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Brooke Pacheco

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# Effects of a 10-Week Periodized Resistance-Training Program on Speed-Performance in Male High School Athletes

BROOKE PACHECO

For successful performance as a team sport athlete, strength, speed, and endurance abilities are of high importance. Since the requirement profile for field sports like soccer and football requires peak performance in at least two of these abilities, it is essential for pre-season training programs to employ training methods that address the sport-specific physiological abilities that are most dominant in that particular team sport. For example, the requirement profiles for football and soccer show the importance of both strength and speed abilities. During a game, football and soccer players alike repeatedly perform many tasks, such as linear and change-of-direction sprinting, requiring strength as well as speed and strength combined (i.e., power). These tasks make substantial contributions to scoring and defending and can contribute significantly to the outcome of the game. When it comes to high school sports, however, the question becomes what type of pre-season resistance-training program would most benefit players when they take the field in competition. Generally, fall high school athletes have a short time to train for their sport, 10-12 weeks during the summer. The question is, will a 10-week, resistance-training program be long enough to have an impact on strength and speed before the start of regular season play?

Existing research on the effectiveness of short-term resistance training on strength and speed is both limited and conflicting. Hoffman and Kang (2003) conducted a 15-week strength and conditioning program for 53 Division-III collegiate football players that showed no significant improvements in performance on the T-test, a standard measurement of change-of-direction (COD) speed. An 8-week study by Tricoli et al. (2005) that looked at the short-term effects of lower-body functional power development on speed variables on 32 young men also showed no significant improvements in COD speed. However, an 8-week study on 26 athletic men by McBride et al. (2002) found significant improvements in COD sprint times after both heavy- and light-load squat training.

In research related to the effectiveness of various types of strength-training programs on motor performance, there is evidence to suggest that periodized resistance training (PRT) programs are the safest and most beneficial way for coaches to prepare their athletes for competition (Jimenez, 2009). The goal of PRT is to manipulate the training volume and intensity in phases so athletes can reach their highest potential by the end of the training period. With proper manipulation of the training variables, athletes will not only peak at the appropriate time for competition, but the potential risk for injury or overtraining will be reduced (Hoffman, 2003).

A focused literature review of PRT by Jimenez (2009) found that most studies mainly examined strength training with young males as their subject population and focused on the differences between periodized and non-periodized programs. The review concluded that the scientific literature encouraged researchers and exercise professionals to use periodization models during resistance training and conditioning programs. Jones et al. (2009) conducted a 9-month study of PRT on exercise equipment using 38 subjects that did not show improvements on COD speed. However, Keiner et al. (2013) conducted the longest intervention in the literature with a two-year study testing 132 elite youth soccer players examining the effects of a PRT intervention on COD performance. Results of the study showed that the long-term PRT program (i.e., greater than 15 weeks) had a positive effect on the performance of COD speed variables.

Along with these findings, the Keiner et al. (2013) study also showed a significant correlation between relative maximum strength and sprint speed. Sprinting speed depends on both strength and power of the muscle contraction to drive the arms and legs in order to give an athlete the capacity to achieve high speeds (Hoffman, 2003). Starting power is important for athletes on the playing field who need to cover a given distance in the shortest amount of time from a still position. A defensive end, for example, must be able to generate maximum force at the beginning of his movement, when muscle contractions create initial speed, in order to get to the quarterback as quickly as possible. Accelerating power, the capacity of an athlete to increase speed and to achieve high speeds, certainly benefits most team-sport athletes from wide receivers in football to strikers in soccer. Starting power and accelerating power both rely on strength to generate speed.

Findings in the literature are inconsistent in studies investigating strength and combined speed-strength or power parameters, especially involving COD speed. Several have found a medium to high correlation between absolute (as opposed to relative) muscular strength and sprint performance measurements. Hori et al. (2008) and Requena et al. (2009) both showed a clear influence of strength training on acceleration and sprint speed of 29 semi-professional rugby players, where a study by Harris et al. (2000) showed no significant effect of high-power, high-force, or combined weight-training methods on power in 42 trained men.

