Original Article

# The effects of a four week primary and secondary speed training protocol on 40 yard sprint times in female college soccer players

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**ABSTRACT**

Wagganer, J.D., Williams, R.D. & Barnes, J.T. (2014). The effects of a four week primary and secondary speed training protocol on 40 yard sprint times in female college soccer players. *J. Hum. Sport Exerc., 9*(3), pp.713-726. Improvements in running speed have been attributed to both primary and secondary speed training techniques. Primary techniques involve attention to running mechanics and form, and secondary techniques involve resisted or assisted sprinting. The purpose of this study was to assess the effect of combining both primary and secondary speed training techniques on 40 yard sprint speed in young soccer players. To compare the effects of pre- and post- four week speed training protocol on 40-yard sprint times in female collegiate soccer players. Twelve (19.5+1.5y) normal weight (BMI: 22.7+3.4 kg·m-2) and body composition (BF: 27.75+3.8%) active white female collegiate soccer players participated in a four week training protocol which implemented primary and secondary speed training methods. A standard running mechanics program was implemented two times per week and was immediately followed by resisted or assisted sprinting. Sled towing was chosen for resisted sprinting, while elastic towing devices were chosen for assisted sprinting. Forty yard sprint times were assessed pre and post protocol. Statistical analysis was conducted using SPSS. A paired samples t-test showed the four week speed training protocol elicited statistically significant reductions in 40 yard sprint times ($p<0.001$). The average sprint time decreased by 0.248 seconds (pre=5.463+0.066 vs post=5.215+0.053). A four week speed training protocol of primary and secondary techniques may play a significant role in reducing 40 yard sprint times in college female soccer athletes. Values are presented as (mean+SEM) **Key words**: BIOMECHANICS, SPRINTING, EXERCISE PHYSIOLOGY

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## INTRODUCTION

The development and achievement of maximal running speed is very important for soccer players who spend the majority of a game at low to moderate intensity exercise levels, interspersed with highly-intense bouts of sprinting (Bloomfield et al., 2007; Bradley et al., 2010; Spencer et al., 2005). For experienced players the ability to quickly accelerate to maximal running speed, approximately every 90 seconds during a match (Taskin, 2008), is a product of stride length and stride frequency (Baechle & Earle, 2008; Hunter et al., 2005; Lockie et al., 2013). Two interventions for increasing maximal running speed involve primary and secondary training methods. Primary methods focus on running mechanics while secondary methods refer to either assisted or resisted sprinting aimed at increasing stride length and/or frequency, ground reaction force (Weyand et al., 2000; Weyand et al., 2010), and by stimulating changes to the neuromuscular system (i.e., recruitment of more fast-twitch muscle fibers) (Behrens & Simonson, 2011; Cissik, 2005; Flanagan & Comyns, 2008). While primary and secondary training methods have been shown to individually improve maximal running speed, there is a limited amount of research detailing the combined effects.

In regards to primary sprint training, both stride length and stride frequency can be positively augmented by emphasizing correct running mechanics. Sprinting can be separated into two phases; the drive and recovery phase. The drive phase, produced by muscular contraction of the hip extensor and quadriceps muscles, refers to the point where the foot strikes the ground just in front of the athlete's center of gravity (Baechle & Earle, 2008) and ends as the toe leaves the ground (Cissik, 2004; Cissik, 2002; Morin et al., 2011). After completion of the drive phase, the recovery phase will begin with the athlete drawing the heels up towards the buttocks contributing to a high knee lift and end with the foot contacting the ground (Baechle & Earle, 2008; Cissik, 2005; Baechle & Earle, 2008). The possibility of improving sprint times by improving running mechanics has a great deal of research support (Cronin & Hansen, 2006; Hunter et al., 2004; Hrysomallis, 2012; McFarlane, 1987; McFarlane, 1993; West & Robson, 2000).

