SPRINT TRAINING METHODS IN

NCAA DIVISION III COLLEGIATE SOCCER PLAYERS

by

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ABSTRACT

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The production of various speed-enhancement devices has increased in order produce varied high-speed actions impacting performance and actions requiring maximal speed, acceleration, or agility. The purpose of this study was to compare and assess the effects of assisted sprint training (AST), resisted sprint training (RST), and free sprint training (FST) on kinematic factors in NCAA Division III collegiate soccer players (n = 37) during the acceleration and maximal velocity phase of a 36.6 meter (m) sprint. The study determined if differences exist between AST, RST, and FST in enhancing sprint time. The measurements of stride length and stride frequency was assessed as important kinematic variables affecting sprint time. The subjects, using their assigned training modality, underwent a 6-week, 12-session training program. The training progression started with 10 meters (m) and ended with 60 m sprints. Sprints were recorded by video and digitized using biomechanical analysis software. Pre- and post-tests for all three methods were compared using two-way repeated measures ANOVAs and Scheffe post-hoc tests were used to determine any differences among types of training groups. Significant improvement in split and interval times (9.1 m, 18.3 m, and 36.6 m) and stride lengths from the pre- to post-tests were indicated, but there were no differences in improvement among the training groups. Therefore, even though the use of RST and AST programs incorporating the bungees decreased sprint times in a 36.6 m run, it was not significant as compared to FST. Sprint speed development may be based on so many factors that it can be highly difficult to pinpoint where and how training throughout different stages of a sprint optimizes improved performance. It is important for coaches and strength and conditioning specialists to fully recognize specific ways to induce neuromuscular adaptations for sprinters.

KEY WORDS

Kinematics, sprint training, acceleration, maximal velocity, speed

CHAPTER I

INTRODUCTION

Field playing athletes are required to use short bursts of energy in game situations with explicitly quicker reaction times in order to better their overall field sport performance. In the game of soccer, athletes must acquire the ability to cover short distances quickly in a small amount of time. Sprint training is of prime importance of speed for coaches, and athletes, whether elite, non-elite, collegiate, or youth, however the exact method to improve maximal running speed and acceleration is still undefined. It is important to understand and determine the extent to which maximal velocity and acceleration are distinct attributes in soccer players (21). The bouts of high-intensity and very-high intensity running occur about every 90 seconds, last approximately two to four seconds, and are most often associated with critical match-related skills, such as separating from or closing on an opponent (43). Coaches and strength and conditioning specialists have focused on speed training methods that can enhance velocity and acceleration within the sprint cycle. In recent years, the production of various speed-enhancement devices has increased (11). Sleds, parachutes, and the use of elastic-cords or bungee cords are examples of external devices used for speed training. However, there is controversy as to which specific external device and what type of technique, such as resisted or over speed training, will improve acceleration throughout the different phases of the sprint cycle. The effect of these speed training tool ordinances on sprint time and the movement kinematics of speed, including stride length and stride frequency, have yet been acceptably quantified (22).

The ability of soccer players to produce varied high-speed actions may impact soccer match performance and can be categorized into actions requiring maximal speed, acceleration, or agility (21). Sprint time is vital in the game of soccer in terms of winning or losing the ball to the opposing team, or even scoring a goal. Sprinting speed is composed of stride frequency multiplied by stride length, as well as the capability to reach a high velocity (29). Speed is the movement distance per unit time, or the time taken to cover a fixed distance. Stride length and stride frequency, mechanically determine running speed or sprint time (11). Attempts to improve speed must induce neuromuscular adaptations that increase either stride length or stride frequency without a significant detriment to the other (26). One must train by applying greater force in the following ways: in less time, proper direction, and through the proper range of motion.

Stride length and stride frequency can change depending on the specific phase of a sprint. There is little research investigating the effects of heavy resistance exercises, such as speed training programs that involve weight or an increased amount of body mass percentage being towed, on subsequent sprint running performance. Sprint running comprises different phases, including initial acceleration, attainment of maximal velocity, and maintenance of maximal velocity, each with specific mechanical demands (45). This quantifies to the same measurement of the relationship between first-step quickness (0-5 meters (m)), acceleration (0-10 m) and maximal speed (≥ 20-30 m) (22). The National Football League (NFL) Combine's evaluation of the physical test battery uses a 36.6 m sprint with split times at 9.1 m and 18.3 m. The 36.6 m sprint test is strongly associated with acceleration because it has been previously suggested that the differences in 9.1 m and 18.3 m sprint times are measures of acceleration (36). The 9.1 m split time is necessary to calculate acceleration, or sprint momentum. The 18.3 m split time is calculated by subtracting the end time at 36.6 m from the time at 18.3 m. (36). As with football, soccer players require different speeds for different positions and agility for certain demands of a specific play in a game situation. For these sports, acceleration and maximum speed are relatively independent qualities (1).

One important aspect of sprinting is not just the actual phase of the sprint's distance itself, but understanding sprinting within the cyclical movement phase. This can be described as everything from toe-off to foot contact and mid-stance of support. The moment the toe leaves the ground, or "toe-off", until the thigh begins moving forward in recovery, is the initial movement within a sprint cyclical phase. From the moment the thigh blocks, or stops, until the thigh begins to accelerate in a negative direction, the lower leg musculature initiates neuromuscular activation and prepares for ground contact. After touch down, the athlete's center of gravity should be over the contact point of the foot, thus creating mid stance support until the next cyclical movement of the leg. This is the technique for sprinting at maximal velocity. However, it is still questionable as to whether coaches and strength and conditioning specialists can drill athletes to use a maximum acceleration of the hip flexors and a maximum deceleration of the hip extensors by incorporating speed enhancement drills that will increase overall stride length and stride frequency.

If soccer players can increase their stride length during the acceleration phase, they can cover more distance in a shorter amount of time, thus increasing their running velocity. An increase in utilization of elastic energy during the support stage of the sprint cycle follows an increase in stride length (40). Any type of stored elastic energy in the muscles, tendon and fascia surrounding the muscle provides a greater force in less time. Athletes must apply force in the proper direction. Forces must be forward and backward without the braking forces that are often applied by athletes reaching with the touchdown too far forward from their center of gravity, resulting in a loss of velocity and force. In order for athletes to apply force through full or optimal range of motion, the athlete must apply the necessary force in as small amount of time as possible to obtain maximal velocity output. One mechanism by which faster sprinters achieve a higher running velocity is by exerting a larger force on the ground, producing a longer stride length (1). The goal for any athlete to increase sprint time by training for proper stride length mechanics and form is to understand the proper relationship of ground and air distance for ones center of gravity. Athletes employ horizontal forces on the ground in order to accelerate the body forward while, at the same time, overcoming air resistance (1). The net result of a longer ground contact time and unchanged flight time is a reduced stride frequency (1).

Stride frequency can become detrimental if decreased after being trained improperly with resisted speed training. However, if the amount of the percentage of body mass being pulled is beneficial to the athlete's performance, then the production of a greater force and decreased ground contact time will increase stride frequency and create changes in velocity (37, 40). To increase stride frequency at maximal running, sprinters must shorten the contact time by extending the knee joint less at the end of the contact phase (37). Velocity of the recovery leg during the flight phase must be increased by generating greater mechanical power from the hip extensors and knee flexors (7, 8 42). In order to properly enhance force development in sprinting for both male and female soccer players, athletes need to perform training movements that involve rapid acceleration against resistance. This acceleration should extend throughout the movement with no intention to decelerate at the end of the movement (3).

Sprint resistance training is a sports-specific method of training to enhance the force production of the muscles by adding an external load to the body or performing hill or slope training (30). The research on sprint training has concluded that weight training, plyometric, and sprint resistance are all implicated in the improvement of stride length, but not increases in stride rate (13). There are few references in the literature concerning the comparisons of resisted and assisted speed training protocols, and none that look into affected kinematic variables for both male and female collegiate soccer athletes. Sprint-resisted and –assisted methods have been used with the aim of improving maximal sprint running performance by changing step length and step rate respectively, which are components of speed (29). Variations of these two methods can be used with elastic cord speed training. Resisted sprint training (RST) includes an elastic-cord or bungee cord designed to create an overload effect to elicit a greater neural activation and increase the recruitment of fast-twitch muscle fibers during acceleration (43). Assisted sprint training (AST), also known as supramaximal and over speed training, uses a harness bungee cord or elastic-cord to create a stretch shortening release while at maximal speeds in order to achieve higher velocities beyond the current capability of the athlete. Overspeed training seems to improve maximal velocity via increasing stride length, stride rate, and muscular activity of the lower extremities (3). Free sprint training (FST) is training without the use of an external device, also considered unloaded sprinting. FST been shown to increase running velocity over short distances (15-20 m) (22, 40) and increase in horizontal power because of significant gains in step length. Free sprint training increases sprint time within the first initial steps of a sprint, and significantly from 0 to 5 m and 0-10 m foot contact time because of a reduction in mean flight time (22). All of these speed training techniques can affect kinematic variables of a sprint.

Manufacturers have developed the Speed Harness™ (Power Systems, Knoxville, TN, USA) in order to provide a steady and sturdy resistance or assistance in the execution of the sprint. The theory upon which manufacturers base the efficacy of these products is that sprint speed is the product of stride length and stride frequency, and accordingly, increasing one of both of these components without negatively impacting the other will result in an increase in speed (43). It is important to understand the research underlying the use of elastic towing devices to create either a resisted or assisted speed training environment for athletes. It has been concluded that both RST and AST impact maximal velocity differently as the result of their effect on the rate of change in velocity, or acceleration, over the total distance covered (43). In one study comparing assisted and resisted sprint training in Division IA Female Collegiate Soccer Athletes, (43), results indicated that subjects in the assisted sprint training group increased their acceleration in response to their assigned protocol during the initial 13.7 m of a 36.6 m sprint, whereas subjects in the resisted sprint training group responded to their assigned protocol with an increase in acceleration during the final 22.9 m of the 36.6 m sprint. Even though multiple research articles have concluded that both resisted and assisted sprint training protocols are capable of stimulating a training effect with an increase in short distance velocity of 36.6 m, it varies as to where each type of training actually creates an affect on sprint kinematics within a specific distance. There is also controversy as to which specific external device and what type of methods, such as resisted or assisted speed training, will improve acceleration and overall maximal power output due to little research.

Purpose of the Study

The purpose of this study was to compare and assess three speed training techniques and their effects on sprint time in NCAA Division III collegiate soccer players in a 36.6 m run. The study was implemented to determine if differences exist between AST, RST, and FST in enhancing sprint time. The measurements of stride length and stride frequency were assessed as important kinematic variables affecting sprint time.

Hypotheses

It was hypothesized that:

H 1: A six-week AST program would more effectively decrease total sprint time of a 36.6 m sprint in NCAA Division III collegiate soccer players as compared to RST and FST.

H 2: A six-week RST program would more effectively decrease sprint time during the acceleration phase of a 36.6 m sprint in NCAA Division III collegiate soccer players as compared to AST and FST.

H 3: A six-week AST program would more effectively decrease sprint time during the maximum velocity phase of a 36.6 m sprint in NCAA Division III collegiate soccer players as compared to RST and FST.

H 0: Total sprint time in NCAA Division III collegiate soccer players after a six-week AST and RST program would not effectively decrease as compared to the other methods of sprint training.

Independent Variable

The independent variable was the sprint training method used. This study looked at the effects of resisted elastic-cord training (RST), assisted elastic-cord training (AST), and free sprints training (FST) protocols.

Dependent Variable

The dependent variable was the data collection for split time measurements of total sprint time, sprint time during the acceleration phase, sprint time during the maximal velocity phase, stride length, and stride frequency at 9.1 m, 18.3 m, and 36.6 m after pre- and post-test results for each subject.

Delimitations

This study was delimited to available Division III male and female soccer players available to the experiments. Subjects were trained with a 6-week program during an off-season conditioning period because each subject was participating in controlled team conditioning sessions (Appendix A). Subjects were not trained during the regular season because of uncontrollable limitations. All subjects were current active team members. This did not include practicing medical and academic redshirt players. This study was delimited to subjects who have passed a medical screening and health questionnaire

(Appendix B), and was free from any previous medical history within the past year that could have affected collected data results. If subjects sustained an injury, they would be dropped from the study. Because the purpose of this study was to determine the effects of elastic cord speed training programs on sprint performance using stretch tubing, subjects would only be trained with this external device. A specific warm-up prior to each training session was only implemented to loosen and activate the muscles, therefore not being a limiting factor that could affect the outcome of data results. Training sessions were completed two times a week.

Limitations

While performing at 95 to 100% maximal power output, athletes are constantly increasing their core body temperature and perspiration rate. This study did consider each subject's hydration status. Sprint training programs require exertional muscle power, endurance, and flexibility. However, the level of fatigue for each athlete was not accounted for. Rest intervals between sets, reps, and training sessions were provided to allow for recovery of the ATP-PCr energy system. Even with controlled team conditioning sessions, and a controlled experimental 6-week sprint training program, an athlete's dietary intake could effect proper muscle lactate acid buildup and recovery, muscle activity firing rates, recovery time between sessions, and overall exertional energy of the subject. Each subject's diet was not taken into consideration because of unsupervised hours away from the controlled setting of the experiment. Factors such as social life outside of the controlled training, class scheduling, homework load, and studying hours were not taken into consideration. It is important to understand specific procedures and correct form and technique while training with the elastic-cord external device, but it cannot be controlled as to previous experience with speed training techniques for each subject, as well as if each subject maintained proper form and technique for every training session.

