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The Effects Of Depth Jump Implementation Of Sprint Performance In Collegiate And Club Sport Athletes

Ryan Bean
Eastern Kentucky University

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BY

RYAN MITCHELL BEAN

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BY

RYAN MITCHELL BEAN

Submitted to the Faculty of the Graduate School of
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DEDICATION

This thesis is dedicated to,

My family for their unwavering love and support.

I could not have done this without you.

ACKNOWLEDGEMENTS

When I began working on this thesis I was given a quote by Dr. Michael Lane stating; “If you want to get this done you must have the mindset of Keyser Soze, “are you prepared to do what the other guy is not?”” It is with this quote that my mindset was forged for the next six months. Therefore, I would like to take this opportunity to thank Dr. Lane for his mentorship and guidance over the past year. If there is anything I have learned under his tutelage it is to aim higher than I originally thought possible. I would like to thank Dr. Heather Adams-Blair for giving me the opportunity to continue my education here at Eastern Kentucky University and supporting me, even when I made it difficult for her. I would like to thank my other committee members Dr. Aaron Sciascia and Dr. Matthew Sabin for helping guide me throughout this process. They also gave me amazing revisions to help me get this paper written much better than when I first started. I ended on draft ten. I would also like to thank Zach Salyers, Lee Doernte, Jonathan Isaacs, Pete Collopy, and Sara Johnson for their amazing assistance in data collection and everything else. I would lastly like to thank all the Eastern Kentucky University Women’s Basketball, Men’s Basketball, Women’s Rugby, Men’s Hockey, and Cheerleaders who volunteered to participate in my study. I quite literally could not have done this without all of you.

ABSTRACT

Introduction; Depth jumps (DJ) are popular high-intensity plyometric exercises typically reserved for highly-trained individuals. DJs cause an individual to undergo high amounts of stress during the eccentric and concentric phase. This extreme loading allows individuals to increase lower body strength and power output. Muscular strength and power have a transfer effect to sprint speed; however, few have examined if implementing DJs into training can increase sprint speed. **Purpose;** The purpose of this study was to determine if the implementation of DJs into a sprint training program would increase sprint speed more so than sprinting alone. **Methods;** 5 collegiate level and 13 club level athletes participated in this study (6 males and 13 females). Subjects performed 3 maximal 40-yard sprints with 3 to 5 minutes of rest between sprints. Subjects were randomized into either a control group, a sprint training group, or a DJ group. The DJ and sprint group performed 2 training sessions/week, with both groups performing the same sprint training protocol. The DJ group had DJs of varying intensities. Following 6 weeks of implementation, subjects were retested on the 40-yard sprints in the same manner as before. **Results;** One-way ANOVA were conducted using paired comparisons to determine significance. Significant differences were observed after implementation for the 40-yard sprint (-.24±.43s) ($P<.01$), 20-30yard split (-.13 ± .11s) ($P<.05$), and a 20-40yard split (-.20 ± .18s) ($P<.01$). No differences were observed between groups. The DJ group changes showed the largest effect sizes of any group in these measures; 1.12, 1.6, and 2.5 respectively. **Discussion;** The effect sizes of the changes in sprint speed demonstrate that DJs may benefit sprint speed. It can be

concluded from this study that maximal sprint speed was improved more so than acceleration due to the improvements observed from 20-30yards and 20-40yards. These indicate the maximal speed phase of sprinting. Further research is needed to determine if DJs can improve sprint performance in highly-trained athletes.

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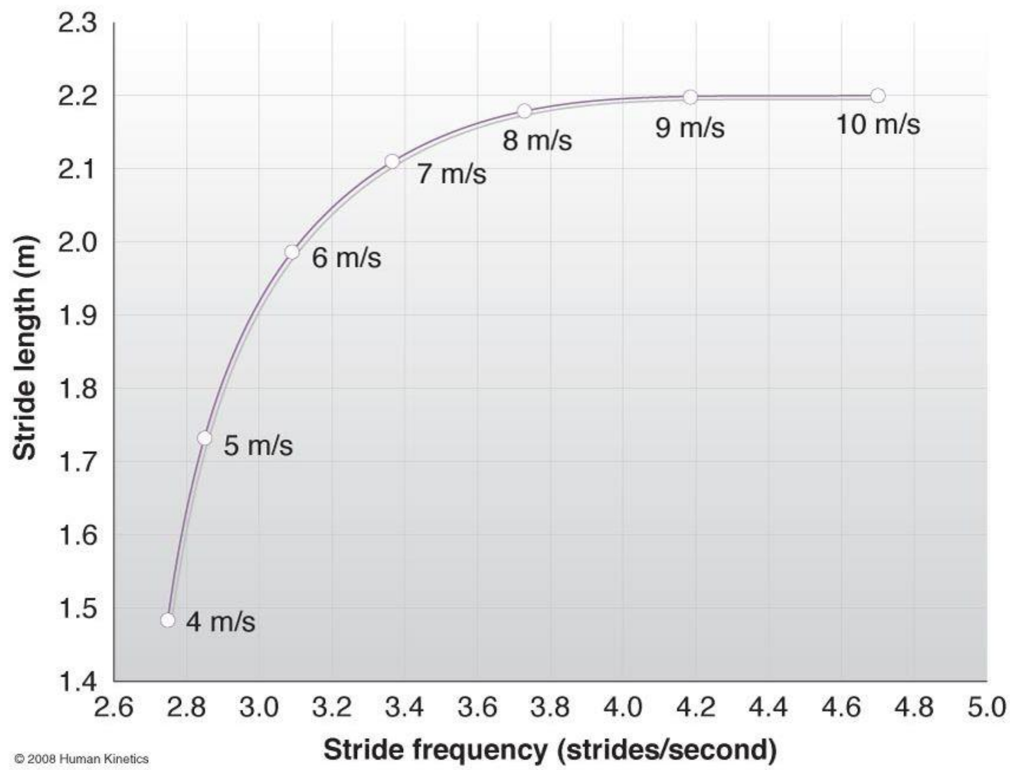
CHAPTER I

INTRODUCTION

The National Strength and Conditioning Association (NSCA) divides athletic performance into multiple parameters (16) with one of those parameters being sprint performance. Sprinting is a series of running strides that repeatedly launch the individual's body as a projectile at maximal acceleration or velocity (or both), usually over brief distances and durations (16). This is critical in both flow sports (i.e. soccer and basketball) and non-flow sports (i.e. American football and track and field) that stress the anaerobic metabolic pathway.

There are multiple biomechanical factors that contribute to sprint performance such as technique, biomechanical predispositions, and anthropometric measurements. Additional factors include stride frequency (SF), stride length (SL), and force production (f) in both the vertical (VF) and horizontal (HF) plane. These four factors are more able to be modified in short term (less than 1 year) training.

In the current study, SF refers to the amount of foot contacts placed during a sprint whereas SL refers to the distance covered between contacts. These two factors have an intricate relationship that inevitably reaches a plateau. Figure 1 demonstrates that as SL improves it inevitably reaches an anatomical limit. A person's leg length will determine how far an individual can stride. As such, improving SL can only occur to a certain point. It is due to this limitation that it has been found that increasing SF may prove to be more beneficial when performing sprint training (20,48). Figure 1 also shows that SF can continue to increase after SL has ceased to increase. The key for this relationship to succeed is to avoid a negative correlation between these two variables. A negative correlation states that as one variable increases then the other suffers a proportionate decrease. This would occur if SL was decreased yet SF was improved. This would result in sprint performance remaining stagnant (20,48). Avoiding a negative correlation between variables is not specific to sprinting but is the main priority of coaches in many aspects.



Adapted, by permission, from Dillman, 1975.

Figure 1. Stride Frequency and Stride Length Interaction; This graph shows the logimetric relationship between the stride length and stride frequency during a sprint. It can be interpreted from this graph that as stride length reaches 2.2 meters (m) then diminishing returns are observed. However, stride frequency can be seen still improving once this point is reached (16).