Secondary sprint training techniques can be divided into two distinct categories: resisted and assisted sprinting. Resisted sprinting can be performed via two methods: hill training and sled towing (Baechle & Earle, 2008). Both methods act to increase running speed by increasing stride length and ground force reaction power (Corn & Knudson, 2003; Weyand et al., 2010), primarily during the driving phase (Cronin & Hansen, 2006), via an increase in muscle force output of the hip and knee extensors (Paradisis & Cooke, 2006; Zafeiridis et al., 2005). While not all research supports the effectiveness of this form of sprint training (Clark et al., 2010), there appears to be some supportive data (Harrison & Bourke, 2009; Upton, 2011; West et al., 2013). More specifically, several studies utilizing young field athletes performing 2-3 resistive, 10-13% of body weight, sprinting sessions per week for four to six weeks resulted in significantly improved sprint times compared to unresisted sprint training (Harrison & Bourke, 2009; Lockie et al., 2003; Spinks et al., 2007; Upton, 2011; West et al., 2013). The body weight percentage resistance utilized in these studies appears to be appropriate for allowing the athlete to achieve approximately 90% of maximum sprint velocity (Cissik, 2005; Lockie et al., 2003) while also promoting an increase in ground force reaction (Alcaraz et al., 2008; Paridisis & Cooke, 2006).

Assisted sprint training methods are typically conducted by a towing device based upon one of two factors: 1) a percentage of body weight or 2) a set reduction in standard sprint distance. The first method, originally developed by Sandwick (1967), suggests an athlete be towed at a rate that reduces a 50 yard sprint by approximately 0.5 seconds. The second method suggests that athletes not exceed speeds greater than 106-110% of their unassisted maximal running velocity (Clark et al., 2009) and the distance covered should not exceed 30-40m in length (Cissik, 2005). If one of these two guidelines is not followed, normal running mechanics will be negatively altered and the assisted sprint efforts will not produce faster unassisted sprint speeds. Since there is very limited research on the effects of assisted sprinting, no universally accepted guidelines are in place. Therefore, the data regarding stride rate and assisted sprinting remains unclear. Studies utilizing young athletes have shown significant increases in stride length and/or frequency with assisted sprints between 4-10% of body weight (Clark et al., 2009; Corn & Knudson, 2003; Hauschildt, 2010; Leblanc & Gervais, 2004; Mero & Komi, 1985; Paradisis & Cooke, 2006). Also, studies support assisted sprints act to impose more eccentric muscle contractions, which lead to more muscle hypertrophy (Chen, 2007; Farthing & Chilibeck, 2003; Gottschall & Kram, 2005; Paradisis & Cooke, 2006) and a more efficient neuromuscular recruitment pattern (Behm, 1995; Behrens & Simonson, 2011; Flanagan & Comyns, 2008). While these benefits are mostly supported by past data, currently there is limited research on the interactions of primary and secondary sprint training techniques in college athletes.

Sprint training has been shown to be a valuable practice in the strength and conditioning setting to potentially achieve greater running speeds. Currently, there is limited research describing the effects of the combined effects of primary and secondary sprint training methods on sprint speed. Therefore, the purpose of this research was to determine the effects of a 4-week training protocol, including both primary and secondary sprint training techniques, on 40-yard sprint time in female collegiate soccer players. It was hypothesized that performing both sprinting techniques during a 4-week time span will cause a decrease in 40-yard sprint times.

## MATERIAL AND METHODS

### Participants

Twelve (19.5+1.5y) normal weight (BMI: 22.7+3.4 kg·m-$^{2}$) and body composition (BF: 27.75+3.8%) active white female collegiate soccer players participated in a four-week protocol utilizing primary and secondary speed training methods. All participants had >8 years of soccer-specific sport training. However, none of the participants had been trained in the technical aspects of sprinting. All participants voluntarily read and signed informed consent, which was approved by the Human Subjects Committee at the University where the research took place.

### Procedures

This investigation was conducted after the first training micro cycle, mid-January through mid-February, of the soccer training season. During the 4-week experimental training protocol the participants were performing three non-consecutive days per week of basic endurance resistance training. The participants conducted the same routine, with the resistance determined by the strength of the individual. The routine consisted of a full-body circuit training style regimen that progressed from larger muscle groups to smaller muscle groups. Each session required 8-12 exercises, 3 sets of each exercise, 12-15 repetitions per exercise, and lasted approximately 60 minutes. Along with the resistance training regimen, a basic aerobic conditioning program was conducted. This program consisted of five days per week of assigned distance runs, adjusted to the relative ability of each participant. The running distances were as follows: two non-consecutive days of long intervals (i.e., 300-800 m), two non-consecutive days of fixed distance high-intensity (i.e., 1 mile), and a moderate over distance day (i.e., 3-5 miles).