It was the intent of this study to conduct further research on strength training and COD speed, with particular interest in whether a 10-week (short-term) periodized resistance-training program would improve relative strength and COD speed in male high school athletes. This study also aimed to determine if there was a correlation between relative strength and speed.

## Methods

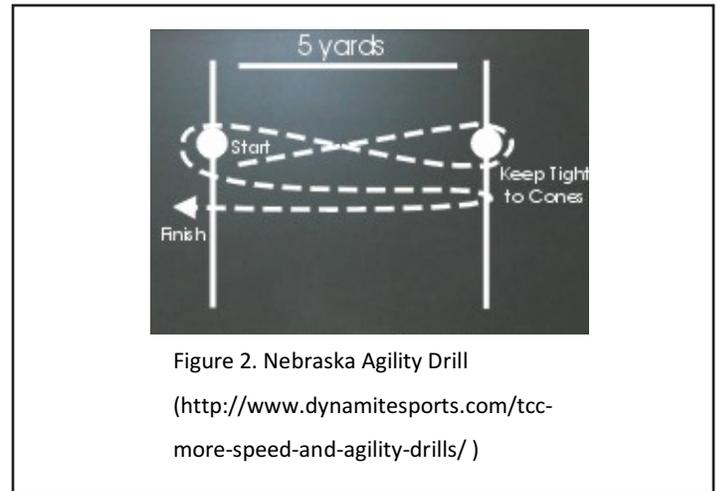
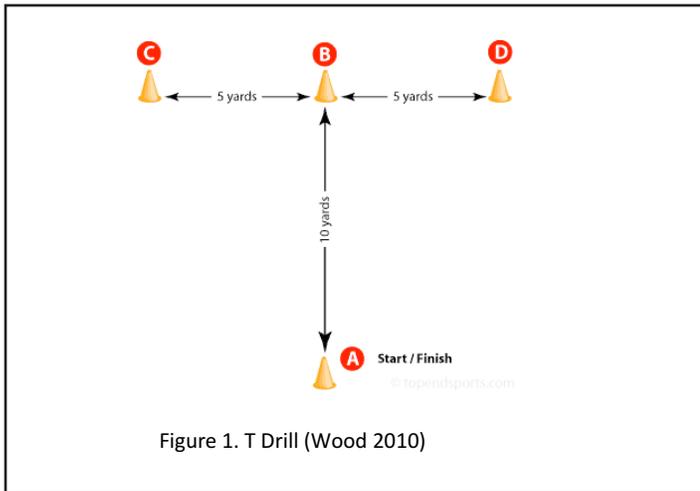
*Participants.* Eighteen athletes familiar with strength-training/conditioning exercises and medically cleared to participate in their pre-season training programs volunteered for this study. Males

were specifically recruited because the protocol for the 10-week training program required heavy-load lifting that they had previously been trained to perform. Females were not chosen because they were not familiar with the exercises, and their training protocol would have been introductory based. Football and soccer players were chosen for the study because both sports require players to have the physiological abilities of strength, power, and speed for successful performance on the playing field. In addition, high school athletes who participate in these respective fall sports are traditionally limited to pre-season, summer-training programs that span approximately 10-12 weeks in length. The participants were recruited from Coventry High School in Rhode Island because the athletic facilities were equipped with the necessary training tools, and the athletic department already had a strength and conditioning program in place.

*Instruments.* Three speed-related performance tests were administered to establish speed ability baseline scores: the “T Drill” (Figure 1), the “Nebraska Agility” drill (Figure 2), and a 20-meter dash. The T Drill uses a combination of change-of-direction sprinting and side shuffling. The Nebraska Agility Drill uses a combination of change-of-direction sprinting and backpedaling. The 20-meter dash measures linear forward sprinting.

