Effect of an 8-Week Combined Strength & Power Training Program on Club Head Speed in Collegiate Golfers

By

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Effects of an 8-Week Combined Strength & Power Training Program on Club Head Speed in Collegiate Golfers

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Abstract

The purpose of the study was to determine whether an 8-week strength and power resistance training program would elicit an increase in club head speed (CHS). In addition to measuring CHS, this study aimed to determine if there were increases in muscular strength and power as a result of the 8-week program. **Procedures:** The participants for this study consisted of 6 male and 6 female NCAA division II collegiate golfers, age ranging from 18-23 years. All participants were experienced golfers and were not competing in a school supported golf season at the time of the study. The participants were separated by gender, then randomly assigned to either the intervention (N=6) or control group (N=6). Pre-test measures were taken to measure CHS, vertical jump height, back squat 1RM, deadlift 1RM, and clean 1RM. The average and peak swing velocities from 3 max effort swings were recorded and analyzed. The participants then proceed to undergo an 8-week resistance training program. The experimental group performed a strength and power resistance training intervention designed to elicit muscular strength and power. The control group performed their normal off-season resistance training program. The participants trained three days a week. The intervention and control group were then tested post-treatment for CHS and VJ height, and 1RM power clean, back squat, and deadlift. **Results:** The average and peak of the control groups' CHS pre-test was 101.4 ±8.25 mph. After the 8-week study, the control group decreased CHS to an average of 97.6 ±3.82 mph. The average of the control groups' VJ pre-test was 19.9 ±6.92 inches with a slight increase to 20.0 ±1.235 inches with a peak VJ pre-test of 26.3±7.2 inches (p=0.024). The average of the control groups' pre-test back squat 1RM was 201.7 ±81.4 lbs. with a slight increase to 209.2 ±13.7 lbs. and was found to be significant p=0.026. The average of the control groups' deadlift 1RM pre-test was 230 ±43.2 lbs. and slightly increased to 244.2 ±14.0 lbs. post-test. However, the deadlift was not significant p=0.138. The average of the control groups' clean 1RM was 99.2 ±33.40 lbs. which increased to 111.5 ±10.9 lbs. post-test (p=0.031). The average of the intervention groups' CHS pre-test was 101.36 ± 7.52 mph which increased to 104.6 ±2.47 mph post-test (p=0.004). The average for the intervention groups' VJ pre-test was 19.05 ±3.78 inches which improved to 21.25 ±1.40 inches post-test (p=0.024). The average back squat 1RM for the intervention group at pre-test was 216.6 ±82.0 lbs. which improved to 254.2 ± 32.36 lbs. post-test, and reported significance p=0.026. The average deadlift 1RM for the intervention group at pre-test was 257.5 ±86.2 lbs. which improved to 289.2 ±16.3 lbs. post-test, and reported no significance of p=0.138. The average clean 1RM for the intervention group pre-test was 117.5 ±43.2 lbs., which improved to 148.8 ±14.6 lbs. post-test, and reported significance of p=0.031. The Pearsons' correlation test reported 1RM back squat was significant (r=0.70, p=0.025), while the VJ trended towards significance (r=0.73, p=0.069). **Conclusion:** The results of this study revealed that an 8-week strength and power resistance training program increased muscular strength and based on a Pearsons' correlation was significantly related to CHS.

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Chapter 1: Introduction

Background

Strength is the maximal force that a muscle or muscle group can generate at a specified velocity (Harman, Johnson & Frykman, 1992). Achieving success in athletics depends on the attainment of a threshold level for maximum strength, power, and speed (Young, Gabbett, Haff, Newton, Watts, Sheppard, 2014). Strength development has been proven to either indirectly or directly improve athletic performance, building the foundation for all other athletic qualities (Siff, 2003). Training for strength gains elicits several physiological adaptations that contribute to increased athletic performance. The aforementioned adaptations include an increase in: muscle fiber size, muscular strength, maximal rate of force production, anaerobic power, and fat free mass (Baechle & Earle, 2008). These adaptations help athletes obtain other critical elements specific to any and all athletic movements such as flexibility, balance, coordination, and the ability for an athlete to produce force (Smith, Callister, Lubans, 2011).

Power is defined as the product of force on an object and the object's velocity in the direction in which the force is exerted (Baechle & Earle, 2008). When it comes to power, force is the product of mass and acceleration (Baechle & Earle, 2008). Athletes involved in ball striking are likely to benefit with increased power and force output (Carvahlo, Mourao, & Abade, 2014). Considering golf consists solely of ball striking, power becomes a very applicable attribute for a golfer to possess in order to maximize driving distance and increase performance. Maximal swing speed has been shown to be directly proportional to the distance a golf ball will travel, and is influenced by the body's ability to produce force to the ball (Thompson, Cobb, Blackwell, 2007).

Strength and power training serves many advantages athletes can apply towards their sport. Exercise selections are based off of various types of resistance exercises, the movement and muscular requirements of the sport, and the athlete's ability to perform the movements with safe and proper technique (Garhammer, 1986). Although there are several resistance training exercises suitable for strength development, the focus should be on primary muscle groups based on relative importance to the athlete's sport (Baechle & Earle, 2008). The more similar training is to the actual sports movement, the greater the likelihood that there will be a positive transfer to said sport (Garhammer, 1986). This concept is commonly referred to as the specific adaptation to imposed demands (SAID) principle (Baechle & Earle, 2008).

Golf is classified as an intermittent sport that combines moderate paced walking, standing in a golf posture, and ball striking (Smith, Callister, Lubans, 2011). Golf was previously considered a sport of technique and strategy rather than physical fitness (Hetu & Christie, 1998). However, recent research has shown that strength, power, and flexibility training can increase club head speed (Doan, Newton, Kwon, & Kraemer, 2006). Golf specific exercises activate the muscles used in golf with comparable patterns of motor coordination between agonist, antagonist, and synergist muscles. Golf specific exercises include movement patterns that simulate the golf swing, often by accommodating resistance with medicine balls, exercise bands, and free weights. The medicine ball golfer swing, is an exercise done which requires one to hold a medicine ball while mimicking the golf swing at a slow controlled pace, thus making this movement golf specific and a common exercise used by golfers. By addressing sports specific needs such as the golf swing, golfers have the potential to improve their overall performance by increasing drive distance (Smith et al., 2011).

The full golf swing refers to the movement required to drive the ball, and is the primary movement involved with all golf swings (Maddalozzo, 1987). The primary objective for a golfer executing a full golf swing is to produce maximum distance, accuracy, control, and consistency, by utilizing varied clubs with club head speed. All movements of the body during the full golf swing must be made in sequence, and at a pace which allows the golf club to be swung in a path that produces on-center hits and maximum club head speed (Maddalozzo, 1987). Club head speed is strongly correlated ($r = 0.95$) with golf handicap, with improved club head speed predominantly benefiting performance through an improved driving distance (Read, Miller, & Turner, 2013). Recent research in strength and conditioning has shown that higher muscular strength and power outputs result in higher club head speed (Read et. al., 2014).

The ability to achieve high movement velocities requires skillful force application across a range of power outputs and muscle action (Baechle & Earle, 2008). The golf swing for example, is a high velocity movement requiring the muscles in use to contract at high rate (Teu, Kim, Fuss, & Tan, 2006). This study aims to implement training methods that will elicit strength and power production, with the purpose of ultimately increasing club head speed. Power exercises should be done at the start of a training session due to the fact they require the highest level of skill and concentration and are most affected by fatigue (Fleck & Kramer, 2003). This makes it critical to program power movements appropriately within an athlete's training. The proposed study will prescribe power movements at the beginning of specific resistance training sessions to ensure the athlete is able to perform each exercises with maximal effort. Athletes who perform power movements while fatigued are prone to using poor technique as well as increase their risk of injury (Fleck & Kramer, 2003).

Among elite and professional golfers resistance training is a common practice in their training, not only to maintain performance, but to increases club head speed as well (Smith, Callister, Lubans, 2011). Professional golfers are able to rotate faster in their swing thus generating club head speed, a factor which is vital in obtaining maximum drive distance (Fletcher & Hartwell, 2004). When planning a strength program for golf, the objectives should be designed to improve the golfer's muscular strength and power. A well designed strength program will improve a golfer's potential to increase his or her performance by increasing their ability to drive the ball further, and decrease their risk of injury (Maddalozzo, 1987).

Statement of Problem

In this experimental study the club head speed of collegiate golfers was examined. This study analyzed the effect of an 8-week strength and power training program on maximal effort club head swing speed using a driver.

Purpose

The purpose of the study was to determine the effect that specific strength and power resistance training had on club head speed in collegiate golfers.

Hypothesis

The participants, following an 8-week strength and power resistance training program, would have an increase in club head swing speed. Additionally, the specific 8-week strength and power resistance training program would cause an increase in muscular strength and power.

Research Questions

RQ 1: Does an 8-week strength and power resistance training program elicit an increase in club head speed?

RQ 2: Does an 8-week strength and power resistance training program elicit an increase in strength and power measurement testing?

RQ 3: Does an increase in strength elicit an increase in club head speed?

RQ 4: Does an increase in power elicit an increase in club head speed?

Delimitations

One of the delimitations for this study is the specific training modalities designed to elicit strength and power development. The primary emphasis was to train for muscular strength and power only and not endurance or muscular hypertrophy. This study adhered to a strict training protocol performed three times per week. Another delimitation is that the study only tested amateur collegiate Division II male and female golfers with 3 to 4 years of high school golf experience and 1 year of collegiate golf and strength training experience. Additionally, this study measured club head speed using the Batmaxx 500 to determine if there is an effect from an 8-week strength and power resistance training program in collegiate male and female golfers. This study measured strength using a 1RM protocol in the squat, deadlift, and clean. This study measured power using the "Just Jump!" recording vertical jump height. This study was performed at altitude. This study was performed during the ASU golf team's off-season.

Limitations

Limitations to the study include the participant's effort given during each training and testing session. Participants were encouraged to give maximal effort throughout this study. Other limitaitons include the accuracy of the Batmaxx 500 for measuring velocity of the golf club head, the limited population size due to the total number of ASU golfers (6 men and 6 women), and the accuracy of the "Just Jump" mat for measuring power. The study was also constrained to the accuracy of the equipment and its ability to measure club head speed. The ASU golfers were not playing golf during the course of this study. However, they still participated in golf tournaments under their own admission. The number of golf rounds performed during the current study, approximently 1 round per week, is far less than the amount normally played by the subjects, which is approximently 4 rounds per week. The 1 RM strength measures of this study only targeted muscles groups specific to golf performance, and this specific training program.

Assumptions

It was assumed that the participants would follow the training program strictly. It was also assumed that all participants would give maximal effort in all testing procedures and training sessions. It was assumed that the participants used in this study would respond positively and have an increase in club head speed following a specific 8-week strength and power training program intervention. It was assumed that due to the nature of the training program, the program would elicit neuromuscular changes that would improve the club head speed of golfers. It was also assumed that an increase in club head speed is a result of training and not a result of playing golf.

Definition of Terms

Balance: The ability to maintain a stable center of gravity from which locomotion in the erect bipedal position may be performed or continue.

Coordination: The ability to perform smooth efficient movement patterns during a physical activity.

Countermovement jumps (CMJ): Starting from an upright standing position, make a preliminary downward movement by flexing at the knees and hips, then immediately and forcefully extend the knees and hips again to jump vertically up off the ground.

Intensity (Explosive, Moderate, Heavy):

Explosive Intensity- Movements in which the rate of force development is maximum or near maximum for any given type of muscle action.

Moderate Intensity- Requires a moderate amount of effort and noticeably accelerates the heart rate.

Heavy Intensity- Requires heavy resistance loads that may be moved at slower speeds requiring maximum strength.

Motor Unit: A motor neuron and all of the muscle fibers that are innervated by that motor neuron.

Motor Unit Recruitment: The stimulation of a motor neuron and its associated muscle fibers in order to generate muscular force for some sort of locomotion.

Muscle Fibers:

Type I- The motor neuron size is relatively small, nerve conduction velocity is relatively slow, contraction speed is relatively slow, relaxation speed is relatively slow, fatigue resistance is relatively high, force production is relatively low, power output is relatively low, endurance is relatively high, aerobic enzyme content is relatively high, anaerobic enzyme content is relatively low, capillary density is relatively high, mitochondria density and size is relatively high/large, fiber diameter is relatively small, and color is red (Baechle & Earle, 2008).

Type IIa- The motor neuron size is relatively large, nerve conduction velocity is relatively fast, contraction speed is relatively fast, relaxation speed is relatively fast, fatigue resistance is intermediate, force production is intermediate, power output is intermediate, endurance is intermediate, aerobic enzyme content is intermediate, anaerobic enzyme content is relatively high, capillary density is intermediate, mitochondria density and size is intermediate, fiber diameter is intermediate, and color is white/red (Baechle & Earle, 2008).

Type IIx- The motor neuron size is relatively large, nerve conduction velocity is fastest, contraction speed is fastest, relaxation speed is fastest, fatigue resistance is relatively low, force production is highest, power output is highest, endurance is relatively low, aerobic enzyme content is relatively low, anaerobic enzyme content is highest, capillary density is relatively low, mitochondria density and size is relatively low/small, fiber diameter is largest, and color is white (Baechle & Earle, 2008).

Power: The rate of doing work, measured as the product of force and velocity.

Skill acquisition: To gain or refine sport or movement pattern skill.

Specificity: A training type that is selected in order to elicit precise gains to that body system.

Speed: For this study speed is considered similar to velocity, meaning it is the rate of change in location or distance the club head and body segments take to travel in a given amount of time.

Strength: Maximum voluntary force generating capacity of a muscle or group of muscles.

Strength Training: Training that attempts to elicit increased maximum muscular force capability. Generally incorporates 2-6 sets, of ≤6 repetitions, ≥ 85% 1 Repetition Maximum, 2-4 minutes rest between sets, 2-4 times per week on non-consecutive days (Baechle & Earle, 2008).

Chapter 2: Review of Literature

Different sports and people of all skill levels use strength training as a process to elevate athletic performance (Lambeth, Hale, Knight, Boyd, Luczak, 2013). Research has identified the complexity of the golf swing motion and the necessary activation of large muscles in the body to successfully complete the golf swing motion (Lambeth et al., 2013). There are many training modalities one can select from when compiling a resistance training program specific to improving golf performance. Researchers have studied characteristics of highly skilled golfers, and determined that golfers with the most strength, flexibility, range of motion, and balance possessed higher skill levels (Lephart, Smoliga, Myers, Sell & Yung-Shen, 2007). Doan et al. (2006) discovered strength, power, and flexibility training can increase club head speed and driving distance. A comprehensive literature review was needed to determine the effects of strength and power training on club head speed.