In order to maintain a consistent training and testing environment, all experimental procedures were conducted on an indoor track facility. University athletic training staff were present during all training sessions, providing both support and ad libitum fluids to the participants.

Prior to conducting each experimental primary and secondary speed training drills all participants completed a warm-up of light jogging, dynamic stretching, and sprints of increasing intensity. Immediately following the warm-up, the participants completed two 40-yard sprint trials, with the best time utilized for statistical analysis. Participants were assessed in random order; however, a five minute recover time was required between sprint trials. Manual timing was conducted by the same researcher with a handheld stopwatch (Model 360 electronics USA, Victorville, CA, USA). Each sprint trial required the participant to begin from a completely motionless 3-point standing position, with the researcher starting the stopwatch clock on first movement. The pre- and post-protocol sprint trials were conducted under the same conditions and similar time of day. Posttests were administered one-week post protocol to allow for sufficient recovery. It should also be noted that the athletes received similar verbal encouragement on both pre and post test data collection days.

The speed training method protocol consisted of eight training sessions, two per week, conducted over the 4-week experimental period (Table 1). The primary drills intentionally begin with basic (i.e., single component emphasis) movements followed by more increasingly complex (i.e., combination of single components) movements. All drills were initially implemented at walking speeds, then progressed to faster speeds (i.e., what the participant could perform in with proper mechanics) within each session and during the entire four-week protocol (McFarlane, 1987). The secondary drills consisted of sled towing for resisted sprinting, while elastic towing devices were chosen for assisted sprinting (Clark et al., 2009; Cronin & Hansen, 2006). In addition to the four-week speed training protocol the athletes participated in resistance training, and conditioning specific to their designated sport. Off-season resistance training and aerobic conditioning began six weeks prior to the speed training protocol. Resistance training exercises included many sports specific lifts in which fast speed of movement was emphasized.

**Primary Drills**

The primary technique drills used in this study were intended to teach the participants the 'ideal' sprinting biomechanics. The 'Walk and line', 'Skip and line', and 'March and line' drills, emphasizing back side mechanics, were implemented to teach participants how to properly perform 'ankling' and 'casting'. Ankling is the action of properly lifting the foot off the ground in an effort to minimize the amount of time the foot is in contact with the ground. Proper ankling requires a rigid ankle that will minimize the amount of power lost to the ground and reduce injuries (Cissik, 2002). 'Casting' is the action of immediately dorsiflexing the ankle, along with hyperextension of the big toe, once the back foot breaks contact with the ground. High knee drills stress the front side mechanics of sprinting while still emphasizing ankle dorsiflexion (i.e., casting) and plantar flexion. These drills are designed for conditioning the hip flexors and emphasize driving the forefoot back down to the ground from the hip. The participants were encouraged to stay tall, but not lean back when performing high knee drills as this most closely replicates full speed running body position (Cissik, 2005; McFarlane, 1993; Kristensen et al., 2006).

In addition to teaching 'casting' and 'ankling', the aforementioned drills also stressed proper 'heel kicks', which encourages bringing the heel to the buttocks in order to shorten the legs radius of rotation. This is achieved by promptly bringing the heel directly up towards the buttocks and stepping 'over' the opposite knee. This action also encourages a high knee lift, which is an important determinant of speed. During these drills the participants were told to concentrate on plantar flexing when the foot makes contact with the ground, and immediately dorsiflex (i.e., casting) upon the foot breaking contact with the ground (Cissik, 2005).

In an effort to emphasize front side mechanics while also reinforcing 'casting', 'Rhythm high knee' drills were implemented. While this drill does focus on front side mechanics, it still stresses back side mechanics (i.e., casting, ankling, hip flexor contraction, etc.). Initially this drill was conducted individually, but within a few days the participants were encouraged to add arm swings.

In addition to performing front and backside mechanic drills separately, it is important to perform drills that emphasize both. One such drill is called an 'A' drill, which required participants to focus on plantar flexion and casting, pulling the heel towards the buttocks, and stepping over the opposite knee, while landing on the forefoot. With the addition of arm swings, this drill closely mimics real-time sprinting (McFarlane, 1993). Another drill implemented were 'B' drills, which are similar to 'A' drills. However, the minor difference involves the participant powerfully striking the ground with each foot strike. Performing 'A' and 'B' drills help reinforce the circular movement of the foot in front of the body to a position under the body for support (Kivi & Alexander, 2000). The participants in this study were well trained, young, soccer players and quickly mastered (i.e., two sessions; end of Week #1) 'A' drills, a requirement (Cissik, 2005), before performing the more advanced 'B' drills. Once 'A' and 'B' drills were mastered the participants were able to perform biomechanically correct 'Rhythm Runs' and 'Rhythm Sprints' drills, which were a combination of all the aforementioned drills. Along with these running and sprinting drills, bounding and power starts were implemented as a means for improving ground force production and rate of muscle force development (Jakalski, 2002).