All three tests mimic movement patterns that are used on both the football and soccer field. In each speed test the athlete attempted to complete the test as quickly as possible, and the test administrator recorded the athlete’s time. A three-repetition maximum (3RM) back squat was used as a baseline measurement for strength. The 3RM was chosen because it is one of the safest exercises for the age group and is considered one of the most reliable measures of lower body strength (Urquhart et al., 2015). Pre and post tests were administered on the playing fields, and the training program was conducted in the weight room at Coventry High School.

To begin the training program each subject was given a periodized resistance-training packet based on the results of their 3RM back squat and bench press (Table 1). The training packet was divided into three phases, with each phase lasting three weeks in duration: the Hypertrophy Phase (H-Phase), the Strength Phase



(S-Phase), and the Power Phase (P-Phase). Pre and post tests rounded out the 10-week program. This type of program was chosen because multiple studies in the literature (Kamandulis et al., 2012; Keiner et al., 2014) have reported positive changes in speed when using periodized resistance training.

Each of the three phases in the protocol built upon the previous phase with planned, systemic variations in exercises, intensity, and volume in order to address the various physiological needs of each participant. The primary objective of the H-Phase was to prepare the participants for the more strenuous training they experienced in the subsequent phases. The S-Phase was designed to “ramp up” the intensity of training where both the sets and the intensity increased while the repetitions decreased. Finally, the P-Phase exercises were performed with greater attention to the athlete’s sport and position on the field of play to provide greater opportunity for strength carryover.

A variety of isotonic and isometric exercises, as well as single- and multi-joint movements, were performed. Primary lifts consisted of power cleans, split jerks, hang cleans, back squats, front squats, bench presses, dead lifts, and Bulgarian split squats, which were consistent throughout all three phases (Table 1). Multi-joint movements were chosen as primary lifts because they provide potential to develop both muscular strength and power. Secondary lifts were chosen to supplement the primary lifts by engaging all

muscle groups and promoting a full-body workout (Table 2).

#### Procedures.

Prospective participants for the study were notified of the opportunity to enroll through the athletic director, football and soccer coaches, the training coordinator, and the head strength coach at Coventry High School. Prospective participants attended a meeting where information was provided about the study, questions were answered, and parental/participant consent forms were distributed. Interested athletes who could not commit to the entire 10 weeks of training (including pre and post testing) or who recently had a sport-related injury were not eligible to participate. All participants or their parents signed a university IRB-approved consent form prior to participation in the study. Once consent was obtained the 18 male participants were divided into two groups. Athletes able to commit to three sessions per week were assigned to the periodized resistance training group (PRTG) to create the best scenario for compliance. Other athletes who were interested in participating but could not commit were assigned to the control group (CG). Nine athletes participated in the periodized resistance-training intervention (PRTG), and the other nine participated in the control group (CG) and performed pre-season training on their own.

All participants in both the PRTG and CG were pre and post tested over a few days (constituting “the 10th week” of the

H-Phase			S-Phase			P-Phase		
(A) Clean Progression			(A) Clean Progression			(A) Clean Progression		
(B) Hang Clean	%	WT	(B) Hang Clean	%	WT	(B) Power Clean	%	WT
5	LT		3	LT		3	LT	
5	LT		3	LT		2	LT	
5	MOD		3	MOD		2	MOD	
5	MOD		3	MOD		1	HVY	
5	MOD		3	MOD		3x1	HVY	
(C1) Back Squat	%	WT	(C1) Back Squat	%	WT	(C1) Back Squat	%	WT
8	50%		4	70%		3	68%	
8	60%		4	77%		2	75%	
8	65%		4	82%		1	85%	
8	70%		4	85%		1	92%	
8	70%		4	85%		3x1	97%	
(C2) Seated Hurdle Hops 4x5			(C2) Vertical Med Ball Sq. Throw 4x5			(C2) Squat Jumps 4x6		
(D1) BB Bench Press	%	WT	(D1) BB Bench Press	%	WT	(D1) BB Bench Press	%	WT
8	50%		4	70%		3	65%	
8	60%		4	77%		2	75%	
8	65%		4	82%		1	85%	
8	70%		4	85%		1	92%	
8	70%		4	85%		3x1	97%	