Significance of the Study

Continuous research on speed training is needed to determine its effects of kinematic changes in the acceleration and maximal phase of sprinting, especially in athletes who are not just track sprinters, but require short spurts of energy throughout games. Soccer athletes spend approximately 10-20% in intermittent bouts of high-intensity running (43). Maximum velocity and acceleration can be frequently associated with successful field performance because the range of sprint distances recorded during games (1.5 m – 105 m) indicates the requirements of both acceleration and maximum speed capacities (21). Elastic towing devices are a cheaper, quicker, and easier way to train multiple athletes within a team because training requires a “double man” or “partner”. They require body weight, instead of requiring external loads of a sled. These external devices can provide additional help with the body's reactive force generation capacity to overcome the inertia while accelerating the body at low velocities (22), thus positively affecting kinematic variables in order to produce a decrease in sprint time throughout the different phases of a sprint. Both of these speed training techniques can affect kinematic variables of a sprint. It is important to analyze stride length and stride frequency and major determinants in increasing speed in order to determine whether RST or AST improves acceleration in collegiate athletes. Results of such studies could help determine which speed training method collegiate soccer coaches could incorporate into helping train acceleration in sprints. A gap seems to lie within the research as to which method is best to use for soccer players. Previous research has suggested that athletes participating in short-distance acceleration events use assisted speed-training protocols because it enhances acceleration within those first 5 to 15 yards (43). If a productive speed training protocol can enhance an athlete in force production to perform sport specific movements that involve rapid acceleration against resistance, such information could be useful to incorporate into soccer specific needs for coaches.

Operational Definitions

Acceleration phase – 9.1 and 18.3 m sprint times are measures of acceleration (35, 36)

Assisted sprint training (AST) – also known as supramaximal or over speed training; high speed partner gravity assisted towing and pulling system using an external device such as a harness or stretch tubing while at maximum speed

Free sprint training (FST) – traditional speed training without wearing or resisting any external device

M**aximal velocity phase –** 30-40 m of a sprint is considered the maximal velocity phase, or where maximal velocity is reached (35)

Resisted sprint training (RST) – sprinting with added load while attempting to provide velocity and movement pattern specificity during power training for the sprinter

Speed – movement distance per unit time, or the time take to cover a fixed distance. Speed is a scalar quantity and will be measured in m per second (m/s)

Stride frequency – the number of strides per minute (15); stride frequency in this study will be measured in hertz, and stride per second.

Stride length – the distance covered by one stride; a stride is the interval from one event on one leg until the same vent on the same leg in the following contact (15). Stride length will be measured from toe off from one limb to subsequent toe off from the same limb.

Velocity – the time rate of change of position (15); velocity is also known as speed. Velocity will be measured in m per second (m/s) for total time, time in the acceleration phase, and time in the maximal velocity phase.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study was to compare and assess three sprint training methods and their effects on sprint time on NCAA Division III collegiate soccer players in a 36.6 meter run. Soccer is a sport where athletes spend approximately 80-90% of their performance time at a low to moderate intensity and the remaining 10-20% in intermittent bouts of high-intensity running (5, 6, 43). These high-speed actions during soccer competition are categorized into actions of acceleration, maximal speed, and agility. However, soccer, as well as other field sports, is believed to have different running mechanics than sprint athletes, as well as significant correlations between acceleration and maximum speed (21). Linear sprinting is composed of acceleration and maximum velocity phases, and performance in each phase may be evaluated discretely and may require specific training methods (1, 8). The focus of this study was to investigate a 6-week program consisting of resisted elastic cord sprint training (RST), assisted elastic cord sprint training (AST), and free sprint training (FST) programs and their effects on a short distance (36.6 m) total sprint time, as well as to break down and assess the sprint times during the initial acceleration phase and maximal velocity phase. The purpose of this literature review is to examine the importance and physiology of sprint speed in soccer, to report important kinematic factors and their function, and to describe the specificity of speed training programs in each phase of a sprint.

Importance of Sprint Speed in Soccer

Soccer is an extremely popular sport that athletes anywhere from the amateur level to the professional level are playing. Soccer is a non-cyclical and intermittent sport in which short-duration maximum-intensity activities, for example, sprints over a distance of 10-20 m, and high-intensity actions, such as counterattacks, are intertwined with activities of low and moderate intensities (2). Match analyses have been performed in order to better understand the use of anaerobic power within the game of soccer. Sprint distances covered in the game of soccer all vary depending on the position being played. An analysis revealed that forwards, outside midfielders, and outside defenders covered statistically longer sprinting distances than the central defenders and central midfielders (2). During a 90-minute soccer game, elite-level players run about 10 km, or on average for any player, between 200 and 1,200 m (2), at an average intensity close to the anaerobic threshold (80-90% of maximal heart rate) (41). This anaerobic threshold maintains a player's energy expenditure in order to perform any type of jumping, tackling, turning, changing pace, and sprinting movements within any given second of a soccer game. A sprint bout occurs approximately every 90 seconds, each lasting an average of 2-4 seconds (41, 43). Sprinting constitutes approximately 1-12% of the total distance covered during a match, corresponding to the 0.5-3.0% of effective playtime. (2, 21, 41). However, distances vary between each sprint.

Acceleration and maximum speed phases are specifically independent from each other, making it almost impossible to simulate the same soccer sprints throughout a match. Not every sprint covers the same amount of distance, and sprints within a specific play can mean changing the direction of play at the same time. Recent studies report that

96% of sprint bouts during a soccer game are shorter than 30 m, and 49% are shorter than 10 m (41, 44). Using a 36.6 m run can still be appropriate to test sprint speed for soccer players because we can see their full sprinting potential after they reach maximal velocity. The maximum velocity phase is anywhere between 18.3 m and 36.6 m, where it is thought that maximum velocity of a sprinter is reached (35) The acceleration phase of a sprint occurs within the first 10 m, while the initial acceleration is reached within the first few strides in order to obtain maximal velocity. Elite, collegiate, and amateur athlete sprint times differ within certain covered distances. Professional players are faster than amateur over 10 m or 15 m, and some report fast sprint times over 30 m or 40 m (41). The complexities of soccer sprints create unanswered questions in regards of the different phases in a sprint. In a game, most soccer players are already moving at moderate speeds before a high-intensity burst of energy takes place, such as a sprint and changing direction. It is many cases, a soccer player initiates sprints when already moving at a constant or moderate speed, however it is still important to look at the acceleration phase of a sprint for soccer players because of constant changes in direction and speed (21). Therefore, top speed will be achieved more often than distance, as time param would otherwise predict (21). It is still important to investigate acceleration within field sport athletes, such as soccer players, because of the demands of rapid changes, especially in direction (21). Acceleration can be related to agility because it requires the ability to change direction, as well as starting and stopping abruptly. Further research is still required to determine the important physiological and biomechanical factors in sprint performance, as well as in the acceleration phase and maximal velocity phase.

Physiology of Sprinting

The specificity of different speed components may be attributable to differences in the musculature recruited; in the requirements for strength to be developed at specific muscle lengths; in the requirements for strength to be developed in either shortening or lengthening contraction modes; or in the complex motor control and coordination of several muscle groups (21). When a muscle is stretch to its maximum length, potential muscle energy is stored in the connective tissue in order to be used in a high-force output. This then initiates a stretch-reflex potential, allowing multiple muscles to perform high-intensity movements, such as linear sprinting (15). The ability of the neuromuscular system to produce maximal power output and increase running speed appears to be critical in sports, including soccer, that require multiple bouts of sprinting performance. Running speed, or velocity, is the product of stride length and stride frequency (26). Attempts to improve speed must induce neuromuscular adaptations upon kinematics.

To effectively improve running speed, one must develop sound mechanics that combine the actions of upper and lower extremities to effectively produce muscular force (12, 30). This is used to generate a propulsive ground reaction force by creating a vertical impulse to propel the body over a given distance as quickly as possible (8, 30). Allowing the body to propel forward over a specific distance requires a release of muscular energy while sprinting in order to reach a maximal velocity. Energy for such muscular performance lasts during brief maximal exercise of 10 seconds or less, and is primarily derived from the breakdown of stored muscle phosphagen, including adenosine triphosphate (ATP) and phosphocreatine (PCr), and glycolysis (38). However, short sprints are constantly being repeated during a soccer match. When sprinting exercises last for up to 30 seconds, the contribution of anaerobic energy production to the energy yield decreases and a significant amount of energy is derived from aerobic metabolism (38). Soccer is a 90 minutes game, incorporating mostly aerobic energy, but being able to attain an anaerobic threshold for sprinting is required. Recent evidence suggests that 13% of energy during a 10 second sprint and 27% of energy during a 20-second sprint is generated aerobically (38). Therefore, addressing both aerobic and anaerobic energy systems utilized in soccer may determine the importance in training for short or long distances.

Greater lower limb force production has been thought to improve running speed because of kinematic changes by potentially increasing adaptations for an increase in stride length, decreases ground contact time, and an increase in stride frequency (30). Biomechanical analyses have been completed on the perspective of linear kinematics of sprinting. Kinematics describes motion, or movement characteristics, and the function of the percentage of the total gait cycle or time. A sprinter's center of mass partly determines the direction and magnitude of the ground reaction forces, depending on position, acceleration, and stretch-reflex. Maintaining maximal energy efficiency is dependent on the storage and use of elastic potential energy as well as the transfer of energy from one body segment to another through two joint muscles, for example, the rectus femoris and hamstrings (28). The potential and kinetic energy lost after the center of mass falls toward the ground is converted into elastic potential energy and stored in the muscles. This storage of energy within the muscles is very important in the role of sprinting. Sprint velocities vary, as well as stride length and stride frequency, depending on the reaction forces of the lower body musculature in the acceleration phase and maximal velocity phase.

Sprint velocity is the product of step length and step frequency (8, 9, 12, 15, 16, 24, 42). Step length and step frequency have the power to enhance sprint velocity in the acceleration phase and maximal velocity phase of a sprint. Each step consists of a stance phase and a swing phase. During the stance phase, the foot is in contact with the ground, and the swing phase is from ipsilateral foot strike to ipsilateral foot strike (12). There is a significant increase in stride length in the acceleration phase of a sprint and a greater increase in stride frequency in the maximal velocity phase. This is based on the impulse-momentum relationship (18). The impulse-momentum relationship states that the product of a system's mass and velocity is equal to the product of force and time of force application applied in the same direction (18). In other words, the change in momentum is equal to the effect of the impulse applied in the direction of movement. Propulsive motions occur during the acceleration phase, with minimal braking forces at foot strike. However, braking forces create 43% of the stance phase in the maximal velocity phase (12). Propulsive and braking forces depend mainly on the lower extremity musculature of a sprinter.

One investigation while sprinting noticed that different speed components share some relation depending upon the ratio of leg strength to body mass and fiber type proportion(little and Williams 10?). High concentric force capacities for accelerating a body at rest and high contraction velocities are necessary to maintain a high movement speed. These high contraction velocities are composed of sagittal plane joint movements and power, including hip extension, hip flexion, knee extension, hip abduction and ankle plantarflexion. Importantly, the hamstrings and gluteus maximus generate forward propulsion by extending the hip after the swing phase, when the foot is ahead of the body. The quadriceps and ankle plantarflexors contract to push the sprinter forward by extending the knee and plantarflexing the foot (28). Training hip extensor and the gluteal muscles could create a possible increase in stride length, correlating with an increase in stride frequency.

Sprint Training with External Devices

Further research investigating movements requiring greater force production may still be needed to determine the relationship of velocity and muscular actions in sprint performance (12). Specific velocity increases have been shown with strength training programs using different speeds of movement (17), including resisted sprint training and assisted sprint training. Therefore, according to Izquierdo, 2002 (17), "it would be of interest to determine force-velocity and power-velocity relationships in order for that athletes to perform training exercises at specific loads and (or) at a velocity similar to the conditions of muscle performance required in the actual competitive movement." Research has included general speed and strength, velocity-specific strength, movement specific sprint-associated exercises, resisted training, and over speed training as training methods for improving sprint performance (3). All of these training methods involve training the kinematic variables of sprinting in hopes of producing a decrease in sprint time. A decrease in sprint time is based on the demands of maximal speed strength. Investigating the strength relationships between maximal dynamic force capacity of the lower body and powerful lower body movements (32) is the primary reason for implementing the use of a sprint training program in order to decrease sprint time. Failure to optimize basic force producing characteristics of muscles may hinder the developmental potential of power adaptation and muscular expression (32). With the use of resisted and assisted sprint training methods, such muscular adaptations and other fitness components can be utilized when trying to produce an increase in velocity.

Sprint training methods should primarily focus on decreasing sprint time. Assessing the multiple biomechanical variables that make up a sprint provide results and reasoning behind altered sprint velocities. Sprint times can be reviewed in the acceleration phase and maximal velocity phase. Multiple articles have even compared the velocity and biomechanical variables after an implemented sprint training intervention (1, 3, 4, 8, 9, 18, 20, 23, 24, 26, 42, 47). Variance does lie between short-distance quickness and maximal speed measures (12). These two measurements can be assessed as independent qualities of overall sprint time with regard to the relationship between first-step quickness (0-5 m), acceleration (0-10 m) and maximal speed (≥ 20-30 m).

Resisted Sprint Training

Resisted sprint training (RST) includes towing with sleds, elastic cords, parachutes weighted vests, and uphill sprinting. RST has been shown to increase hip extensor strength, thus improving overall stride length and velocity (1, 4). A greater neuromuscular activation of muscle fibers is being recruited in order to produce a greater force during ground contact phase of a stride. Therefore, the goal of RST should be an attempt to maximize gains in both force and velocity to elicit positive power adaptations (12). Because starting strength is essential for soccer players, RST is thought to be an additive neuromuscular apparatus and a measurement of very fast force production capabilities to decrease sprint velocity in the first 10 m of a sprint.

