

Research article

THE EFFECTS OF A 6-WEEK PLYOMETRIC TRAINING PROGRAM ON AGILITY

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Received: 21 June 2006 / Accepted: 07 August 2006 / Published (online): 01 September 2006

ABSTRACT

The purpose of the study was to determine if six weeks of plyometric training can improve an athlete's agility. Subjects were divided into two groups, a plyometric training and a control group. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All subjects participated in two agility tests: T-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing. Univariate ANCOVAs were conducted to analyze the change scores (post – pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F_{2,26} = 25.42$, $p=0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F_{2,26} = 27.24$, $p = 0.000$ was also found. The plyometric training group had quicker posttest times compared to the control group for the agility tests. A significant group effect $F_{2,26} = 7.81$, $p = 0.002$ was found for the Force Plate test. The plyometric training group reduced time on the ground on the posttest compared to the control group. The results of this study show that plyometric training can be an effective training technique to improve an athlete's agility.

KEY WORDS: Jumping, training, performance variables, quickness.

INTRODUCTION

Plyometrics are training techniques used by athletes in all types of sports to increase strength and explosiveness (Chu, 1998). Plyometrics consists of a rapid stretching of a muscle (eccentric action) immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle and Earle, 2000). The stored elastic energy within the muscle is used to produce more force than can be provided by a concentric action alone (Asmussen and Bonde-Peterson, 1974; Cavagna, 1977; Komi, 1992; Miller, et al., 2002; Pfeiffer, 1999; Wathen, 1993). Researchers have shown that plyometric training, when used with a periodized

strength-training program, can contribute to improvements in vertical jump performance, acceleration, leg strength, muscular power, increased joint awareness, and overall proprioception (Adams, et al., 1992; Anderst et al., 1994; Bebi et al., 1987; Bobbert, 1990; Brown et al., 1986; Clutch et al., 1983; Harrison and Gaffney, 2001; Hennessy and Kilty, 2001; Hewett et al., 1996; Holcomb et al., 1996; Miller et al., 2002; Paasuke et al., 2001; Potteiger et al., 1999; Wilson et al., 1993).

Plyometric drills usually involve stopping, starting, and changing directions in an explosive manner. These movements are components that can assist in developing agility (Craig, 2004; Miller et al., 2001; Parsons et al., 1998; Yap et al., 2000;

Young et al., 2001). Agility is the ability to maintain or control body position while quickly changing direction during a series of movements (Twist and Benickly, 1995). Agility training is thought to be a re-enforcement of motor programming through neuromuscular conditioning and neural adaptation of muscle spindles, golgi-tendon organs, and joint proprioceptors (Barnes and Attaway, 1996; Craig, 2004; Potteiger et al., 1999). By enhancing balance and control of body positions during movement, agility theoretically should improve.

Table 1. Demographic data. Data are means ($\pm$ SD).

	Control group n =14 (♂=10, ♀=4)	Training group n =14 (♂=9, ♀=5)
Age (yrs)	24.2 (4.8)	22.3 (3.1)
Height (m)	1.70 (.10)	175.4 (8.6)
Weight (kg)	81.2 (21.1)	80.1 (14.9)

It has been suggested that increases in power and efficiency due to plyometrics may increase

agility training objectives (Stone and O'Bryant, 1984) and plyometric activities have been used in sports such as football, tennis, soccer or other sporting events that agility may be useful for their athletes (Parsons and Jones, 1998; Renfro, 1999; Robinson and Owens, 2004; Roper, 1998; Yap and Brown, 2000). Although plyometric training has been shown to increase performance variables, little scientific information is available to determine if plyometric training actually enhances agility. Therefore, the purpose of this study was to determine the effects of a 6-week plyometric training program on agility.

METHODS

Subjects

Twenty-eight subjects volunteered to participate. Subjects were randomly assigned to two groups, a plyometric training group and a control group (Table 1). Subjects were at least 18 years of age, free of lower extremity injuries, and were not involved in

Table 2. Plyometric 6-week training protocol.