Table 2

*Phase by Phase Progression of Secondary Lifts*

(D2) Med Ball Chest Throw 4x5	(D2) Med KNL Ball Chest Throw 4x5	(D2) Explosive Push Ups 4x6
(E) Incline DB Press 2xMax Reps (MOD)	(E) Incline DB Press 2xMax Reps (MOD)	(E) Incline DB Press 1xMax Reps (MOD)
(F1) DB RDL 4x8 (HVY)	(F1) DB RDL 4x8 (HVY)	(F1) DB Bench Press 1xMax Reps (MOD)
(F2) DB Skullies/Press 3x10 (MOD)	(F2) DB Skullies/Press 3x10 (MOD)	(F2) DB Reverse Fly 3x10 (MOD)
(F3) DB Hammer Curl 3x10 (MOD)	(F3) DB Hammer Curl 3x10 (MOD)	(F3) Hip Flips 4x4

study). Participants were given two trials for each drill with 5-minute rest periods between each trial and 20-minute rest periods between each of the three drills. All participants were instructed on how to perform the drills before the test trials began. The order of participation remained the same for all three tests and before each second trial, and the participants were told their previous score. Two trial recorders timed each participant using stopwatches. The slowest time between the two timers was used for each trial, and then the fastest time between the two trials was used as their final test score. For each participant, the T Drill was performed first, followed by the Nebraska Agility Drill, and finished with the 20-meter dash.

To obtain a baseline measurement for strength, each participant performed a three-repetition maximum back squat (3RM) following the three speed tests. This number was then used in the Brzycki equation to calculate their 1-RM. After review of the literature, this equation was used because it is considered one of the more attractive alternatives for estimating 1 repetition values and has satisfied the validation criteria established by the literature (Nascimento, 2007). All participants were reminded of the proper form and execution of the back squat before testing began. Participants were also weighed on a calibrated scale. Body weight was used later to calculate their relative strength. All procedures were duplicated during post testing.

Participants in the PRTG were required to train three days per week from May 18 to July 24. Each session lasted approximately 90 minutes, with a 15-minute warm-up of light jogging and stretching and a 10-minute cool down. PRTG participants were divided into three groups based on their level of strength and ability. In order to maximize training efficiency and safety in the weight room, levels were determined by knowledge of exercises, competence in performing exercises, and their absolute strength measurement. All participants performed the same exercises, but the intensities varied among them based on the amount of weight they could lift. Everyone was instructed on proper form and execution of lifts as well as proper spotting techniques. Participants had rest periods between sets and recorded the weight lifted in the space provided

on their training packet. Attendance was taken daily. If a participant missed a session they were required to make it up on their own time. If participants consistently missed sessions without making them up, they were dropped from the study.

In the H-Phase (3 weeks, 3 sessions per week), participants performed 3 sets of their primary lifts using 5 to 8 reps/set and 4/5 sets of their secondary lifts using 8-10 repetitions/set with moderate to heavy resistance (i.e., amount of weight lifted). In the S-Phase (3 weeks, 3 sessions per week), they performed the same primary lifts as in the H-Phase but with a different group of secondary lifts. Once again, they performed 3 sets of their primary lifts using 3 to 6 repetitions/set and 4/5 sets of the secondary lifts using 8-10 repetitions/set with heavy resistance. In the P-Phase (3 weeks, 3 sessions per week), they once again performed the same primary lifts and another group of secondary lifts that were performed with more explosive power focusing on the speed of the lift. They performed 7 sets of their primary lifts using 2 to 5 repetitions/set and 1 to 3 sets of the secondary lifts using 6 to 10 repetitions/set with light to moderate resistance. The number of repetitions and sets varied depending on the type of exercises performed (Table 1 and 2). While lifting was taking place, feedback on proper execution form, spotting techniques, verbal motor cues, and movement modifications were frequently given to all participants throughout the duration of the training sessions. All post tests were conducted in the same fashion as the pre tests.