Research has shown continuous challenges in determining appropriate loads with a resisted towing intervention. Resistance for a horizontal exercise, such as a sled pull, is a product of the vertical, or gravitational, force of the weighted sled and the coefficient friction between the sled and ground (18). If a load is too heavy, it could cause detrimental changes of an athlete's sprint technique, thus having negative affects on any improvements of sprint velocity (18). According to research on resisted towing (16, 40, 46), recommendations of 10, 12.5 and 13% of the athletes total body mass is an appropriate towing magnitude. If the load is too heavy for the athlete, then it is not producing the optimal effects for changing biomechanical factors to help increase sprint time. The percentage of load being used for resisted towing should not decrease the athlete's speed by more than 10% and the horizontal velocity should not drop below 90% of the athlete's maximal velocity (1, 4). In one study, researchers attempted to limit the reduction in velocity arising from a weighted sled, parachute, and weighted belt to less than 10% (1). After pilot studies of participants in the study, the sled was loaded to 16% of body mass to produce a decrease in velocity around 10% of unloaded sprinting, and the weighted belt was loaded to around 9% of body mass. Results indicated difficult kinematic readings because of differences in the reduction of running velocity between all three devices. Differences in running velocity and sprint kinematics between the phases of a sprint cycle depend on the ranges of loads of a device applied to the athletes (1, 23). Lockie et al, 2003 (23) initially created a pilot study to develop a formula (load = ([body mass x %body mass/100] – sled weght)) to determine the relationship between towing loads and sprint velocity above 15 m. Using two loads (12.6% and 32.2% of body mass show that stride length reduced by around 10 and 24% for each load, and stride frequency decreased as well (23), indicating that higher loads may be more of a disturbance to normal sprint kinematics in the acceleration phase. With all research studies investigating the effects of resisted towing, understanding that towing with a sled may have a greater impact on solely the acceleration phase than on maximum sprint speed in the maximal phase of a sprint (4). However, increases in sprint time will not result unless proper sprinting mechanics are thought to be reinforced while using the external sprint training device.

Sled Towing

The use of sleds is more common among the research on resisted sprint training. Alcaraz et al., 2008, investigated the kinematics of unloaded sprinting at maximum velocity to sprinting while towing a sled, parachute, and wearing a weight belt in order to establish which intervention was more appropriate in producing an overload on the athlete in hopes of increasing the maximal velocity phase time. The load of the sled was less than 10% of each subject's body mass in order to avoid any detrimental changes in sprinting mechanics. Subjects were active competitive athletes in either sprinting or long jumping. Results did show a greater decrease in running velocity for all three devices, however it was difficult to compare the effects of these devices on biomechanical variables because the decrease in sprint velocity was different for each device (1). Maximum velocity reduction was greatest with the sled intervention, making it a better training method for improving maximum sprint speed due to increasing an athlete's capability to generate horizontal and vertical sprinting forces in order to produce a longer ground contact time and unchanged flight time, thus creating a decrease in stride frequency in the acceleration phase of a sprint (1). Athletes showed a shorter take-off distance due to the fact that they did not utilize full leg extension.

Clark et al., 2010, studied the effect of resisted sprint training using weighted sleds and weighted vests on 25 male NCAA Division III lacrosse players. Because previous literature has indicated that elite sprinters typically accelerate for 30 to 50 m, reach maximum velocity between 30 and 60 m, and decelerate after 60 m (8), subjects completed 3 maximal effort sprints while assessing measured sprint times and average velocity over the distance interval between 18.3 m and 54.9 m. The subjects were first pre-tested for height and body mass measurements. They completed a 10-minute warm-up consisting of jogging, a variety of movement drills, and static stretching before completing three maximum-effort 54.9 m sprints with five minute rest periods between each sprint. Pilot tests were then administered where data was used in a regression analysis (23, 38) to indicate that a 10% body mass towed by the weighted sled and 18.5% body mass of the weighted vest, both not being adjusted during the whole time of testing. The load of the weighted vest was above the 10% rule due to the fact that decreasing sprinting velocity may depend on the coefficient of friction of the training surface and its relationship with specific physical characteristics of the subjects (8, 23). All training groups participated in 13, 60-minute training sessions of their assigned resisted training method over 7 weeks. After a 20-minute warm up consisting of dynamic stretches, neuromuscular coordination exercises specific to sprinting, and footwork and agility drills, the experimental groups sprinted with their assigned external device for the first two sets, and without the external device in the last two sprints of the last set in order to reinforce proper sprinting technique. After comparing fastest times of pre- and post-testing, the entire subject population's results displayed a significant decrease in stride length, increase in stride rate, and decreases in ground contact time. These results indicated that weighted sled and weighted vest resisted sprint training offered no effect as compared to the unloaded sprint subjects, possibly due to the loads used by the sled and vests. The weighted sled group towed 10% body mass and the weighted vest group towed 18.5% body mass. In conclusion, this study's results did not demonstrate significantly greater improvements in sprint velocity with the use of weighted sleds and vests as compared to unloaded sprinting.

The effects of resisted sprint training on speed and strength performance was examined in on 15 rugby players after towing predetermined loads of 13% body mass added to a sled by Harrison and Bourke, 2009. Detrimental effects in sprint technique and speed in the first 15 m of a sprint resulted after a short-term resisted sled towing intervention comparing towing loads of 12.6% and 32.2% of body mass to unloaded sprinting load was shown in an investigation in field sport athletes (23) Subjects completed six sprint trials; two unloaded, two towing a load of 12.6% body mass (90% of maximum 15 m velocity) and two towing a load of 32.2% body mass (80% of maximum 15 m velocity. Even though several authors have suggested that an athlete's horizontal velocity should only fall to approximately 90% of their maximum when towing resisted sleds, sprinters still seemed to be compensating for a decrease in stride length by emphasizing stride frequency after subjects in the study achieved an average velocity drop of around 9% (90% maximum) (23). Therefore another study decided to implement a six-week resistance training intervention on 30 m sprint times, as well as maximal speed achieved in 30 m sprints from both a static and flying start (16). Pre- and post-test results indicated that start and acceleration capabilities during the first 5 m (acceleration phase) increased by the resisted sprint training intervention. Starting strength, which can be determined by neuromuscular adaptation of the ratio of fast to slow twitch fibers and the measure of very fast force production capabilities, is essential in the game of soccer. The results of this study also agreed with Spinks et al., 2007 (40), who looked at the effects of an 8-week, two, one-hour session per week, resisted sprint training compared to nonresisted sprint training on acceleration performance and kinematics in soccer, rugby union and Australian football players. The constant loads used throughout the testing were predetermined by each subject's specific characteristics, as well as by determining the load required as a percentage of body mass (%body mass = (-1.96 - %velocity) + 188.99) and the sled load required to produce a specific velocity (load = 9[body mass x %body mass] – sled weight)). Results concluded that resisted sprint training improved the initial acceleration phase of a sprint after an 8-week resisted sprint training program. Zaffeirdisi et al, 2005, also concluded that with a resisted sled towing protocol, an increase in running velocity and kinematics are important components in the acceleration phase (0-20 m) of a sprint.

One study investigated the effects of different speed training protocols on sprint acceleration kinematics and muscular strength and power in 35 male, field sport athletes after towing 12.6% of their body mass over a two day intervention (22). Resisted sprinting overloads can increase lower-limb muscular force output, affecting training adaptations, thus leading to changes in step characteristics, such as stride length and stride frequency, happening over time (22). Results indicated an increase in velocity at the 0-5 m and 5-10 m split time, as well as an increase in mean stride length between pre- and post-test results. These results may indicate an increase in power generated during the support phase of a stride must be translated horizontally, in terms, by increasing step length changes to produce an effective transition to acceleration. Reactive power consists of higher movement speed and ballistic activities encouraging stretch-shortening cycle action, therefore, sled towing indicated an improvement of stretch-reflex and having the ability to offset eccentric loads (22).

Research has concluded that with an increase in stride length, an increase in the utilization of elastic energy during the support stage of the sprint cycle can be completed through the use of a resisted sled towing program because of the recruitment of hip and knee extensors. The recruitment of hip and knee extensors provides a greater application of power in the horizontal direction (40). Keogh et al., 2010, looked at weighted sleds with a heavy load that was substantially larger than the percentage of body mass (172.2 kg for all subjects), or strongman-type load because it was thought that overloading the muscles in movements similar to that found in a sprinting sport context will increase overall performance. Its important to understand that recommendations to improve sprinting speed should not substantially exceed the 10% body mass rule, (1, 4, 16, 40, 46), this study determined that using loads remarkably higher than 20% body mass would aim at challenging resistance in a horizontal exercise would increase muscular strength, not speed. After comparing kinematics and velocities of the acceleration phase (first 5 m) and maximum velocity phase (last 5 m) kinematics of heavy sled pulls in a 25 m sprint after completing three sets of heavy sled pulls over 25 m, acute response results showed a lower average velocity in both the acceleration and maximal velocity phases of a 25 m sprint. There was an increase sprint time after training in the acceleration phase due to increased changes in stride length between subjects because of the shorter ground contact time characteristics, as well as an increase in stride frequency was indicated in the maximal velocity phase. Overall, it is important for sprint training methods and the affects of load percentages, to replicate the demands of a specific sport.

Parachute

Parachute resisted training is like that of the sled, but provides an increase in running velocity without any detrimental effects to running mechanics. According to Martinopoulou et al., 2011, in parachute sprinting, resistance is applied right behind the athletes' body center of gravity and is caused by air. Therefore, the aim of this study was to determine the effects of a four week resisted training intervention program using a parachute on sprint performance on 16 sprinters. Tests during the program were completed two days after the last training session, allowing a 24-36 hour recovery period. After pre- and post-test results from 50 m trials were assessed, it was indicated that resisted sprint training with a parachute improved speed in the acceleration phase (0-20 m) (24). An increase in stride length was indicated in the first 20 m, and an increase in stride frequency was shown in the maximal velocity phase. Limitations arise within this study because the load of the parachute being towed by the subjects was not stated. Overall, when an increase in velocity in higher speeds is achieved, there is a result of an increase in stride frequency (24, 25).

Paulson and Braun, 2011, also completed a study comparing the acute kinematic effects of parachute resisted sprint training and no parachute sprinting in collegiate track athletes after performing a 36.56 m (40 yard) dash. However, their results differed from Martinoupoulou et al., 2011. Results after training indicated that stride frequency and stride length were not acutely affected while sprinting with a parachute. Even the speed of the parachute sprint training was significantly decreased by 4.4%, indicating that the parachute may have not provided an appropriate load to make kinematic changes. A gap between the research of these two studies' results is indicated, most likely due to the fact that very few parachute sprint training studies have been reported on supporting its benefits.

Elastic Cord

According to Corn et al., 2003, elastic cords provide a negative loading in order to assist concentric actions of the lower leg musculature to produce an increase in power output while sprinting. The concentric actions of a sprint cycle are considered the velocity component of power production in the lower body. A Power Systems (Knoxville, TN) Speed Harness of medium and heavy tubing was used in Corn and Knudson's study in order to provide a resisted towing force. Elastic cord towing devices have been claimed to increase both stride frequency and stride length because of a pull that tows a sprinter to supramaximal speed (11). Nine subjects, both male and female collegiate sprinters, performed 20 m sprints with the Speed Harness. Results indicated that stride length increased by 6.8% under the towed sprint training condition (10). Horizontal velocity in the acceleration phase was acutely increased in the towed sprints by 7.1% as a result of applied horizontal forces. However, a question does still lie as to whether adaptations after training from the towed sprints are short-term or long-term.

Myer et al., 2007, compared ground based speed training with elastic cord and uphill treadmill resisted sprint training methods on related kinematic measures and sprint start speed. The hypothesis stated that ground-based training with the elastic cord would not affect kinematic variables of a sprint measured during the acceleration phase because research stated that inclined treadmill sprinting can create a load resistance based off gravitational pull and spatial position during sprint bouts performed on any incline greater than 0%. Thirty-one high school female soccer players trained twice a week, for six weeks, with their assigned training method. There was a slight decrease in sprint time in the acceleration phase and stride frequency after the 60 yard sprint. The elastic cord resistance used in this study was at a relatively lower magnitude, agreeing with Zaferidies et al (47) who after utilizing 5 kilograms of resistance in its training protocol, recommended using a lighter-resistance in order to achieve optimal training effects of resistive ground-based training.

Among the research, sled towing as a form of resisted sprint training has been investigated more than other forms of resisted sprint training. Few studies have been reported on effects of parachute and elastic cord speed training; therefore it is still unclear as to whether these methods of resisted sprint training protocols can enhance sprint speed and power. It is important to included unloaded sprinting (FST) in any study in order to always compare sprint time and sprinting mechanics of other sprint training methods back to the control. Limitations within most of these articles included between gender affects. Articles that include male and female subjects contrasting or compare the differences of kinematics and sprint time between genders. Gender differences could play a major role with any type of internal validity. The load being towed is also a key-limiting factor in many studies on the beneficial percentage of body mass that should be towed when implementing any type of resisted sprint training program. Long-term studies varied in how many weeks subjects were tested, but most used a 24-36 hour recovery window between training sessions. Also, within any uncontrollable 24-hour study, it is hard to supervise what subjects do on off days. Unless a coach has them in a controlled environment of conditioning or off-season workouts, subjects may be completing their own various routines of high-intensity workouts that could cause bias in any sprint training method program results.

Assisted Sprint Training

Partner assisted elastic cord towing, downhill sprinting and high-speed treadmill sprinting are all examples of assisted sprint training methods. The purpose of assisted sprint training is to increase sprint velocities and train the neuromuscular system to take both faster and longer strides, thus increasing the stride length. However, stride length eventually ends up reaching a plateau prior to achievement of maximal velocity. The attention of assisted sprint training should focus primarily around stride frequency (4). With assisted sprint training, the stretch-shortening cycle (SSC) of the neuromuscular system can lead to muscles enduring larger stretch loads in order to store a greater amount of elastic power during the eccentric phase of the SSC (4). This could lead to an overall improvement in ground contact time and force generation correlating with an increase in stride frequency.

The mastery of achieving optimal sprint technique can be correlated with a decrease in flight time and a decrease in time during the amoritization phase of a running stride (3). Over speed sprint training has been shown to improve maximal velocity by increasing stride frequency or muscular activity of the lower body. However, as with resisted sprint training, the optimal load of assistance to increase speed and sprint performance is still unclear with elastic cord sprint training. Therefore, Bartolini et al., 2011, underwent a study to determine the optimal elastic cord assistance to increase sprint performance in 18 collegiate women soccer players. All subjects participated in 3 testing conditions, consisting of randomly assigned 0, 10, 20, 30, and 40% body weight assistance (BWA). These BWA percentages with elastic cord tension were determined by a crane scale measurement. Split times at the 0-5, 5-10, 10-15, 15-20, and 20-25 yards and kinematics were measured for analyzing. Post hoc measurements concluded that with an increase in BWA, sprint times acutely decreased by up to 30%, and as BWA increased, sprint times decreased up to 30% BWA for up to 15 yards (3). Overall, 30% of BWA with an elastic cord sprint training intervention appeared to be the optimal BWA to decrease sprint times in collegiate women soccer players for distances anywhere up to 15 yards. Assisted running helps to increase stride frequency in the maximal velocity phase after an acute short-term sprint training intervention. Therefore, in this study, increases in both the stride frequency, and stride length, can be correlated with the implementation of the elastic cord sprint training program.