All the aforementioned primary drills were conducted to help establish correct sprinting neuromuscular movements patterns. The final two primary drills implemented in this study were 'bounding' and 'power starts', both of which were aimed at developing explosive leg power. The 'bounding' style that was utilized required the participants to bound off each leg as high as possible using a running form gait while emphasizing a high-knee lift at a slow jogging pace. Participants maintained a straight line running form and were told to focus on exploding vertically, allowing the knee lift to continue to vertical drive, rather than horizontally while still moving at a slow jogging pace. The 'power starts' were conducted from a 3-point stationary position, with an emphasis on back side mechanics (i.e., applying power behind the body). Participants were instructed to focus on driving the body forward, primarily via back side mechanics, during the 12-15 yard sprint, allowing for a 25 yard deceleration distance.

**Secondary Drills**

The secondary technique drills utilized in this study included assisted sprints and resisted sled pulls. For the assisted sprints, the Speed Harness™ (Power Systems, Knoxville, TN, USA) was attached to the researcher by a waist belt and the opposite end attached via a waist strap to the towed participant. The tow cable utilized for each participant was based upon body weight. The tow cable utilized for each participant was selected based upon the following body weight parameters: <124 lbs = lightest resistance, 125-150 lbs = medium resistance, and >150 lbs = heavy resistance. This set up ensured that the assistive force was equal to 106-110% of body weight. Prior to the start of each sprint, the research assistant would sprint 10 yards ahead of the towed participant. At that point the participant was instructed to sprint the 20-yard distance, while the research assistant continued to sprint the final 30 yards. This combined sprinting action maintained a constant assistive force on the participant throughout the 20 yard sprint. After completing the 20 yard sprint, and the 30 yards with the research assistant, an additional 20 yards were allocated for deceleration. Participants were given a minimum of three minutes of recovery between assisted sprint repetitions.

The resisted sled pulls were conducted with a weighted sled (Power Systems Inc., Knoxville, TN) attached to the participant via a 3-m cord and waist harness. All resistive sprint training was conducted on an artificial turf soccer field allowing the smooth and bare underside of the sled to freely slide. The waist harness was chosen so the participant would not experience too much forward lean during the resistive sprints (Alcaraz et al., 2008). The weighted sled was adjusted for each participant to provide a resistance that was equivalent to 10-15% of total body weight (Lockie, et al, 2003; Spinks et al., 2007). This range was selected because it is the maximum amount of weight suggested that still allows for proper sprinting mechanics (Alcaraz et al., 2008). In order to ensure optimal performance, participants wore their own athletic training gear and footwear during all experimental protocol procedures (Berchue, Mayhew, & Piper, 2005). Participants were given a minimum of three minutes of recovery between resisted sprint repetitions.

**Statistical Analyses**

Following data collection and analyses, means and standard deviations were calculated for all results. A paired samples t-test was used to determine if there was a significant difference between pre and post protocol 40-yard sprint times. Statistical analysis was conducted using SPSS v19.0 statistical software package (SPSS Inc., Chicago, IL) with a statistical significance level set at $p < 0.05$.