### **Data Analysis.**

For both pre and post test PRTG and CG, means and standard deviations were calculated for absolute strength, relative strength, body weight, and the fastest score for each of the six speed performance tests. Pearson correlation coefficients were calculated between relative strength and each of the speed performance results for the pre and post-test scores. A series of one-way ANOVAs were used to determine changes in strength and speed from the pre to post test and differences between the control and PRTG groups. Significance was set at  $p < .05$ .

**Results**

Participants in both the PRTG and CG were between 15 and 17 years of age. There were nine PRTG participants, comprised of eight football players and one soccer player, with an average body mass of 76.65 kg ± 10.43 kg. There were nine CG participants, comprised of six soccer players and three football players, with an average body mass of 68.04 kg ± 4.08 kg.

There was a significant difference for absolute strength (F(1,32) = 52.02, p<.001). The PRTG mean (1,329.68 N ± 260.65 N) was greater than the CG mean (872.32 N ± 154.7 N). There was also

Relative strength was most highly correlated (-.72) with the Nebraska Agility Drill for the PRTG pre-test.

**Discussion**

The purpose of this study was to investigate whether a short-term periodized resistance-training program would improve relative strength and change-of-direction speed in male high school athletes. The results from the pre and post tests show that both groups showed some improvement in their speed. It was determined that the PRTG may have improved because the resistance-training protocol

**Table 3**

*Comparison of PRTG and CG Pre and Post Test Means*

	Absolute Strength (Newtons)		Relative Strength (Newtons/Body weight {N})		Nebraska Agility Drill (sec)		T Drill (sec)		20 m dash (sec)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
<b>Test Group</b>	1,217.21 ± 261.54	1,406.54 ± 250.02	1.69 ± 0.33	1.87 ± 0.27	8.56 ± 0.40	7.96 ± 0.30	9.49 ± 0.30	9.21 ± 0.23	3.38 ± 0.10	3.30 ± 0.16
<b>Control Group</b>	770.48 ± 149.94	884.173 ± 145.23	1.16 ± 0.24	1.33 ± 0.22	8.61 ± 0.68	8.51 ± 0.61	9.24 ± 0.36	9.22 ± 0.72	3.29 ± 0.15	3.37 ± 0.19

a significant difference for relative strength {i.e., weight lifted {N}/body weight {N}} (F(1,32) = 34.9, p<.001). The PRTG mean (1.78 ± 0.31) was greater than the CG mean (1.24 ± 0.24). The training effect approached significance (p = .055) for the Nebraska Agility Drill, with the PRTG mean (8.26 sec ± 0.46sec) faster than the CG mean (8.56 sec ± 0.63 sec). Both the PRTG and CG increased absolute, and thus relative, strength with the training activities.

was designed more to develop lower body strength where the CG may have improved because, even though they were training on their own, they were participating in sport-specific training involving speed and agility drills during the period of the study. However, there was a significant difference for both absolute and relative strength, with the PRTG mean greater than the CG mean. The training effect also approached significance for the Nebraska Agility Drill with the

PRTG mean faster than the CG mean.

Even though football and soccer players are similar in that they both rely on change-of-direction movements on the playing field, football players vary from soccer players in physiological traits and athletic skill sets. Where football players utilize more combined speed-strength actions, soccer players utilize more combined speed-agility actions. While the short-term training protocol did not significantly improve the PRTG change-of-direction speed as expected, it did increase their absolute and relative strength over the course of the training program, which resulted in a high correlation between relative strength and COD speed on the Nebraska Agility Drill. In relation to the research question, the periodized resistance-training program may not have resulted in significant COD changes; however, it did have a positive effect on strength.

There are several studies in the literature that are consistent with this study's findings. Regarding the effectiveness of short-term training programs on speed and strength, an 8-week study by Tricoli et al. (2005) and a 15-week study by Hoffman and Kang (2003) both showed no significant improvements in performance on COD speed. In research related to the effectiveness of periodized resistance training on motor performance, Jones et al. (2009) conducted a 9-month PRT program that also found little to no improvements on COD speed. However, in terms of the correlation between relative strength and COD speed, the findings from this research are supported by a study by Keiner et al. (2013), who found a significant correlation between relative maximum strength and sprint speed of 132 elite youth soccer players. Likewise, studies by Hori, et al. (2008) and Requena, et al. (2009) showed a clear influence of strength training on acceleration and sprint speed of 29 semi-professional rugby players.