Anatomy of golf swing

Increased popularity of golf has led to more multidimensional approaches to improve performance (Smith et al., 2011). Strength and conditioning has been identified as an optimal component of a multidimensional approach to increased golf performance (Smith et al., 2011). The golf swing consists of three full phases. A basic understanding of each phase of the golf swing and the primary muscles used to achieve this movement is a critical component when designing a strength and power program for increased club head speed. The full golf swing refers to the movement required to drive the ball, and is the primary movement in which all golf swings are based (Maddalozzo, 1987). The first phase is termed the preparation phase and entails the grip, posture, stance, and ball position. The primary purpose of the grip is to insure that the hands and wrist work together in order to transfer the force generated by the body and leg action during the swing to the ball (Maddalozzo, 1987). The posture and alignment the golfer assumes when addressing the ball directly affects the plane of swing, and the club head pathway (Maddalozzo, 1987). The second phase consists of both a backswing and downswing, termed the execution phase. The purpose of the backswing is to establish a perfectly balanced, powerful position at the top of the swing (Maddalozzo, 1987). The downswing is initiated by the rotation of the hips. At this point the golfer must lengthen the lever arm, which results in an increased acceleration of the club head (Maddalozzo, 1987). Phase three, the recovery phase, incorporates the follow-through after maximum effort has been attained (Maddalozzo, 1987). See Figure 1 (Appendix A) for an illustration of the full golf swing.

Three main factors that affect club head speed are: muscular force applied through the limb segments, the distance over which the force acts, and the segmental sequence which contributes to the final velocity (Fletcher & Hartwell, 2004). When striking a golf ball, one leads with the hips, trunk, and then shoulders; the movement follows under the summation of speed principle and therefore greater torque is applied to the club through the eccentric/concentric sequence of spinal rotation (Fletcher & Hartwell, 2004).This allows for an ordered sequence of body segments involved and is a pattern of movement that produces high speed at the most distal end of a kinematic chain (Neal, Lumsden, Holland & Mason, 2007). The sequential order of a maximal speed golf swing begins with the large, strong, proximal muscles followed by the smaller, weaker, distal muscles (Neal et al., 2007). For example in golf , the extension of the legs, rotations of the torso and various extension and rotations of the joints of the upper limb lead to high club speeds when ball contact is made (Neal et al., 2007).

Muscles involved

The anatomical analysis of the golf swing reveals the major muscles involved during each phase of the golf swing (refer to Figure 1). During the preparation phase major muscles used include: deltoids, rectus abdominus, palmaris longus, abductor pollicis brevis, and flexor pollics brevis (Maddalozzo, 1987). The execution phase requires action from these major muscles: biceps, extensor carpi ulnaris, flexor carpi ulnaris, posterior deltoid, latissmius dorsi, triceps, external oblique, rectus abdominus, quadriceps, gastrocnemius, soleus, teres minor, teres major, and gluteus maximus (Maddalozzo, 1987). The recovery phase prompts action from the same muscles used during the execution phase in addition to the trapezius and hamstrings (Maddalozzo, 1987). Therefore, training muscles specific to the full golf swing would be expected to enhance golf performance.

Strength Training

Several studies have reported that strength, flexibility, and range of motion are directly related to club head speed and drive distance, which is thought to result in increased performance (Lambeth et al., 2013). Maximizing drive distance results in a shorter distance to the hole, which allows for shorter and potentially easier shots; thus, increasing the opportunity for fewer strokes per hole and an overall lower score. A proper golf swing requires a combination of flexibility, muscular strength and balance (Thompson, Cobb, Blackwell, 2007). Muscular strength, balance, and flexibility are all adaptations that are acquired through proper strength training (Baechle & Earle, 2008). This indicates that strength training is an ideal method in training for the full golf swing. Using strength training to address requirements for a mechanically sound golf swing will elicit these aforementioned adaptations, resulting in a more efficient golf swing potentially increasing club head speed and drive distance. In the case of a golfer, a significant measure of performance would be increased drive distance.

Measures of Strength

Resistance training is often prescribed based on percentage of a participant's maximum muscular strength (Materko & Santos, 2009). The best method for assessing lifting strength is by measuring the 1-repetition maximum (1RM) capacity test (Materko & Santos, 2009). A 1RM is the maximal amount of resistance that can be moved through the entire range of motion for a given exercise using a specific modality such as free weights (Carpinelli, 2011). When selecting exercises for 1RM testing, primary exercises should be performed because the large muscle groups and multiple joints are better able to handle the heavy loads (Baechle & Earle, 2008). These lifts would include the back squat, deadlift, and power clean. The NSCA recommends these lifts because they have been shown to be the most efficient lifts for developing lower body and core strength and power (Baechle & Earle, 2008). These large muscle groups are also the primary muscles used in golf performance. Many resistance training experts have claimed that it is important to know the 1RM so that a given percent of the 1RM can be used in a training study to maximize chronic adaptations, such as an increase in muscular strength (Carpinelli, 2011). The American College of Sports Medicine (ACSM) claimed that specific percentages of the 1RM produced strength gains for trainees with varying resistance training experience from novice to trained athletes (Carpinelli, 2001). 1RM testing is an adequate measure of strength in addition to supplying useful data for determining specific percentages for exercises in strength and power training programs.

Volume

Training for strength gains requires a systematic approach based off a specific selection of exercises, repetition ranges, volume, intensity, and rest intervals. The selection of volume refers to the number of sets and repetitions, while rest intervals refers to inter-set resting periods. Berger (1963) determined that three sets of six repetitions created maximal strength gains in the squat and bench, making the ideal selection for strength training ≤ 6 repetitions (Baechle & Earle, 2008). The use of appropriate exercise intensities and rest intervals allows for the "selection" of specific energy systems during training and results in more efficient and productive regimens for specific athletic events with various metabolic demands (Baechle & Earle, 2008). When performing strength training the primary energy system required is anaerobic in nature making phosphagen and glycolysis the main energy systems (Baechle & Earle, 2008). The golf swing is an anaerobic movement, and is the movement being analyzed for the proposed study. Although golf does require light aerobic capacity work from walking the course, the proposed study will not be training this energy system. When training for strength and power combining resistance and aerobic endurance training may interfere with strength and power gains primarily if the aerobic endurance is trained at a high volume (Baechle & Earle, 2008). However, in contrast no adverse effects on aerobic power are shown resulting from heavy resistance training (Baechle & Earle, 2008).

Rest Periods

Training for strength loads performed at maximal to near maximal intensities will require a rest period that will allow for adequate recovery time (Kramer & Koziris, 1992). Robinson, Stone, Johnson, Penland, Warren & Lewis (1995) observed that in the back squat exercise, 3 minutes of rest resulted in greater strength gains versus a 30 second rest period. The selection of rest is a critical factor in obtaining ultimate gains from strength training. Implementing longer resting periods will ensure optimal strength gains, by allowing full recovery for a golf specific strength program, which in turn will aim to increase club head speed. The common outlined rest periods for strength and power training falls into a range of 2-5 minutes, however the length of rest is dependent on the intensity of the exercise being performed (Baechle & Earle, 2008). Exercises performed at a near maximum effort will require longer rest periods closer to 5 minutes, whereas exercises performed at submaximal efforts can prescribe rest periods of 4, 3, or even 2 minutes. The current study implemented rest periods based on submaximal efforts allowing 2 minutes rest for the primary exercises in order to elicit strength and power gains (Baechle & Earle, 2008).

Adaptations from Strength Training

Strength training will activate the firing of more motor units during high intensity physical activity (Baechle & Earle, 2008). Since the golf swing is a rapid fire motion, which prompts the muscles in use to contract at a high rate, it is the aim of this study to acquire this adaptation through strength training in order to increase club head speed. There is a positive relationship between the amount of force produced and the rate of motor unit firing (Allen & Boxhorn, 1988). Force is needed to accelerate mass at a greater rate, which relates to a golfers need to accelerate the club head in order to achieve maximal speed throughout the swing. Evidence shows that anaerobic training can enhance the firing rates of recruited motor units (Adem, Jossan, D'Argy, Gillberg, Nordberg, Windbad, & Sara, 1989). In addition, ballistic muscle contractions are especially critical to increase the rate of force development (Adem et al., 1989). This is a crucial factor, considering the second and third phases of the golf swing incorporate ballistic muscle contractions. Neural control affects the maximal output of a muscle by determining how many motor units are involved in a muscle contraction and the rate at which motor units are fired. Muscle force is greater when more motor units are involved in the contraction, the size of the motor unit is increased, and the rate of firing is faster (Baechle & Earle, 2008). Maximal strength and power improvements generally occur from an increase in the recruitment of high threshold motor units (Baechle & Earle, 2008). These adaptions are achieved by selecting specific exercises, volume and intensities in order to elicit improvements in maximal strength and power. Therefore, the current study targeted high threshold motor units by utilizing higher intensities and large muscle multi-joint movements as outlined by the National Strength and Conditioning Association (NSCA) (Baechle & Earle, 2008).

Balance

Golfers require balance during all phases of the golf swing making balance acquired through strength training extremely beneficial. Static balance is best defined as the ability to maintain a position without moving for a period of time (Baechle & Earle, 2008). Balance is critical for any golfer to possess when performing nontraditional movements that occur during competition and training, such as the sequential motion of the full golf swing. Dynamic balance, which is acquired from performing sport specific loaded movements with strict posture and technique, would theoretically improve dynamic balance during a full golf swing (Baechle & Earle, 2008). Improved static and dynamic balance from a strength training program should result in smooth full swings (Maddalozzo, 1987).

Flexibility

The golf swing requires not only balance and muscular strength, but flexibility in order to successfully complete all three phases of the full golf swing (Thompson, Cobb & Blackwell, 2007). The degree of movement that occurs at a joint is referred to as range of motion (ROM). The ROM of a particular joint is determined by connective tissue structure, and the activity being performed (Baechle & Earle, 2008). ROM is specific to each joint's anatomy and the movement required at the joint (Baechle & Earle, 2008). Flexibility is a measure of ROM and has both static and dynamic components (Baechle & Earle, 2008). Static flexibility is the range of possible movement about a joint and its surrounding muscles during a passive movement (Baechle & Earle, 2008). Dynamic flexibility refers to the available ROM during active movements and therefore requires voluntary muscular contractions (Baechle & Earle, 2008). Dynamic flexibility is important for a golfer to possess in order to maintain a fluid consistent motion during all three phases of the full golf swing (Maddalozzo, 1987).

Strength Training and its Effects on Club Head Speed

A study by Lambeth et al. (2013) was designed to determine the effects of a combined strength and functional training program on golf performance. Golf performance was determined by measuring club head speed. Participants were enrolled in the Professional Golf Management program at Mississippi State University and reported playing golf a minimum of four days per week. A total of 10 participants took part in this study. Participants were randomly placed in either a control group or experimental group on the initial day of assessment. No participants reported having participated in any resistance training 8-weeks prior to the study. The experimental group began each session with a dynamic warm up consisting of movements designed to elevate the heart rate. All participants in the experimental group were instructed to complete between two and four sets and between six and twelve repetitions for each exercise depending on the weekly program. The prescribed strength program consisted of lower body, upper body, and full body exercises. The lower body exercises included: back hyperextensions, leg press, leg curl, reverse lunge, Bulgarian lunge, walking lunge, dumbbell forward lunge, and Smith squat. The upper body exercises included: bench press, dumbbell row, shoulder complex, dumbbell incline press, lat pull-down, double curls, dumbbell bench, dumbbell curl to press, and horizontal pull-ups. Total body exercises consisted of standing cable twist, and cable wood chop. The purposed study will incorporate variations of exercises seen in Lamberth et al.'s (2013) study, as well as following similar movement patterns specific to the golf swing. Golf performance was assessed using the VectorPro 200 system to measure club head speed. The VectorPro 200 system is used to measure speed and is similar to the BatMaxx 500 which will be used to measure club head speed in the proposed study. The control group was only pre and post tested during the same weeks on golf performance. The control group was instructed to take three practice swings followed by one max effort swing where driver swing speed was measured. This measure was retested at the end of the six week study. The experimental group, after following the six week resistance training program, was able to increase swing speed from 48.90$\pm$ 1.48 m/s to 50.87$\pm$ 3.62 m/s compared to the control group 48.91$\pm$1.52 m/s to 46.31$\pm$ 0.67 m/s. It is evident that a six week strength training program on golf performance increases club head speed (Lamberth et al., 2013).

A study by Kim (2010) examined the effects of core muscle strength training on flexibility, muscular strength and drive shot performance in female professional golfers. A total of 17 participants completed the study. The participants were divided into a control group and an experimental group. The experimental group followed a 12-week combined core muscle strengthening program evaluating flexibility, maximal strength gains, and driver shot performance. The control group did not participate in any form of resistance training. In this study drive shot performance was measured by club head speed. Flexibility was determined by forward and backward flexion of the spine using a sit and reach apparatus. Maximum strength was measured by one repetition max effort (1RM) of the back extension and back squat. Drive shot performance was analyzed for club head speed and carry distance using Swing Dynamics Launch Monitor and evaluated by experienced technicians. The strength portion of this study included the following exercises: tubing dead lift, tubing squat, incline crunch, back extension, leg raise, hip abduction, body twist, kneeling rollout, and medicine ball rotation. The tubing in this section refers to elastic bands of increasing tension. In weeks 1-4 all movements required three sets of twelve repetitions. In weeks 5-8 the volume was increased to three sets of thirteen repetitions as well as increasing the tension of tubing. A final increase of volume occurred during weeks 9-12 up to three sets of fourteen repetitions, tension was also increased. The second part of the strength portion of the study included the following exercises: deadlift, squat, incline crunch, hyper extension, body turning, tubing hip abduction, cable crunch kneeling rollout, and medicine ball swing. The deadlift, squat and medicine ball swing used during the second phase of the Kim (2010) study are a few exercises that will also be prescribed in the proposed research study, as they are hypothesized to elicit strength and power development. Exercises such as the medicine ball swing will also be used in the exercise program of the proposed study. In weeks 1-4 all resistance lifts consisted of three sets of twelve repetitions at 60% of 1RM. In weeks 5-8 the volume increased to three sets of thirteen repetitions at 65% of 1RM, and in weeks 9-12 volume was increased yet again to three sets of fourteen repetitions at 70% of 1RM. The control group did not participate in any core strengthening training. The club head speed of both the control and experimental groups was analyzed at the start and finish of the 12-week study. There was a significant increase in club head speed and carry distance after 12 weeks of core strengthening complex training in the experimental group. The club head speed of the experimental group increased from 38.77 meters/second to 40.12 meters/second. The control group decreased from 39.33 meters/second to 38.56 meters/second, a non-significant decrease of 0.77 meters/second. The carry distance increased by 9 yards in the experimental group. The control group was only able to increase carry distance by an insignificant 1 yard. The author of the 12-week study (Kim, 2010) concluded flexibility and core muscle strengthening exercises helped enhance flexibility of the core region, as well as muscular strength of the lower back and lower limbs. These adaptations in turn appeared to enable an increase in driver performance and club head speed in the experimental group. Similar exercises were used in the current study.