In Sugiura and Aoki, 2008, investigation of supramaximal running and its effects on stride frequency and stride length, 8 healthy, well trained male sprinters volunteered to participate in a supramaximal sprint training program by using an isotonic motor-driven towing system to produce an assisted force. Subjects were instructed to run two maximal and two supramaximal runs over a 50 m distance, followed by a 20 m approach run in order for the subjects to quickly reach higher velocities (42). Results after pre- and post-tests indicated an increase in running velocity from maximal to supramaximal sprint speed, due to the increase in stride frequency. In order to increase stride frequency, intervention goals must shorten contact time by extending the knee joint less at the end of the contact phase, and the velocity of the recovery leg during the flight phase must be increased by generating greater mechanical power from hip extensors and knee flexors (42, 43). Suguira and Komi et al, 2008, grouped their subjects' results into "pitch" type sprinters and "stride" type sprinters. Pitch-type sprinters in the study increased rate of stride length due to towing, and stride-type sprinters within the study showed a greater rate in stride frequency. With assisted sprint training, an increase in stride frequency is greater than that of stride length, determining the use of stride-type sprinters. Assisted sprint training to improve speed in the maximal velocity phase creates a longer flight time, causing a change from running to hopping, thus reducing flight time and increase stride frequency during an unloaded (40). Creating a sprint that is more of a "hopping" action leads to an increase in flight time, thus producing larger stride lengths and an overall greater stride frequency, as well as utilizing potential energy stored within the tendons of muscles in order to produce a stretch-relfex.

The little research on the effects of assisted sprint training is still unclear on the consistency of sprint time and biomechanical factor measurements. Limitations do exist within assisted sprint training. With assisted elastic cord sprint training, tension of the cord throughout the entire sprint is quite impossible to maintain unless it can be mechanically controlled. Tension of the cords in Bartolini et al., 2011, potentially lost their tension relative to the subjects' body weight by 15 yards, which left subjects to run at a normal body weight with no assistance. With the motor-driven towing machine (40), a specific velocity (105-110%) of maximal running could be set and maintained throughout the entire sprint, where velocity of maximal running could not be maintained with assisted elastic cord. Braking forces may even cause a larger limitation when trying to increase speed because of a greater stride length and in increase in flight time due to a high assistance load (3). Even though there are little studies among research that look at solely assisted sprint training, there are a few studies that compare resisted sprint training and assisted sprint training methods.

Comparing Intervention Methods of Sprint Training

Musculature around the hips is deemed more important in sprinting because of the effect of the lower extremity acting as a kinetic chain (4). Hip flexors are known to improve stride frequency by pulling the leg forward at a faster rate (46). Hip extensors drive the body forward in order increase stride length by improving concentric and eccentric muscle contractions during the ground contact phase (4). Among the previous research presented, resisted sprint training methods are used to improve stride length, assisted sprint training methods are used to improve stride frequency, and both methods are used to improve total sprint time. The relationship between sprint training being a sport-specific exercise for sprinters in field-sport athletes is that it mimics in the possibility of recreating sprint technique, leading to the best transfer method for increasing velocity. However, there are very little studies presenting the relationship between different sprint training intervention methods to unloaded sprinting.

LeBlanc and Gervias, 2004, examined sprint time and kinematics of acute sprint trials under assisted (over speed) and resisted training conditionings as compared to normal, or free, sprint training during the acceleration phase and maximal velocity phase. Six subjects from the University of Alberta participated in 3 trials of or resisted or assisted sprint training while using a Stroops Double-Time^{TM} Overspeed Trainer. Average speed was recorded as velocity, or in m per second (m/s), stride rate was recorded as strides per second (strides/s), and stride length was recorded in m per stride. However, this study concluded that a greater average running speed was noted because of possible increases in stride length, not stride frequency with assisted sprint training during the acceleration phase. Acute results also concluded that resisted sprint training was very similar to unloaded sprint training because they both had similar findings in sprint time, stride length, and support time (20). Biomechanical factors associated after assisted sprint training indicate similarities with free sprint training because of the possible change in neural activity prior to contact in order to compensate for greater contact forces during breaking (20). This study's result did correlate with previously mentioned research that acute resisted sprint training methods have similar mechanics, including an increase in stride length, during the acceleration phase of a sprint.

Upton, 2011, compared the effects of assisted and resisted sprint training on acceleration and velocity in Division IA female soccer athletes. The subjects completed 40-yard sprints using an elastic-cord resisted device. The training methods intervention was a 12-session, 4 week training program using RST and AST as compared to a traditional sprint training program at split times of 5 yards, 15 yards, and 40 yards (36.6 m). Studies have implemented interventions for six and eight weeks (16, 47), but due to the time constraint of pre-match training period associated with Division IA soccer, the four week training program was used (43). According to the results of the study, it was concluded that resisted sprint training protocols can decrease sprint time within the maximal velocity phase, or distances in a sprint greater than 15 yards, whereas assisted sprint training protocols can improve maximal velocity in shorter distances, anywhere from standing to five yards and less than 15 yards. This indicated that training modalities impact maximal velocity differentially as the result of their effect on acceleration over the total distance covered. Studies have show differences, where resisted sprint training will increase sprint time during the initial acceleration phase (16, 18, 20, 38, 45). More importantly, only subjects in the assisted sprint training group using an elastic-band towing device creating a mean initial assistive force equal to 14.7% of the subjects' body mass, increased their 5 yard and 15 yard acceleration (41). The resisted towing method with the elastic cord also showed an increase in stride length.

Based on the literature reviewed, it is essential to understand that sprint training methods vary on their effects on sprint speed, not only for total time, but when comparing the acceleration phase and maximal velocity phase. Kinematics that composes running velocity, including stride length and stride frequency, can be altered depending on the training method and load. There are many acute and long-term interventions creating an increase in sprint speed; however it is still yet quantifiable as to whether assisted or resisted sprint training will help increase speed for different distances when comparing male and female soccer players. There are few studies comparing the two to free sprint training, especially using elastic cord or bungee cords (Overspeed Trainer). Because different results have been shown for both methods, it is important determine sport-specific demands of an athlete prior to implementing a speed enhancement training program. Therefore, having a better understanding of the role of sprint physiology on the outcomes of sprint training interventions will help coaches, athletic trainers, and strength and conditioning specialists improve sprint speed and technique for their athletes, especially field-sport athletes, including soccer.

CHAPTER III

METHODS

The purpose of this study was to determine the effects of various methods of sprint training techniques on soccer players' sprint time. Research has explored various methods, including sled towing, resisted parachute, and elastic cord speed training protocols, and its effect on the acceleration phase of a sprint cycle. Field athletes are required to use short bursts of energy in game situations with quicker reaction times. Intermittent bouts of high energy require an increase in power output. A gap does lie between speed training as far as what techniques more effectively correct or enhance sprint kinematics, as well as which technique is sport specifically beneficial. Various sports differ in the physiological demands of an athlete during competition, and little research has been conducted to look into a soccer player's enhancement in force production in order to perform sport specific movements that involve rapid acceleration against resistance. Research has failed to determine whether resisted or assisted sprint training affects measurements within the acceleration phase (0 to 18.3 meter (m)) or maximal velocity phase (18.3 m to 36.6 m).

Research Design

A randomized, controlled experimental design of all subjects will be utilized to evaluate the relationship between three, 6-week sprint training protocols on sprint times measurements of a 36.6 m (40 yard) sprint.

Subjects

This study was administered at a NCAA Division III university with men and women's soccer teams. Subjects (n=37) were between the ages of 18 and 23, depending on their class or athletic year. Any athlete that met the previously stated delimitations were not included in the study. All subjects were current active team members. This did not include practicing medical and academic redshirt players. Any athlete that sustained an injury throughout the study was dropped from the data collection. Goalkeepers were exempt for experimental testing because of different physiological demands placed upon them as compared to field players. Subjects did not have to have background knowledge of speed, power, and muscular endurance training methods because they will be instructed with proper directions according to the program they are randomly assigned to. Each subject had to be in excellent cardiovascular condition and capable of completing a speed-training program of high intensity, which was based off of the medical questionnaire. Because these subjects were members of an accredited collegiate athletic team, each subject had to receive medical approval through the school's healthcare facility and medical staff prior to any testing or speed training. If any of these subjects did not meet any of the above listed inclusion requirements, they were dropped from the study and resulting data. Details of this study were submitted to each institution's Institutional Review Board (IRB) (Appendix C) for consent and approval of the implementation of this study.

Recruitment of subjects were done upon questioning of both men and women's head soccer coaches for full active team participation during the controlled, off-season, conditioning environment that lasts until the school's academic week for spring break. Both coaches were thoroughly be explained to about speed training research, the various speed training programs being physically implemented, testing procedures, dates of testing, inclusion and exclusion factors, as well as, as the study being solitary voluntary with approval through the coaches and the medical staff. Two consent procedures were administered (Appendix D). The method of consent documentation was on hard copy, printer paper. All subjects on both the men and women's soccer team fully understood the consent forms. The nature of the information to be provided for the prospective subjects will be similarly displayed for both consent forms. Subjects were instructed that they were free to withdraw their consent to participate in this study at any time without prejudice and they would be given the opportunity to ask questions about the research. The location and length of time that the survey data and video recordings will be kept on a confidential USB drive, only available to the researcher themselves, at the Keiffer Kinesiology Lab on Texas Lutheran University's (TLU) campus in Seguin, Texas.

Tests and Instruments

36.6 m Sprint

A 36.6 m sprint was used in this study to test for sprint time and stride length measurements. The 36.6 m sprint with split times at 9.1 m and 18.3 m is implemented within the NFL test battery during its annual combine (36). The 9.1 and 18.3 m split times are measurements of acceleration (36). Split times at 9.1 and 18.3 m were measured as well, because although the 36.6 m sprint is a measure of maximum speed, it is affected by acceleration (36).

Stroops Double-Time™ Overspeed Trainer

The Stroops Double-Time™ Overspeed Trainer (Power Systems, Knoxville, TN) elastic band towing device can be purchased from various fitness training and conditioning companies. It is partner training and was used for the RST and AST sessions to provide resistance or assistance.

Test Center (TC) Timing System

The Test Center (TC) Timing System (Brower Timing Systems, Draper, UT) was used to determine the 36.6 m sprint time, as well as record split time measurements at 9.1 and 18.3 m.

Electronic Timing Lights/Gates

Electronic timing lights/gates (Brower Timing Systems, Draper, Utah) were set up at four points within the 36.6 m sprint; starting line, 9.1 m, 18.3 m, and 36.6 m. Timed lighting was more appropriate to use in order to measure split times throughout each phase of the sprint.

Dartfish ProSuite 7

Dartfish ProSuite 7 (Dartfish, Alpharetta, GA) is one of the latest versions of an effective and complete video analysis software package, which includes necessary functionality to analyze technical performance during and after training. Dartfish ProSuite 7 provided the measurements for stride length and stride frequency at all three split times. Neon tape was used to help video analyze stride length and stride frequency.

Neon tape was placed on the toe and heel of both subjects' athletic shoes. Video was analyzed on a compatible computer with the Dartfish digital analyzing software. A meter stick was used to help analyze and convert distances into meters displayed on video feedback from Dartfish. All digitizing using the Dartfish was performed by the same operator to maximize the consistency of the dependent variables.

Training

A six-week training protocol (Appendix F) consisting of resisted speed training (RST), assisted speed training (AST), and free sprint training (FST), was randomized among all prospective subjects into three equal groups. Subjects performed baseline 36.6 m sprints, participated in the six-week protocol, and then perform post-test 36.6 m sprints. Each athlete (n = 37) was randomly and evenly divided into three groups (RST, AST, FST) based off of the fastest times. The FST, or control group, involved athletes performing FST without an external device or any type of resistance. The testing lasted over a 6-week, post-season, spring training period, where each athlete in each group participated in two, approximately 20-30-minute training sessions per week. Before the intervention period, subjects were given verbal instructions and orientation sessions to practice with their assigned method of speed training protocol. Distances were marked with orange cones in order for the subjects to know how far they were performing their maximal sprint. The distance progression was based off of training both phases of sprinting. Each subject in the FST group was instructed to sprint with maximal power (95-100%) to the indicated distance. Once the subject reached the end cone, they immediately decelerated into a jog, walk, and then complete stop. Subjects in the RST group were attached to his or her partner by the Stroops Double-Time™ Overspeed Trainer. The subject training in the RST group was out in front. The lead subject walked out in front to the point of maximal tension. From that point, each distance were measured and marked with a cone. The subject then was instructed to sprint with maximal power (95-100%), while the following subject resisted the sprint. Once the lead subject reached the end cone, they decelerated to a stop, while the following subject accelerates to release the tension. Each subject in the AST group was attached to his or her partner by the Stroops Double-Time™ Overspeed Trainer. The subject training in the AST was behind their partner. The lead partner started running forward away from the following athlete, while he or she waited for the point of maximal tension. Once he or she felt the tension of the harness pulling them forward, the athlete would bungee out and sprint for the marked distance. FST went through the same program, completing the same volume of distances covered per week. All training programs were conducted outside on a natural grass soccer field. The sessions throughout the week increased in intensity and length in order to reach the maximal length of 36.6 m. Subjects performed their sprints out to 60 m by the end of week six. Subjects partnered up with the same subject for every session to decrease any variability. Pre- and post-tests measurements were performed prior to and after the administered 6-week training program, respectively. Equipment was set up and used to calculate sprint time, stride length, and stride frequency.