For the duration of the study, the PRTG trained three days a week performing exercises specific to improving hypertrophy, strength, and power. The CG trained the same number of days a week, but their training consisted of performing and practicing soccer-related skills for developing agility and sprinting speed. Considering the length of the training protocol, the three-day-per-

week work-out schedule was not enough time to have a training effect to show significant improvement compared to the CG. In addition, the training protocol was not specific enough in relation to the three speed tests chosen. While the training protocol was specific to developing speed and strength skills used on the playing field, it may not have been specific to developing the speed and strength skills used for the pre and post tests.

These findings could also suggest that the pre and post tests chosen for this particular study did not provide enough precision or were not the best measure of COD speed for the PRTG because of the nature of the participants' sports, their physiological abilities, or their athletic skill sets. The distance covered and the time it took to complete each COD speed drill may not have been long enough to show much improvement. In addition, COD drills incorporate agility as one of the main skills needed for proper execution. Unlike strength and endurance, which are fitness components that can be developed with training, agility is a skill that is difficult to learn.

Another factor that affected the outcome of the study resulted from the selection of participants into PRTG and CG based on time commitment to create the best scenario for compliance. The PRTG was predominantly football players, where the CG was predominantly soccer players. While the PRTG of football players was training three times per week in a weight room under supervision of the researcher, the CG of soccer players was training three times per week in self-organized practices that included speed and endurance drills. Discussions with CG members indicated no evidence of their participation in any type of resistance training.

Limitations. There were several limitations that could have affected the outcome of this study. Factors such as parental consent and medical clearance limited the pool of athletes who could be recruited. The recruitment pool had to be limited to only those students who were currently on a fall sport roster and medically released for participation. Since a good majority of the rostered athletes were graduating seniors, that further limited the pool. In addition, since the remaining rostered athletes were under the age of 18, they needed parental consent to participate.

Attendance was another limitation of this study because of issues such as commitment of participants and transportation. Commitment issues could have resulted from lack of interest, absence of incentives, or conflicting priorities such as work, driver's education, or family responsibilities. With respect to transportation issues, it was difficult for athletes to attend all three sessions per week, especially if they did not have a driver's license. Since five weeks of the study took place during the summer months, there was no bus transportation to and from the school. If a participant missed a session, they were required to make up that session on their own time. Average attendance for the PRTG was 2.9 sessions per week. After discussions with the CG it was determined that their average attendance was 2.7 sessions per week.

## Conclusion

The periodized resistance-training protocol increased strength, but so did the pre-season activities of the CG. The correlation between speed and relative strength was not improved with training. This short-term, three-day program was not enough to result in significance differences in change-of-direction speed. For future research several changes should be considered. One important consideration should be in regard to the recruitment pool; the participants should be chosen from the same sport. In addition, the training protocol should better match the skills and movements used specifically in the sport played by the athlete. In order to increase the number of participants in the study, more flexibility should be considered for the days per week and the hours of availability. While keeping the short-term time frame of the study, one should consider scheduling more sessions than three times per week.

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## About the Author



Brooke Pacheco is a graduating senior at Bridgewater State University with a major in Physical Education and a minor in Studio Art. Her research was conducted in the summer of 2015 under the mentorship of Dr. Pamela Russell (Movement Arts, Health Promotion, and Leisure Studies) through funding provided by an Adrian Tinsley Program summer research grant. Brooke presented this work at the 2016 National Conference on Undergraduate Research at the University of North Carolina – Asheville. She will also present it at the American College of Sports Medicine Annual Meeting and World Congress in Boston this summer. Brooke's future goal is to attend graduate school in the area of Exercise Physiology and Kinesiology. She hopes to teach Physical Education at the high school level and would also like to secure a coaching or training position working with college athletes.