A systematic review of strength and conditioning programs designed to improve fitness characteristics in golfer was compiled by Smith, Callister, & Lubans (2011). This review was conducted in three stages. The first stage consisted of an online database search which included or excluded articles based off of title and abstract. The second stage took the relevance of each study into consideration. Reference list for the full-text articles were checked for additional articles prior to the final stage. The final stage involved all three authors independently assessing eligibility of the studies based off of the following criteria: all participants were golfers, included an evaluation of strength and conditioning, study design was experimental, and included baseline and post-intervention assessments. A formal quality score for each study was completed on an 8-point scale. The following questions were used to assess the quality of each study: 1) did the study include a non-training group? 2) Were participants randomly collected? 3) Were the groups comparable on measures at baseline? 4) Did the authors report an indicator of reliability for study assessment techniques ($r > 0.70$)? 5) Was the program adequately described in the methods section? 6) Did the authors report a power calculations to detect hypothesized changed? 7) Was the study adequately powered to detect changes in outcomes? 8) Did the study report effect size? Low quality studies received less than 2 points, medium-quality studies received 3-5 points, and high-quality studies received 6-8 points.

In these reviewed studies, participants were predominately male recreational golfers ranging in age (20-79 years). The duration of the strength and conditioning programs ranged from 5 to 11 weeks. Each program included resistance training, flexibility training, or both. The majority of programs implemented generic resistance and flexibility training exercises using machine weights, free weights, bar-bells, and static stretching. The studies of this review used some sort of periodization that manipulated the volume and resistance in an increasing manner. The current study also aims to periodize the volume and intensity by increasing intensity while prescribing appropriate volume based off empirical evidence. Figure 2 (Appendix B) outlines a common periodization model for resistance training (Baechle & Earle, 2008). Several studies discussed measured club head speed as an indication of improved golf performance. The majority of the studies reported significant increases in CHS ranging from 1.5% to 9.5% (Doan, Newton, Kwon, Kramer, 2006; Fletcher & Hartwell, 2004; Hetu, Christie, & Faigenbaum, 1998; Lephart, Smoliga, Thompson, Cobb & Blackwell, 2007; Thompson & Osness, 2004; Westcott, Dolan, Cavicchi, 1996). All studies that assessed strength did so by administering one or ten repetition maximum tests on various resistance training exercises, such as squat and bench. All of the following studies reported increases in muscular strength in addition to an increase in golf performance (Doan et al., 2006, Hetu et al., 1998, Lephart et al., 2007, Thompson, Cobb, & Blackwell, 2007; Westcott, Dolan & Cavicchi, 1996). Logically, strength training when designed to increase club head speed will elicit an increase in golf performance and strength.

Golf is played by people of all ages, abilities, and physical fitness levels (Lamberth et. al., 2014). With rising popularity there has been a parallel interest in studying factors associated with improving golf performance (Lamberth et. al., 2014). This can then be associated by golfers of all age and skill levels. A study by Thompson, Cobb & Blackwell (2007) found that an 8-week progressive functional strength training program increased club head speed in older golfers ranging in age from 50-60 years old. Participants for this study were members of a private golf club and reported playing a minimum of 40 rounds of golf per year. Eighteen total golfers participated in this study and were randomly placed into either a training group (N=11) or a control group (N=7). Club head speed was measured on a SwingMate radar measuring device for both the control group and experimental group pre and post treatment. The participants were allowed to warm up until they felt comfortable taking practice swings with their driver. Next all participants were instructed to hit 5 balls by taking full golf swings. The highest swing speed for each participant was used in data analysis. The experimental group participated in an 8-week progressive functional training program modeled from the National Academy of Sports Medicine's Optimum Performance Training Model (Clark & Corn, 2001). The first phase of the model focused on spinal stabilization and development of neuromuscular control during functional movements. The second phase had a primary goal of developing muscular strength. The third and final phase emphasized speed and muscular power development. The participants were required to attend three 90-minute training sessions per week for 8 consecutive weeks led by the lead researcher. Each session began with a 5-minute warm up session designed to increase blood flow. Throughout the program the exercises were systematically progressed to accommodate improvements in exercise performance. Exercises for the lower body included: back hyperextensions, leg press, back squat, walking lunges, split squat, and leg curl. Exercises for the upper body included: bench press, dumbbell row, lat pull-down, inverted row, shoulder complex, and dumbbell curls. Total body exercises incorporated movements in the transverse plan of motion to better mimic the golf swing and included: standing cable twist, and cable wood chops. The exercise selection for this study not only complements strength gains but also incorporates golf specific needs by addressing movement patterns specifically geared towards the full golf swing. The control group did not participate in any functional training program and were instructed to go about their regular routine outside of the study. Club head speed for the experimental group was increased by 4.9% from 127.3 km/h pre-test to 133.6 km/h post-test. The control group decreased by 1.0% in club head speed falling from a pre-test score of 134.5 km/h to 133.3 km/h. Strength for the experimental group was measured by an arm curl test. The experimental group, using the same resistance as the pre-test, increased from 16.1 $\pm$ 6.0 repetitions to a post-test score of 18.0 $\pm$ 6.7 repetitions. The control group decreased from a pre-test score of 15.8 $\pm$ 5.7 to 15.3 $\pm$ 6.0 post-test. While the age range is significantly older (Thompson, Cobb & Blackwell 2007) compared to the target age of the proposed study, a properly executed golf swing by a proficient golfer follows the same movement pattern and does not differ with age. Strength adaptations will still occur in older populations, and can be an appropriate comparison to studies that target younger golfers (Baechle & Earle, 2008). The current study aimed to mimic the procedures with a goal of also eliciting an increase in club head speed using a strength training program and similar exercises.

A study by Westcott et al. (1996) examined the effects of an 8-week generic strength and flexibility program on club head speed, strength, and range of motion. Seventeen male golfers between 16 and 28 years old were selected for this study. A quasi-experimental design was used for this study, randomly dividing all participants into two groups, intervention group (INT) and comparison group (COM). Club head speed was measured using the Swing Mate by Beltronics, strength was measured based off a 10-RM of the bench press, and range of motion of the hip flexor was evaluated using an electric goniometer. The INT performed an 8-week generic strength and flexibility program. Fifteen exercises were performed using either machine or free weights and a stretch mate apparatus. The strength exercises included leg extensions, leg curls, leg presses, machine flys, bench press, pullovers, lateral raises, bicep curls, tricep extensions, low back extension, abdominal crunch, neck flexion, neck extension, chins, and dips. Although the exercise selection differs from the proposed study, the muscles being targeted are similar, and are specifically selected to aid in a more efficient golf swing. Each training session the participants completed 2 sets of each exercises using a weight load that permitted 6-8 repetitions, taking approximately 30 minutes to complete. The COM only performed pre and post treatment measures of club head speed, strength, and range of motion. After the eight week intervention, the INT showed significant increases in strength yielding a +56% increase, range of motion of hip flexion increased by +22%, and hip extension increased by +43%, and a 6.0% increase in club head speed from 94.3 mph to 99.8 mph. The control group showed no change in club head speed posting a 93.2 mph pre-test score compared to 93.0 mph post-test score. Hip flexion increased slightly by +4% and hip extension increased by +16%. Although the control group increased in flexion and extension of the hip, it was far less significant than the percent increases produced by the INT group. Muscular strength was not assessed in the control participants for this study. There were no negative effects on the golf swing reported during this study.

A study by Hetu & Christie (1998) examined the effects of an 8-week strength and flexibility program measuring club head speed, strength, and range of motion. A total of seventeen participants were used for this study, 12 male and 5 female recreational golfers (mean age=31 $\pm$6.7 years). A one group pre and post-test design was used for this study. There was no control group assigned to this study. All participants participated in a twice-per week program consisting of strength training, flexibility, and plyometric exercises. Measures for strength were measured using a 1-RM protocol in the bench press. Range of motion was measured using a sit and reach test protocol as well as a total body rotational test. Ten total exercises were performed using either machine or free weights. The exercises used for this study were as follows: back squat, leg curl, bench press, dumbbell curl, hyperextension, walking lunge, reverse lunge, lat pull-down, seated row, and wood chop. The exercises selected for this study were chosen to accommodate strength gains, while targeting muscles involved in the golf swing. This same concept will be assimilated into the proposed study. Analysis of the pre and post-test scores showed that strength training was associated with significant increases in muscular strength. Muscular strength training increased 1RM bench press from a pre-test mean score of 44.8kg to 51.2kg, yielding a 14.2% increase. The sit and reach flexibility test increased from a pre-test mean score of 25.0cm to a post-test mean score of 34.7cm, yielding a 38.8% increase. Finally club head speed increased 6.3% from baseline to post-test. Because there was no control group for this study, the data suggest strength training may be a worthwhile activity for golfers (Hetu & Christie, 1998).

Power Training

When training for power there are two types of movements performed, "power with high speed, and power with low speed"; both variables reflect the ability to produce force at a given speed (Baechle & Earle, 2008). Performing power at low speed would be applicable to a football lineman pushing against the force and bodyweight of their opponent. Power at high speeds is best suited for badminton and golf athletes whose muscles quickly reach high velocity as a result of the minimal inertial resistance of the lightweight racket/club and the athlete's arm. Therefore, the ability to exert force and power at high speed is critical to making rapid adjustments in a stroke such as the sequential motion of the full golf swing (Baechle & Earle, 2008). Eliciting force and power production for a golf athlete increases their ability to exert more force through the ball and elevates the chance to increase club head speed, and therefore allows for maximal drive distance (Doan, Newton, Kwon, & Kraemer, 2006).

The recommended volume, according to the National Strength and Condition Association (NSCA), for power exercises is three to five sets for a trained athlete (Baechle & Earle, 2008). Volume assignments for power training are typically lower than those for strength training in order to increase the quality of the exercise, resulting in fewer goal repetitions and lighter loads (Baechle & Earle, 2008). Depending on the type of power exercise and level of intensity, repetition selection in power movements depends on the total number of desired attempts at a specific load. Goal repetitions for "power single-effort movements" have a range of 1-2, while "power multiple-effort movements" fall into a 3-5 repetition range (Fleck & Kramer, 2003). When assigning rest period lengths for training muscular power, a period of 2-5 minutes is desired. This is equal to the recommended rest periods for strength training (Baechle & Earle, 2008). The volume for the current study followed the desired volume and rest periods aforementioned in an 8-week strength and power program (Figure 2, Appendix B), with the aim to increase club head speed in collegiate golfers.

Power exercises are only one part of an athlete's overall training program. Plyometric exercises are one modality that has proven to be beneficial in power development (Baechle & Earle, 2008). However, rate of force development exercises such as Olympic lifting movements and weighted jumps, result in significant power increases (Baechle & Earle, 2008). The action of the golf drive can be classified as a rapid sequential movement that culminates in an impact with the ball utilizing the highest possible force in the shortest amount of time (Fletcher & Hartwell 2004). Thus power training has a tremendous influence on golf performance.

The assessment of power can be carried out using a vertical jump test (de Blas, Padulles, Amo & Guerra-Balic, 2012). The vertical jump has been traditionally used to evaluate physical fitness as well as mechanical power (de Blas et. al, 2012). Muscle power can be assessed from the recorded performance of various rapid movements such as: the length or height of various jumps, maximum running and throwing velocity, and time to complete rapid movements (Markovic & Jaric, 2007). Maximum vertical jump testing has been routinely used in the assessment of movement performance, and is a valuable index of muscle power; it will be used in the proposed study (Markovic & Jaric, 2007). The integration of power training into a strength program is suggested to be the best form of resistance work to produce superior performances in golfers (Fletcher & Hartwell, 2004).

Power Training and its Effects on Club Head Speed

A study by Fletcher & Hartwell (2004) examined the effects of an 8-week combined weights and plyometric training program on golf drive performance. Eleven male golfers volunteered for this study. All participants were regular club golfers golfing at least 3 times a week with a mean golf handicap 5.5 ($\pm$3.7), which classifies as a very good golfer. Club head speed was assessed using Golftex Prografix for Windows along with a pro swing analyzer. Drive distance was measured using a series of preset markers and a tape measure. The same driving range, club, model, and compression of ball was used in the pre- and post-training measurements. The experimental group participated in an 8-week strength training program consisting of free weight exercises and medicine ball work. Resistance exercises included: bench press, squat, single arm row, lunge, shoulder press, upright row, crunches, back extension, and side bends. All resistance lifts followed a volume design of three sets of six to eight repetitions. The medicine ball exercises included: seated horizontal twist, standing horizontal twist, standing back extensions, and golf swings. Each medicine ball exercise consisted of three sets of eight repetitions. The resistance portion was performed in a controlled manner; when the participants were able to complete eight repetitions, intensity was increased by 5 kilograms. The power portion used 3 kg medicine balls as resistance and was performed using an explosive manner, mimicking the golf swing. The researchers found that there was a significant increase in golf drive distance and club head speed following an 8-week combined weights and plyometric conditioning program. The experimental group increased club head speed from 179.8±9.1 km·h^{-1} pre-test to 182.6±6.2 km·h^{-1} post-test, yielding a 1.5% increase. The experimental group increased drive distance by 4.3% from 225.6±16 m pre-test to 235.7±11.4 m post-test. The control group had a slight increase in club head speed from 172.3±17.1 km·h^{-1} pre-test to 173±18.7 km·h^{-1} post-test, producing a 0.5% increase. The control group slightly decreased drive distance by -0.7% from 220.8+19 m pre-test to 219.3+30.7 m post-test. Figure 3 shows the relationship between golf club head speed and driving distance (Fletcher & Hartwell, 2004). This figure indicates drive distance increases along with an increase in club head speed.

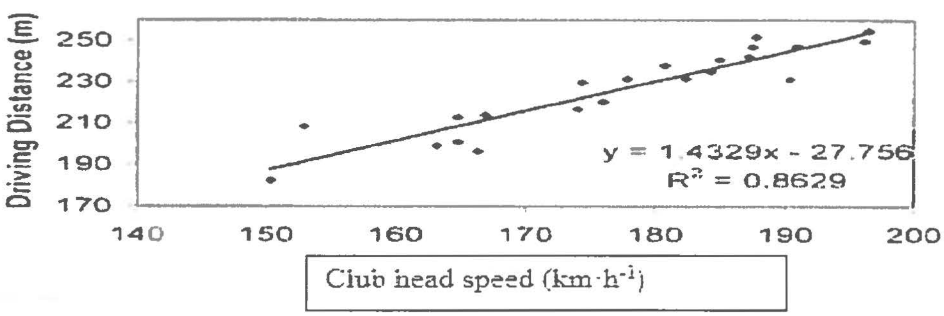

Figure 1. The relationship between golf club head speed and driving distance (n=22).

Doan et al. (2006) conducted an 8-week conditioning program combining strength training and power exercises on male and female collegiate golfers with a mean age of 19.3 ± 1.5 years. Participants included 10 men and 6 women varsity golf athletes. There were not enough collegiate golfers on the university teams to allow adequate statistical power, therefore there was no control group used for this study. All participants completed the same golf-specific resistance-training program supervised by certified strength and conditioning specialists. The training program was performed 3 times per week (Monday, Wednesday, Friday) lasting approximately 90 minutes per session. Trunk strengthening exercises were performed at the beginning of each training session followed by the resistance-training program finishing with a stretching program. Trunk strengthening included variations of crunches and medicine ball Russian twist. Medicine ball (MB) throws were used as an explosive movement with the aim to elicit power production and was performed at the end of each resistance-training session. For the medicine ball standing throw participants took their normal golf stance and posture holding a 2-4kg MB as they mimic the golf swing releasing the MB at the position of impact with maximum velocity. This movement is identical to the MB golfer swing which was prescribed in the current study, and was the specific modality being used to increase power production.