Design and Analysis

The test-retest reliability of the pre- and post-test measures shown in Table 2 (Appendix E) was determined by the Chronbach Alpha coefficient over three trials. A two-way repeated measures ANOVA was used to determine the differences in the type of training (groups) across the pre- to post-test trials. The dependent variables were the measures of time and stride length at each interval: 9.1m, 18.3m, and 36.6m, as well as the split time at 18.3m and overall time at 36.6m. The two independent variables were: 1) the type of training (groups), either control, assisted training, or resisted training; and 2) the pre- and post-test trials. Type of training (groups) is a between-subjects variable, while the pre- and post- test trials are within-subjects (repeated) variables.

Scheffe post-hoc tests were used to determine any differences among types of training (groups), for either main effects or interactions with the trials. Partial eta^2 was used to determine effect size for each statistical test. All statistical significance was defined as $p < 0.05$.

CHAPTER IV

MANUSCRIPT

Key Words. kinematics, sprint training, acceleration, maximal velocity, speed

In the game of soccer, athletes must acquire the ability to cover short distances quickly. Sprint training is important for coaches, and athletes, but the exact method to improve maximal running speed and acceleration is still undefined. It is important to understand and determine the extent to which maximal velocity and acceleration are distinct attributes in soccer players (21). The bouts of high-intensity and very-high intensity running occur about every 90 seconds, last approximately two to four seconds, and are most often associated with critical match-related skills, such as separating from or closing on an opponent (43). In recent years, the production of various speed-enhancement devices has increased (11). Sleds, parachutes, and the use of elastic-cords or bungee cords are examples of external devices used for speed training. There is controversy as to which specific external device and what type of technique, such as resisted or over speed training, improves acceleration within acceleration or maximal velocity sprint phases. The effect of these speed training tool ordinances on sprint time and the movement kinematics of speed, including stride length and stride frequency, have yet been acceptably quantified (22).

The ability of soccer players to produce varied high-speed actions may impact soccer match performance and can be categorized into actions requiring maximal speed, acceleration, or agility (21). Sprint time is vital in the game of soccer in terms of winning or losing the ball to the opposing team, or even scoring a goal. Sprinting speed is composed of stride frequency multiplied by stride length, as well as the capability to reach a high velocity (29). Stride length and stride frequency, mechanically determine running speed or sprint time (11). Attempts to improve speed must induce neuromuscular adaptations that increase either stride length or stride frequency without significantly detrimenting the other (26). One must train by applying greater force in the following ways: in less time, proper direction, and through the proper range of motion.

Differential effects of sprint kinematics and times mirror the multidimensional nature of sprinting. Sprint training comprises different phases, including initial acceleration, attainment of maximal velocity, and maintenance of maximal velocity, each with specific mechanical demands (45). The National Football League (NFL) Combine's evaluation of the physical test battery uses a 36.6 m sprint with split times at 9.1 and 18.3 m. The 36.6 m sprint test is strongly associated with acceleration due to the differences in 9.1 m and 18.3 m sprint times are measures of acceleration (35). Soccer players require different speeds for different positions and agility for certain demands of a specific play in a game situation. For these sports, acceleration and maximum speed are relatively independent qualities (1).

If soccer players can increase their stride length during the acceleration phase, they can cover more distance in a shorter amount of time, thus increasing their running velocity. An increase in utilization of elastic energy during the support stage of the sprint cycle follows an increase in stride length (40). Athletes must apply force through full or optimal range of motion, the athlete must apply the necessary force in as small amount of time as possible to obtain maximal velocity output. One mechanism by which faster sprinters achieve a higher running velocity is by exerting a larger force on the ground, thus producing a longer stride length (1). The goal for any athlete to increase sprint time by training for proper stride length and form is to understand the proper relationship between ground and air distance for ones center of gravity. When sprinting, athletes employ horizontal forces on the ground in order to accelerate the body forward while, at the same time, overcoming air resistance with a longer ground contact time and unchanged flight time is a reduced stride frequency (1).

Stride frequency can become detrimental if decreased after being trained with resisted speed training. The percentage of body mass being pulled can provide a greater force production and decreased ground contact time, producing an increase in stride frequency and velocity (37, 40). To increase stride frequency at maximal running, sprinters must shorten the contact time by extending the knee joint less at the end of the contact phase (37). In addition, velocity of the recovery leg during the flight phase must be increased by generating greater mechanical power from the hip extensors and knee flexors (7, 8 42). In order to properly enhance force development in sprinting for both male and female soccer players, training movements that involve rapid acceleration against resistance should be implemented, and this acceleration should extend throughout the movement with no intention to decelerate at the end of the movement (3).

Sprint resistance training is a sports-specific method of training to enhance the force production of the muscles by adding an external load to the body or performing hill or slope training (30). The research on sprint training concluded that weight training, plyometric, and sprint resistance were all implicated in the improvement of stride length, but not an increase in stride rate (13). There are few studies in the literature concerning the comparisons of resisted and assisted speed training protocols, and none that look into affected kinematic variables for both male and female collegiate soccer athletes. Sprint-resisted and –assisted methods have been used with the aim of improving maximal sprint running performance by changing step length and step rate respectively (29). Variations of these two methods can be used with elastic cord speed training. Manufacturers have developed the Speed Harness™ (Power Systems, Knoxville, TN) in order to provide a steady and sturdy resistance or assistance in the execution of the sprint. The use of elastic towing devices could potentially create either a resisted or assisted speed-training environment for athletes. It can also be stated that both RST and AST impact maximal velocity differentially as the result of their effect on the rate of change in velocity, or acceleration, over the total distance covered (42). Evidence does suggest that subjects in the assisted sprint training group increased their acceleration in response to their assigned protocol during the initial 13.7 m of a 36.6 m sprint, whereas subjects in the RST group responded to their assigned protocol with an increase in acceleration during the final 22.9 m of the 36.6 m sprint suggesting enhance speed endurance (42). Research varies as type of training creates an affect on sprint kinematics within a specific distance. It is not established which specific external device and what type of methods, such as resisted or assisted speed training, would improve acceleration and overall maximal power output due to little research.

The purpose of this study was to compare and assess three speed training techniques and their effects on sprint time in NCAA Division III collegiate soccer players in a 36.6 m run. The study would determine if differences exist between AST, RST, and

FST in enhancing sprint time. The measurements of stride length and stride frequency would also be assessed as important kinematic variables affecting sprint time.

Methods

Experimental Design to the Approach

Subjects were randomly assigned to each training group based on the fastest pre-test overall 36.6 m sprint times. The independent variables were the three running conditions: AST, RST, FST. The dependent variables were the split times (0–9.1 m, 0–18.3 m, and 0–36.6 m), interval times (0–9.1 m, 9.1–18.3 m, and 18.3–36.6 m), stride length, stride frequency, and interval steps. Steps were measured from toe-off of the right foot to the next consecutive toe-off of the right foot. After completing a 6-week, 12-sessions program with their assigned sprint training group, it was hypothesized that sprint times from AST would significantly increase overall sprint time (36.6 m) and significantly increase the maximal velocity phase sprint time. Theory holds that RST would significantly increase the acceleration phase sprint time based on improvement of other kinematic variables assessed.

Subjects

This study was administered at a NCAA Division III university with men and women's soccer teams ($n = 37$) in the southwest United States. Their mean ±SD age, body weight, and height were male and female, respectively, 19.11±1.05 years, 67.85±8.61 kg, and 171.76±8.74 km. Participants were experienced competitors and voluntarily underwent all testing procedures, which were conducted within the context of their normal performance evaluation. Any athlete that sustained an injury throughout the study was dropped from the data collection. Goalkeepers were exempt from experimental testing. Subjects did not have background knowledge of speed, power, and muscular endurance training methods, but were instructed with proper directions according to the program they are randomly assigned to. Each subject was in excellent cardiovascular condition and capable of completing a speed-training program of high intensity, which was based from physical examination (Appendix B TLU PPE). Institutional Review Board (IRB) approval was given from each institution for this study.

Team coaches were briefed on available speed training research, the various speed training programs being physically implemented, testing procedures, dates of testing, inclusion and exclusion factors, as well as, as the study was voluntary with approval. Two consent procedures were administered (Appendix D). Subjects were instructed that they were free to withdraw their consent at any time without prejudice and they were given the opportunity to ask questions about the research. All subjects remained healthy, obtained no injuries and participated in each scheduled conditioning session throughout the six-week program.

Procedures

A six-week training protocol (Appendix E) consisting of assisted sprint training AST, RST and FST, was randomized among all prospective subjects into three equal groups (Appendix E). Subjects performed baseline 36.6 m sprints, participated in the 6-week protocol, and then performed post-test 36.6 m sprints. Each athlete (n = 37) was randomly and evenly divided into three groups (RST, AST, FST) based off of the fastest times from pre-testing (36.6 m). FST involved subjects performing sprinting without an external device or any type of resistance.

The program lasted over a 6-week, post-season, spring training period, where each subject in each group participated in two, approximately 20 to 30-minute training sessions per week. Before the intervention period, subjects were given verbal instructions and orientation sessions to practice with their assigned method of speed training protocol. Distances were marked with orange cones in order for the subjects to know how far they were performing their maximal sprint. The distance progression was based off of training both phases of sprinting.

Each subject visited the testing facility once before (pre) and once after the intervention (post), at the same time of day, for a series of measurements. Each subject in the FST group was instructed to sprint with maximal power (95-100%) on a natural grass soccer field to the indicated distance. Once the subject reached the end cone, they immediately decelerated into a jog, walk, and then complete stop. Subjects in the RST group were attached to his or her partner by the Stroops Double-Time™ Overspeed Trainer. The subject training in the RST group was out in front. The lead subject was told to walk out in front to the point of maximal tension. From that point, each distance was measured and marked with a cone. The subject was instructed to sprint with maximal power while the following subject resisted the sprint. Once the lead subject reached the end cone, they decelerated to a stop, while the following subject accelerated to release the tension. Each subject in the AST group was attached to his or her partner by the Stroops Double-Time™ Overspeed Trainer. The lead partner started running forward away from the following athlete, while he or she waited for the point of maximal tension. Once he or she felt the tension of the harness pulling them forward, the athlete would bungee out and sprint for the marked distance. The FST subjects went through the same program, completing the same volume of distances covered per week.

Before each session, a 15-minute warm up period consisted of jogging, static stretching, dynamic stretching, and submaximal sprinting were administered. The sessions throughout the week increased in intensity and length in order to reach the maximal length of 36.6 m. Subjects remained with the same partners throughout the entire program. Pre- and post-tests measurements were performed prior to and after the administered six week training program, respectively. Equipment from Texas State University Health and Human Performance Department and Keiffer Kinesiology Lab at Texas Lutheran University (TLU) were used to calculate sprint time, stride length, and stride frequency.

Kinematic Analysis

A 36.6 m sprint was used in this study to test for sprint time and stride length measurements. The Stroops Double-Time^{TM} Overspeed Trainer (Power Systems, Knoxville, TN) elastic band towing device can be purchased from various fitness training and conditioning companies. The Stroops Double-Time^{TM} Overspeed Trainer is partner training and was used for the RST and AST sessions to provide resistance or assistance. The Test Center (TC) Timing System (Brower Timing Systems, Draper, UT) was used to determine the 36.6 m sprint time, as well as record split time measurements at 9.1 m and 18.3 m. Electronic timing lights/gates were set up at four points within the 36.6 m sprint;

starting line, 9.1 m, 18.3 m, and 36.6 m. Timed lighting was more appropriate to use in order to measure split times throughout each phase of the sprint. Dartfish ProSuite 7 (Dartfish, Alpharetta, GA) is one of the latest versions of an effective and complete video analysis software package, which includes necessary functionality to analyze technical performance during and after training. Dartfish provided the measurements for stride length and stride frequency at all three split times. Neon tape was used to help video analyze stride length and stride frequency. Neon tape was placed on the toe and heel of both subjects' athletic shoes. Video was analyzed on a compatible computer with the Dartfish digital analyzing software. A meter stick was used to help analyze and convert distances into meters using the Dartfish was performed by the same operator to maximize the consistency of the dependent variables.

Statistical Analysis

The level of significance was set at p=0.05. Pearson's correlations were performed with SPSS statistical software (V 19; IBM, Armonk, NY, USA). Effect sizes (d) of individual parameters were calculated as the absolute value of changes to the group mean divided by the pretest between-subject SD. The test-retest reliability of the pre- and post-test measures was determined by the Chronbach Alpha coefficient over three trials. Table 1 (Appendix F) reports the reliability for both the pre- and post-test trials for each dependent variable. The coefficient of 0.52 is low; however, the post-test reliability for the 9.1m times was 0.94, very high. The reliability of the step measures and stride frequency measures for each of the three intervals ranged from moderate to low; consequently, there appeared to be too much random variability in these variables to be appropriate for analysis. Based on the test-retest reliability of the pre- and post-test measures, the five measures of time and three measures of stride length were determined to be appropriate for analysis, but not the three measures of steps or stride frequency at each interval.

A two-way repeated measures ANOVA was used to determine the differences in the type of training (groups) across the pre- to post-test trials. The dependent variables were the measures of time and stride length at each interval: 9.1m, 18.3m, and 36.6m, as well as the split time at 18.3m and overall time at 36.6m. The two independent variables were: 1) the type of training (groups), either control, assisted training, or resisted training; and 2) the pre- and post-test trials. Type of training (groups) is a between-subjects variable, while the pre- and post- test trials are within-subjects (repeated) variables. Scheffe post-hoc tests were used to determine any differences among types of training (groups) and partial eta^2 was used to determine effect size for each statistical test. All statistical significance was defined as $p < 0.05$.

Results

Descriptive values from pre-test to post-test for time and stride length are shown in Appendix G (Tables 3-6). Repeated measures ANOVA indicated a significant improvement in times and stride lengths from the pre-test to post-test, but no differences in improvement among the training groups. For the 9.1m split times, taken from the start to the 9.1m mark, a significant main effect for trials was observed, $F(1, 34) = 34.0$, $p < 0.0001$, partial eta^2 = 0.500, a very large effect. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 2.0$, $p = 0.147$, partial eta^2 = 0.107, a moderate effect. For the subjects' times to the 9.1m mark, there was improvement from an average of 1.79±0.17 seconds for the pre-test, to an average of 1.67±0.10 seconds for the post-test, but no significant differences in improvement among the training groups (Figure 1).

