mazzetti, S. A., & Gomez, A. L. (2000). The effect of the meridian shoe on vertical jump and sprint performances following short-term combined plyometric/sprint and resistance training. *The Journal of Strength & Conditioning Research*, *14*(2), 228-238.

Markovic, G. (2007). Does plyometric training improve vertical jump height? A meta-analytical review. *British journal of sports medicine*, *41*(6), 349-355.

Markovic, G., & Mikulic, P. (2010). Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. *Sports medicine*, *40*(10), 859-895.

Meylan, C., & Malatesta, D. (2009). Effects of in-season plyometric training within soccer practice on explosive actions of young players. *The Journal of Strength & Conditioning Research, 23*(9), 2605-2613.

Miller, M. G., Herniman, J. J., Ricard, M. D., Cheatham, C. C., & Michael, T. J. (2006). The effects of a 6-week plyometric training program on agility. *Journal of sports science & medicine*, *5*(3), 459.

Myer, G. D., Ford, K. R., Brent, J. L., & Hewett, T. E. (2006). The effects of plyometric vs. dynamic stabilization and balance training on power, balance, and landing force in female athletes. *Journal of strength and conditioning research*, *20*(2), 345.

Nicol, C., Avela, J., & Komi, P. V. (2006). The stretch-shortening cycle. *Sports medicine, 36*(11), 977-999.

Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and validity of the T-test as a measure of agility, leg power, and leg speed in college-aged men and women. *The Journal of Strength & Conditioning Research*, *14*(4), 443-450.

Piper, T. J., & Erdmann, L. D. (1998). A 4-step plyometric program. *Strength & Conditioning Journal*, *20*(6), 72-73.

Plisk, S.S. (2000). Speed, agility and speed endurance development. In: *Essentials of Strength Training and Conditioning* (2nd ed.). Baechle, T.R. and Earle, R.W. eds. Champaign, IL: Human Kinetics. pp. 427–470.

Reilly, T., & Dorand, D. (2003). Fitness assessment. In: *Science and Soccer* (2nd ed.). Reilly T. and Williams, M.A. eds. Routledge. pp. 21–46.

Reilly, T., Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *Journal of sports sciences*, *18*(9), 669-683.

Rimmer, E., & Sleivert, G. (2000). Effects of a plyometrics intervention program on sprint performance. *The Journal of Strength & Conditioning Research*, *14*(3), 295-301.

Roozen, M. (2004). Illinois agility test. *NSCA's Performance Training Journal*, *3*(5), 5-6.

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of sports sciences*, *24*(9), 919-932.

Thomas, K., French, D., & Hayes, P. R. (2009). The effect of two plyometric training techniques on muscular power and agility in youth soccer players. *The Journal of Strength & Conditioning Research*, *23*(1), 332-335.

Váczi, M., Tollár, J., Meszler, B., Juhász, I., & Karsai, I. (2013). Short-term high intensity plyometric training program improves strength, power and agility in male soccer players. *Journal of human kinetics*, *36*(1), 17-26.

Vincent, W., & Weir, J. P. (2012). *Statistics in Kinesiology* (4th Ed). Champaign, IL: Human Kinetics.

Wagner, D. R., & Kocak, M. S. (1997). A multivariate approach to assessing anaerobic power following a plyometric training program. *The Journal of Strength & Conditioning Research*, *11*(4), 251-255.

Yap, C. W., & Brown, L. E. (2000). Development of speed, agility, and quickness for the female soccer athlete. *Strength & Conditioning Journal*, *22*(1), 9.