The first day of the 8-week resistance-training program included the following exercises: incline bench press, bent arm pullover, dumbbell upright row, leg curl, back extension, dumbbell step-up, medicine ball speed rotations, and medicine ball standing throw. The second day of training included: bench press, low cable row, dumbbell military press, leg curl, seated good morning, parallel squat, medicine ball speed rotations, and medicine ball standing throw. The third day of resistance-training comprised of: dumbbell bench press, one arm dumbbell row, dumbbell shoulder circuit, dumbbell lunges, leg extensions, medicine ball speed rotations, and medicine ball standing throw. All exercises for the first 4 weeks were performed for 3 sets of 10-12 repetitions excluding the medicine ball speed rotations and standing throw which were 2 sets of 10 repetitions. The last 4 weeks of the 8-week Doan et al. (2006) study, volume was decreased to 3 sets of 7-9 repetitions excluding medicine ball speed rotations, and medicine ball standing throw, which increased to 4 sets of 8 repetitions. The selection of exercises is comparable to the current study, specifically the parallel squat, military press, medicine ball speed rotations, and medicine ball standing throw.

Club head speed was measured using Qualitative swing analysis, while strength was determined using a 1RM protocol in the bench press and parallel squat (Doan et al., 2006). Flexibility was measured using Marvel video capture card, edited in Adobe Premiere 5.1 computer software allowing the researchers to analysis trunk flexibility. All fitness variables assessed in the study showed significant improvement. Strength for the 1RM bench press increased by 10.18%, and a 13.27% increase was seen in the parallel squat 1RM. Power was measured using medicine ball throw velocity (m/s), which increased by 19.87% from 5.81 m/s to 6.96 m/s. Club head speed increased significantly by 1.62% from 47.3 m/s to 48.0 m/s . If all other impact variables were held constant, this 0.7 m/s increase in club head speed equates to approximately a 4.9 meter increase in drive distance, indicating increased club head speed will inevitably improve performance by increasing drive distance (Doan et al., 2006). Evidence of a significant correlation ($r = 0.9$) between club head speed and medicine ball throw velocity suggest the increased club head speed is a result of combined strength and power training (Doan et al., 2006).

A study by Read, Miller, & Turner (2013) examined the effects of postactivation potentiation (PAP) on golf club head speed. Postactivation potentiation is an acute enhancement of muscle function after an intense muscle activity (Kibler, 1996). Read et al. (2013) selected to perform high velocity countermovement jumps to produce the potentiating effect. Sixteen male golfers participated in the study, and all reported having played golf for a minimum of three years. Participants were randomly separated into a control group and experimental group. Both the experimental group and the control group performed a 10 minute warm-up consisting of dynamic stretching followed by three practice shots for maximal club head speed. After the warm up each group took three shots analyzed using the FlightScope launch monitor. The experimental group was asked to perform three maximal effort counter movement jumps 60 seconds prior to having their club head speed measured. The control group took three full golf swings, resting 60 seconds between attempts. This research showed that increased counter movement jump peak power is strongly correlated to enhanced club head speed ($r = 0.95$). The results revealed that the experimental group increased club head speed by 2.2% (2.25mph), suggesting PAP using counter movement jumps increases club head speed. This relates to the current study by indicating that increased power production may result in increased club head speed.

Conclusion of Literature Review

When assessing golf performance it is important to understand that golf is a sport where performance can be affected by many variables (Thompson et al., 2007). Research in strength and conditioning has aimed to enhance golf performance by increasing club head speed (Read et al., 2013). Current research has evaluated multiple means of improving club head speed through strength and resistance training programs. Even though there are several ways to elicit an increase in club head speed using strength and power training, the majority of these methods produced similar results of increasing performance. Improvements in club head speed can be credited to the result of physiological adaptations acquired during strength training. Greater activation of high threshold motor units are found to elicit increased club head speed following strength and plyometric training programs (Read et al., 2013).

Increasing drive distance as a measure of performance has been reviewed and shown to be strongly correlated to an increase in club head speed. Increasing drive distance allows for shorter, more accurate iron shots to be hit into the greens, and is an important ingredient in overall golf performance (Doan et al., 2006). The methods used to increase drive distance vary between studies, however all studies presented in this literature review adhered to volume and exercise selection that have been shown to elicit power and strength production.

Despite the possibility of improving performance, golfers often refrain from strength and conditioning exercises in fear they will reduce their range of motion, and suffer from muscle stiffness, causing a decrease in performance (Fletcher & Hartwell, 2004). However, as an example, javelin throwers have exceptional musculature and use a great deal of resistance work as part of their training and still manage to have far greater range of motion around the shoulder and torso than a golfer would ever need (Fletcher & Hartwell, 2004).

The sport of golf continues to increase in popularity worldwide (Lamberth et al., 2013). According to several recent surveys, there are 26.4 million active golfers in the United States, ranking golf tenth among the most popular sports and recreational activities in the United States (Doan et al., 2006).With this rise in popularity there has been a parallel interest in studying factors associated with improving golf performance (Lamberth et al., 2013). Few studies have investigated the effects of resistance training on golf performance, but each has shown a significant impact on increasing club head speed. More research is needed in this area to gather information on the effects of strength and power training on golf performance, specifically club head speed.

Chapter 3: Methods

The Setting

This research took place at Adams State University (ASU) in Alamosa, Colorado. ASU is a rural NCAA division II university in southwestern Colorado, located at an elevation of 7,544 feet. The ASU athletic training facility, most specifically the weight room and field house, was used. Club head swing speed measurements were measured pre and post training intervention in the ASU weight room at Plachy Hall. The pre and post power testing, pre and post strength testing, and the 8-week training intervention resistance training sessions were performed in the ASU athletic weight room at Plachy Hall.

Participants

The participants of this study consisted of 6 male and 6 female NCAA division II collegiate golfers, ranging in age from 18-23 years, with a minimum of one year of consistent resistance training experience and a minimum of 1 year of collegiate golf experience. Consistent resistance training experience was defined at continual resistance training several times per week in a periodized resistance training program (Baechle & Earle, 2008). The participants were volunteers and had 3-4 years of high school level golf prior to participating for the ASU golf team for 1 calendar year. The head ASU golf coach gave his consent for the ASU golf team to participate in this study. The participants were not in season during this study.

Instrumentation

There were several instruments used in this study:

Club Head Speed: BatMaxx 500. The maker of this instrument is BatMaxx and the model number is 500. This instrument was provided by the Adams State University Biomechanics Lab.

The BatMaxx 500 was used to analyze club head speed. Both average and peak club head swing speed were measured for 3 maximal effort golf swings.

Golf Clubs: The participants of this study used a driver golf club when measuring club head swing speed. The participants used their own drivers that have been measured and fitted by a professional that follows the Professional Golf Association's standards for club to body segment lengths. They were instructed that they must use the exact same driver for both pre and post-tests.

"Just Jump" VertMat: The vertical jump measurements were taken using the "Just Jump!" mat. The "Just Jump!" mat is manufactured by Probiotics INC, which is located in Hunstville, Alabama. The "Just Jump" mat was provided by the Adams State University strength and conditioning department. The "Just Jump" mat was used to measure pre and post power measurements by measuring vertical displacement.

Weight Equipment: The Adams State University Athletic weight room was utilized for all training and strength and power testing. The 8-week strength and power training program was done using the ASU weight room equipment. See Appendix C for experimental group 8-week weight training resistance program, and Appendix D for control group 8-week weight training resistance program. The power testing utilized a vertical jump measurement using the "Just Jump" mat. The strength measurements utilized free weights. The strength tests were the back squat, deadlift, and power clean, as recommended by the NSCA for testing lower body and core strength and power. The strength tests followed NSCA testing protocols and used the ASU athletic weight room free weight equipment.

Research Design

The experiment consisted of an 8-week study. The participants were randomly placed into a control or experimental group. Six of the participants (3 male, 3 female) were placed in the control group, and performed their normal 8-week off-season training program (see Appendix D). The regular off-season training program has a volume similar to the 8-week intervention, however exercise selection, and intensity for the intervention is what separates the two programs. The other 6 participants (3 male, 3 female) performed an 8-week strength and power training program instead of the regular off season training program (see Appendix C). The 8-week strength and power training program emphasized strength and power adaptations by targeting intensities, volume, and exercise selection that results in strength and power adaptations as outlined by the NSCA Essentials of Strength and Conditioning textbook (Baechle & Earle, 2008).

Each participant performed a pre-treatment measure of club head speed, max effort vertical jump, 1RM power clean, 1RM back squat, 1RM deadlift, and then completed an 8-week training program. All participants were allowed 48-72 hours to recover fully following the 8-week training program intervention and prior to performing the post-treatment test of all measures. Each participant then performed a post-treatment measure of club head speed, max effort vertical jump, 1RM power clean, 1RM of the squat, and 1RM deadlift. The pre and post-treatment testing were all be done in the aforementioned order. The participants tested club head speed and, after 5 minutes rest, maximum effort vertical jump height, then allowed twenty-four hours rest. The participants then tested the 1RM power clean, 1RM squat, and 1RM deadlift, with 24 hours rest between each 1RM test. The 1RM test was assigned a number and using an excel spreadsheet was randomized. Twenty-four hours rest was implemented allowing for ample rest between tests for reliable results as outlined by Baechle & Earle (2008). This procedure was performed for both pre and post-treatment measures. During the measures of club head speed, pre and post treatment, each participant was given 3 practice swings followed by 5 minutes rest and 3 measured maximal effort swings, with 2 minutes rest between efforts. The rest prescribed is based on NSCA standards for max power testing. The average speed performed out of the 3 attempts was used to analyze average club head speed. The highest value of the 3 attempts was determined as the peak CHS. During the 1RM test each participant followed the protocol for 1RM test outlined by Baechle & Earle (2008), in the NSCA's Essentials of Strength and Conditioning textbook (3rd edition). The 1RM test of the back squat, deadlift, and power clean was used to analyze muscular strength and power. During the vertical jump testing each participant performed 3 maximal effort jumps with 2 minutes rest between each jump trial. The average and peak heights were used to analyze power production.

The independent variables are the 8-week strength and power resistance training intervention and the normal off season resistance training program. The dependent variables for this study include: the average and peak club head speed using the BatMaxx 500, measure of strength for 1RM back squat, 1RM deadlift, and 1RM power clean, and average and peak vertical jump height using "Just Jump!" mat.

Procedures

Permission for this research study was obtained from the Institutional Review Board (IRB) for human participant research at Adams State University. See Appendix E for the IRB approval form. Once IRB approval was obtained, the researcher met with all participants. Consent forms were explained, signed by each volunteer, and collected from all participants by the researcher prior to the beginning of the study. See Appendix F for the participant consent form. In the initial meeting with the participants the researcher stressed the importance of adherence to the training program and testing protocol to ensure safety as well as accuracy/validity. The initial meeting allowed participants to fill out a questionnaire for the researcher to measure their demographic characteristics. See Appendix G for Participant Questionnaire. The participants were expected to have strict adherence to the experiment design. It was explained to the participants that their voluntary participation in this study would in no way negatively affect their academic or athletic status at ASU. The participants signed a consent form that stated their intent to adhere to the experiment.

Following the initial briefing, the participants were separated by gender, then numbered and randomly assigned to either the experimental or control groups using an Excel spreadsheet to randomly assign groups: experimental (N=6) or control group (N=6). They then were tested to obtain pre-treatment measures. Testing consisted of club head speed measured by the BatMaxx 500, vertical jump height measured by "Just Jump" of Probotics INC., 1RM power clean, 1RM back squat, and 1RM deadlift using NSCA 1RM testing protocol (Baechle & Earle, 2008). For pre-test measures, each participant was allowed 3 practice swings followed by 5 minutes rest. After the warm-up, the participants performed 3 maximal effort swings with 2 minutes rest between attempts. The average and peak swing velocities were recorded and analyzed by the researcher. The participants were instructed to use their natural swing with maximal effort during the measured efforts. After a 5 minute rest the participants' power was determined by measuring vertical jump height. Each participant was instructed to warm up by completing ankle jumps for 2 sets of 10 repetitions in order to activate the muscles of the lower extremities. The participants stood in front of the "Just Jump" mat until instructed to step onto the device, where they performed a maximal effort jump landing back on the "Just Jump" mat. Each participant repeated this process a total of three times with 2 minutes rest between attempts. The average and peak heights for each group were recorded. After 24 hours of rest, the participants performed the first of the 1RM test, power clean, back squat, and deadlift, which had been randomly assigned with twenty-four hours rest between each 1RM test. The participants were allowed 24 hours of rest between each strength measurement performing each test at the same time of day. Each 1RM measurement followed the exact same NSCA protocol (Baechle & Earle, 2008). Prior to each 1RM test, the participants were instructed to warm-up with light resistance that easily allows 5 to 10 repetitions followed by a 1 minute rest period. An estimated warm-up load was selected by the strength and conditioning specialist that will allow the participants to complete 3 to 5 repetitions followed by a 2 minute rest period. Then, an estimated near maximal load was selected by the strength and conditioning specialist that allowed the participants to complete 2 to 3 repetitions followed by a 2-4 minute rest period. The load was increased to a perceived maximal effort and attempted by the participants for 1 repetition. If the repetitions were successful, the participants took another 2-4 minute rest, increase the load 5-10% for upper body, and 10-15% for lower body, and repeated a maximal effort attempt. If any participant failed at their first attempt of a 1RM, the load was decreased by 2.5-5% for upper body exercises and 5-10% for lower body exercises after a 2-4 minute rest period until performing a successful 1RM (Baechle & Earle, 2008).

The participants then proceeded to undergo an 8-week resistance training program. The experimental group performed a strength and power resistance training intervention (see Appendix C). The control group performed their normal off-season resistance training program (see Appendix D). The participants trained three days a week on Monday, Wednesday, and Friday. When the participants came in to train they were required to sign in each time prior to the start of their training so compliance could be monitored. The researcher suggested and expected, 100% compliance throughout this study. The researcher supervised and controlled the attendance logs throughout the length of the study. Make up days were made available by scheduling a consultation with the head researcher. The participants were given a copy of the resistance program with instructions to record volume and intensity for each exercise. The primary exercise intensities were based off the 1RM test results (see Appendix C and D). Prior to each training session, the experimental and control group performed a general warm up consisting of mobility drills and dynamic stretches. The warm up consists of five movements completed for 1 set of 8-10 repetitions per movement (see Appendix H). After the warm up, the control group performed their normal 8-week off-season training program provided by the Adams State University strength and conditioning staff (see Appendix D). After the warm up, the experimental group performed a specific strength and power resistance training program (see Appendix A and C). The participants performed their resistance training program, designed to increase strength, power, and thus club head speed, which was written by and under the supervision of the research team. The research team included a certified strength and conditioning specialist (CSCS). The CSCS certification is provided by the NSCA. These measures were taken to ensure reliability as well as to ensure testing and exercises were performed safely and appropriately.