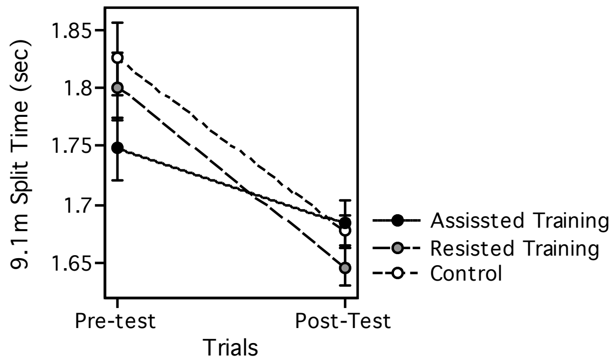

FIGURE 1

Improvement in 9.1 m Split Times

For the second interval times, taken from the 9.1m mark to the 18.3m mark, another significant moderately large effect for trials was observed, $F(1, 34) = 4.2$, $p = 0.049$, partial $eta^2 = 0.108$. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 0.2$, $p = 0.1837$, partial $eta^2 = 0.010$, a small effect. For the subjects' times for the second interval, there was improvement from an average of 1.33±0.16 seconds for the pre-test, to an average of 1.28±0.17 seconds for the post-test, but no significant differences in improvement among the training groups.

For the second interval stride lengths, taken from the 9.1m mark to the 18.3m mark, another significant main effect for trials was observed, $F(1, 34) = 40.8$, $p < .0001$, partial $eta^2 = 0.546$, a very large effect. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 0.2$, $p = 0.812$, partial $eta^2 = 0.012$, a small effect. For the subjects' stride lengths during the second interval, there was improvement from an average of 3.92±0.34 m for the pre-test, to an average of 4.17±0.29 m for the post-test, but no significant differences in improvement among the training groups.

For the 18.3m split times, taken from the start to the 18.3m mark, another significant main effect for trials was observed, $F(1, 34) = 29.4$, $p < 0.0001$, partial $eta^2 = 0.464$, a very large effect. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 1.5$, $p = 0.238$, partial $eta^2 = 0.081$, a moderate effect. For the subjects' 18.3m split times, there was improvement from an average of 3.12±0.30 seconds for the pre-test, to an average of 2.96±0.26 seconds for the post-test, but no significant differences in improvement among the training groups (Figure 2).

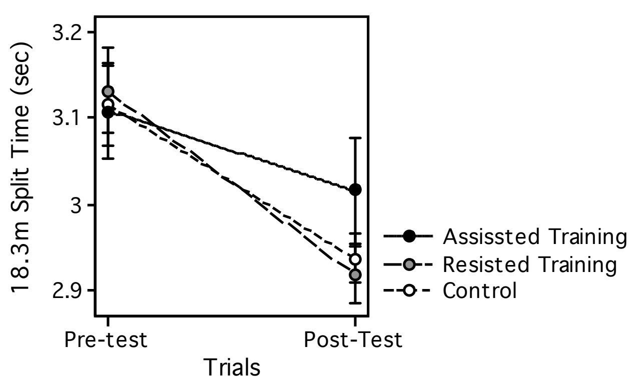

FIGURE 2

Improvement in 18.3 m Split Times

For the third interval times, taken from the 18.3m mark to the 36.6m mark, a very large effect for trials was observed, $F(1, 34) = 47.9$, $p < 0.0001$, partial $eta^2 = 0.585$. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 0.4$, p = 0.666, partial eta^2 = 0.024, a small effect. For the subjects' times for the third interval, there was improvement from an average of 2.52±0.31 seconds for the pre-test, to an average of 2.32±0.26 seconds for the post-test, but no significant differences in improvement among the training groups.

For the third interval stride lengths, taken from the 18.3m mark to the 36.6m mark, a very large main effect for trials was observed, $F(1, 34) = 81.9$, $p < 0.0001$, partial eta^2 = 0.707. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 0.2$, $p = 0.841$, partial eta^2 = 0.010, a small effect. For the subjects' stride lengths during the third interval, there was improvement from an average of 4.16±0.43 m for the pre-test, to an average of 4.62±0.43 m for the post-test, but no significant differences in improvement among the training groups.

Lastly, for the overall 36.6m times, taken from the start to the 36.6m mark, another large main effect for trials was observed, $F(1, 34) = 100.3$, $p < 0.0001$, partial eta^2 = 0.747. The interaction between type of training (groups) and trials was not significant, $F(2, 34) = 0.1$, $p = 0.903$, partial eta^2 = 0.006, a very small effect. For the subjects' 36.6m times, there was improvement from an average of 5.60±0.55 seconds for the pre-test, to an average of 5.27±0.48 seconds for the post-test, but no significant differences in improvement among the training groups (Figure 3).

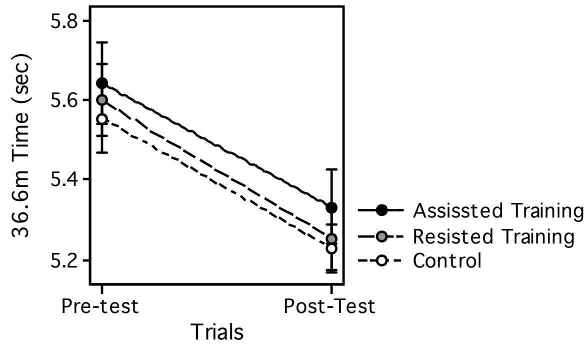

FIGURE 3

Improvement in 36.6 m Times

Discussion

Resistive speed training and AST programs incorporating the bungees decreased overall sprint time in a 36.6 m run, but was not significant as compared to subjects who completed the free sprint training (FST) program. Consistent with previous investigation (8) differences for sprint times were statistically significant in decreasing times, however, the comparison of these three methods offered no ergogenic effect when compared to the free sprint-training group. Both resisted and free sprint training programs have shown to eliciting significant sprint performance improvements in elite athletes (8).

Resisted elastic cord sprint training group did not significantly increase speed above results from the other training groups. After looking at the effects of resisted sprint training on speed and strength performance in male rugby players (16), results indicated no improvement between pre- and post- test results, indicating no training effect during the supramaximal phase of a sprint (0 - 30 m). The lack of significance in this study between the control, RST, and FST decreases in sprint times during the initial 9.1 m for all groups was observed. An 8-week RST training program significantly improved acceleration and leg power performance but was not more effective than a 9-week nonresistance sprint-training program, which was similar to the results in this study (42). Assisted sprint training potentially enables athletes to run faster than their maximal speed through assisted overspeed training, or assisted sprint training. This technique was used in this investigation in order to improve speed throughout the maximal phase of a 36.6 m sprint, as well as decrease overall sprint time.

The results of this study are consistent with those of another two-fold study (45) that determined if a 4-week AST or RST was superior to a free sprint elastic-cord training program by improving 40 yard (yd) sprint times, increasing acceleration and maximal velocity at the 5 yd and 10 yd split times. Subjects participating in the AST session protocol decreased sprint times in the 5 yd and 15 yd, and subjects participating in the RST session protocol decreased sprint times post 15 yds. The results of that study (45) suggest that, athletes who require greater acceleration should participate in AST programs and athletes who require greater maximal velocity should participate in RST programs. Previous research (1,4) suggested that RST programs would help increase stride length within the first few steps up a sprint enabling an athlete to decrease their initial sprint time in the acceleration phase. Assisted sprint training has been found to improve stride frequency once approaching or within the maximal velocity phase, enabling an athlete to decrease their sprint time (3, 44). Future studies need to be conducted on determining which program decreases time within a specific phase of the sprint.

The free sprint training program's results in this study were consistent with similar results for sprint time and stride length in previous research. Free sprint training has been shown to improve strength gains, horizontal power, and encourages high movement speeds and ballistic activities related to rapid stretch-shortening cycle actions (22). The effects of supramaximal velocity on biomechanical variables in male elite sprinters found that velocity increased by 8.5%, stride rate by 1.7%, and stride length by 6.8% over that of the normal maximal running (25). This data suggests and relates to the theory stride length and stride frequency are the most important kinematic variables (8, 9, 12, 15, 16, 24, 25, 32, 42).

It can be suggested that improvements in running speed could be explained from stride length, but not stride frequency (3, 44). Unchanged stride frequency may be associated with ground contact time and braking forces when the stride length is too great. Ground contact time and breaking forces could be assessed the during the eccentric stride phase at supramaximal velocity and correlated with relatively possible increases in stride rate (3, 33). With the use of the elastic-cord and bungees ideally set at 105-110% of maximal speed, it may be difficult to produce such an effect, especially with a medium resistance Overspeed Trainer that stretches to 60 feet, losing slack and elastic tension around 15 yards into a sprint (3).

In this investigation, the average stride length increased between pre- and post-tests, suggesting that training with an elastic cord can be used as an additive training modality. However, the reliability was very low for the measurements of stride frequency and number of steps taken between each interval indicates poor reliability of video analysis with the inability to create an accurate group response to stride frequency. The elastic-cord towing device can exaggerate stride and increase stride length. After 9 sprinters trained with AST and RST programs and completed 20 m sprints, acute changes were noted with an exaggeration of the stride length within the initial acceleration phase over 15 m (11). More research may be needed to examine long-term versus acute affects. A program consisting of an entire season, or more than 6-weeks, in a laboratory controlled study, may be optimal in finding any long-term changes for both sprint times and other kinematic variables.

It's important to assess possible differences in sprint times between each interval, along with stride length and frequency, in order to determine proper training techniques to improve the acceleration phase and maximal velocity phase. However, the current investigation found no significant difference between groups for each time interval and stride length. Sprint training programs comprising a combination of training modalities (plyometric, flexibility, weight training, and sprint training) have been shown to increase running velocity by 7-8%, compared to 4-5%for sprint training alone (42).

PRACTICAL APPLICATIONS

The study demonstrated that both AST and RST produce training adaptations in both male and female collegiate soccer players, but not compared to FST for overall split times and interval times recorded for a 36.6 m sprint (0-9.1 m, 9.1-18.3 m, 0-36.6 m). Statistical analysis indicated no significance between group improvements for of stride length, but did show improvement for all groups. The theory of novelty still lies behind different forms of sprint training and all methods may just be an additive training mode. The improvements in sprint time were not an effect of the training group, as well as the effects of stride length increases between pre- and post-test results for each group. A main goal of this investigation was to compare acceleration and maximal velocity adaptations between each training group. Investigation of sprint mechanics beyond that of the acceleration phase may be warranted, thus limiting reliable and statistically significant data, as is quantification of the effects of speed adaptations with training protocols with various durations and volumes (27). This study only looked at sprint speed, stride length, and stride frequency. Sprint speed development is based on so many factors that it can be highly difficult to pinpoint where and how training throughout different stages of a sprint optimizes improved performance (40). It is important for coaches to know sport-specific demands, and sport-specific kinematic factors that may impact neuromuscular adaptations of sprinting.

CHAPTER V

DISCUSSION

The purpose of this study was to compare and assess three various speed training methods and their effects on sprint time with NCAA Division III collegiate soccer players after performing a 36.6 meter run**.** The main finding based on results indicated that the use of either resisted (RST) or assisted sprint training (AST) programs incorporating the bungees did decrease overall sprint time in a 36.6 m run, but was not significant as compared to subjects who completed the free sprint training (FST) program.

This investigation has enhanced what is already known about sprint training and has had an impact on the future research of the use of elastic cord sprint training methods. This investigation allowed the advancement of the literature of RST and AST using elastic cords with collegiate athletes over an extended period of time. By incorporating a 6-week training program comparing multiple training methods, this investigation has also furthered any previous knowledge about the investigations after a single training method using elastic cords.

Significant increases in sprint time and stride length were identified for all training methods after 6-weeks and 2 sessions per week with 48 hours of rest between each session. No significant differences were noted between training methods. It was determined if further sessions or added weeks for each training session would have led to a continued increase in sprint time, stride length, and stride frequency, or if differences among training groups would have occurred. Changes in the implemented training prescription may have led to continued increases in sprint times because of kinematic adaptations because of previous evidence and the results of this investigation.

For future investigations, it was determined to create a pilot study to test the reliability of the instruments used prior to a full investigation. Performing a pilot study prior to the investigation will allow future researchers to compare results all kinematic variables determine among the three training methods. According to previous research, this would have an effect on the outcome of significant improvements for sprint times based on comparisons of pre- and post-test results for the kinematics variables initially wanting to be examined.

A recommendation for an area of future research should be based on the effective load of a bungee. In this study, for unexplained reasons, the tension of the load of the Overspeed Trainer was unable to be identified. It was only stated that the maximal tension of the cord was reach at 66 feet. Upton, 2011 (43) previously looked at the effect of a 6-week assisted or resisted sprint training program on accerlation and velocity in division IA female soccer athletes. A similar elastic-cord/bungee device was used; Speed HarnessTM (Power Systems, Knoxville, TN). Subjects in AST were instructed to stretch their cord out to 20 yds (18.3 m), creating a mean initial assistive force equal to 14.7 ± 1.6% of body mass. As the subject reached 20 yds prior to deceleration, the assistive force provided by the Speed Harness™ was reduced to an assistive force of 7.4 ± 0.8%. The Trainer (Perform Better) another form a bungee, produced the resisted force for the RST group. Being able to provide a calibration, the resistance was set at 12.6% body mass, producing a sprint speed of 90% of maximal sprint speed (45). Only the AST creating a mean initial assistive force of 14.7% of body mass increased the 5 yd and 15 yd acceleration. As previously stated, RST resisted forces with bungees should be 105-110% of maximal sprint speed in order to create any effect. Even though previous research has stated the importance that in order to improve sprinting speed, towed weight (sleds) should not substantially exceed the 10% body mass rule, (1, 4, 16, 40, 46), future research should look at the exact percentage of maximal speed needed to create velocity and kinematic variable changes.