During sprinting, force production is broken down into two separate variables, VF and HF. Faster and slower sprint times are directly dependent on how VF and HF are manipulated. During sprinting, overall force production is a combination of these two variables so neither one can be overlooked. However, focusing on HF seems to be more important for increasing sprint speed since increasing HF and limiting VF allows an athlete to travel a horizontal distance faster compared to an athlete that produces more VF during the same sprint (See Figure 2). It has also been suggested that individuals produce faster sprint times when HF production is higher (48). Although it is necessary for coaches to understand which mechanisms should be targeted to improve sprint performance, it is also important to understand which sports utilize sprinting and its role in those sports.

During flow sports (sports that transition with few breaks such as soccer and basketball), athletes sprint anywhere from 114-360 meters (soccer) to 0-6% of total time played (basketball) (1,39). These short bouts of sprinting can be turning points in any match due to the intermittent nature of the sports. Research has also shown that having the capability of sprinting is important regardless of position in these sports (14,39,41,45).

When examining non-flow sports, sports that have multiple stoppages in play such as American football and track and field, sprint performance is tested in a less frequent manner. Improving sprint performance is a concern not only for the current coaches of athletes but also the prospective coaches of athletes as well. The National

Football League (NFL) utilizes a 40-yard sprint in its pre-draft combine to establish the maximal sprint speed of potential players. For players in specific position groups such as running backs and wide receivers, this test can make or break an athlete's chance of playing in the NFL. It has been demonstrated that athletes in the combine who run one standard deviation above the current combine mean sprint times have a 93% chance of getting drafted (36). On the other hand, athletes who fail to perform up to these standards and sprint one standard deviation below the mean, only 25% of those athletes end up being drafted.

Finally, track and field has multiple events in which sprint performance capability can alter performance. In the 2016 Olympics, the winning time of the men's 100m sprint was separated by only .08 seconds and .12 seconds in the women's event (34). The 200m sprint was separated by a slightly larger margin of victory in the men's event (.24s) however only by .10s in the women's event (35). Sprinting has also positively affected field events. It has been found that performing a 20m sprint prior to performing three maximal shot puts can improve throwing performance (46). The causational mechanism of this improvement was not entirely concluded; however, the authors did note that athletes of all experience levels could possibly benefit from this intervention.

From the above examples it is apparent that improving sprint performance is necessary when working with athletes in sports that stress the phosphagen (anaerobic) metabolic pathway. However, the training methods and interventions that can be utilized for improving sprint performance varies among coaches. Some coaches attempt to focus on manipulating HF and VF production by employing exercises such as sprinting with resistance (sled pulls) (13,18,23,37) or through more dynamic ballistic movements (plyometrics) (12,24,25,27,31,33,43,47). Coaches utilize these methods due to the perceived benefits of increasing acceleration (13,18,37), power production (5,31,47), and lower body strength (5,7,29,47).

As individuals begin to adapt to resistance training coaches seek alternative ways to stress the individuals. Plyometric exercises can be used in a variety of training methods to manipulate lower body strength and lower body power (7,19,29). Plyometrics have also been shown to have a beneficial effect on sprint performance (12,24,30). One exercise that is common in plyometric training programs is the depth jump (DJ). DJs are executed through a simple process; an individual begins by standing on a box of a certain height with the individual proceeding to step off the box and land in a quarter-squat position. From this point, the individual can perform a maximal vertical jump or maximal horizontal jump with or without an obstacle i.e. a hurdle. The final stage can vary depending on the desired adaptation. DJs have become popular due to the increased knowledge of their benefit transferability to other physiological aspects. DJs have been found to improve maximal strength (9), power production (31), and predict or alter sprint performance in an acute timeframe (4,10).

Although plyometric exercises have been shown to improve a wide range of physiological factors, fewer studies have been conducted on DJs specifically. Of the few studies that have examined DJs, none were found to have examined the effects that they may have on sprint performance when implemented into a training program over the course of six weeks. Therefore, the purpose of this study is to determine if implementing depth jumps along with a sprint training program will improve the sprint performance of collegiate and club sport athletes more so than a sprint program alone. This study hypothesizes that the implementation of depth jumps along with sprint training will improve sprint performance more so than sprint training alone.

ASSUMPTIONS, LIMITATIONS, AND DELIMITATIONS

This study assumes that all participants will give maximal effort during every testing and experimental session along with adequate effort during the warm-up. It is also assumed that subjects will be forthcoming with any injuries that may hinder performance during the experiment. Finally, it will be assumed that all subjects will maintain normal training outside of the experimental protocol regardless of group assignment.

This study is limited to the program deemed significant by the researcher. The programs designed for this experiment were meant to be within the capabilities of all potential participants. This study is also limited to available space and equipment at the university. Due to a lack of indoor facilities, testing was forced to be outside and scheduled around environmental conditions. The current study is using a variety of collegiate and club sport athletes and is therefore limited by the different training programs utilized by the different sports outside of the research protocol.

The examination depth jumps on sprint performance was chosen due to a lack of previous research on their potential relationship. It was also determined that comparing these jumps to not only a control group but also a sprint group to distinguish if the implementation of depth jumps improved sprint performance compared to simply general sprint training. Collegiate and club sport athletes were solely recruited to ensure that all participants would have a higher chance of being accustomed to the stress that would be placed on the body from the training in the study.

CHAPTER II

REVIEW OF LITERATURE

Strength, power, endurance, anaerobic/aerobic capacity, agility, flexibility, balance, body composition, and speed are the eleven parameters of athletic performance defined by the NSCA (16). Manipulating these factors can lead to improvements in athletic performance if done correctly. Speed, more specifically, maximal sprint performance is a priority for coaches of a variety of sports. Sprinting is a series of running strides that repeatedly launch the individual's body as a projectile at maximal acceleration or velocity (or both), usually over brief distances and durations (16). Sprinting is required at times in both flow sports and non-flow sports that stress the anaerobic metabolic pathway. Succeeding or failing to outsprint an opponent during a game can be the difference between a win and a loss.

Sprinting has three distinct phases; the acceleration phases, the maintenance of maximal speed, and the final deceleration phase. Most sports put a great amount of emphasis on the acceleration and deceleration phases since athletes rarely get to the maintenance phase due to the constant changing of the flow of the game. Since this study is focused on maximal 40-yard sprint performance the acceleration and maximal speed phases are more applicable.

SPRINTING IN SPORTS

SPRINTING AND SOCCER

Soccer is one of the most popular sports in the world based on its amount of recreational and league play in South American, European and Asian countries. Understanding how sprinting can affect soccer matches is relevant considering how many athletes play the game. Professional soccer players in the UEFA Europa League sprint an average of 237 ± 123m per match (1). These distances varied between position groups with most of the sprints lasting under five seconds (1). Due to the intermittent play of the sport of soccer, these sprints during a match can be critical turning points where an athlete either beats an opponent to the ball which can result in a goal or fail to do so which can result in a goal for the opposing team. Examinations of the relationship between sprint speed and player position in soccer have concluded that during a 30m sprint the position that an athlete played did not correlate to their performance. Therefore, being able to outsprint an opponent is important regardless of position (45). This research shows how speed is an integral part of soccer; we now transition to another flow sport in basketball.

SPRINTING AND BASKETBALL

Basketball is a popular sport in the United States and is increasing popularity in the rest of the world. Basketball is played at multiple elite levels from college teams to semiprofessional and national teams and finally to the NBA which is home to the most elite players in the world. Therefore, semiprofessional and national players can be considered elite athletes. Players traditionally range from around six feet tall to over seven feet depending on position. With such a wide range of body sizes it can be construed that speed may play a different role for some players more than others. Regardless of position, players spend an average of three to six percent of a game sprinting (39). Backcourt players, point guards and shooting guards, likely have quicker linear speed measures across a 20m distance regardless of gender (14,41). This is thought to occur because of the differences in sprinting load backcourt players undergo compared to frontcourt. Overall it has been shown that backcourt players typically possess faster 20m sprint times than frontcourt players. These findings along with a basic understanding of the game of basketball show that sprinting plays a role in the sport. From this research, it can be concluded that speed does correlate to flow sports. The next question though is does it contribute to non-flow sports.