***Table 1.*** *Speed Training Methods*

| Primary:<br>Weeks 1-4 | Secondary:<br>Week 1 | Secondary:<br>Week 2 | Secondary:<br>Week 3 | Secondary:<br>Week 4 |
|---|---|---|---|---|
| Sessions 1 & 2<br>(2 reps each)<br>1. Walk and line<br>2. March and line<br>3. Skip and line<br>4. High knee drills<br>5. Rhythm high knee drills<br>6. Rhythm runs<br>7. Rhythm sprints<br>8. Bounding and power starts | Session 1<br>Over Speed Elastic Cords:<br>8 reps (20 yard sprint)<br><br>Session 2<br>Resisted Sled Pulls:<br>8 reps (20 yard sprint w/ 10% of athletes BW) | Session 1<br>Over Speed Elastic Cords:<br>8 reps (20 yard sprint)<br>2 unassisted 30 yard sprints<br><br>Session 2<br>Resisted Sled Pulls:<br>8 reps (20 yard sprint w/ 10% of athletes BW) | Session 1<br>Over Speed Elastic Cords:<br>10 reps (20 yard sprint)<br><br>Session 2<br>Resisted Sled Pulls:<br>6 reps of contrast sprints (15 yard sprint w/ 10% of athletes BW followed by 20 yard unweighted sprint) | Session 1<br>Over Speed Elastic Cords:<br>10 reps (20 yard sprint)<br>4 unassisted 30 yard sprints<br><br>Session 2<br>Resisted Sled Pulls:<br>6 reps of contrast sprints (15 yard sprint w/ 10% of athletes BW followed by 20 yard unweighted sprint) |

## RESULTS

The purpose of this study was to determine the combined effects a four week primary and secondary speed training protocol on 40 yard sprint speed in collegiate soccer players. A paired samples t-test showed the four week speed training protocol elicited statistically significant reductions in 40 yard sprint times ($p<0.001$). The mean of the pretest was 5.463+0.066, and the mean of the posttest was 5.215+0.053. A significant decrease from pre-to post-40 yard sprint times was found [$t(11)= -0.248$ seconds, $p<0.001$).

 

## DISCUSSION AND CONCLUSIONS

For many field sport athletes, success depends upon the achievement of maximum sprint speed. Improving sprinting mechanics, via primary and secondary speed training drills, may be effective in improving 40 yard dash performance. While performing primary drill work emphasizes running technique and secondary drill work emphasizes assisted or resisted sprinting, very few articles to date have assessed the combined effects. Therefore, the purpose of the study was to help define the effects of conducting primary and secondary sprinting drills on young athletes who had very limited experience in the physical execution of proper sprint biomechanics.

The primary finding of this study was that sprint time decreased significantly for a sample of collegiate soccer players with no experience in primary and/or secondary speed training techniques. The average pre- 40 yard sprint time, as measured by a handheld device, was 5.46 seconds. Past research has indicated handheld devices tend to produce faster sprint times (0.31+0.07seconds) compared to electronic devices (Mayhew, 2010). Based upon this information it can be assumed that the participants in our study would have likely recorded 40 yard sprint times between 5.36 and 6.05 seconds, with an average of 5.77 seconds, if a laser timer had been utilized. Based upon this assumption the average 40 yard sprint time is faster, approximately 0.2-0.4 seconds, than other studies that have laser timed subjects of similar age (Moore et al., 2007) and sport (Vescovi et al., 2010). Some of the potential reasons for this discrepancy in 40 yard sprint times from our study compared to other studies could be based upon body weight and/or body composition as well as sport related sprinting ability. The study by Moore et al. (2007) utilized college females of similar body weight and BMI, but body composition was not reported. The present study utilized trained college athletes, albeit with minimal experience in sprint training, who may have possessed a distinctive advantage when it came to the ability to sprint (i.e., >8 years of soccer training could be linked to better sprinting ability). The study by Vescovi et al. (2010) did not indicate the average body weight of their soccer athletes of similar age to our study. Therefore, it is possible that the Vescovi et al. (2010) article utilized athletes that were not equally comparable to our studies participants. Overall, the sprint times of our participants were faster than other somewhat comparable studies, but the exact reason is not clearly identifiable.

While this study did show maximum sprint speed improved, it was not the intent of the researcher to determine what portion of the 40 yard sprint this improvement occurred [i.e., first 15 yards (drive phase) or final 25 yards (recovery phase)]. Moreover, the study was not set up to determine the primary stimulus (i.e., primary or secondary drills) for the improved 40 yard sprint times. Also, this study did not utilize a control group due to the timing of season and the program schedule. The author acknowledges the importance of a control group, but it is still evident that the participants in this study (i.e., well-trained soccer players who were accustomed to the training program being conducted at the same time as the experimental sprint techniques were implemented) significantly benefited from the experimental sprint training techniques. Therefore, the results of this study suggest that primary and secondary sprint training techniques accounted for the majority of the improved sprint times (Baechle & Earle, 2008).