Weather was a limitation in the study, especially for pre- and post-testing. For pre-testing, it was a clear, no wind or breeze, and moderately sunny day. Due to time constraints overlapping the soccer team's spring break schedule, post-testing was completed on one day of the week, where teams were able to show up because it was during their normal practice time. During testing times, there was a gust of wind that carried with the subjects as they completed their three trials of 36.6 m sprints. Therefore, it should be noted that sprint time improvements could be highly associated with that of assistive forces of the wind.

Power output depends on proper rest between each interval of testing and session of the program. Athletes may have tended to fatigue, especially after 6-weeks of training with the sprint training program, as well as participating in controlled outside team conditioning sessions. Each team's conditioning sessions lasted the same amount of time as the implemented program. Exhaustion may have set in, which was unable to be controlled due to the fact that this study was not administered in a controlled laboratory setting. More studies should adjust the controlled studies, and possibly implement the program with subjects who are more sedentary, such as the general population. It may also be important to assess the factors between male and female neural adaptations, for this was not addressed in the current study.

Statistical analysis indicated that there were no significant difference between group improvements for stride length. Short burst acceleration is important in most field sport athletes. Coaches, strength and conditioning coaches, and athletes are constantly seeking ways to improve initial sprint time. Based on previously stated research, even though there is evidence all three modes of training used in this study can, in some way, induce neuromuscular adaptations, there currently remains confusion as to which method best improves sprint speed. The improvements in sprint time were not an effect of the training group, as well as the effects of stride length increases between pre- and post-test results for each group. A main goal of this study was to compare acceleration and maximal velocity adaptations between each training group. However, according to Myer et al, 2007, investigation of sprint mechanics beyond that of the acceleration phase may be warranted, limiting reliable and statistically significant data, as is quantification of the effects of speed adaptations with training protocols with various durations and volumes. This study only looked at sprint speed, stride length, and stride frequency. Sprint speed development is based on so many factors that it can be highly difficult to pinpoint where and how training throughout different stages of a sprint optimizes improved performance (40).

APPENDIX SECTION

APPENDIX A

Women's Off-Season Controlled Training

	Monday	Tuesday	Wednesday	Thursday
Morning		• 1 mile • Warm up/agility in gym • General stretching • Weights: Bench, squats, incline, abdominals, leg extensions, chin ups, curls, reverse curls, push ups, Bosu ball	• 1 mile • Warm up/agility in gym • General stretching • Jump rope • Bosu ball stretching • Running rope agilities	• 1 mile • Warm up/agility in gym • General stretching • Weights: Bench, squats, incline, abdominals, leg extensions, chin ups, curls, reverse curls, push ups, Bosu ball
Afternoon	• Practice/ scrimmage 4:15 – 6:00 pm		• Practice/ scrimmage 4:15 – 6:00 pm	

Men's Off-Season Controlled Training

Tuesday Weight Room (Phase 1) No Rest Between Exercise A & B No Rest Between Exercise A & B		
1	Back Squat	1x15,1x12,1x10,1x8
2a	Bench Press	1x15,1x12,1x10,1x8
2b	Weighted Step Up (DB)	4x10 each leg
3a	Incline DB Chest Press	1x15,1x12,1x10,1x8
3b	Standing DB Bent Row	1x15,1x12,1x10,1x8
4a	Bulgarian Split Squat w/ Shoulder Press (one side loaded or to failure)	1x15,1x12,1x10,1x8
4b	Chin up	1x15,1x12,1x10,1x8
ABS (Circuit) – 4 Rounds	Russian Twist (weighted) Bicycle Plank	30 50 60 seconds *1 minute rest*
Thursday Weight Room (Phase 1) No Rest Between Exercise A & B No Rest Between Exercise A & B		
1	Dead Lift	1x15,1x12,1x10,1x8
2a	Bench Press	1x15,1x12,1x10,1x8
2b	Weighted Step Up (DB)	4x10 each leg
3a	Incline DB Chest Press	1x15,1x12,1x10,1x8
3b	Standing DB Bent Row	1x15,1x12,1x10,1x8
4a	Bulgarian Split Squat w/ Shoulder Press (one side loaded or to failure)	1x15,1x12,1x10,1x8
4b	Chin up	1x15,1x12,1x10,1x8
ABS (Circuit) – 4 Rounds	Little Bigs (Grass angels) Back extension (weighted) Jack Knife (fee on stability ball)	30 15 15 *1 minute rest*

Tuesday Weight Room (Phase 2) No More Than 2 mins Rest b/t Sets No Rest Between Exercise A & B		
1	Back Squat	1x12,1x8,2x6
2a	Bench Press	1x12,1x8,2x6
2b	DB RDL	4x10 each leg
3a	Pull Up/Lat pull (wide overhand grip)	1x12,1x8,2x6
3b	Plate Overhead Walking Lunge	4x10 each leg
4a	DB Push up w/ Row	4x10
4b	DB Goblet Sumo Squat	4x10
ABS (Circuit) – 4 Rounds	Russian Twist (weighted) Bicycle Plank (alternate high low every 10 seconds)	30 50 60 seconds *1 minute rest*
Thursday Weight Room (Phase 2) No More Than 2 mins Rest b/t Sets No Rest Between Exercise A & B		
1	Dead Lift	1x12,1x8,2x6
2a	DB incline chest press	1x12,1x8,2x6
2b	Scissor Jumps	4x8 each leg
3a	Standing DB Bent Row	1x12,1x8,2x6
3b	DB Lateral Step Up	4x8 each leg
4a	Plyo Push Up (move in circle)	4x10
4b	Broad Jumps	4x8
ABS (Circuit) – 4 Rounds	Mountain Climbers Little Bigs (Grass Angels) Side Plank	50 20 30 secs each side *1 minute rest*

APPENDIX B

TLU Pre-participation Health Questionnaire

STUDENT-ATHLETE ____

HEALTH QUESTIONNAIRE

This form must be completed annually and returned before the student-athlete will be permitted to practice or play. The American Medical Association recommends that all student-athletes have a qualifying medical evaluation upon initial entrance into an institution's intercollegiate athletic program, and an annual "health status" review. TEXAS LUTHERAN UNIVERSITY supports this policy. Further medical evaluations may be required for specific matters. The following questions must have current answers by the student-athlete:

1. Have you been hospitalized or had a major illness since your most recent
   YES NO
   medical evaluation?

2. Have you had a major injury (including surgery) since your most recent
   YES NO
   medical evaluation?

3. Do you currently have any incompletely healed injury?
   YES NO

4. Are you taking any prescription or non-prescription medication on a regular
   YES NO
   or continuing basis? If YES, please list: ____________________________
   ____

5. Are you taking any nutritional supplements or performance enhancing
   YES NO
   supplements at this time? If YES, please list_________________________
   ____

6. Have you ever become ill from exercising in the heat?
   YES NO

7. Have you ever had a head injury or concussion? If YES, how many?_____
   YES NO

8. Have you ever been knocked out, become unconscious, or lost your memory?
   YES NO
   If YES, how many times? _______ When was the last time? ______

9. Have you ever had a seizure? If YES, when was the last time? ____________
YES NO

10. Do you have frequent or severe headaches?
YES NO

11. Have you ever had numbness or tingling in your arms, hands, legs, or feet?
YES NO

12. Have you ever had a stinger, burner, or pinched nerve?
YES NO
If YES, have you been denied sport participation due to this condition?________

13. Have you ever gotten unexpectedly short of breath with exercise?
YES NO

14. Do you cough, wheeze, or have trouble breathing during or after exercise?
YES NO

15. Do you have asthma? YES
NO

16. Have you ever passed out, gotten dizzy, or experienced chest pains during
YES NO
or after exercise?

17. Do you or any members of your family ever have fainting spells or have any
YES NO
other signs of syncope?

18. Have you ever been treated for or diagnosed with sickle cell trait or sickle cell disease? YES NO

19. Has a physician ever denied or restricted your participation in sports for any
YES NO
heart problems?

20. Have you ever been told that you have a heart murmur, irregular heart beat, or
YES NO
other signs of arrhythmia?

21. Has any family member been diagnosed with enlarged heart, hypertrophic
YES NO
cardiomyopathy, long QT syndrome, Marfans syndrome, mitral valve prolapse,

or any congenital cardiac abnormalities?

22. Have you or any family member been diagnosed with coronary artery disease,
YES NO
high blood pressure, or high cholesterol?

23. Have any members of your family ever suddenly died due to health reasons?
YES NO
If YES, please complete the following:

RELATIONSHIP AGE CAUSE OF DEATH

____

____

____

24. Have you ever tested **positive** for Hepatitis, Hepatitis B, HIV, or any other
YES NO
blood borne pathogens?

25. Do you know of, or do you believe there is any reason you should not participate
YES NO
in intercollegiate athletics at this time? If YES, please explain:_____________

____

SHARED RESPONSIBILITY FOR SPORT SAFETY

Participation in sports requires an acceptance of risk of injury. Athletes rightfully assume that those who are responsible for the conduct of sport have taken reasonable precautions to minimize such risk and that their peers participating in the sport will not intentionally inflect injury upon them.

Periodic analyses of injury patterns lead to refinements in the rules and other safety standards, while often necessary, seldom is effective by itself; and, to rely on officials to enforce compliance with the rule book is as insufficient as to rely on warning labels to produce compliance with safety guidelines. "Compliance" means respect on everyone's part for the intent and purpose of a rule or guideline.

The undersigned, herewith,

A. Understands that he or she must refrain from practice or play while ill or injured, whether or not receiving medical treatment, and during medical treatment until he or she is discharged from treatment or is given permission by the Athletic Trainer or Team Physician to restart participation despite continuing treatment.

B. Understands that having passed the physical examination does not necessarily mean that he or she is physically qualified to engage in athletics, but only that the evaluator did not find a medical reason to disqualify him or her at the time of said examination.

C. Certifies that the answers to the questions above are correct and true.

DATE_____________ SIGNED ____

APPENDIX C

Texas State University Interval Review Board Certificate

TEXAS STATE UNIVERSITY
SAN MARCOS
The rising STAR *of Texas*

Institutional Review Board Application

Certificate of Approval

Applicant: Brittany Bobbitt

Application Number : 2013Z1382

Project Title: Sprint Training in NCAA Division III Collegiate Soccer Athletes

Date of Approval: 12/08/13 09:44:21

Expiration Date: 12/08/14

Assistant Vice President for Research and Federal Relations

Chair, Institutional Review Board

Return to IRB Home

Texas Lutheran University Internal Review Board Approval

TEXAS LUTHERAN UNIVERSITY

1000 West Court Street • Seguin, Texas 78155-5999

November 19, 2013

MEMO

TO: Jim Newberry

FROM: Bill Squires

This is to confirm that the human subject protocol submitted by Brittany Bobbitt, "Sprint Training in NCAA Division III Male and Female Collegiate Soccer Athletes" has been approved by the TLU Institutional Review Board. We understand that you are a member of Ms. Bobbitt's Thesis Committee at Texas State University and will be the faculty sponsor for this research study here at Texas Lutheran in the Kieffer Lab

.

Good Luck with your research.

APPENDIX D

Texas State University Consent Form

CONSENT FORM

Comparison of Sprint Training Methods in NCAA Division III Soccer Players And their Effects on Speed

This project 2013Z1382 was approved by the Texas State IRB on December 08, 2013. Pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Jon Lasser (512-245-3413 - lasser@txstate.edu) and to Becky Northcut, Director, Research Integrity & Compliance (512-245-2314 - bnorthcut@txstate.edu).

Introduction

I, ____, have been asked to participate in this research study, which has been explained to me by **Brittany Bobbitt**. I do hereby give my informed consent to my participation in the experiment. This study is being conducted by **Brittany Bobbitt (Texas State University Graduate Assistant) and Texas Lutheran University Research Assistants.** If I have any further questions concerning this research I may contact the following individuals:

a. **Brittany Bobbitt**, TLU Graduate Assistant Athletic Trainer
   703-581-7231, bob.britt@txstate.edu
   Dr. James Newberry, Professor of Kinesiology, Department Chair of Kinesiology and of Education
   830-372-8123, jnewberry@tlu.edu
   Pat Burns, TLU Graduate Assistant for Baseball, Graduate Student in Exercise Science at Health and Human Performance Department, Texas State University
   cpburns51@yahoo.com
   Chris Kansteiner, Student Assistant for TLU Keiffer Kinesiology Lab
b. Texas State University – Health and Human Performance Department
   i. **Dr. Jack Ransone**, Professor of Athletic Training
   ii. **Dr. John Walker**, Professor of Exercise & Sports Science
   iii. **Dr. Kevin McCurdy**, Associate Professor

Purpose

I have been asked to participate in a research study to assess my speed in a 36.6 m (40 yard) dash after a randomly assigned sprint training program, which includes resisted, assisted, and free sprint training. A randomized, controlled experimental design of all subjects will be utilized to evaluate the relationship between the three six-week sprint training protocols on sprint time measurements of a 36.6 m sprint. As an NCAA Division III athlete, the completion of a health questionnaire at the beginning of the year will determine as to whether or not I am medically cleared to participate in this study. I understand that participation in this study is voluntary, but will be incorporated in spring season conditioning sessions. However, I may choose to stop at any time during the testing procedures or training protocol. If a productive speed training protocol can enhance an athlete in force production to perform sport specific movements that involve rapid acceleration against resistance, such information could be useful to incorporate into soccer specific needs for coaches and strength and conditioning specialists.

Procedures
The study population will consist of TLU men and women's NCAA Division III collegiate soccer teams. Active team members who only play field positions may participate in this study. All training programs and testing procedures, which will be explained in detail below, will be conduced outside on natural grass soccer fields and all subjects will be instructed to wear athletic clothing and running/tennis shoes. Testing procedures' measurements will also be analyzed in the Keiffer Kinsiology Lab on TLU's campus. The following are the procedures for the study.

1. **Health questionnaire:** Before participation in the testing and six-week program, the study administrator, who is a nationally certified athletic trainer, state licensed athletic trainer, and CPR/AED and First Aid certified, will make sure each subject has gained medical approval to participate in TLU collegiate athletics by the TLU Athletic Training Staff. This will determine if each subject is in excellent cardiovascular condition and has the physical capability of participating in such a high-intensive, rigorous training program.