SPRINTING AND AMERICAN FOOTBALL

American football recruits athletes with a wide range of body sizes. Before athletes enter the National Football League (NFL) they first go through the NFL Combine. This is where potential draft picks showcase their skills in front of NFL coaches and general managers. A test that has gained popularity in the NFL combine is the 40-yard dash. This is the NFL's measure of sprint speed for athletes. For certain position groups, running backs and wide receivers, this test can greatly improve or hinder their chances of being drafted. Research has reported that 93% of players who run one standard deviation above the current combine mean sprint times, typically about 4.41 seconds, eventually get drafted. Only about 25% of players in those positions who run one standard deviation below the mean are drafted (36). The validity of the 40-yard dash to accurately predict future performance in the NFL has long been debated. Regardless, it seems to be important in determining a chance to play in the NFL. Improving performance on this test leading up to the draft may benefit players looking to get drafted. A 36.6m sprint, approximately 40 yards, has been shown to be faster in starting players compared to non-starting players in seven out of sixteen position groups (8). Therefore, sprint speed may play a large role in achieving success in football. The preceding findings do not necessarily show a correlation between speed and position skill capability in football but there is a strong case for its ability to benefit performance at all levels along with its importance in the eyes of the NFL. Following is a section on the sport which contains the most absolute form of sprint speed there is, track and field.

SPRINTING AND TRACK AND FIELD

Track and field contains the only sporting events in which sprint performance is directly correlated to success. These events are some of the most anticipated events in the Olympic Games. In the 2016 Olympics, gold and silver in the men's 100m dash was separated by only .08 seconds and the women's event by .12 seconds (34). The 200m sprint was separated by a slightly bigger margin of victory in the men's event, .24s, but only .10s in the women's event (35). This shows how crucial sprint speed is in these events. However, speed is not just limited to the track. Even though sprinting is not a direct part of field events it has been shown to improve performance. Performing a 20m sprint prior to performing three maximal shot puts increased average throwing distance by .56m. The reasoning behind this improvement was not entirely concluded however the authors did note that athletes of all experience levels could possibly benefit from this intervention (46).

BIOMECHANICS OF SPRINTING

There are four biomechanical factors outside of sprint technique, biomechanical predispositions, and anthropometric measurements. SF, SL, and force production (F) in both the vertical (VF) and horizontal (HF) plane are considered more likely to be modified within a short term (less than 1 year) training period. Therefore, manipulating these factors is more feasible when coaches only have a brief amount of time to improve performance.

SF and SL determine how quickly an individual can travel a certain distance. SL reaches an inevitable plateau based on an individual's natural leg length and HF production. SF can still be improved after SL reaches its plateau. (Figure 1). Maximizing both variables will lead to an improvement in sprint performance. If one factor is increased but the other is proportionately decreased, then sprint performance would remain stagnant. This would occur if SL got smaller as SF improved. Avoiding a negative correlation between these variables has been shown to be important (20,48). However, some have suggested that increasing SF would lead to faster sprint times, while others suggested a longer SL would be the significant factor

(32,2). Hunter et. al (2004) concluded that other factors possibly contribute to the interaction observed between SF and SL; leg length, height of takeoff, and vertical velocity of takeoff were mentioned. It was noted that the vertical velocity of the takeoff seemed to be the most prominent limiting factor due to its relationship with HF (see Figure 3). The findings of this study are significant for their conclusion of the negative interaction between SL and SF. One last note made was that vertical and horizontal ground reaction force play a central role in sprint performance and more research is needed to prove their contribution (20).

Overall force production (F) is the product of mass and acceleration, $f = ma$, and “can be thought of as a push or pull acting on a body (17).” From this equation, it can be construed that to increase sprint performance we must be able to accelerate our predetermined amount of mass, bodyweight, faster which would be equal to producing more overall force. Increasing force production with a given mass will require a stronger muscle (17).

During sprinting force is broken down into different subsections, the first one being Ground Reaction Force (GRF). GRF is referred to in Newton’s Third Law of Reaction stating; “for every action there is an equal and opposite reaction”. Meaning that “with every foot contact with the ground the ground generates an upward reaction force (17)”. GRF is measured in either VF or HF. VF propels an individual into a more upward direction. This is the antagonist to HF which propels an individual in a more forward direction. In either case, the more force that is applied into the ground the father the individual will travel in that direction. The nature of how HF interacts with VF during sprinting is outlined in Figure 2. Both VF and HF are required during sprinting. However, limiting VF and maximizing HF is preferred during sprinting to allow an individual to cover the horizontal distance at a faster rate.

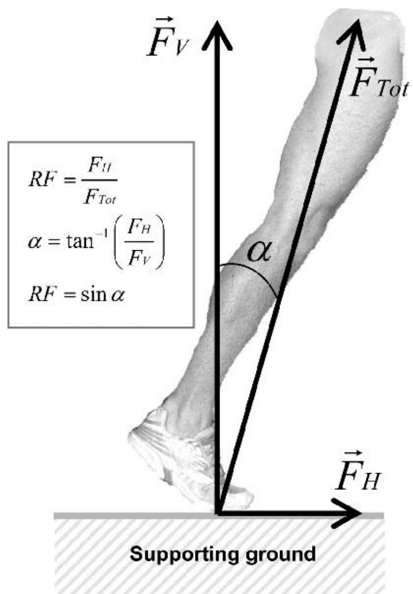


Figure 2. Ratio of Forces During Sprinting; Schematic representation of the ratio of forces (RF) and mathematical expression as a function of the total (FTot) and net positive horizontal (FH) (i.e., contact-averaged) ground reaction forces. The forward orientation of the total GRF vector is represented by the angle a (32).

Research has examined the relationship between HF and SF. During maximal effort sprint performance, improvements were observed when HF production was higher. Weyand (2000) found that SF did not significantly change between subjects. This lead the to the conclusion that HF production led runners to perform better, more so than increasing SF (48). Therefore, aiming to improve HF may be more relevant than trying to improve SF.

Understanding how these four biomechanical factors relate to sprint performance is necessary for strength and conditioning coaches. Along with this understanding, coaches also need to be familiar with the physiological demands different sports place on the body.

PHYSIOLOGICAL FACTORS OF SPRINTING

BASICS OF MUSCULAR PHYISIOLOGY

The muscular physiological predisposition of a person is largely genetic. However, certain factors such as muscular cross-sectional area (CSA) and fiber composition can be altered through training. The CSA of a muscle is directly proportional to the amount of potential force that a muscle can produce (15). Therefore, a muscle with a smaller CSA will produce less force than a muscle with a larger CSA. This relationship is important in sprinting where maximal force output can hinder or improve performance. Muscle fiber composition is the ratio of Type I and Type II muscle fibers an individual has. Type II fibers produce faster contractions than Type I fibers and are generally larger than Type I fibers as well (15). These two properties make Type II fibers more relevant to sprint performance compared to Type I fibers. While following proper training, muscle fibers can shift from Type I to Type II fibers (15). Exploiting this ability can allow athletes to improve sprint performance after training even if they began with a higher amount of slow twitch Type I fibers.

Strength and conditioning coaches routinely attempt to develop programs that will increase strength, speed, and power, however, exercise selection can be challenging. One of the most common exercise of choice for coaches seeking to improve lower body strength is a variation of the squat. The main goal for these exercises is to help athletes get stronger, yet these benefits are known to transfer to speed and power as well (3,5). In terms of the force-velocity curve (Figure 3) improving muscular strength would result in a rightward shift of the curve. Therefore, it can be determined that improving muscular strength is an important factor in improving overall force production and subsequently sprint speed. Muscular strength has also been shown to have transfer effects to increases muscular power output (5). This transitively shows that muscular power output is related to sprint speed through force production.