Training Week	Training Volume (foot contacts)	Plyometric Drill	Sets X Reps	Training Intensity
Week 1	90	Side to side ankle hops	2 X 15	Low
		Standing jump and reach	2 X 15	Low
		Front cone hops	5 X 6	Low
Week 2	120	Side to side ankle hops	2 X 15	Low
		Standing long jump	5 X 6	Low
		Lateral jump over barrier	2 X 15	Medium
		Double leg hops	5 X 6	Medium
Week 3	120	Side to side ankle hops	2 X 12	Low
		Standing long jump	4 X 6	Low
		Lateral jump over barrier	2 X 12	Medium
		Double leg hops	3 X 8	Medium
		Lateral cone hops	2 X 12	Medium
Week 4	140	Diagonal cone hops	4 X 8	Low
		Standing long jump with lateral sprint	4 X 8	Medium
		Lateral cone hops	2 X 12	Medium
		Single leg bounding	4 X 7	High
		Lateral jump single leg	4 X 6	High
Week 5	140	Diagonal cone hops	2 X 7	Low
		Standing long jump with lateral sprint	4 X 7	Medium
		Lateral cone hops	4 X 7	Medium
		Cone hops with 180 degree turn	4 X 7	Medium
		Single leg bounding	4 X 7	High
		Lateral jump single leg	2 X 7	High
Week 6	120	Diagonal cone hops	2 X 12	Low
		Hexagon drill	2 X 12	Low
		Cone hops with change of direction sprint	4 X 6	Medium
		Double leg hops	3 X 8	Medium
		Lateral jump single leg	4 X 6	High

any type of plyometric training at the time of the study.

Procedures

All subjects agreed not to change or increase their current exercise habits during the course of the study. The plyometric training group participated in a 6-week training program performing a variety of plyometric exercises designed for the lower extremity (Table 2), while the control group did not participate in any plyometric exercises. All subjects were instructed not to start any lower extremity strengthening programs during the 6-week period and to only perform activities of normal daily living. Prior to the study, procedures and guidelines were presented orally and in written form. Subjects agreeing to participate signed an institutionally approved consent form.

A 6-week plyometric training program was developed using two training sessions per week. The training program was based on recommendations of intensity and volume from Piper and Erdmann (1998), using similar drills, sets, and repetitions. From a physiological and psychological standpoint, four to six weeks of high intensity power training is an optimal length of time for the CNS to be stressed without excessive strain or fatigue (Adams et al., 1992). It is the belief of some sports physiologists that neuromuscular adaptations contributing to explosive power occur early in the power cycle of the periodization phase of training (Adams et al., 1992). Plyometrics were only performed twice per week to allow for sufficient recovery between workouts as recommended by researchers (Adams et al., 1992).

Training volume ranged from 90 foot contacts to 140 foot contacts per session while the intensity of the exercises increased for five weeks before tapering off during week six as recommended by Piper and Erdmann (1998) and used previously in another study (Miller et al., 2002). 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, two days a week, throughout the study. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise.

Testing procedures

Three tests conducted both pre and post training were used to determine agility outcomes. The T-test (Figure 1) was used to determine speed with directional changes such as forward sprinting, left and right side shuffling, and backpedaling. The Illinois agility test (Figure 2) was used to determine the ability to accelerate, decelerate, turn in different

directions, and run at different angles. 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 et al., 2000; Roozen, 2004). Finally, a force plate test (Figure 3) was used to measure quickness and power (ground contact time while hopping). This test was created to mimic the dot drill that requires an athlete to stay balanced in order to shift their body weight in several different directions.

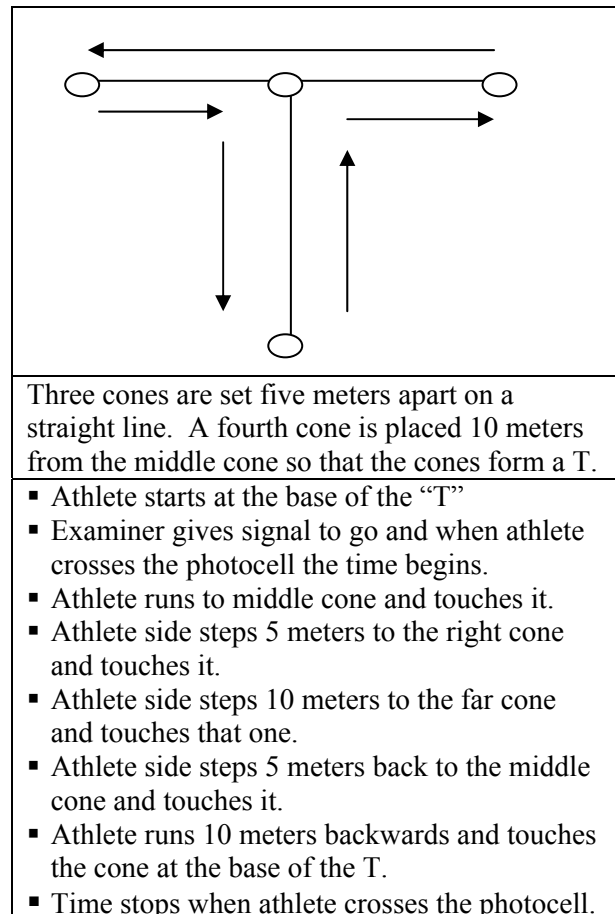


Figure 1. T-Test procedures.