When deciding how to best apply these principles it is important to remember that running mechanics differ significantly over the first 12-15 yards of sprinting. During the acceleration phase the athlete's foot will make ground contact well behind their center of gravity. This suggests that the athlete should primarily focus on front side running mechanics, which involve high knee lift and ankle dorsiflexion, rather than the backside mechanics which involve heel to buttocks and ankle plantar flexion. It should be noted that both will play a role in acceleration, however, front side mechanics are more essential for acceleration (McFarlane, 1993). While the acceleration phase is very important, maximum sprint speed has been shown to be achieved by field athletes (Santana, 2000). In a study conducted by Vescovi et al., 2010, young female soccer and lacrosse players achieved maximum sprint speed between 20 and 30 meters. One of the potential reasons field athletes do achieve maximum sprint speed during games is based upon flying (i.e., walking or jogging) starts, which allow top speed to be achieved sooner (Duthie et al., 2006). Therefore, improving both the drive and recovery phase are equally important for field athletes.

Overall, the majority of research indicates sprinting speed is strongly correlated to free sprint training (i.e., running without any external equipment) (Spinks et al., 2007), ground force reaction (i.e., achieved via weight training) (Weyand et al., 2000; Weyand et al., 2010), and/or plyometric training (Lockie et al., 2012; Rimmer & Sleivert, 2000). While these training techniques are correlated to increased sprint speed, there are studies that suggest current research is not fully conclusive regarding which is the most advantageous or how they interact with each other (Hrysomallis, 2012; Paulson & Braun, 2011). This studies protocol essentially eliminated the potential effects of plyometric training on sprint speed by implementing the training program during the pre-season (i.e., no plyometric training was being conducted). The primary sprint techniques used in the current study are designed to break down free sprinting into smaller, more manageable segments. Through practice these small segments can be progressively learned and assimilated into improved biomechanics while free sprinting (i.e., running without any external equipment). Therefore, its likely better sprinting biomechanics played a role in the significantly improved sprint times. Additionally, the participants were performing a basic resistance training program, shown to affect ground force reaction, which may have played a role in the significant improvement in pre to post 40 yard sprint time and possibly acted as an unaccountable confounding variable. However, the resisted sprints performed in this study can also be considered a form of resistance training, so it's possible this type of secondary sprint training also played a role in the improved 40 yard sprint time due to increasing ground force reaction. It is also possible that this played a larger role in the improved sprint time because the participants were accustomed to the basic resistance training program, but had no experience performing resisted sprint training techniques. Overall, there is very strong evidence supporting the notion that sprint technique drills provide an excellent foundation for improving biomechanics in addition to serving as an excellent warm up to high intensity sprint drills (Cissik, 2005).

One of the secondary training techniques utilized was assisted sprint training, which is a form of overspeed training. The benefits of overspeed training include the stimulation of more eccentric muscle contractions which lead to more effective muscle hypertrophy (Chen, 2007; Coyle et al., 1981; Farthing & Chilibeck, 2003; Gottschall & Kram, 2005; Paradisis & Cooke, 2006), increased load capacity and improved motor unit synchronization of the muscle fibers (Behm, 1995; Behrens & Simonson, 2011; Flanagan & Comyns, 2008), and increased stride length and/or stride frequency (Clark et al., 2009; Hauschildt, 2010; Leblanc & Gervais, 2004; Paradisis & Cooke, 2006). While there are multiple methods for performing overspeed training (i.e., negative sloped high speed treadmills, downhill running, towing devices, etc.), this study utilized a standardized towing-assist device.

The assisted sprint training procedures attempted to produce a constant assisted tow force between 106-110% of the participant's body weight. While every effort was made to ensure assistive force accuracy, limitations in distance and tube resistance characteristics resulted in small differences between participants. Also, while this study did not measure stride length or neuromuscular factors, tow-assist overspeed training has been shown to primarily increase stride length, and subsequently increase eccentric muscle actions, without increasing stride frequency (Paradisis & Cooke, 2006; Gottschall & Kram, 2005; Chen et al., 2007).