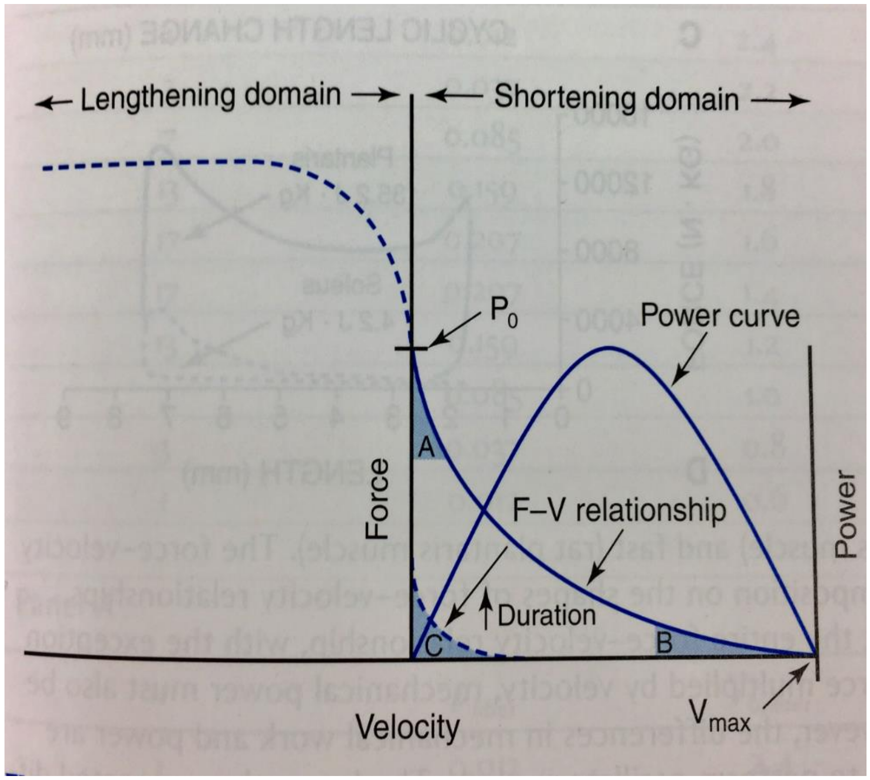


Figure 3. Force-Velocity Curve; The relationship between force and velocity can be interpreted as an inverse relationship. As external force increases it causes a subsequent decrease in velocity. This relationship is important to consider when attempting to improve sprint performance through performing resisted sprinting movements such as; sled towing, bungee cord sprinting, or parachute sprinting (15).

In athletes who have limited training experience, it is easier to focus solely on strength with basic exercises because inexperienced athletes will demonstrate the principle of initial gains. When athletes begin to reach more elite levels this becomes more challenging to accomplish because of diminishing return in performance (42). Heavy squatting has been shown to acutely affect sprint performance in NCAA Division III football players when performed just four minutes prior to sprinting (30). Other squat variations have been shown to increase sprint performance as well (3,11,47). The half back squat has been shown to improve sprint performance after eight weeks of implementation in junior soccer players (11). Similar to the half back squat, a loaded half squat jump was able to induce postactivation potentiation (PAP) (40) and improve sprint performance compared to resting for nine minutes prior to sprinting (47). These examples along with an understanding of how muscular cross-sectional area and strength contribute to muscular power production demonstrate how lower body strength contributes to sprint performance.

SPEED AND POWER

When examining sprint performance, it is important to recall the force-velocity curve (Figure 3). Power output is expressed in terms of GRF during sprinting. Research has shown that the ratio of force (Figure 2) and producing a net positive of horizontal force causes subsequent improvements in a 100m sprint (33). During the acceleration phase, positive net HF has been shown to correlate to performance (22). Therefore, improving HF production and in turn lower body power output can lead to improvements in sprint performance during the acceleration phase at minimum. Even minute improvements in the acceleration phase are important considering the intermittent play of flow sports.

Increasing power output is a common goal in many training programs. Many coaches will utilize a variation of an Olympic lift such as a hang clean or another popular exercise for increasing power, plyometric exercises. Hang cleans have been shown to have a correlation with speed through their connection with strength and power (5). Plyometric exercises have been shown to predict or improve not only power output, but also strength, and most importantly sprint speed (12,25,29,43,47). Increasing power output allows an athlete to apply more overall HF and VF. Given what was stated earlier about the relationship between VF, HF, and speed (28) it can be concluded that this adaptation is desirable when aiming to improve sprint performance. The use of plyometrics in training programs is evident. However, when working with athletes of higher training statuses and more elite levels, coaches are required to utilize more intense plyometric training. This is once again because of initial gains and diminishing return experienced during training. High-intensity plyometric exercises are commonly reserved for athletes with higher training statuses because of their intense and taxing nature on the body along with an increased risk of injury. Certain variations of these exercises have been known to produce great amounts of force on the body. These could potentially lead to serious injuries in untrained individuals.

SPEED AND DEPTH JUMPS

DJs are one of the most common high-intensity plyometric exercise prescribed to athletes. The procedures on how to perform a DJ were stated in the introduction. DJs cause an individual to undergo stress in two different forms. During the landing phase individuals absorb a high amount of force in an eccentric muscle lengthening. During the jumping phase individuals produce as much GRF as they can to maximally get off the ground in either the vertical or horizontal plane. Eccentric and concentric training have been shown to increase muscle strength and CSA (21). Undergoing these stresses and their subsequent adaptations are the reason why DJs are utilized in training programs. When implementing DJs into a program coaches must be cautious on how high boxes are prescribed due to the high amounts of landing force that can be produced (6). No exact box height has been found to be universal for all athletes; therefore, it is more appropriate to determine box height based on each individual athlete's needs. Performing DJs has been shown to acutely increase maximal strength in the form of a squat and sprint performance in rugby/collegiate as well as physically active men (9,10,31). Performing two, four, or six DJs four minutes prior to squatting significantly improved 1RM performance (9). Byrne (2014) showed that implementing three DJs into a dynamic warm-up significantly improves 20m sprint performance compared to a standard dynamic or cardiovascular warm-up in physically active men and women (10). Research has also concluded that DJs can have an impact on power output (31). It was found that when cuing athletes on how to perform DJs it has been observed that saying "get off the ground as fast as possible" was an adequate way to ensure athletes produced the least amount of ground contact time which in turn allowed them to produce greater amounts of VF and less ground contact time (GCT) (38). These conclusions show that DJs may elicit an effect on multiple areas of performance. However, all the studies found throughout this literature review examined DJ's utilized in an acute timeframe. This leads investigators to infer that DJs can induce PAP in individuals. Yet, no studies were found examining the effects of depth jumps being implemented over the course of a multiweek training period. With such a wide range of potential benefits it seems reasonable to examine how DJs can improve sprint performance when utilized in such a training period.

Based on the current body of knowledge examined above, it can be determined that sprint performance is required in various sports. Understanding its importance is why coaches and athletes seek to improve it via different methods. Also, it can now be understood what biomechanical and physiological factors play a role in sprint performance. Finally, we can conclude that DJs may be a viable option as a method for improving sprint performance. However, limited research is available on the relationship between DJs and sprint performance when DJs are implemented into a multiweek training program.

CHAPTER III

METHODOLOGY

SUBJECTS

21 collegiate and club sport athletes, ages 18 to 25, were recruited to participate in this experiment. Morphological characteristics, height, 171 ± 13cm; body mass, 73 ± 18 kg; and age, 20.5 ± 1.5 yrs, were obtained. All participants selected to participate were healthy and injury free prior to and during the experiment. Subjects were excluded from the study if they had sustained any injuries within the previous three months that would hinder full participation in the study. Testing took place during the months of August through October with at least two rest days provided between testing sessions to ensure adequate recovery time. Testing and experimental sessions were conducted during the offseason, preseason, or beginning of the regular season of all participating subjects. Prior to participation, volunteers completed consent documentation approved by the Eastern Kentucky University Institutional Review Board.

PROCEDURES

Prior to participation, all potential subjects were addressed by the lead investigator to determine willingness to participate in the experiment. During the first visit, subjects were asked to complete an informed consent document, a health history questionnaire, and a video recording consent form. Subjects were also given an overview of the experiment. Height and body mass were established using a wall mounted tape measure and Tanita SC-331S Total Body Composition Analyzer (Tanita Corporation of America Inc., Arlington Heights, IL). Following familiarization with the testing procedures, subjects were given a designated dynamic warm-up prior to testing which is listed in Table 1. Testing on day one consisted of subjects running three separate forty-yard sprints with three to five minutes of rest in between repetitions to allow for adequate recovery. Maximal effort sprint speed was recorded using a standard stopwatch during the forty-yard sprint. Stopwatches have been shown to be within .22 seconds of electronic timing gates (26). For time to be recorded during the test, subjects had to begin with the whole body behind the starting line. A timer counted down from three seconds and once the countdown reached one, subjects began their sprint. Timers began off the first movement of the subject. One researcher was at the forty-yard line and a second researcher was located at the twenty-yard line. This method was employed to provide alternative perspectives for the recorders. Each researcher depressed the stopwatch button as each subject crossed the finish line. The positioning of the researchers at 2 different aspects of the run allowed for a difference in perspective i.e. a posterior view (20-yard line) and horizontal view (40-yard line). The average of the two times was recorded. If subjects started the sprint prior to the timer reaching the end of the countdown, the time was not recorded, and the subject was asked to repeat the test. Subjects were instructed to position themselves in a manner they felt comfortable prior to each sprint, however, they were instructed to begin every trial in the same manner.