After 8 weeks, the participants were allowed adequate rest of 48 to 72 hours as outlined by Baechle & Earle (2008). The experimental and control group were then tested post-treatment for club head speed and vertical jump height using the aforementioned protocol. Both groups used the above-mentioned 1RM testing protocol in the power clean, back squat, and deadlift, in a similar randomized and timely manner as the pre-testing.

Reliability

Following the procedures of this experiment should produce a high level of reliability. Additional researchers would be able to duplicate this study if they have access to a training facility, equipped with free weights, medicine balls, BatMaxx 500 device, and a "Just Jump!" mat. The 8-week strength and power intervention was designed based off empirical based research and was reviewed by a CSCS giving the intervention a high level of reliability. Following the aforementioned NSCA protocols during 1RM testing should ensure reliability. The 1RM testing methods have been shown to be highly reliable (Baechle & Earle, 2008). The BatMaxx 500 has been shown to be reliable in a study testing the effectiveness of heavy bats for warm up on bat velocity in collegiate baseball players (Symanski, Donahue, Stover, Boyce, Africa, Greenwood, & Beam, 2013). The "Just Jump" mat has also been shown to be reliable by Waller (2011). The use of Division II athletes should produce similar results if the testing protocol and equipment used are the same. Participants are more likely to yield similar results as long as the training intervention follows empirical evidence as outlined throughout the literature review. Also, both pre and post-treatment tests were performed using the exact same procedures and performed under the supervision of the exact same researcher team.

Validity

The purpose of this study was to determine if a strength and power resistance training intervention would result in increased golf club head speed. The strength and power resistance training intervention used empirical evidence provided by the NSCA Essentials of Strength and Conditioning textbook (Baechle & Earle, 2008). The strength and power resistance training intervention used research that was discussed previously in the literature review. Similar strength and power resistance training interventions have been shown in previous research to improve golf club head speed (Doan et al., 2006; Fletcher & Hartwell, 2004; Fradkin, Sherman, & Finch, 2004; Hetu, Christie, & Faigenbaum, 1998; Latella et al., 2008; Lephart et al., 2007; Thompson, Cobb & Blackwell, 2007; Thompson & Osness, 2004; Westcott, Dolan & Cavicchi, 1996). This training intervention was also developed with the assistance of the Director of Strength and Conditioning at ASU who is a CSCS. The data collected from the experiment should be valid based on the type of resistance training intervention. The use of strength and power training would appear to elicit increased performance in club head speed in a wide range of golfers (Lambeth et al., 2013). Additionally, the primary lifts being performed (squat, deadlift, and power clean) are movements that have been shown to improve muscular strength and power, which has been shown to be significantly correlated to improved club head speed (Baechle & Earle, 2008; Doan et al., 2006; Fletcher & Hartwell, 2004; Read, Miller & Turner, 2013).

The BatMaxx 500 is a computer photosensing timer that measured club head speed by calculating the time that it takes for the golf club head to pass between two laser beams (Higuchi, Nagami, Mizguchi, & Anderson, 2013). Symanski et al. (2013) have shown the BatMaxx to be valid and reliable when testing the speed of an implement (golf club head).

Vertical jump height, as measured by the "Just Jump" mat, has been shown to be a valid measure of power (Leard, Cirillo, Katsnelson, Kiniatek, Miller & Trebincevic, 2007). There is also a high level of validity for measuring power output through vertical jump testing (Mitchell & Sale, 2011).

Treatment of Data

Data was collected and recorded using an Excel spreadsheet. Statistical evaluation of the data was accomplished using independent samples t-tests. Differences were considered significant at a $p \leq 0.05$. Data was analyzed using the 2013 SPSS Version 22 statistical analysis software. The Adams State University golf team was divided by gender and then randomly assigned into the experimental and control groups which served as the independent variables for this study. The dependent variables include: average and peak club head speed, pre and post 1RM test of the deadlift, squat, and power clean, as well as peak and average vertical jump height. Pre-to-post-test changes in all dependent variables were analyzed to determine any between and within group differences. A Pearsons correlation test was run to determine if any of the strength and power variables had any correlation to increased CHS ($p<.05$).

Chapter 4: Results

All participants competed for a NCAA Division II collegiate golf team. The participants' peak and average CHS and vertical jump height were tested, along with tests of strength using a 1RM testing protocol in the squat, deadlift, and clean. Differences in mean scores for peak and average CHS, VJ, back squat 1RM, deadlift 1RM, and clean 1RM (post-test minus pre-test) were analyzed. An independent t-test was performed using SPSS (Version 22, 2013) with difference scores (post-test minus pre-test) of each variable measured. The difference scores were calculated using by subtracting each participant's post-test score from their pre-test score, for each dependent variable measured. The difference scores of the control group and intervention group were the two groups' compared with the independent t-test. Data was analyzed in this fashion to compare relative values (the change observed), as opposed to absolute values because of the individual differences participants have in CHS, strength, and power. Using this type of analysis removes any individual differences and solely examines the change in measures that occurred because of the independent variable. This test was chosen since there are two experimental conditions (intervention, control) and participants were assigned to each condition testing the differences in mean scores of each of the variables via a pre-test and post-test. The independent variable for this study was the 8-week program. The dependent variables included: peak and average CHS, peak and average vertical jump height, squat 1RM, deadlift 1RM, and clean 1RM. For all variables, the significance level was set at $p < 0.05$. Before the independent t-tests were run, data was checked for assumptions of normality with the Kolmogorov-Smirnov test and Shapiro-Wilk test. All dependent measures except the difference scores for the control group in the back squat met these assumptions ($p>.05$); therefore, a non-parametric independent samples Mann-Whitney U test was run to compare the difference scores for the back squat between the control and experimental group. The back squat difference scores in the control group violated both the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, ($p<0.05$), therefore a non-parametric t-test (independent-samples Mann-Whitney U test) was run to compare back squat scores between the experimental and control group. Tables for this study can be found in Appendix I.

Descriptive Statistics

A total of 12 collegiate golfers (N=6 male, N=6 female golfers) aged 18-23 years volunteered for this 8-week study. All participants had 100% completion rate for this study. The participants' data was separated into a control (N=6) and intervention group (N=6). All dependent variables for each subject pre and post-test are shown in tables 1 through 7 below. Table 8 shows the group statistics for the change in each dependent variable for the current study.

The average of the control groups' CHS pre-test was 101.4 ±3.8 mph. The peak CHS velocity for the control group pre-test was 123 ±18.6 mph. The control group after completing their 8-week off season training program decreased the average CHS to 97.6 ±17.2 mph post-test ($p=0.004$). The peak velocity however remained unchanged at 123 ±17.8 mph. The average of the control groups' VJ pre-test was 19.9 ±0.1 inches. The peak height for the control group's pre-test was 26.3 ±7.1 inches. Post-test average VJ height for the control group was 20.0 ±0.1 inches ($p=0.024$). The peak height slightly increased to 26.3 ±3.7 inches post-test. The average of the control groups' pre-test back squat 1RM was 201.7 ±81.4 lbs. After the 8-week study the control groups' back squat 1RM was 209.2 ±7.5 lbs. The average of the control groups' deadlift 1RM pre-test was 230 ±43.2 lbs. After the 8-week study, the control group slightly increased the deadlift 1RM to 244.2 ±17.5 lbs. ($p=0.138$). The average of the control groups' clean 1RM was

99.1 ±33.4 lbs. After the 8-week study, the average clean 1RM was 123.4 ±12.3 lbs. post-test (p=0.031).

The average of the intervention groups' CHS pre-test was 101.36 ±7.52 mph, with a peak CHS of 113 ±9.2 mph. After completing the 8-week strength and power intervention, average CHS was 104.6 ±2.47 mph and was reported as significant (p=0.004). The peak CHS after the 8-week strength and power intervention increased to 114.3 ±8.25 mph in the intervention group (p=0.004). The average for the intervention groups' VJ height pre-test was 19.05 ±3.78 inches, with a peak height of 26.4 ±3.78 inches. After the 8-week intervention the VJ height average increased to 21.25 ±2.20 inches, with a peak height of 28.3 ±3.63 inches and was reported significant (p=0.024). The average back squat 1RM for the intervention group pre-test was 216.7 ±82.01 lbs. After the strength and power program, the intervention groups' back squat 1RM was 245.1 ±37.5 lbs. but reported no significance (p=0.063). The average deadlift 1RM for the intervention group pre-test was 257.5 ±99.01 lbs. After the strength and power program the average deadlift 1RM post-test was 289.2 ±31.6 lbs. and reported no significance (p=0.138). The average clean 1RM for the intervention group pre-test was 117.5 ±43.3 lbs. After the strength and power program the post-test clean 1RM was 148.8. ±31.21 lbs. and was reported significant (p=0.031).

Table 1. 1RM Back Squat Pre-test/Post-test

Control			Intervention		
Participants	Pre-test	Post-test	Participants	Pre-test	Post-test
1	220	255	1	345	365
2	275	275	2	220	315
3	315	320	3	280	335
4	135	135	4	155	185
5	115	115	5	165	175
6	150	155	6	135	150
Average	201.7	209.2	Average	216.7	245.1
Peak	315	320	Peak	345	365

Table 2. 1RM Deadlift Pre-test/Post-test

Control			Intervention		
Participants	Pre-test	Post-test	Participants	Pre-test	Post-test
1	255	275	1	390	425
2	275	280	2	275	315
3	275	315	3	315	365
4	205	205	4	205	225
5	185	185	5	205	245
6	185	205	6	155	160
Average	230	244.2	Average	257.5	289.2
Peak	275	315	Peak	390	425

Table 3. 1 RM Clean Pre-test/Post-test

Control			Intervention		
Participants	Pre-test	Post-test	Participants	Pre-test	Post-test
1	110.2	132.2	1	154.3	198.4
2	132.2	154.3	2	132.2	176.4
3	132.2	154.3	3	154.3	176.4
4	88.18	88.18	4	88.18	110.2
5	44.09	52.91	5	132.2	143.3
6	88.18	88.18	6	44.09	88.18
Average	99.2	111.7	Average	117.5	148.8
Peak	132.2	154.3	Peak	154.4	198.4

Table 4. Pre-test CHS

Pre-Test CHS Control Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (MPH)	Peak (MPH)
1	123	123	121	122.3	123
2	110	120	112	114	120
3	116	118	112	115.3	116
4	82.5	83	82.1	82.5	83
5	87.1	94.4	94	91.8	94.4
6	82.5	83	82.1	82.5	83
Group Total				101.4	123

Pre-Test CHS Intervention Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (MPH)	Peak (MPH)
1	112	96.2	99.6	102.6	112
2	113	103	107	107.7	113
3	96.1	103	107	102	107
4	102	102	102	102	102
5	108	108	105	107	108
6	88	87.3	85.4	86.9	882114.
Group Total				101.3	113

Table 5. Post-test CHS

Post-Test CHS Control Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (MPH)	Peak (MPH)
1	121	123	122	122	123
2	110	99	108	105.7	110
3	114	111	105	110	114
4	82.3	82	83.2	82.5	83.2
5	84	84	84	84	84
6	77	83	84.6	81.5	84.6
Group Total				97.6	123

Post-Test CHS Intervention Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (MPH)	Peak (MPH)
1	104.6	102	106	104.2	106
2	114.3	115	113.2	114.2	115
3	104	100.6	99.8	101.5	104
4	105	108	108	107	108
5	110	110	112	110.7	112
6	88	91.3	91.3	90.1	91.3
Group Total				104.6	114.3

Table 6. Pre-test Vertical Jump

Pre-Test Vertical Jump Control Group					
Participants (M/F)	**Trial 1**	**Trial 2**	**Trial 3**	**Average (inches)**	**Peak (inches)**
1	24.9	26.3	23.6	24.9	26.3
2	26.3	28	27.9	27.4	28
3	26	25	26.1	25.7	26.1
4	11.1	11.7	11.2	11.3	11.7
5	16.5	16.4	16.6	16.5	16.6
6	13.7	13.3	13.9	13.6	13.9
Group Total				19.9	26.3
Pre-Test Vertical Jump Intervention Group					
Participants (M/F)	**Trial 1**	**Trial 2**	**Trial 3**	**Average (inches)**	**Peak (inches)**
1	20.2	20.5	19.9	20.2	20.5
2	17.5	18.2	18.3	18	18.3
3	25.8	25.9	26.4	26	26.4
4	15.5	15.8	16.1	15.8	16.1
5	18.3	18.7	18.3	18.4	18.7
6	16.4	15.4	15.9	15.9	16.4
Group Total				19.05	26.4

Table 7. Post-test Vertical Jump

Post-Test Vertical Jump Control Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (inches)	Peak (inches)
1	23.2	24	23.2	23.5	24
2	25.8	27.1	26.3	26.4	27.1
3	27.7	27.3	27.4	27.5	27.7
4	11.8	11.6	11.7	11.7	11.8
5	17.4	18	17.8	17.7	18
6	13.7	13.3	13.9	13.6	13.9
Group Total				20	27.7

Post-Test Vertical Jump Intervention Group

Participants (M/F)	Trial 1	Trial 2	Trial 3	Average (inches)	Peak (inches)
1	21.4	21	21.5	21.25	21.5
2	22.8	22.6	23	22.8	23
3	26.2	27.5	28.3	27.3	28.3
4	18.9	18.6	18.5	18.3	19.9
5	20.1	20.1	20.5	20.2	20.5
6	16.9	17.3	17.7	17.3	17.7
Group Total				21.25	28.3

Table 8. Change in dependent variables pre-test and post-test.

	Intervention	N	Mean	Std. Deviation	Peak
Post CHS minus pre CHS (average – mph)	Intervention Control	6 6	3.25 -3.78	2.47 3.82	1.30 0.00
Post VJ minus pre VJ (average – inches)	Intervention Control	6 6	2.20 0.17	1.41 1.23	1.90 1.40
Post back squat minus Pre back squat lbs.	Intervention Control	6 6	37.50 7.50	32.37 13.69	20.00 5.00
Post deadlift minus pre Deadlift lbs.	Intervention Control	6 6	31.67 17.50	16.33 14.05	35.00 40.00
Post clean minus pre clean lbs.	Intervention Control	6 6	30.86 11.50	6.64 4.96	44.00 22.20

CHS Measurements

The CHS average difference scores for both the control and intervention groups passed the Levenes test for equality of variances ($p>.05$), therefore equal variances were assumed. Participants that were in the intervention group obtained a significantly greater change in average CHS (3.25 mph post-pre-test), than the control group which actually decreased average CHS (-3.78 mph), $t(10)=-3.78$, $p<.05$. The independent samples test reported a significance $p=0.004$. The peak CHS for the control group pre-test was 123 ±18.6 mph. There was no change in the peak CHS for the control group following the 8-week study 123 ±17.8 mph. The peak CHS for the intervention group pre-test was 113 ±9.2 mph. The peak value for the intervention group increased 1.3 mph after the 8-week study to 114.3 ±8.25 mph. The results show that the intervention group significantly increased average CHS, and peak CHS, when compared to the control group, that showed no change in peak values, and decreased CHS.