The kinematic assessment of tow-assist overspeed training, via an elastic band system, in college-aged individuals has been studied by several authors (Kristensen et al., 2006; Leblanc & Gervais, 2004; Corn and Knudson, 2003; Clark et al., 2009). All of these studies showed significant acute increases in horizontal velocity measures, 1.2% to 7.1%, primarily due to increased stride length. They study by Corn and Knudson (2003) reported the highest horizontal velocity measures, utilizing similar tow-assisted methodology as our study. Corn and Knudson (2003) chose tow force based upon the manufacturer's recommendations of medium elastic tubing for individuals under 180 pounds and heavy elastic tubing for individuals over 180 pounds. Our study utilized a similar set up, implementing tow assist values based upon achieving a 106%-110% body weight based upon a light, medium, or heavy elastic tubing. Moreover, research supports performing tow assisted sprint training within this 106-110% body weight range will optimally develop kinematic running patterns most similar to non-assisted horizontal running patterns (Cissik, 2005; Clark et al., 2009; Kristensen et al., 2006; Leblanc and Gervais, 2004). By following similar methodology as Clark et al. (2009), it is believed that our study successfully maintained an optimal tow assist percentage similar to 106-110% body weight.

The other secondary sprint training techniques utilized were resisted sprints, which have been shown to increase sprint speed (Cissik, 2005; Hrysomallis, 2012) via increased recruitment of motor neuron and muscle fibers (Cissik, 2005). When performing resisted sprints (e.g., sled towing), 10-15% of body weight is suggested for maximal fast twitch fiber activation and maintenance of proper sprinting mechanics (Lockie et al, 2003; Spinks et al., 2007). While heavier loads have been shown to beneficially improve the arm drive (Lockie et al., 2003) and acceleration phase (Lockie et al., 2003; Cissik, 2005), sprinting kinematics have been shown to be impaired (Cronin & Hansen, 2006; Maulder et al., 2008). While less supportive data is available (Clark et al., 2010), resisted sprinting is believed to increase trunk lean and ground contact time, while decreasing stride length (Cissik, 2005) and increasing stride frequency (Lockie et al., 2003). While this study did not specifically assess neuromuscular recruitment, ground contact time, stride length and/or stride frequency; the resisted sprints are believed to be one of the reasons for the improved sprint times primarily because the participants had no experience performing these techniques. Their lack of experience, but excellent body awareness and neural coordination based upon their sport training background, possibly aided their ability to quickly benefit from resisted sprints.

When applying primary and secondary techniques to a program, the season (i.e., pre-, in-, post-, etc.) and specificity of the sport must be considered (Baechle & Earle, 2008). When implementing a general program, for any sport where running speed is important, it is appropriate to implement speed training protocol 2-4 days per week. Primary techniques and mechanics of sprint training can be included in daily workouts to act as a biomechanical foundation and/or a warm up activity. Power starts can then be implemented to emphasize the acceleration phase of sprinting followed by either resisted or assisted sprint training (Cissik, 2005). With resisted sprinting, the coach may want to allow for one day per week with heavier resistance to allow for development of acceleration and improved arm drive (Lockie, et al, 2003).

While an interaction effect is evident in the findings of our research, it is likely that running mechanics accounted for a larger portion of speed improvements over the four-week protocol compared to assisted and resisted sprinting (Baechle & Earle, 2008). Past research indicates physiological gains (i.e., sprint-based gains achieved primarily by assisted and resisted sprinting) usually occur after >6 weeks of sprint training (Baechle & Earle, 2008; Clark et al., 2010). However, it is possible that the participants in this study were able to benefit from the shortened (i.e., 4 week) training program, mostly attributed to improved sprint mechanics (Cissik, 2005; Cronin & Hansen, 2006; Hrysomallis, 2012). Based on the results of our study it is not possible to measure the effect that each type of sprint training had on these subjects. Past research has indicated that total sprint speed may increase due to the acceleration phase (Zaferidis et al., 2005) rather than the maximum speed phase. The results of this study were unable to identify the exact portion of the 40-yard sprint that accounted for the significant reduction in sprint time. In addition, this study did not measure distance splits, therefore it was impossible to know the exact portion (e.g., time to sprint speed max, drive or recovery phase) of the 40 yard sprint that accounted for the significant improvements in total sprint speed.