Prior to training, all subjects had their baseline agility tested, using the three tests previously mentioned. The total testing session was approximately one hour for each subject which included warm-up, ten minute rest times between tests and approximately three minutes between reps. Each test was explained and demonstrated. Before testing, subjects were given practice trials to become familiar with the testing procedures. All tests were counterbalanced pre and post testing to ensure that testing effects were minimized. Subjects performed each test 3 times and the results were averaged.

Statistical analysis

Pre and post values for the dependent variables were analyzed to determine if the distributions were

normal using Kolmogorov-Smirnov goodness-of-fit test and the Shapiro-Wilk Normality test. Change scores (post – pre) were computed for each of the dependent variables: T-Test agility, Illinois Agility Test and the force plate test. Single factor ANCOVAs were used to test for differences between groups (Control, Plyometric Training) for the dependent variable change scores using the pre-test values as a covariate. Alpha was established *a priori* at $p < 0.05$. The Statistical Package for Social Science (version 11.0: Chicago, Ill) was used to calculate the statistics.

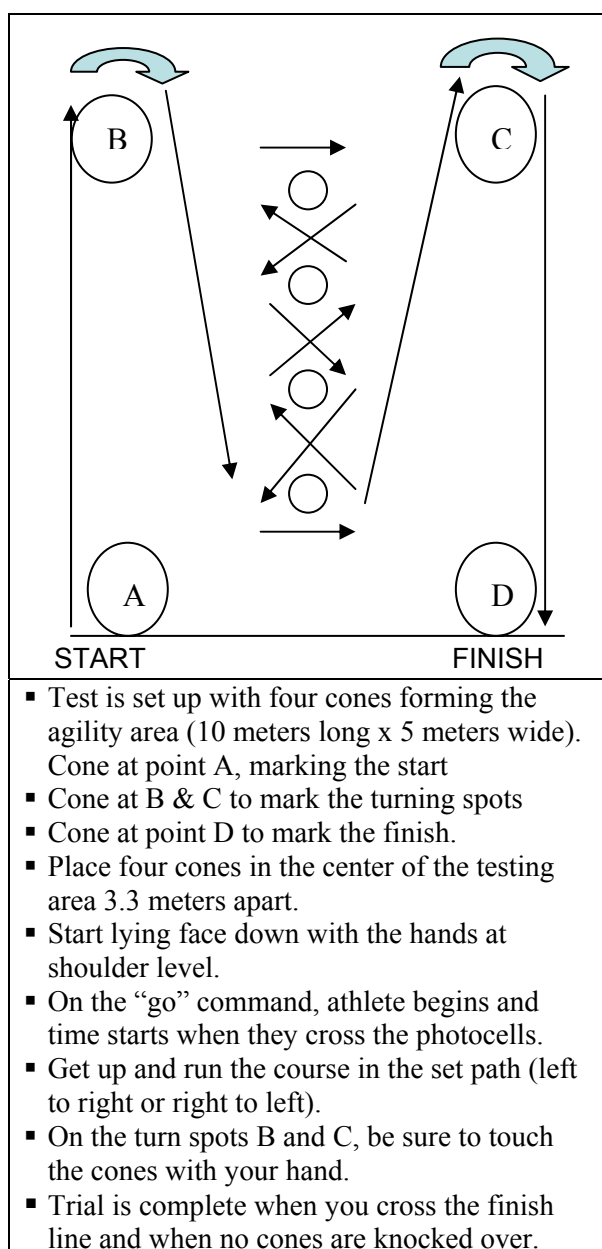


Figure 2. Illinois Agility Test procedures.

RESULTS

The means and standard deviations for times of the groups for all three tests are provided in Table 3.

Tests of normality indicated that dependent variables were normally distributed. The single factor ANCOVA revealed a significant group effect $F_{2,26} = 25.42$, $p = 0.000$, power = 1.00 for the T-test agility measure change score, when controlling for Pre-test differences. As shown in Table 3, the plyometric group improved their T-Test agility times by -0.62 ± 0.24 sec, while the control group times were virtually unchanged 0.01 ± 0.14 sec. For the Illinois Agility test change score, a significant group effect $F_{2,26} = 27.24$, $p = 0.000$, power = 1.00 was found, when controlling for Pre-test differences. The plyometric training group improved their Illinois Agility Test times by -0.50 ± 0.32 sec and the control group times changed by -0.01 ± 0.05 sec. A significant group effect $F_{2,26} = 7.83$, $p = 0.002$, power = 0.923 was found for the force plate test change score, when using the Pre-test values as a covariate. The plyometric training group improved their force plate agility test times by -26.37 ± 21.89 msec and the control changed their times by -0.98 ± 6.33 msec, see Table 3.