Vertical Jump Height Measurements

The VJ average difference scores for both the control and intervention groups passed the Levenes test for equality of variances, therefore equal variances were assumed. Participants that were in the intervention group have significantly greater change in average VJ (2.2 ±1.4 inches) than the control group (0.166 ±1.2 inches), $t(10)=2.657$, $p<.05$. The independent samples test reported a significance of $p=0.024$. The peak height pre-test for the intervention group was 26.4 ±7.17 inches. The peak VJ height for the intervention increased to 28.3 ± 3.63 inches post-test. The mean change in peak vertical jump height for the intervention group was 1.9 ±1.34 inches. The peak VJ height for the control group pre-test was 26.3 ± 7.17 inches. The VJ height peak for the control group post-test increased to 27.7 ± 6.82 inches. The control group had a vertical jump height mean change of 1.4 ±0.98 inches ($p=0.024$).

Back Squat 1RM Measurements

The 1RM back squat for both the control and intervention group passed the Leven's test for equality of variances ($p>.05$), therefore equal variances were assumed. Participants that were in the intervention group have greater change in average back squat 1RM (37.50 ±32.36 lbs.) than the control group (7.50 ±13.69 lbs.), $t(10)=2.091$ $p=0.063$. However, the independent samples test reported no statistical significance, $p=0.063$. The mean change in the 1RM back squat for the intervention group was 37.5 lbs. ± 32.365. The mean change for the back squat 1RM in the control group was 7.5 ±13.693 lbs. Due to a high mean difference and same sample size, a non-parametric t-test was run on the back squat 1RM measurements. The independent samples Mann-Whitney U Test was run on the 1 RM back squat measurements reporting a significance of $p=0.26$.

Deadlift 1RM Measurements

The 1RM deadlift for both the control and intervention group passed the Leven's test for equality of variances, therefore equal variances ($p>.05$) were assumed. The participants for the intervention group had a greater change in average 1RM deadlift (31.66 ±16.32 lbs.) than the control group (17.50 ± 14.05 lbs.) $t(10)=1.611$ $p=0.138$. However, the independent samples test reported no significance, $p=0.138$.

Power Clean 1RM Measurements

The 1RM clean for both the control and intervention group passed the Leven's test for equality of variances, therefore equal variances ($p>.05$) were assumed. The participants for the intervention group have greater average change in the 1RM clean (30.86 ±6.64 lbs.) than the control group (11.5 lbs.), $t(10)=2.510$ $p=0.031$ The independent samples test reported significance at $p=0.031$.

Correlation Test

A Pearson's correlation test was run to determine if any of the strength and power variables back squat, deadlift, clean, and vertical jump had any correlation to increased average CHS ($p<.05$). The 1RM back squat was significant ($r = 0.64$, $p=0.025$), as was the vertical jump ($r = 0.73$, $p=0.007$), and 1RM clean ($r = .70$, $p=0.012$). There was no correlation between the 1RM deadlift and CHS ($r=0.54$, $p=0.069$), although it trended towards significance. Graphs and tables showing the results of the Pearson's correlation test can be found in Appendix J.

Chapter 5: Discussion

The purpose of this study was to determine if an 8-week strength and power intervention had a positive effect on increasing CHS. Additionally this 8-week study was designed to determine if the specific strength and power resistance training program would increase muscular strength and power. The hypothesis and each research question were evaluated and discussed based on the results of the study.

Hypothesis and Research Question 1

The hypothesis predicted that an 8-week strength and power resistance training program would increase the CHS in collegiate golfers. Research question one (RQ 1) posed the same inquiry as the hypothesis. The CHS average for the control group decreased after the 8-week study from 101.4 mph to 97.6 mph, a decrease of 3.78 ±3.82 mph. The peak CHS velocity for the control group from pre-test to post-test showed no change, 123 ±18.6 mph to 123 ±17.8 mph. The CHS average for the intervention group following the 8-week study increased from 101.3 mph to 104.6 mph (3.25 ±2.47 mph). The peak CHS velocity for the intervention group increased pre-test to post-test from 113 ±9.2 mph to 114.3 ±8.25 mph. Since the average CHS in the intervention group increased, and the CHS in the control group decreased, the data is statistically significant ($p=.004$) and does in fact support both the hypothesis and RQ1.

A study by Fletcher & Hartwell (2004) examined the effects of an 8-week combined weights and plyometric training program on golf drive performance. For this study golf drive performance was analyzed using Golftex Prografix, a similar radar device to that used in the current study. The experimental group participated in an 8-week strength training program with similar exercises, volume and intensities of the current study. Free weight and medicine ball exercises were used to elicit increases in strength, power, and drive distance. The current study also used free weights and medicine balls to elicit increases in strength and power. All resistance lifts followed a volume design of three sets of six to eight repetitions much like that of the current study. The experimental group increased CHS by 1.5% resulting in increased drive distance of 4.3% (Fletcher & Hartwell, 2004). The control group increased CHS by 0.5% but slightly decreased drive distance by 0.7%. Fletcher & Hartwell's study shows similarities to the current study, in that while both groups tested increased their CHS, the more significant increase of the experimental group produced an increase in overall distance performance compared to the control group's minor increase of CHS which resulted in a no further improvement of their drive distance. The current study did not measure drive distance although it was assumed drive distance is correlated with increased CHS. The current study also revealed that between both groups there were increases in the majority of strength and power variables tested. However, the intervention group netted much higher increases in the mean differences of each of these variables tested resulting in an increase of CHS from pre-test to post-test.

Research Question 2

Research question two (Q2) asked if an 8-week strength and power resistance training program would elicit an increase in strength and power measurement testing. Overall, both the control and experimental groups showed increases in strength and power. There was no significance reported for the back squat and deadlift between the two groups, although both the back squat ($p=0.063$) and deadlift ($p=0.138$) variables were close to the $p<0.05$, and are considered trending towards significance, especially the back squat. The clean revealed a significance of $p=0.031$. It is worth mentioning that the increases of the intervention group were far greater in the power clean, back squat, and deadlift than that of the control group. The intervention group had a greater mean change in their back squat 1RM average (37.5 ±32.3 lbs.) than the control group (7.5 ±13.7 lbs.). Although there was no statistical significance that the back squat changes were greater for the intervention group vs control group (p=.063), the values indicate that this data is trending toward significance. Increases, although not significant (p=.138) were also seen in the mean change in 1RM deadlift for the intervention group (31.7 ±16.3 lbs.) which is also trending towards being significant. The control group although increased their mean change 1RM deadlift (17.5 ±14.0 lbs.) but it was much lower than the intervention group. The mean change 1RM clean for the intervention group increased (30.9 ±6.6 lbs.). The control group slightly increased the mean 1RM clean (11.5 ± 15.0 lbs.). The 1RM power clean was statistically significant (p=0.031) between the two groups.

Since all strength and power variables tested increased more so in the intervention group, the data from this study supports RQ2 that an 8-week strength and power resistance training program does in fact increase muscular strength and power.

Muscular power was measured by analyzing the participants' average and peak vertical jump height using the "Just Jump" mat. While the control group demonstrated an insignificant increase in average VJ height from 19.9 ±6.92 inches to 20.0 ±0.16 inches, the intervention group demonstrated a much greater increase in average VJ height from 19.05 ±6.92 inches to 21.25 ±1.4 inches. Peak height for the control group pre-test was 26.3 ±7.17 inches which slightly increased to 27.7 ±6.82 inches post-test. The intervention group had a peak vertical jump height pre-test of 26.4 ±3.78 inches, which increased to 28.3 ±3.63 inches post-test (p=0.024).

There were also signs of increased muscular power and strength in the control group, but to a lesser degree. This is most likely due to the fact the population being tested had not recently performed a planned out resistance training program of any kind and would respond to any type of increased training volume, in this case the regular off season resistance training program (Baechle & Earle, 2008). While not specifically designed to elicit strength and power, the regular off-season training program had similar parameters of volume as well as exercise movements. There is evidence that low-intensity resistance training can promote marked increases in muscular hypertrophy, in many cases equal to that of traditional high intensity exercises (Schoenfeld, 2013). Current research indicates that low-load exercises can indeed promote increases in muscle growth in untrained subjects, and that these gains may be functionally and metabolically meaningful (Schoenfeld, 2013). This could help explain the reasoning behind the slight increases in strength and power by the control group.

A study by Thompson, Cobb and Blackwell (2007) found that an 8-week progressive functional strength training program increased club head speed in older golfers. While CHS was the main variable being analyzed, increases in strength were also measured using an arm curl repetition test. The experimental group showed an increase in CHS, and in muscular strength, increasing from 16.1 repetitions to 18.0 repetitions. The control group decreased CHS as well as muscular strength, from 15.8 repetitions to 15.3 repetitions (Thompson, Cobb & Blackwell, 2007). The current study shows similarities to Thompson, Cobb, and Blackwell (2007) in that the intervention group was able to increase muscular strength by following a program designed for strength and power, which ultimately increased CHS. While the control group for the current study had slight increases in muscular strength there was no improvement in CHS. This is similar to the control group of the Thompson, Cobb, and Blackwell (2007) study that decreased CHS after 8-weeks of sedentary activity. This indicates that participating in a program designed to increase muscular strength does in fact improve muscular strength, and supports RQ2.

Research Question 3

Research question three (RQ3) asked if an increase in strength would elicit an increase in CHS. Due to the increases in strength and CHS seen in the intervention group the data from the current study supports RQ3. In addition to the increased mean changes of all strength variables, there was a positive correlation between CHS and the back squat, r=0.64, p=0.025, and also CHS and the power clean, r=0.70, p=0.007. The deadlift did not show a positive correlation with CHS, r=0.54, p=0.069, but did appear to be trending towards a positive correlation. The results of the control group showed slight increases in the mean changes of the back squat, deadlift, and power clean, however these increases were not enough to improve CHS. Because the increases where only minor, one can assume that they were not significant enough to elicit a change in CHS.

A study by Westcott et al. (1996) examined the effects of an 8-week generic strength and flexibility program on CHS, strength, and range of motion. This study closely mimics the current study by assigning the participants to a control and experimental group while analyzing CHS, muscular strength, and range of motion. Club head speed was measured using the Swing Mate by Beltronics, a similar laser displacement device used in the current study. Strength was measured based off a 10-RM of the bench press. The experimental group performed an 8-week strength and flexibility program. The control group only performed pre and post treatment of CHS, strength and flexibility. This differs from the control group of the current study in that they performed an 8-week off-season training program. The strength program of Westcott et al. (1996) incorporated comparable exercises targeting similar muscle groups as the intervention group of the current study. In addition Westcott et al.'s (1996) study closely followed volumes recommended by the NSCA of 6-8 repetitions of the primary exercises to elicit strength, also similar to the current study. After the eight week intervention, the experimental group showed significant increases in strength yielding a 56% increase in 10-RM bench press and a 6.0% increase in CHS from 94.3 mph to 99.8 mph. The control group showed no change in CHS posting a 93.2 mph pre-test score compared to 93.0 mph post-test score. Muscular strength was not assessed in the control participants for Westcott et al.'s study. The agreement of the Westcott et al. (1996) study results and those of the current study further supports RQ3 in that increases in muscular strength does indeed positively affect CHS.

Further supporting RQ3 is a study by Hetu & Christie (1998) which examined the effects of an 8-week strength and flexibility program measuring CHS, strength, and range of motion. Variables such as muscular strength, and CHS were used in the current study, thus making Hetu & Christie (1998) a suitable comparison. The main differences between Hetu & Christie's (1998) study and the current study includes the exclusion of a control group in Hetu & Christies's (1998) study, therefore the experimental groups are being examined only. Hetu & Christie (1998) had 12 male and 5 female recreational golfers complete strength, flexibility and plyometric training twice a week. Exercise selections from Hetu & Christie (1998) that mirrored movements from the current study include: back squat, bench press, lunge, and row. Additionally, strength was measured using a 1RM protocol in the bench press. While the bench press wasn't used in the current study, the assessment of strength using a 1RM test protocol shows similarities between the two studies. The plyometric training incorporated into the aforementioned study, addressed power development in hopes to elicit an increase in CHS (Baechle & Earle, 2008). This is similar to the current study's attempt to incorporate MB plyometric throws, and the clean in order to increase CHS in the intervention group. Hetu & Christie's (1998) analysis of the pre and post-test scores showed that strength training was associated with significant increases in muscular strength. Muscular strength increased in the bench 1RM from 44.8kg to 51.2kg, resulting in a 14.2% increase. The pre to post-test CHS for Hetu & Christie (1998) increased from 78.4 ±13.3 kph to 83.3 ±14.4 kph. The current study also showed increases in strength. Although the back squat and deadlift did not show a statistically significant value, the slight increases coincided with a significant increase in CHS ($p=0.04$). However, the clean was significant at $p= 0.031$. The explosive nature of the clean is speculated to compliment the speed and intensity of the full golf swing. This makes the clean a useful movement to incorporate into a resistance training program when trying to increase CHS. The comparison of Hetu & Christie's (1998) study and the current study helps to support RQ3 in that increases in muscular strength as a result of a comprehensive resistance training program might be worthwhile in eliciting increases in CHS.

Research Question 4

Research question four (RQ4) asked if an increase in power would elicit an increase in CHS. There was a positive correlation between vertical jump height and CHS ($r=0.73$, $p=0.007$). This positive correlation between VJ height and average CHS for the current study supports RQ4. Both groups showed increases in the mean change in VJ height, intervention (2.20 ±1.41 inches), and control group (0.166 ±1.24 inches). The control group only slightly increased, and it is assumed that it was not enough of an increase to elicit an increase in CHS; in fact, the control group actually decreased CHS from 101.4 ±17.8 mph to 97.6 ±17.2 mph.

Doan et al. (2006) conducted a study using an 8-week conditioning program combining strength training and power exercises with male and female collegiate golfers. The use of male and female golfers as well as an intervention combining strength and power exercises makes this study a valuable comparison for the current study. There were not enough collegiate golfers on the university teams to allow adequate statistical power, therefore there was no control group used for the Doan et al. (2006) study. All participants completed the same golf-specific resistance-training program supervised by certified strength and conditioning specialists. CHS was measured using a similar radar device, while strength was determined using a 1RM protocol in the bench press and parallel squat (Doan et al., 2006). The same protocol was used in the current study to analyze strength measures excluding the bench and including the deadlift and clean. Power was measured using medicine ball throw velocity (m/s), which increased by 19.87% from 5.81 m/s to 6.96 m/s. Although the method to measure power in the current study, vertical jump height, differed from Doan et al. (2006), the concept behind increasing power output in order to improve CHS performance remains the same in both studies. The integration of power training into a strength program is suggested to be the best form of resistance work to produce superior performances in golfers (Fletcher & Hartwell, 2004). However, Doan et al. (2006) incorporated upper body assessments of strength and power, while the current study only tested strength and power variables of the lower extremities. The results from Doan et al. (2006) indicated CHS increased significantly by 1.62% from 47.3 m/s to 48.0 m/s. The current study revealed a significant increase in average vertical jump height from 19.05 inches to 21.25 inches ($p=0.024$), as well as an increase in average CHS 101.3 mph to 104.6 mph ($p=0.004$) in the intervention group. The comparison of the results from Doan et al. (2006) and the current study, specifically the increase in muscular power in both, further supports RQ4 in that increases in muscular power do indeed positively affect CHS.