Following the familiarization day, subjects underwent simple randomization into one of three potential groups. Subjects were given a choice between the numbers; one, two, and three. These numbers were designated to an experimental or the control group depending on when the individual began the experiment. Following randomization, group one was labeled the control group that had no training protocol added to their daily exercise routines. Group two was assigned a sprint training program for two days a week. The sprint program employed sled pulls at a mass of an individual sled loaded with 20% bodyweight. Previous research has demonstrated that this weight is optimal for improving propulsive GRF impulse (13). Group three was assigned the same sprint training program as group two, however; the program also employed DJs of varying intensity. The DJs followed a basic progression model focusing on adaptations in muscular strength for the first three weeks followed by muscular power in the final three weeks (16). This progression incorporated lower level heights to allow individuals to become re-familiar with the exercises. The progression of boxes also allows more force to absorbed during the DJs and subsequently causes the individuals to produce more power to overcome that force as box heights increase. The program was performed beginning on a box at a height of 15, 30, 45, or 60cm. A hurdle was placed in front of each box and was set to an individualized height for each subject depending on the maximal countermovement jump height (CMJH) achieved relative to hurdle height settings. Hurdles were lowered one level below maximal CMJH to allow the subjects to safely clear the hurdle on each repetition while still striving to achieve maximal height on each jump. Hurdles were implemented to give subjects a target to jump over which has been shown to reduce GCT and cause greater GRF, among other benefits (44). Hurdle height was set to the level below maximum countermovement jump height of each subject. Subjects stepped off the box landing in a quarter squat position rather than with legs fully extended to reduce the risk of potential injury. Upon landing, subjects performed a maximal vertical jump over the hurdle. Once the subject cleared the hurdle and landed in the quarter squat position, the repetition was complete.

Subjects were asked to not deviate from their normal exercise routine. However, subjects in group two and group three were monitored during their two experimental sessions each week. A researcher was present to determine safety and proper technique of each exercise. Researchers did not provide training benefits such as: recommended loading, instructing how hard to work, or providing information outside of general safety guidelines. All experimental days had at least one researcher that was a certified athletic trainer or certified strength and conditioning specialist to monitor execution. Subjects underwent a dynamic warm-up prior to each experimental session that was deemed significant by the strength and conditioning coach of that team. Following the six-week training implementation, subjects were retested in the forty-yard sprint to determine the effects of implementation. The final testing day was executed in the same manner as the first testing day. Subjects were again given the standardized warm-up Followed by performance of three maximum forty-yard sprints with three to five minutes of rest in between repetitions.

STATISTICAL ANALYSIS

Descriptive statistics were calculated and reported as means and standard deviations for continuous variables, and frequencies and percentages were reported for categorical variables to determine change after implementation. An analysis of variance (ANOVA) test was conducted to determine the difference in sprint performance times overall and between groups. Least Significant Difference (LSD) post hoc tests were carried out using paired comparisons to determine where the significant differences existed. Subjects were excluded from the experiment if they failed to attend ten out of the twelve experimental sessions. The level of significance was set at a p-value of $p \leq .05$. Responsiveness to training was measured using Effect Size (ES) set at a value of .5. All statistical analyses were conducted using the Statistical Package for Social Sciences (SPSS) (IBM Version 23 Armonk, New York). See Tables 1-3.

Table 1. Dynamic Warm-Up

Exercise	Sets	Repetitions/Distance
High Knees	1	20 yards
Butt Kicks	1	20 yards
Bunny Hops	1	20 yards
High Knee Hugs	1	10 yards
Lift and Reach	1	10 yards
¼ Squat and Lift	1	10 yards
Forward Lunges	1	20 yards
Side Lunges	1	20 yards
Leg Kicks	1	20 yards
Lift and Scoop	1	10 yards
Toe Walks	1	10 yards
Arm Circles	1	10 Forward & 10 Backward
10-yard Burst	1 @ 50%	10 yards
	1 @ 75%	
	1 @ 85%	

Table 2. Sprint Program

Week/Day	Exercise	Sets	Repetitions	Load
1.1	10-yard Burst	10	1	Unloaded
1.2	Sled Pull	10	1x10-yards	20% BW
2.1	20-yard Burst	8	1	Unloaded
2.2	Sled Pull	12	1x10-yards	20% BW
3.1	40-yard Sprint	6	1	Unloaded
3.2	10-yard Burst	10	2	Unloaded
4.1	30-yard In ‘n Out	8	1	Unloaded
4.2	10-yard Burst	8	1	Unloaded
5.1	20-yard Burst	10	2	Unloaded
5.2	Sled Pull	10	1x15-yards	20% BW
6.1	40-yard Sprint	8	1	Unloaded
6.2	Sled Pull	8	1x15-yards	20% BW

*BW = bodyweight

Table 3. Depth Jump Program

Week/Day	Ground Contacts	Box Height (cm)
1.1	20	15
1.2	20	15
2.1	18	15
2.2	18	30
3.1	15	30
3.2	12	30
4.1	12	45
4.2	10	45
5.1	8	45
5.2	6	60
6.1	8	60
6.2	10	60

*****cm = centimeters

CHAPTER IV

RESULTS

The participants for this study (Tables 4-7) included collegiate (n=8) and university club level athletes (n=13). Due to physical ailments independent to the study along with schedule conflicts, three subjects missed fewer than two training sessions. Three subjects were dropped from the study due to inability to attend 83% (10/12) of training sessions. Subjects were undergoing independent resistance based training along with other optional training modalities throughout the duration of this study. It should be noted that researchers began with 35 participants, however, due to scheduling conflicts 14 participants were forced to drop from the study. It was believed that due to an insufficient N size results were only found to be trending towards significance in most measurements.

Demographics of each group can be observed in Table 4. Paired T-tests showed significant differences on the 40-yard sprint for the control ($P<.01$) and sprint ($P<.01$) groups following testing. Improvements were expected to be seen for the sprint group. As for the control group, improvements were considered to occur due to the majority of subjects in the group participating in basketball (Table 5). This may have better adapted the subjects to sprinting during the duration of the study. Meaningful ES changes showed that the DJ group (1.12) responded highly to the implementation.

A significant difference was observed following testing in the overall 40-yard sprint regardless of group (P<.01). The DJ group showed trends toward significance following implementation (P=.06) (Table 5).

Significant differences were also observed during the 20 to 30-yard split for the control group only (P<.05). These differences were also thought to be caused by training underwent by subjects during the study. ES changes were found to be meaningful for the sprint (.75) and DJ (1.6) groups with the DJ group eliciting the greater responsiveness to training (Table 6).

No significant differences were observed between groups following testing during the 20 to 40-yard split. A significant difference was observed for the total subjects regardless of group (P<.01). Meaningful ES changes were observed for the control (.60) and DJ (2.5) groups with the DJ group eliciting the greater responsiveness to training (Table 7).