While this study implemented ankle dorsiflexion prior to ground contact, in an attempt to store elastic energy, a few studies (Mann, 1981; Mann et al., 1986) have indicated this does not aid in horizontal propulsion. Instead this dorsiflexion action of the ankle may help to minimize vertical displacement the center of gravity acting to decrease the horizontal breaking effect (Wiemann & Tidow, 1995), while also helping to promote a power transfer from hip extension into the ground (Brown & Vescovi, 2012). Moreover, this study emphasized ankle plantar flexion as the center of gravity passed over the foot (i.e., drive phase) (Cissik, 2004). Somewhat conflicting information suggests the athlete should focus on the ankles ability to quickly and repeatedly absorb vertical forces (Brown & Vescovi, 2012) rather than the performance of active plantar flexion (Krustrup et al., 2005). While the action of the ankle during the drive phase is somewhat controversial, there is more definitive support indicating the hamstrings are in a biomechanically advantageous position (i.e., lever arm) to produce high levels of force (Bosch & Klomp, 2005). Moreover, a recent study by Kugler and Janshen (2010) stated that total force exerted during the 'drive' phase does not have to be maximal, rather it should be 'optimal' in terms of the vertical and horizontal displacement planes. Indicating running technique is more important than total force produced (Morin et al., 2011). Therefore, while this study emphasized the action of the ankle, it may not have played a significant role in the improved sprint times of the participants.

Apart from the sprint training techniques implemented in this study, the participants were still conducting seasonal aerobic and resistance conditioning programs. The majority of the aerobic conditioning program was conducted at submaximal speeds. However, it is possible that the aerobic conditioning program may have inadvertently played a role in the experimental sprint training protocol results. Also, the resistance training program may have played a minor role in the improvements of the sprint performance due to quicker and more powerful ground force reaction times (Baechle & Earle, 2008). Beyond these potential confounding factors, the participants in this study were well-trained (i.e., >8 years' experience) soccer athletes, but were very inexperienced in sprint training methods. In addition to these factors, this study did not implement a control group. A control group was not utilized due to the implementation of the program while the participants were in a specific season (i.e., not in the off-season). Therefore, a small portion of the significant decrease in sprint times may be due to several confounding factors within this study.

It should be concluded that a four-week speed training protocol combining primary and secondary techniques is effective in improving sprint times in female college athletes (Figure 1). The degree to which primary and/or secondary techniques contribute to the improvement in sprint times was unknown in this study, and should be an emphasis of future studies. The resistance training program may have acted as a confounding variable, albeit minor, in the observed speed improvements for this sample. It may also be appropriate that sprint training protocols be implemented at more times during the training cycle: as this study suggests that significant gains are achievable in as little as four weeks. For example, the program may be extremely applicable to a pre-season, where training time is limited and implemented again during the off-season. It should also be noted that the training protocol utilized has a great practical utility as it is relatively time efficient and does not require the use of expensive equipment. In conclusion, implementing primary and secondary sprint techniques should lead to improved biomechanics, which can translate into more efficient force production during a sprint. More research needs to be conducted on the individual and interaction effects of primary and secondary sprint training techniques across various populations, periods of time (i.e., weeks or months), and across the seasons of training programs (i.e., pre-, in-, post-, and off-season).

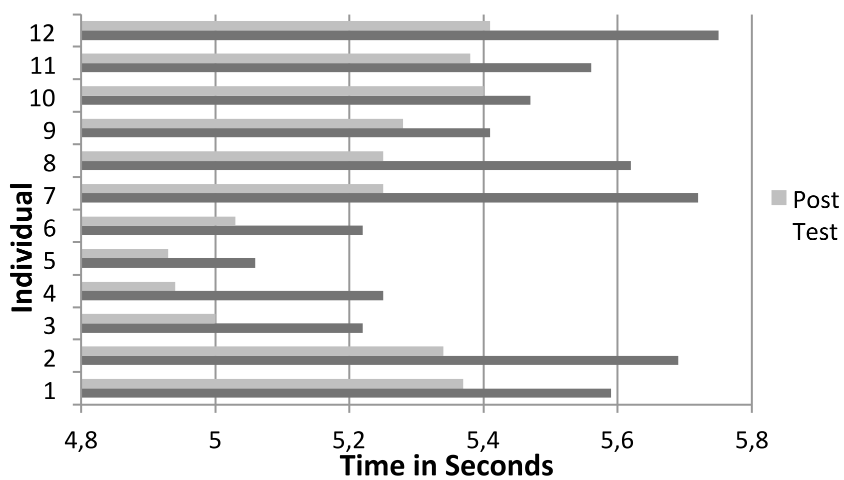


***Figure 1.*** *Changes in 40-Yard Dash Time*

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