2. **Six-week sprint training program:** Subjects will participate in a six-week sprint training program. Two sessions will be held each week to allow 24-48 hours of muscle recovery time between each training session. Subjects will be randomly divided into an assisted, resisted, or free sprinting training program. Subjects in the AST and RST groups will be paired according to height and weight. They will be training with their partner at each session, but there will be a 10-minute break between each partner's individual training session. The six-week program will be a progressive training protocol, consisting of sprinting 20-60 m in total distance, anywhere from 3-4 reps for 3-4 sets, depending on the week.

3. **Warm up**: Prior to each training session, subjects will complete a warm up session. This will consist of a controlled soccer off-season (spring season) conditioning, static stretching for five minutes, and dynamic stretching. Dynamic stretches will consist of two down and back (36.6 m) of lunges, butt kicks, A-skips, high knees, in-and-outs, and a backwards run.

4. **Control:** Subjects randomly assigned to free sprint training will be considered the controlled treatment group. Free sprint training will involve sprinting without the use of an external device.

5. **36.6 m sprint test battery:** A 36.6 m sprint will be used in this study to test for sprint time and stride length measurements. The 36.6 m sprint with split times at 9.1 m and 18.3 m is implemented within the NFL test battery during its annual combine. The 9.1 and 18.3 m split times are measurements of acceleration. Split times at 9.1 and 18.3 m will be measured as well, because although the 36.6 m sprint is a measure of maximum speed, it is affected by acceleration. Taking split times as these specific points of the sprint could provide an analysis of sprint ability, anywhere from reaction time to the actual start of a play. A Brower timing system will be used to determine the 36.6 m sprint time, as well as record the split time measurements at 9.1 and 18.3 m.

6. **Stroops Double-Time™ Overspeed Trainer:** An Overspeed Trainer elastic band towing device can be purchased from various fitness training and conditioning companies. The Overspeed Trainer is partner training and will be used for the RST and AST sessions to provide resistance or assistance.

7. **Dartfish ProSuite 7:** Dartfish ProSuite 7 (Dartfish, Alpharetta, Georgia) is one of the latest versions of an effective and complete video analysis software package which includes necessary functionality to analyze technical performance during and after training. Dartfish ProSuite 7 will provide the measurements for stride length and stride frequency at all three split times.

8. **Testing procedures:** Pre- and post-test measurements of total sprint time, split times, stride length, and stride frequency will be recorded and analyzed for each subject. This will help determine any difference between sprint training methods.

Potential Risks and Discomforts

Potential risks can be associated with any type of training program, including the use of RST and AST. Subjects may be at potential risks of injuries, including muscle strains mainly to the lower body, and delayed onset muscle soreness if not trained properly. Subjects with a slight increase in blood pressure according to their health questionnaire may experience increase in vital signs, such as dyspnea, increase in blood pressure, heart rate, and stroke volume post training. Any type of manufactured equipment has the possibility of breaking, therefore there is a potential risk that The Overspeed Trainer may break or snap off, coil backward or forward and hit the subject.

In order to avoid any previously mentioned risk and discomforts, proper techniques will be administered. A proper warm up will be implemented before each training session, and light stretching will be required after each training session in order to decrease any muscle lactate buildup. The Health Questionnaire provided by the TLU athletic training staff will prevent and drop out any subject who may clinically present with hypertension, cardiac impairments, and cardiovascular disorders. All equipment use will be tested but the researcher or research assistants before the six-week program in order to make sure they are working properly according to the instructions and are intact. If any of the previous potential risks listed above are brought upon any of the subjects, they can be treated at the Athletic Training facility at TLU, provided that all subjects are TLU athletes and have released information pertaining to insurance coverage with the Athletic Training Staff

Possible Benefits

The benefits from this investigation will provide information for the coaches, athletic community, rehabilitation community, and guidance for soccer players. The results of this investigation may help me learn about:

1. Increasing my overall sprint time
2. Increasing my acceleration speed
3. Body movement deficits
4. Proper muscular training to provide a greater load for sprinting

Confidentiality

All data collection during the study's procedures reflects respect for the privacy, feelings, and dignity of subjects. All measurements will be completed and kept private to the researcher, research assistants, and supervising faculty of TX State and Texas Lutheran University. I will not be forced to perform within the study under any circumstances that I do not wish to par-take in. I will be evaluated upon my physical fitness or physical abilities, but solely just by quantitative measurements.

Authorization

The Athletic Training Program for TX State and TLU supports the practice of protection for human subjects participating in this research and any other related activities. The consent form is provided so that I can decide whether I wish to participate in the present study.

____ ______________________

Participant Name Printed (18 yrs or older) Phone #

____ ______________________

Signature Date

____

Principal Investigator Signature

Texas Lutheran University Consent Form

CONSENT and INFORMATION FORM

Comparison of Sprint Training Methods in NCAA Division III Soccer Players And their Effects on Speed

Introduction

I, ____, have been asked to participate in this research study, which has been explained to me by **Brittany Bobbitt**. I do hereby give my informed consent to my participation in the experiment. This study is being conducted by **Brittany Bobbitt (Texas State University Graduate Assistant) and TLU Kinesiology majors Research Assistants.**

Purpose of the Study

It has been explained to me that the purpose of this study is to compare and assess three speed training techniques and their effects on sprint time with NCAA Division III collegiate soccer players in a 36.6 m run. The study will determine if differences exist between AST, RST, FST in enhancing sprint time. The measurements of stride length and stride frequency will also be assessed as important kinematic variables and their effects on sprint time.

Confidentiality

I understand that any information about me obtained as a result of my participation in this research will be kept as confidential as legally possible. In any publications that result from this research, neither my name nor any information from which I might be identified will be published without my consent. The means used to maintain confidentiality are:

1. My data will be given a code number for research identification, and my name will be kept anonymous.
2. Data, along with consent forms, will be kept in a locked file cabinet.
3. Only the principal investigator and/or faculty sponsor will have access to my identification data.

Voluntary Participation

Participation in this study is voluntary. I understand that I am free to withdraw my consent to participate in this study without prejudice. Refusal to participate or withdraw will involve no penalty. I have been given the opportunity to ask questions about the research, and I have received answers concerning areas I did not understand. If I have further questions concerning this research I may contact the following individuals:

Brittany Bobbitt: Principal Investigator (703-581-7231)
Jack Ransone: Thesis Chair (ransone@txstate.edu)
James Newberry: Thesis Committee Member (jnewberry@tlu.edu)

I willingly consent to participate in this research.

_______________________________________ ______________
Signature of Subject Date

______________________________ ____________________________
Phone Number Email

APPENDIX E

Six-week Sprint Training Program and Directions

ATP-CP Anaerobic Speed Work

Intensity	95-100% of maximal
Distance of run	20-60 m (target distance = 36.6 m)
Reps/Set	3-4
Sets	3-4 (5)
Total Distance in Set	80 – 120 m
Total Distance in Session	400 – 600 m
Recovery period for reps	2 minutes
Recovery period for sets	3 minuteds

Warm Up

The same warm-up session will be completed prior to each training session for the 6 weeks. Athletes in the AST and RST groups will be paired according to height and weight. They will train with their partner at each session, but there will be a 10-minute break between each partner's training session.

Soccer post-season/off-season conditioning
Static stretching x 10 min
Dynamic stretching/warm up x 2 down and backs (36.6 m)

1) Lunges
2) Butt kicks
3) A skips
4) High knees
5) High knee in and out
6) Backwards run (jog forward, run back)

Protocol with Speed Harness/Free Sprint Training

Distances will be marked with orange cones so the athlete knows how far he/she will be performing their maximal sprints. The distance progression is based off of training during the phases of sprinting.

Week	Distance(m)	Reps	Reps Distance (m)	Sets	Sets Distance (m)
1	10	3	30	3	90
2	20	3	60	3	180
3	30	3	90	2	180
4	40	3	120	2	240
5	50	3	150	1	150
6	60	3	180	1	180

Free Sprint Training (FST)
Each athlete in the FST group will be instructed to sprint with maximal power (95 – 100%) to the indicated distance. Once the athlete reaches the end cone, they will immediately decelerate into a jog, walk and then complete stop.

Resisted Spring Training (RST)
Each athlete in the RST group will be attached to his or her partner by the Power System Speed Harness. The athlete training in the RST group will be out in front. The lead athlete will walk out in front to the point of maximal tension. From that point, each distance will be measured and marked with a cone. The athlete will then be instructed to sprint as with maximal power (95-100%), while the following athlete leans backs and resists the sprint. Once the lead athlete reaches the end cone, the lead athlete will decelerate to a stop, while the following athlete accelerates to release the tension.

Assisted Sprint Training (AST)
Each athlete in the AST group will be attached to his or her partner by the Power System Speed Harness. The athlete training in the AST will be behind their partner. The lead person will start running forward away from the following athlete, while he or she waits for the point of maximal tension. Once, he or she feels the tension of the harness pulling them forward, the athlete will then sprint for the marked distance.

APPENDIX F

TABLE 1

Test-Retest Reliability for Pre- and Post-tests

	Pre-Test	Post-Test
9.1 m time	0.82	0.87
9.1 m stride length	0.52	0.94
9.1 m steps	0.16	0.11
9.1 m stride frequency	0.32	0.03
9.1 m – 18.3 m interval time	0.74	0.84
9.1 m – 18.3 m interval stride length	0.97	0.93
9.1 m – 18.3 m interval steps	0.63	0.45
9.1 m – 18.3 m interval stride frequency	0.32	0.03
18.3 m time	0.89	0.92
18.3 m – 36.6 m interval time	0.79	0.89
18.3 m – 36.6 m interval stride length	0.93	0.91
18.3 m – 36.6 m interval steps	0.73	0.56
18.3 m – 36.6 m interval stride frequency	0.57	0.76
36.6 m time	0.97	0.97

APPENDIX G

TABLE 3

Descriptive Values from Pre-test to Post-test for All Groups

Variable	Mean	Standard Deviation
9.1 m time pre-test	1.78	0.17
9.1 m time post-test	1.67	0.10
9.1 m stride length pre-test	3.30	0.17
9.1 m stride length post-test	3.57	0.20
9.1 m – 18.3 m interval time pre-test	1.32	0.16
9.1 m – 18.3 m interval time post-test	1.29	0.17
9.1 m – 18.3 m interval SL pre-test	3.92	0.34
9.1 m – 18.3 m interval SL post-test	4.17	0.29
18.3 m time pre-test	3.11	0.29
18.3 m time post-test	2.96	0.26
18.3 m – 36.6 m interval time pre-test	2.52	0.31
18.3 m – 36.6 m interval time post-test	2.32	0.26
18.3 m – 36.6 m interval SL pre-test	4.16	0.43
18.3 m – 36.6 m interval SL post-test	4.62	0.43
36.6 m time pre-test	5.6	0.55
36. 6 m time post-test	5.27	0.47

TABLE 4

Descriptive Values from Pre-test to Post-test for FST (Control) Subjects

Variable	Mean	Standard Deviation
9.1 m time pre-test	1.82	0.19
9.1 m time post-test	1.68	0.08
9.1 m stride length pre-test	3.33	0.14
9.1 m stride length post-test	3.59	0.16
9.1 m – 18.3 m interval time pre-test	1.29	0.13
9.1 m – 18.3 m interval time post-test	1.26	0.11
9.1 m – 18.3 m interval SL pre-test	3.96	0.30
9.1 m – 18.3 m interval SL post-test	4.20	0.18
18.3 m time pre-test	3.12	0.28
18.3 m time post-test	2.94	0.17
18.3 m – 36.6 m interval time pre-test	2.47	0.30
18.3 m – 36.6 m interval time post-test	2.29	0.22
18.3 m – 36.6 m interval SL pre-test	4.14	0.42
18.3 m – 36.6 m interval SL post-test	4.63	0.29
36.6 m time pre-test	5.55	0.52
36. 6 m time post-test	5.23	0.38

TABLE 5

Descriptive Values from Pre-test to Post-test for AST Subjects

Variable	Mean	Standard Deviation
9.1 m time pre-test	1.75	0.16
9.1 m time post-test	1.68	0.13
9.1 m stride length pre-test	3.27	0.20
9.1 m stride length post-test	3.56	0.24
9.1 m – 18.3 m interval time pre-test	1.36	0.20
9.1 m – 18.3 m interval time post-test	1.32	0.24
9.1 m – 18.3 m interval SL pre-test	3.93	0.43
9.1 m – 18.3 m interval SL post-test	4.21	0.34
18.3 m time pre-test	3.11	0.33
18.3 m time post-test	3.02	0.37
18.3 m – 36.6 m interval time pre-test	2.56	0.32
18.3 m – 36.6 m interval time post-test	2.32	0.26
18.3 m – 36.6 m interval SL pre-test	4.21	0.49
18.3 m – 36.6 m interval SL post-test	4.63	0.60
36.6 m time pre-test	5.64	0.61
36. 6 m time post-test	5.33	0.57

TABLE 6

Descriptive Values from Pre-test to Post-test for RST Subjects

Variable	Mean	Standard Deviation
9.1 m time pre-test	1.80	0.17
9.1 m time post-test	1.64	0.10
9.1 m stride length pre-test	3.29	0.18
9.1 m stride length post-test	3.57	0.19
9.1 m – 18.3 m interval time pre-test	1.32	0.14
9.1 m – 18.3 m interval time post-test	1.27	0.13
9.1 m – 18.3 m interval SL pre-test	3.88	0.29
9.1 m – 18.3 m interval SL post-test	4.10	0.32
18.3 m time pre-test	3.13	0.30
18.3 m time post-test	3.92	0.20
18.3 m – 36.6 m interval time pre-test	2.53	0.32
18.3 m – 36.6 m interval time post-test	2.33	0.30
18.3 m – 36.6 m interval SL pre-test	4.13	0.39
18.3 m – 36.6 m interval SL post-test	4.59	0.35
36.6 m time pre-test	5.60	0.55
36. 6 m time post-test	5.25	0.48

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