Table 4. Subject Demographics

Group	Sport	Gender	Height (cm) (Mean±STD Dev.)	Weight (kg) (Mean±STD Dev.)	Age (yrs) (Mean±STD Dev.)
Control	Cheerleading (1) Basketball (3) Rugby (1)	F (4) M (1)	175±13	75±15	20.6±2.1

Table 4 (continued)

Group	Sport	Gender	Height (cm) (Mean±STD Dev.)	Weight (kg) (Mean±STD Dev.)	Age (yrs) (Mean±STD Dev.)
Sprint	Cheerleading (3) Basketball (1) Rugby (1) Hockey (1)	F (3) M (3)	173±11	78±16	21.3±1.4
Depth Jump	Cheerleading (5) Basketball (1) Rugby (1)	F (5) M (2)	165±14	70±22	19.7±1.2
Total	Cheerleading (9) Basketball (5) Rugby (3) Hockey (1)	F (12) M (6)	171±13	73±18	20.5±1.6

*cm = centimeters; kg = kilograms; yrs. = years; F = female; M = male

Table 5. Pre- versus Post-Testing 40yard Sprint Mean

Group	Pre 40	Post 40	P-value	Effect Size
Control	5.74	5.65	.004*	.2
Sprint	5.82	5.61	.014*	.33
Depth Jump	5.93	5.57	.060	1.12
Total	5.84	5.60	.001*	

*=P<.05

Table 6. Pre- versus Post-Testing 20-30yard Split Mean

Group	Pre 40	Post 40	P-value	Effect Size
Control	1.31	1.29	.045*	.16
Sprint	1.37	1.23	.985	.75
Depth Jump	1.49	1.28	.823	1.6
Total	1.40	1.27	.033*	

*=P<.05

Table 7. Pre- versus Post-Testing 20-40yard Split Mean

Group	Pre 40	Post 40	P-value	Effect Size
Control	2.71	2.55	.236	.60
Sprint	2.52	2.44	.169	.32
Depth Jump	2.81	2.44	.923	2.5
Total	2.68	2.48	.008*	

*=P<.01

CHAPTER V

DISCUSSION

The gap in the knowledge found by the researchers through reviewing the literature of the effects of DJs on athletic performance measures (4,9,10,31) was a lack of information on the correlation between DJ implementation and sprint performance during prolonged training periods. Therefore, the primary objective of this study was to determine if implementing DJs into a sprint training program would improve sprint performance in collegiate and club sport level athletes. The researchers aimed to provide a linear progression program that would elicit adaptations of lower body muscular strength during the first three weeks of training followed by adaptations in lower body power production in the following three weeks. This progression was believed to provide adequate stimulus to the athletes without creating an exceedingly high risk of injury. After disseminating the findings of this study, there is not enough evidence to accept the research hypothesis that DJs improved sprint performance. This is primarily the result of a small sample size. However, there is a trend within the data that suggests sprint performance can be positively influenced by sprint training and DJs when added to a pre-existing training program.

Data analysis showed that subjects in the control group had the fastest mean sprint time prior to the intervention (5.74±.44). Due to the simple randomization process there was no control over the group assignments, therefore it was believed that the control group contained the fastest mean sprint time to begin testing because it contained the majority of subjects who play basketball. Considering the nature of basketball, it was assumed that these subjects may have begun the study better adapted to sprinting than other subjects. This study found that subjects decreased 40-yard sprint time by an average of .221s ($P<.01$) regardless of group following the six-week intervention. This improvement is a substantial increase for any individuals undergoing sprint training. When considering the previous statements about the 200m sprint in the Olympics an increase of this magnitude can be the difference between first and second place (35). One subject improved overall performance by .746s. This improvement was an outlier in the data which led the researchers to believe that due to a lack of prior sprint training it is possible that some subjects underwent the effects of initial gains. Subjects failed to significantly increase sprint time during the acceleration phase. This was believed to be due to a lack of technical training on starting stance and stride technique. Subjects also improved maximal speed during the 20-30yard split ($P<.05$). No significant differences were observed between the groups following experimentation. It is worthwhile to note that the change observed in the DJ group had a larger effect size than the sprint or control group in the measures found to be significantly different. This suggests that if DJs had been implemented for a longer duration, more frequently, or if more subjects had participated in the study then a significant difference may have been observed between the groups. The trends observed in this experiment correlate to similar findings verifying that DJs may have an impact on sprint performance (10). It should also be noted that 16 out of 18 (88%)

subjects who completed this experiment improved sprint performance following the six weeks of training. This was believed to be caused by possible changes in training methodology due to the transition from off-season to in-season for some athletes. It is also believed that two subjects failed to improve sprint performance due to pre-existing muscle soreness experienced outside of the study. It should be noted that even though vertical jump performance was not measured in this experiment many subjects stated they felt their jump height had increased following training. This claim cannot be validated but is optimistic for coaches.

PRACTICAL APPLICATIONS

The conclusions of this study are important for coaches seeking to improve sprint performance. The observation of improvements in maximal sprint speed following six weeks of training can be something coaches may utilize in the future. The programs of this study were designed to be easy to implement along with modifiable based on training experience. It should be noted that sessions took no longer than 30 minutes to complete. This provides coaches with a time efficient method of improving sprint performance. Improving sprint performance is on the mind of many coaches and therefore this experiment may prove useful for coaches of a variety of sports.

FUTURE STUDIES

Future research is needed to better understand if there is a correlation between DJ implementation into training and sprint performance. Future research should utilize larger experimental groups to better conclude significant differences between the groups. Subjects performed DJs over a hurdle in the current study to minimize GCT and maximize force production. However, future research should determine if performing horizontal jumps rather than vertical jumps during DJs can improve HF production which may lead to faster sprint times. Utilizing athletes out of season may prove to be more beneficial to better avoid subjects being fatigued due to excess training and potential overreaching. It should also be noted that indoor facilities were not utilized during this experiment and should be considered to provide more accurate pre- and post-testing speed measurements by controlling the testing environment. Utilizing electronic timing equipment may prove more definitive and accurate compared to standard stopwatches. Such timing gates were not available to the researchers at the time of this experiment. Determining the reliability between timers when utilizing the staggered stationing from the current study will be useful in establishing if accurate times are measured. The exercises utilized in the current study were chosen because of assumed lack of previous sprint training by the potential subjects. Different exercises may improve sprint performance more so than the exercises in the current study. Lastly, recruiting athletes from a singular sport may prove to be more reliable due to the variability observed between groups in the current study.

REFERENCES

1. Andrzejewski, M., Chmura, J., Pluta, B., Strzelczyk, R., & Kasprzak, A. (2013). Analysis of Sprinting Activities of Professional Soccer Players. *Journal of Strength and Conditioning Research,27*(8), 2134-2140. doi:10.1519/jsc.0b013e318279423e
2. Armstrong, L., D. L. Costill, and G. Gehlsen. Biomechanical Comparison of University Sprinters and Marathon Runners. *Track Tech.* 87:2781-2782, 1984.
3. Baker, D., & Nance, S. (1999). The Relation Between Running Speed and Measures of Strength and Power in Professional Rugby League Players. *The Journal of Strength and Conditioning Research,13*(3), 230. doi:10.1519/1533-4287(1999)013<0230:trbrsa>2.0.co;2
4. Barr, M. J., & Nolte, V. W. (2011). Which Measure of Drop Jump Performance Best Predicts Sprinting Speed? *Journal of Strength and Conditioning Research,25*(7), 1976-1982. doi:10.1519/jsc.0b013e3181e4f7ba
5. Barr, M. J., Sheppard, J. M., Agar-Newman, D. J., & Newton, R. U. (2014). Transfer Effect of Strength and Power Training to the Sprinting Kinematics of International Rugby Players. *Journal of Strength and Conditioning Research,28*(9), 2585-2596. doi:10.1519/jsc.0000000000000423
6. Bean, R. M., Lane, M., & Doernte, L. (n.d.). Impact Kinetics of Depth Jumps with Varying Heights Relationships to Body Composition of Individuals [Abstract]. Retrieved June 7, 2017.
7. Behrens, M., Mau-Moeller, A., Mueller, K., Heise, S., Gube, M., Beuster, N., . . . Bruhn, S. (2016). Plyometric training improves voluntary activation and strength during isometric, concentric and eccentric contractions. *Journal of Science and Medicine in Sport,19*(2), 170-176. doi:10.1016/j.jsams.2015.01.011
8. Black, W., & Roundy, E. (1994). Comparisons of Size, Strength, Speed, and Power in NCAA Division 1-A Football Players. The Journal of Strength and Conditioning Research, 8(2), 80. doi:10.1519/1533 4287(1994)008<0080:cosssa>2.3.co;2
9. Bullock, N., & Comfort, P. (2011). An Investigation into the Acute Effects of Depth Jumps on Maximal Strength Performance. *Journal of Strength and Conditioning Research,25*(11), 3137-3141. doi:10.1519/jsc.0b013e318212e224