Fletcher & Hartwell (2004) studied the effects of an 8-week combined weights and plyometric training program on golf drive performance of eleven male golfers, all of which were classified as very good with a handicap of 3.7. The average handicap of the golfers of the current study was 10.2, which is still classified as a good golfer. The level of golfer in Fletcher & Hartwell's study (2004) would likely be equivalent to that of a varsity NCAA D2 golfer making the subjects used in both studies similar in skill level. Exercises used by the experimental group in Fletcher & Hartwell (2004) such as the back squat, DB row, lunge, back extension were also utilized within the current study's resistance intervention. Fletcher & Hartwell (2004) also used a loading method of increasing 5 kilograms after 8 successful repetitions in order to achieve the overload principle, thus aiming to increase muscular strength and power. This concept has been thoroughly discussed within the literature review, as well as implanted within the current study's strength and power intervention. Additionally Fletcher & Hartwell's (2004) study had their control group test CHS and drive distance pre and post-test while sticking to their regular resistance routine throughout the study. Considering the level of golfers participating in Fletcher & Hartwell (2004), the type of regular training could be assumed, at the very least, to maintain sufficient strength and conditioning status that accommodates a high level of play. The same could be said for the control group of the current study, which followed their regular off-season training program. The main difference between Fletcher & Hartwell's (2004) study and the current study is the exclusion of measuring strength and power pre and post-test. While the current study measured muscular strength and power using 1RM testing protocols pre and post intervention, Fletcher & Hartwell (2004) did not record 1RM tests of any kind. Rather Fletcher & Hartwell (2004) based the intervention around modalities which focused on strength and power. These modalities include resistance training and MB plyometric drills. Since the control group did not participate in any form of plyometric training it can be assumed that any change in CHS and drive distance is a result of the type of training performed by the experimental group. The experimental group increased CHS from 179.8 ±9.1 $km \cdot h^{-1}$ to 182.6 ±6.2 $km \cdot h^{-1}$ yielding a

1.5% increase. This increase of 1.5% in CHS ultimately resulted in a 4.3% increase in drive distance from 225.6 ±16m to 235.7 ±11.4m. The control group in Fletcher & Hartwell (2004) did improve in CHS but only slightly (0.5%) from 172.3 ±17.1 $km \cdot h^{-1}$ to 173 ±18.7 $km \cdot h^{-1}$. However, the control group decreased drive distance by 0.7% from 220.8 ±19m to 219.3 ±30.7m. These results suggest that the use of resistance and plyometric training can have potential positive effects on increasing CHS and drive distance in high level golfers. Although the methods used to elicit strength and power in the current study differs from Fletcher & Hartwell (2004), the focus on increasing strength and power remained constant, and ultimately resulted in an improvement of CHS. Based on the similarities of the parameters of the Fletcher & Hartwell (2004) study and the current study, as well as the results, data indicate that an increase in muscular power can increase CHS, supporting RQ4.

Conclusion

When examining the results from the current study, the researcher concluded that an 8-week strength and power resistance training program can increase CHS, and muscular strength and power in male and female collegiate golfers. The data from this study also suggest that since lesser increases in strength and power were seen in the control group that the mean change between the strength variables needs to increase further than they did in the control group in order to promote an increase in CHS. The data from this study revealed strength increases by the intervention group far surpassed that of the control group. This data suggests that increases in strength in the intervention group is positively correlated to the increased CHS.

Chapter 6: Summary and Conclusions

Summary of Major Findings

The purpose of the study was to determine whether an 8-week strength and power resistance training program would elicit an increase in CHS. Additionally this study was designed to determine whether an 8-week strength and power resistance training program would increase muscular strength and power. CHS was measured using the BatMaxx 500 recording pre-test and post-test measures. A total of three swings were performed both pre-test and post-test. The average and peak of the three swings was recorded and then analyzed by the researcher. The muscular power output was measured by the average and the peak of three trials of the vertical jump test, both pre and post-testing. Vertical jump testing was chosen by the researcher since it's a universal measurement of anaerobic power output (Mitchell & Sale, 2011). The strength and power resistance training intervention used empirical evidence and recommendations provided by the NSCA Essentials of Strength and Conditioning textbook (Baechle & Earle, 2008).

The researcher hypothesized that an 8-week strength and power resistance training program would elicit an increase in CHS, as well as muscular strength and power. Based on the results of the study, the greater increases in strength and power by the intervention group produced a significant increase ($p=0.004$) in average CHS from 101.3 mph to 104.6 mph. The intervention group reported increases in the back squat (37.5 ±32.36 lbs.), deadlift (31.6 ±16.32 lbs.), clean (31.2 ±14.5 lbs.), and VJ (2.2 ±1.41 inches). Ultimately these improvements of muscular strength and power resulted in an increase of the average CHS by 3.25 mph in the intervention group from pre-test to post-test measures. There was slight increases in the back squat (7.5 ±13.69 lbs.), deadlift (17.5 ±14.05 lbs.), clean (12.3 ±10.94 lbs.), and VJ (0.166 ±1.23

inches) for the control group. However there was a slight decrease in the overall average CHS from pre-test to post-test by 3.78 ±3.82 mph. Peak velocity for CHS in the control group showed no change from pre-test 123 ±18.6 mph to post-test 123 ±17.8 mph. However, peak velocity for CHS in the intervention group showed a slight improvement from pre-test 113 ±9.2 mph to 114.3 ±8.25 mph post-test.

The increases by the intervention group where much greater than the control group. This is believed to be due to the more intensive and specific training program. A possible reason for these significant increases is due to the prior training experience of the participants. Not having repeated exposure to high intensity resistance training allows for the initial adaptations of training to be far greater than compared to an experienced lifter (Baechle & Earle, 2008). The same concept would also explain the slight increases in strength and power in the control group. Although these increases were much less than the intervention group, the increases are speculated to be the result of the consistent physical activity seen in the off-season training program (Appendix D). Because both the control and intervention group prior to this study had very limited exposure to resistance training of any kind, adaptations were seen in both populations. Since the adaptations were far greater in the intervention group, it is speculated that the nature of the strength and power resistance training program is far superior in eliciting muscular strength and power, compared to that of the standard off-season training program performed by the control group.

Recommendations and Future Research

Future research on the topic of increasing CHS through resistance training in golf is needed to further determine the most efficient means of improving golf performance. Even though the researcher was able to control the weight room training sessions for each participant, their activities outside of the study were not controlled by the researcher. A more controlled environment would be ideal for future research. For example, controlling outside physical activity such as amount of golf played. This could be done by placing restrictions on golf activities of any kind during the study. Also, nutritional habits and amount of sleep are variables that could influence strength gains or losses and may help limit confounding factors of the study. Analyzing nutritional habits could be done with food logs that monitor micro and macro nutrients. The current study could have explored other options in the intervention group, such as analyzing the effects of strength training and power training individually. This could be done if the intervention group is divided into two groups, one group performs a strength development based intervention, and the other performs a power development based intervention. Keeping all other procedures the same, this would allow future researchers to determine which resistance based intervention is better for increasing CHS. Based on the positive correlations between vertical jump ($r=0.73$, $p=0.007$) and 1RM clean ($r=0.70$, $p=0.012$) on increasing CHS, it is speculated that performing a power development training intervention would be better for increasing CHS. Based on the positive correlations between vertical jump ($r=0.73$, $p=0.007$) and 1RM clean ($r=0.70$, $p=0.012$) on increasing CHS, it is speculated that performing a power development training intervention would be better for increasing CHS.

The current study did not measure flexibility as a possible variable for increasing CHS. It is recommended that future research should incorporate measures of flexibility of the trunk and upper extremities in discovering more possible variables behind increased CHS using resistance training; this was done, in part, in studies by Doan et al. (2006), Kim (2010), Thompson, Cobb & Blackwell (2007), Westcott et al. (1996). In addition other variables to consider include: increases/decreases in lean and fat mass, drive distance, and EMG readings of the muscles used throughout the golf swing. Tracking body composition using skin fold calipers, and a seven site formula, would help the researcher to analyze any changes in fat and lean mass which might affect golf performance (Baechle & Earle, 2008). Drive distance could be used to determine changes in golf performance and measured using preset markers on a designated golf course (Fletcher & Hartwell, 2004). Additionally, EMG readings attached on the major muscle groups of the upper and lower torso might provide insight on the activity of the muscles being used during the full golf swing (Lim, Chow, & Chae, 2012). The full golf swing demands higher trunk muscle activation, especially during the downward follow-through phase of the swing, and is responsible for the majority of golf related injuries (Marta, Silva, Vaz, Burno, & Pezarat-Correia, 2013). Focusing on the muscles of the trunk may provide insight on developing specific training programs that will aim to target and strengthen the torso and hopefully improve golf performance.

There were only 12 participants used in the current study. This resulted in a small sample size; a larger sample size would give more consistent and comprehensive results. Additionally, only collegiate golfers from Adams State University, a division II NCAA institution were used for this study. A future recommendation for this study would be to use more elite level golf athletes (semi/professional golfers) for a strength and power resistance training program intervention. The range of golf handicaps among high level golfers will likely be smaller than that of a group of recreational level golfer (Lambeth et al., 2013). Thus, the use of high level golfers is ideal for future research. The current study did not explore differences between its male and female participants, thus focusing on gender specific groups may provide further insight on how resistance training aimed at increasing CHS affects each gender. The researcher speculates that male participants would generate greater increases in muscular strength and power, thus increasing CHS. Due to the slight increases of strength and power seen by the control group, future research might generate more significant results by having the control group perform primary movements only and exclude the secondary lifts from the resistance training. There are many different possible routes to explore to expand upon this study, but it ultimately depends on the research goals of the research team. More research is needed in this area to gather information on the effects of strength and power training on golf performance, specifically CHS.

Practical Applications

Since the current study did find an increase in CHS, strength and conditioning professionals may be able to apply similar procedures from this study to determine the most efficient method in designing strength and power resistance programs for collegiate level golfers. Increasing CHS has been shown to increase drive distance, which is a direct measure of golf performance, and will possibly improve one aspect of the golf athlete's game (Fletcher & Hartwell, 2004). The sport of golf continues to grow in popularity worldwide (Lamberth et al., 2013). With this rise in popularity, there is a parallel interest in studying factors associated with improving golf performance (Lamberth et al., 2013). The results of this study should provide a good reference for designing and programming strength and power resistance training for golf athletes.

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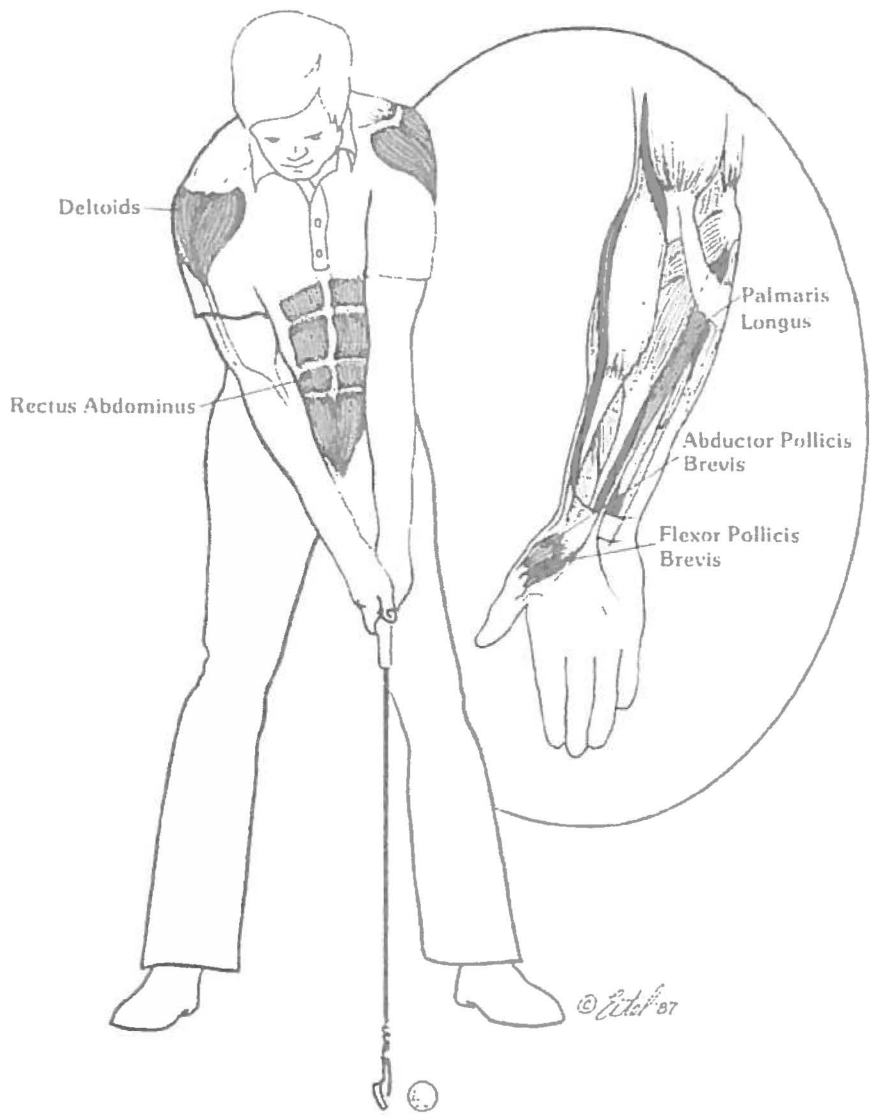
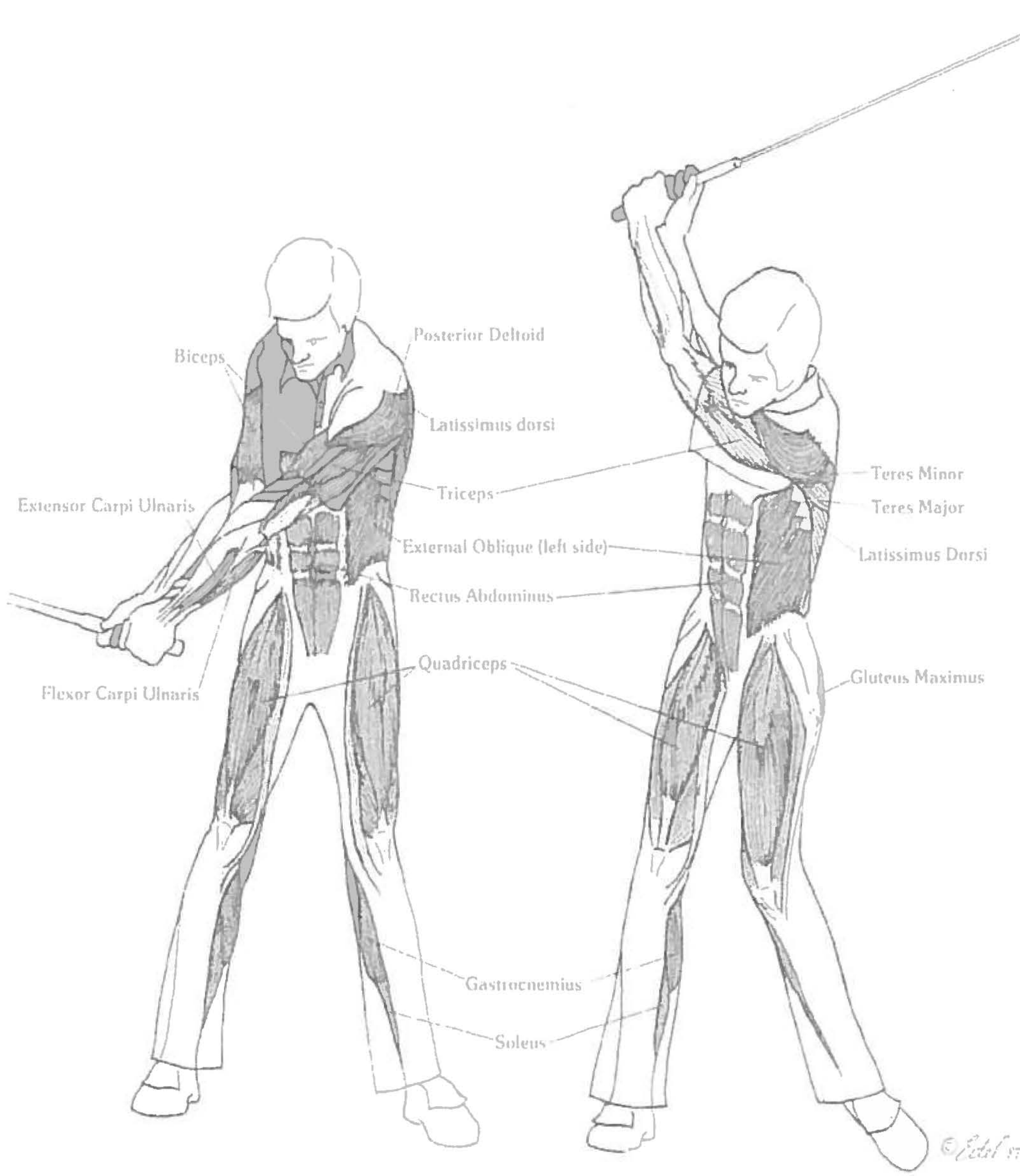
Appendix A