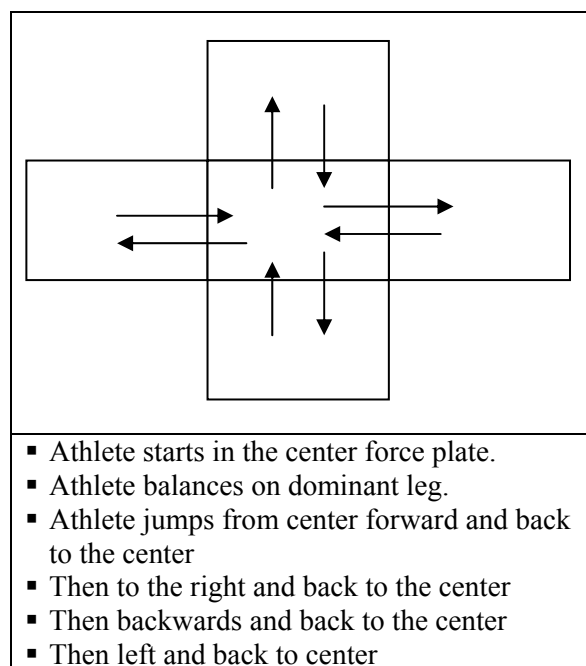


Figure 3. Force Plate Agility procedures. Force Plate – going clockwise on dominant foot.

DISCUSSION

For the T-test, times were improved by 4.86%, for the Illinois agility test, 2.93%, and for the force plate, subjects improved by over 10%. By finding significant differences for all three tests, our results indicate that the plyometric training improved times in the agility test measures because of either better motor recruitment or neural adaptations. In a previous study of plyometric training, the authors

Table 3. Means ($\pm$ Standard Deviations) for the 3 Agility Measures.

Agility Test	Pre-test	Post-test
T-Test (sec)		
Training	12.8 (1.0)	12.1 (1.1) *
Control	12.6 (1.1)	12.6 (1.1)
Illinois Agility Test (sec)		
Training	17.1 (1.7)	16.6 (1.6) *
Control	16.5 (.95)	16.5 (.9)
Force Plate (msec)		
Training	256.9 (28.2)	230.5 (37.2) *
Control	233.1 (20.6)	232.1 (20.7)

* Indicates significant change (post – pre) when using Pre-test score as a covariate, $p < 0.05$.

speculated that improvements were a result of enhanced motor unit recruitment patterns (Potteiger et al. 1999). Neural adaptations usually occur when athletes respond or react as a result of improved coordination between the CNS signal and proprioceptive feedback (Craig, 2004). However, we could not determine if neural adaptations occurred via synchronous firing of the motor neurons or better facilitation of neural impulses to the spinal cord which also supports the suggestions of Potteiger et al. (1999). Therefore, more studies are needed to determine neural adaptations as a result of plyometric training and how it affects agility.

We chose to use a force plate test to determine ground contact time when preparing to change direction, which is a major component of agility and a benefit of plyometric training. Roper (1998) used a four-point drill, which is very similar to the test we implemented using the force plate, since the movement patterns require forward, backward and lateral changes in direction in a rapid succession. He stated that the relationship between plyometric exercise and increased performance in agility tests may be high due to their similar patterns of movement to facilitate power and movement efficiency by the immediate change in direction upon landing. Our results using the force plate test support Roper's claims that a plyometric training program can decrease ground reaction test times because of increases in muscular power and movement efficiently.

In our study, subjects who underwent plyometric training were able to improve their times significantly on both the T-test and Illinois agility test. Therefore, we found a positive relationship between plyometric training and improvements of both agility tests. This improvement in agility is beneficial for athletes who require quick movements while performing their sport and support results from other studies. In a study of tennis players, the authors used a T-test and dot drill test to determine

speed and agility (Parsons and Jones, 1998). They found that the players became quicker and more agile; enabling them to get to more balls and be more effective tennis players. Renfro (1999) measured agility using the T-test with plyometric training while Robinson and Owens (2004) used vertical, lateral and horizontal plyometric jumps and showed improvements in agility.

CONCLUSIONS

The results from our study are very encouraging and demonstrate the benefits plyometric training can have on agility. Not only can athletes use plyometrics to break the monotony of training, but they can also improve their strength and explosiveness while working to become more agile. In addition, our results support that improvements in agility can occur in as little as 6 weeks of plyometric training which can be useful during the last preparatory phase before in-season competition for athletes.

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KEY POINTS

- Plyometric training can enhance agility of athletes.
- 6 weeks of plyometric training is sufficient to see agility results.
- Ground reaction times are decreased with plyometric training.

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