10. Byrne, P. J., Kenny, J., & Rourke, B. O. (2014). Acute Potentiating Effect of Depth Jumps on Sprint Performance. *Journal of Strength and Conditioning Research,28*(3), 610-615. doi:10.1519/jsc.0b013e3182a0d8c1
11. Chelly, M. S., Fathloun, M., Cherif, N., Amar, M. B., Tabka, Z., & Praagh, E. V. (2009). Effects of a Back Squat Training Program on Leg Power, Jump, and Sprint Performances in Junior Soccer Players. *Journal of Strength and Conditioning Research,23*(8), 2241-2249. doi:10.1519/jsc.0b013e3181b86c40
12. Chelly, M. S., Hermassi, S., & Shephard, R. J. (2015). Effects of In-Season Short term Plyometric Training Program on Sprint and Jump Performance of Young Male Track Athletes. *Journal of Strength and Conditioning Research,29*(8), 2128-2136. doi:10.1519/jsc.0000000000000860
13. Cottle, C. A., Carlson, L. A., & Lawrence, M. A. (2014). Effects of Sled Towing on Sprint Starts. *Journal of Strength and Conditioning Research,28*(5), 1241-1245. doi:10.1519/jsc.0000000000000396
14. Delextrat, A., & Cohen, D. (2009). Strength, Power, Speed, and Agility of Women Basketball Players According to Playing Position. *Journal of Strength and Conditioning Research,23*(7), 1974-1981. doi:10.1519/jsc.0b013e3181b86a7e
15. Farrell, P.A., Joyner, M.J., & Caiozzo, V.J. (2012). *ACSMs Advanced Exercise Physiology.* Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins
16. Haff, G., & Triplett, N. T. (2016). *Essentials of strength training and conditioning*. Champaign, IL: Human Kinetics.
17. Hall, S. J. (2015). *Basic biomechanics*. New York, NY: McGraw-Hill Education.
18. Harrison, A. J., & Bourke, G. (2009). The Effect of Resisted Sprint Training on Speed and Strength Performance in Male Rugby Players. *Journal of Strength and Conditioning Research,23*(1), 275-283. doi:10.1519/jsc.0b013e318196b81f
19. Hewett, T. E., Stroupe, A. L., Nance, T. A., & Noyes, F. R. (1996). Plyometric Training in Female Athletes. *The American Journal of Sports Medicine,24*(6), 765-773. doi:10.1177/036354659602400611
20. Hunter, J. P., Marshall, R. N., & Mcnair, P. J. (2004). Interaction of Step Length and Step Rate during Sprint Running. *Medicine & Science in Sports & Exercise,36*(2), 261-271. doi:10.1249/01.mss.0000113664.15777.53

21. Jones, D. A., & Rutherford, O. M. (1987). Human muscle strength training: the effects of three different regimens and the nature of the resultant changes. The Journal of Physiology, 391(1), 1-11. doi:10.1113/jphysiol.1987.sp016721
22. Kawamori, N., Newton, R., & Nosaka, K. (2014). Effects of weighted sled towing on ground reaction force during the acceleration phase of sprint running. *Journal of Sports Sciences,32*(12), 1139-1145. doi:10.1080/02640414.2014.886129
23. Kawamori, N., Nosaka, K., & Newton, R. U. (2013). Relationships Between Ground Reaction Impulse and Sprint Acceleration Performance in Team Sport Athletes. *Journal of Strength and Conditioning Research,27*(3), 568-573. doi:10.1519/jsc.0b013e318257805a
24. Lockie, R. G., Murphy, A. J., Callaghan, S. J., & Jeffriess, M. D. (2014). Effects of Sprint and Plyometrics Training on Field Sport Acceleration Technique. *Journal of Strength and Conditioning Research,28*(7), 1790 1801. doi:10.1519/jsc.0000000000000297
25. Maćkała, K., & Fostiak, M. (2015). Acute Effects of Plyometric Intervention Performance Improvement and Related Changes in Sprinting Gait Variability. *Journal of Strength and Conditioning Research,29*(7), 1956 1965. doi:10.1519/jsc.0000000000000853
26. Mann, J. B., Ivey, P. J., Brechue, W. F., & Mayhew, J. L. (2015). Validity and Reliability of Hand and Electronic Timing for 40-yd Sprint in College Football Players. *Journal of Strength and Conditioning Research,29*(6), 1509-1514. doi:10.1519/jsc.0000000000000941
27. Markström, J. L., & Olsson, C. (2013). Countermovement Jump Peak Force Relative to Body Weight and Jump Height as Predictors for Sprint Running Performances. *Journal of Strength and Conditioning Research,27*(4), 944-953. doi:10.1519/jsc.0b013e318260edad
28. Marques, M. C., & Izquierdo, M. (2014). Kinetic and Kinematic Associations Between Vertical Jump Performance and 10-m Sprint Time. *Journal of Strength and Conditioning Research,28*(8), 2366-2371. doi:10.1519/jsc.0000000000000390
29. Masamoto, N., Larson, R., Gates, T., & Faigenbaum, A. (2003). Acute Effects of Plyometric Exercise on Maximum Squat Performance in Male Athletes. *Journal of Strength and Conditioning Research,17*(1), 68-71. doi:10.1519/00124278-200302000-00011

30. Mcbride, J. M., Nimphius, S., & Erickson, T. M. (2005). The Acute Effects of Heavy-Load Squats And Loaded Countermovement Jumps On Sprint Performance. *Journal of Strength and Conditioning Research,19*(4), 893 897. doi:10.1519/00124278-200511000-00029
31. Mcclenton, L. S., Brown, L. E., Coburn, J. W., & Kersey, R. D. (2008). The Effect of Short-Term VertiMax vs. Depth Jump Training on Vertical Jump Performance. *Journal of Strength and Conditioning Research,22*(2), 321 325. doi:10.1519/jsc.0b013e3181639f8f
32. Mero, A., Komi, P., & Gregor, R. (1992). Biomechanics of Sprint Running. *Sports Medicine,13*(6), 376-392. doi:10.2165/00007256-199213060-00002
33. Morin, J., Edouard, P., & Samozino, P. (2011). Technical Ability of Force Application as a Determinant Factor of Sprint Performance. *Medicine & Science in Sports & Exercise,43*(9), 1680-1688. doi:10.1249/mss.0b013e318216ea37
34. Olympic Games Track & Field Men's 100m. (2016). Retrieved from https://www.olympic.org/rio-2016/athletics/100m-men
35. Olympic Games Track & Field Women's 200m. (2016). Retrieved from https://www.olympic.org/athletics/200m-women
36. Park, P., & Aldous, D. (2016). Does the NFL Combine Really Matter. Retrieved May 26, 2017, from https://www.stat.berkley.edu/~aldous/Research/Ugrad/Paul_Park.pdf
37. Petrakos, G., Morin, J., & Egan, B. (2015). Resisted Sled Sprint Training to Improve Sprint Performance: A Systematic Review. *Sports Medicine,46*(3), 381-400. doi:10.1007/s40279-015-0422-8
38. Phillips, J. H., & Flanagan, S. P. (2015). Effect of Ankle Joint Contact Angle and Ground Contact Time on Depth Jump Performance. *Journal of Strength and Conditioning Research,29*(11), 3143-3148. doi:10.1519/jsc.0000000000000980
39. Puente, C., Abián-Vicén, J., Areces, F., López, R., & Coso, J. D. (2017). Physical and Physiological Demands of Experienced Male Basketball Players During a Competitive Game. *Journal of Strength and Conditioning Research,31*(4), 956-962. doi:10.1519/jsc.0000000000001577
40. Robbins. (2005). Postactivation potentiation and its practical applicability: A brief review. *Journal of Strength and Conditioning Research, 19*(2), 453 8.

41. Scanlan, A. T., Tucker, P. S., & Dalbo, V. J. (2014). A Comparison of Linear Speed, Closed-Skill Agility, and Open-Skill Agility Qualities Between Backcourt and Frontcourt Adult Semiprofessional Male Basketball Players. *Journal of Strength and Conditioning Research,28*(5), 1319 1327. doi:10.1519/jsc.0000000000000276
42. Scully, G. W. (2000). Diminishing Returns and the Limit of Athletic Performance. *Scottish Journal of Political Economy,47*(4), 456-470. doi:10.1111/1467-9485.00173
43. Sleivert, G., & Taingahue, M. (2004). The relationship between maximal jump squat power and sprint acceleration in athletes. *European Journal of Applied Physiology,91*(1), 46-52. doi:10.1007/s00421-003-0941-0
44. Smith, J. P., Kernozek, T. W., Kline, D. E., & Wright, G. A. (2011). Kinematic and Kinetic Variations Among Three Depth Jump Conditions in Male NCAA Division III Athletes. *Journal of Strength and Conditioning Research,25*(1), 94-102. doi:10.1519/jsc.0b013e3181b6041c
45. Taşkin, H. (2008). Evaluating Sprinting Ability, Density of Acceleration, and Speed Dribbling Ability of Professional Soccer Players with Respect to Their Positions. *Journal of Strength and Conditioning Research,22*(5), 1481-1486. doi:10.1519/jsc.0b013e318181fd90
46. Terzis, G., Karampatsos, G., Kyriazis, T., Kavouras, S. A., & Georgiadis, G. (2012). Acute Effects of Countermovement Jumping and Sprinting on Shot Put Performance. *Journal of Strength and Conditioning Research,26*(3), 684 690. doi:10.1519/jsc.0b013e31822a5d15
47. Vanderka, M., Krčmár, M., Longová, K., & Walker, S. (2016). Acute Effects of Loaded Half-Squat Jumps on Sprint Running Speed in Track and Field Athletes and Soccer Players. *Journal of Strength and Conditioning Research,30*(6), 1540-1546. doi:10.1519/jsc.0000000000001259
48. Weyand, P. G., Sternlight, D. B., Bellizzi, M. J., & Wright, S. (2000). Faster Top Running Speeds are Achieved with Greater Ground Forces not more Rapid Leg Movements. *Journal of Applied Physiology*. Retrieved June 6, 2017.

APPENDICES

A. CONSENT TO PARTICIPATE IN RESEARCH STUDY

Consent to Participate in a Research Study

Acute Effects of Depth Jumps on Sprint Performance in Division I Athletes

Why am I being asked to participate in this research?

You are being invited to take part in a research study on the Acute Effects of Depth Jumps on Sprint Performance in NCAA Division I and University Recreational Club Sport Athletes. You are being invited to participate in this research study because you are a Division I/Club Sport athlete. If you take part in this study, you will be one of about 60 people to do so. ***You cannot take part in this study if you are injured, have experienced a lower body injury in the previous three months, are pregnant, or could be pregnant.***

Who is doing the study?

The person in charge of this study is Ryan Bean, a graduate student in the Exercise and Sports Science department at Eastern Kentucky University. There may be other people on the research team assisting at different times during the study.

What is the purpose of the study?

The purpose of this study is to determine if the addition of a depth jumps into a sprint workout can improve the sprint performance of athletes in six weeks.

Where is the study going to take place and how long will it last?

The research procedures will be conducted in the Jack Ison Varsity Weight Room and Roy Kidd Stadium. You will need to come in 14 times during the study. Each visit will take about 25-30 minutes. The total amount of time you will be asked to volunteer for this study is 6-8 hours over the next 8 weeks.

What will I be asked to do?

You are asked to come to the weight room, dressed appropriately for physical activity. Your necessary information will be recorded (first and last name, age, sex, race). The first session will be for baseline testing and to help you become familiar with the testing procedures. During this time, you will be screened for general health and drug/supplement consumption (done by a health history questionnaire). If you have any major health conditions, such as injuries to the lower extremities or pregnancy, you will be excluded from the remainder of the study. You will perform a standardized warm-up (light jogging and stretching) prior to performing three 40-yard sprint tests. The average time of each trial will be recorded. The 40-yard sprints during testing sessions will be recorded via video camera in order to break down sprint speed per ten-yard interval. These recordings will be in no way distributed or viewed outside of this research study.

Your first meeting will involve a sprinting only workout or a workout consisting of depth jumps, you will begin by standing on a box no more than 60 cm, you will proceed to step off the box landing controlled and athletically, then you immediately perform a vertical jump over a hurdle, and sprinting depending on which group you are randomly assigned to. You will then schedule your remaining test session meetings, which will occur at the same time of day and which days of the week. You will be asked to avoid strenuous physical activity 24 hours before each testing session.

Warm up – If you are in the two experimental groups you will perform a warm-up that is deemed significant enough by the strength coach assigned to that sport before taking part in the next portion of the test. Directly after the warm up you will perform 3 sub-maximal 10-yard sprints (one-minute rest period between each repetition).

Depth Jump testing -Group three will start by adjusting a hurdle to mid-thigh height and then performing 2-5 repetitions at the box height programmed for that day. You will be given 1-3 minutes rest between each set. After the final set, you will transition into the sprinting protocol for that particular day.

Sprint testing – Groups two and three will perform the strength coach's warm-up. Each sprint repetition will be performed with maximal effort and you will be given 1-3 minutes rest between each set.

Cool-down – After all of the testing is finished you will go through a brief cool down of static stretching the major muscle groups and foam rolling those muscle groups.

Experimental sessions – Prior to the first testing visit, you will be assigned into one of three groups. Only groups two and three will be the experimental groups. You will be informed prior to the first testing visit which group you will be in. Upon arrival, you will be given your warm-up from the strength and conditioning.

Are there reasons why I should not take part in this study?

Like all maximal exercise performance tests, there could be risks of physical injury. Because the testing involves exercises for the upper and lower portions of the body, it is possible that muscle injuries such as sprains or strains could occur during performnace of the exercises. However, each testing session will be monitored and supervised by a member of the research team with knowledge of muscle injuries and how to manage them should they occur. The researchers will be present to make sure that any risk to you is minimal, and if necessary will stop the testing. All researchers in this study are either certified Strength and Conditioning Coaches or Athletic Trainers.

What are the possible risks and discomforts?

To the best of our knowledge, the physical activity you will be performing has no more risk of harm than you would experience in your everyday sport training and/or conditioning. You may experience the sensation of fatigue or muscle soreness once the test is complete. Although we will have made every effort to minimize this, you may find some questions we ask you (or some procedures we ask you to do) to be upsetting or stressful. If so, we can tell you about some people who may be able to help you with these feelings.

Will I benefit from taking part in this study?

We cannot and do not guarantee that you will receive any benefits from this study.

Do I have to take part in this study?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you chose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

If I don't take part in this study, are there other choices?

If you do not want to be in the study, there are no other choices except to not take part in the study.

What will it cost me to participate?

There are no costs associated with taking part in this study.

Will I receive any payment or rewards for taking part in the study?

There will be no monetary compensation.

Who will see the information I give?

Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about this combined information. You will not be identified in these written materials.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, your name will be kept separate from the information you give, and these two things will be stored in different places under lock and key.

However, there are some circumstances in which we may have to show your information to other people. For example, the law may require us to show your information to a court. Also, we may be required to show information that identifies you to people who need to be sure we have done the research correctly; these would be people from such organizations as Eastern Kentucky University.

Can my taking part in the study end early?

If you decide to take part in the study, you still have the right to decide at any time that you no longer want to participate. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to end your participation in the study. They may do this if you are not able to follow the directions they give you, if they find that your being in the study is more risk than benefit to you.

What happens if I get hurt or sick during the study?

If you believe you are hurt or if you get sick because of something that is done during the study, you should call Ryan Bean at 765-918-7393 immediately. It is important for you to understand that Eastern Kentucky University will not pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. That cost will be your responsibility. Also, Eastern Kentucky University will not pay for any wages you may lose if you are harmed by this study.

Usually, medical costs that result from research-related harm cannot be included as regular medical costs. You should ask your insurer if you have any questions about your insurer's willingness to pay under these circumstances.

What if I have questions?

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, Ryan Bean at 765-918-7393. If you have any questions about your rights as a research volunteer, contact the staff in the Division of Sponsored Programs at Eastern Kentucky University at 859-622-3636. We will give you a copy of this consent form to take with you.

What else do I need to know?

You will be told if any new information is learned which may affect your condition or influence your willingness to continue taking part in this study.

I have thoroughly read this document, understand its contents, have been given an opportunity to have my questions answered, and agree to participate in this research project.

____

Signature of person agreeing to take part in the study

____

Date

____

Printed name of person taking part in the study

____

Name of person providing information to subject