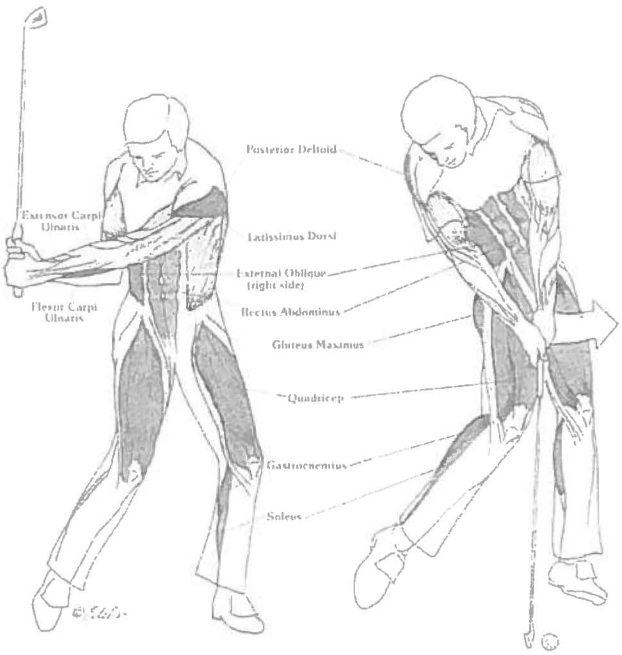
Anatomical analysis of the full golf swing



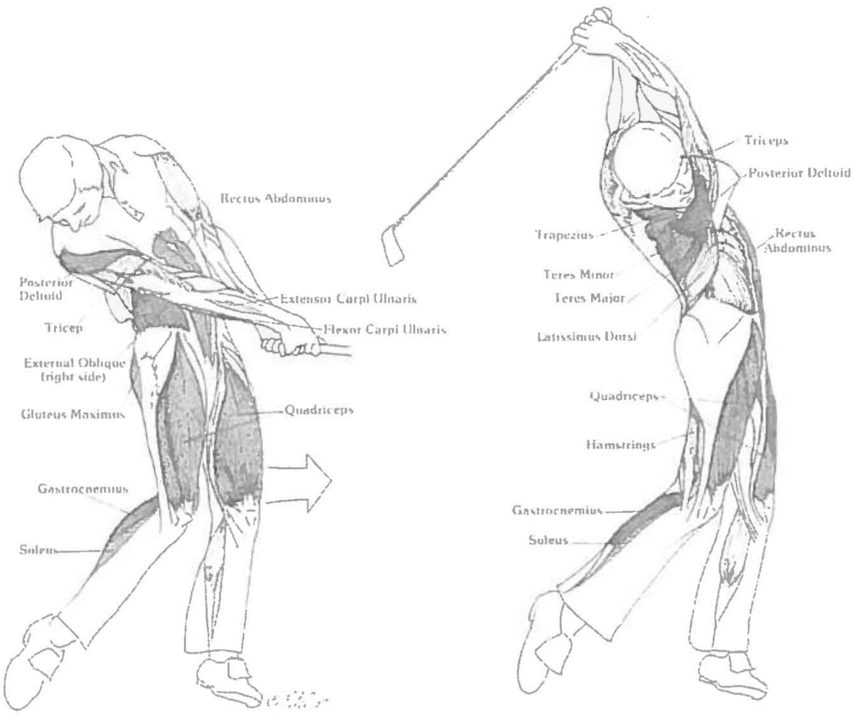
Hand position of the golf swing



Execution phase, and Backswing



Execution phase, and Downswing



Recovery phase, the follow thorough

Figure 1. Full golf swing and muscles involved.

(Maddalozzo, 1987)

Appendix B

Periodization Model for Resistance Training

Period		Preparation → First Transition		Competition	
Phase/ Variable	Hypertrophy and endurance	Basic Strength	Strength /Power	Peaking	Maintenance
Intensity	Low to moderate	High	High	Very high	Moderate
	50-75% 1RM	80-90% 1RM	87-95% 1RM 75-90% 1RM	≥93% 1RM	=80-85% 1RM
Volume	High to moderate	Moderate	Low	Very low	Moderate
	3-6 sets	3-5 sets	3-5 sets	1-3 sets	=2-3 sets
	10-20 reps	4-8 reps	2-5 reps	1-3 reps	=6-8 reps

Figure 2. Periodization Model for Resistance Training (Baechel & Earle, 2008)

Appendix C

8-week Strength and Power Training Program

Note: The percentages under the Intensity refer to % of 1RM tests results, at pre-test.

Week 1

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	5 x 6	120s	70, 75, 80, 83, 85%
B1. Push Press	5 x 6	120s	70, 75, 80, 83, 85%
C1. Front Squat	5 x 6	120s	70, 75, 80, 83, 85%
D1. Incline DB bench	3 x 8	60s	Moderate
D2. Seated Row	3 x 8	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	5 x 6	120s	70, 75, 80, 83, 85%
B1. Back Squat	5 x 6	120s	70, 75, 80, 83, 85%
C1. Trap Bar Jump	5 x 6	120s	70, 75, 80, 83, 85%
D1. DB shoulder press	3 x 8	60s	Moderate
D2. Pull up	3 x 8	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	5 x 6	120s	70, 75, 80, 83, 85%
B1. BB RDL	5 x 6	120s	70, 75, 80, 83, 85%
C1. MB golfer swing	3 x 8	90s	Explosive
C2. MB OH throw	3 x 8	90s	Explosive
D1. MB side toss	3 x 8	90s	Explosive
D2. Plate sit-up	3 x 8	60s	Heavy

Week 2

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	5 x 5	120s	72, 77, 82, 85, 87%
B1. Push Press	5 x 5	120s	72, 77, 82, 85, 87%
C1. Front Squat	5 x 5	120s	72, 77, 82, 85, 87%
D1. Incline DB bench	3 x 8	60s	Moderate
D2. Seated Row	3 x 8	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	5 x 5	120s	72, 77, 82, 85, 87%
B1. Back Squat	5 x 5	120s	72, 77, 82, 85, 87%
C1. Trap Bar Jump	5 x 5	120s	72, 77, 82, 85, 87%
D1. DB shoulder press	3 x 8	60s	Moderate
D2. Pull up	3 x 8	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	5 x 5	120s	72, 77, 82, 85, 87%
B1. BB RDL	5 x 5	120s	72, 77, 82, 85, 87%
C1. MB golfer swing	3 x 8	90s	Explosive
C2. MB OH throw	3 x 8	90s	Explosive
D1. MB side toss	3 x 8	90s	Explosive
D2. Plate sit-up	3 x 8	60s	Heavy

Week 3

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	5 x 4	120s	75, 78, 83, 86, 90%
B1. Push Press	5 x 4	120s	75, 78, 83, 86, 90%
C1. Front Squat	5 x 4	120s	75, 78, 83, 86, 90%
D1. Incline DB bench	3 x 8	60s	Moderate
D2. Seated Row	3 x 8	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	5 x 4	120s	75, 78, 83, 86, 90%
B1. Back Squat	5 x 4	120s	75, 78, 83, 86, 90%
C1. Trap Bar Jump	5 x 4	120s	75, 78, 83, 86, 90%
D1. DB shoulder press	3 x 8	60s	Moderate
D2. Pull up	3 x 8	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	5 x 4	120s	75, 78, 83, 86, 90%
B1. BB RDL	5 x 4	120s	75, 78, 83, 86, 90%
C1. MB golfer swing	3 x 8	90s	Explosive
C2. MB OH throw	3 x 8	90s	Explosive
D1. MB side toss	3 x 8	90s	Explosive
D2. Plate sit-up	3 x 8	60s	Heavy

Week 4

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	3 x 5	120s	60, 70, 75%
B1. Push Press	3 x 5	120s	60, 70, 75%
C1. Front Squat	3 x 5	120s	60, 70, 75%
D1. Incline DB bench	3 x 6	60s	Moderate
D2. Seated Row	3 x 6	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	3 x 5	120s	60, 70, 75%
B1. Back Squat	3 x 5	120s	60, 70, 75%
C1. Trap Bar Jump	3 x 5	120s	60, 70, 75%
D1. DB shoulder press	3 x 6	60s	Moderate
D2. Pull up	3 x 6	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	3 x 5	120s	60, 70, 75%
B1. BB RDL	3 x 5	120s	60, 70, 75%
C1. MB golfer swing	3 x 6	90s	Explosive
C2. MB OH throw	3 x 6	90s	Explosive
D1. MB side toss	3 x 6	90s	Explosive
D2. Plate sit-up	3 x 6	60s	Heavy

Week 5

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	5 x 3	120s	78, 83, 88, 91, 93%
B1. Push Press	5 x 3	120s	78, 83, 88, 91, 93%
C1. Front Squat	5 x 3	120s	78, 83, 88, 91, 93%
D1. Incline DB bench	3 x 8	60s	Moderate
D2. Seated Row	3 x 8	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	5 x 3	120s	78, 83, 88, 91, 93%
B1. Back Squat	5 x 3	120s	78, 83, 88, 91, 93%
C1. Trap Bar Jump	5 x 3	120s	78, 83, 88, 91, 93%
D1. DB shoulder press	3 x 8	60s	Moderate
D2. Pull up	3 x 8	60s	Body weight

Exercise	*Set/Rep*	*Rest*	*Intensity*
A1. Clean	*5 x 3*	*120s*	*78, 83, 88, 91, 93%*
B1. BB RDL	*5 x 3*	*120s*	*78, 83, 88, 91, 93%*
C1. MB golfer swing	*3 x 8*	*90s*	*Explosive*
C2. MB OH throw	*3 x 8*	*90s*	*Explosive*
D1. MB side toss	*3 x 8*	*90s*	*Explosive*
D2. Plate sit-up	*3 x 8*	*60s*	*Heavy*

Week 6

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	4 x 3	120s	83, 88, 91, 93%
B1. Push Press	4 x 3	120s	83, 88, 91, 93%
C1. Front Squat	4 x 3	120s	83, 88, 91, 93%
D1. Incline DB bench	3 x 6	60s	Moderate
D2. Seated Row	3 x 6	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	4 x 3	120s	83, 88, 91, 93%
B1. Back Squat	4 x 3	120s	83, 88, 91, 93%
C1. Trap Bar Jump	4 x 3	120s	83, 88, 91, 93%
D1. DB shoulder press	3 x 6	60s	Moderate
D2. Pull up	3 x 6	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	4 x 3	120s	83, 88, 91, 93%
B1. BB RDL	4 x 3	120s	83, 88, 91, 93%
C1. MB golfer swing	3 x 6	90s	Explosive
C2. MB OH throw	3 x 6	90s	Explosive
D1. MB side toss	3 x 6	90s	Explosive
D2. Plate sit-up	3 x 6	60s	Heavy

Week 7

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	4 x 2	120s	90, 90, 95, 95%
B1. Push Press	4 x 2	120s	90, 90, 95, 95%
C1. Front Squat	4 x 2	120s	90, 90, 95, 95%
D1. Incline DB bench	3 x 6	60s	Moderate
D2. Seated Row	3 x 6	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	4 x 2	120s	90, 90, 95, 95%
B1. Back Squat	4 x 2	120s	90, 90, 95, 95%
C1. Trap Bar Jump	4 x 2	120s	90, 90, 95, 95%
D1. DB shoulder press	3 x 6	60s	Moderate
D2. Pull up	3 x 6	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	4 x 2	120s	90, 90, 95, 95%
B1. BB RDL	4 x 2	120s	90, 90, 95, 95%
C1. MB golfer swing	3 x 6	90s	Explosive
C2. MB OH throw	3 x 6	90s	Explosive
D1. MB side toss	3 x 6	90s	Explosive
D2. Plate sit-up	3 x 6	60s	Heavy

Week 8

Exercise	Set/Rep	Rest	Intensity
A1. Hang Clean	6 x 1	120s	90, 95, 95, 98, 100, 100%
B1. Push Press	6 x 1	120s	90, 95, 95, 98, 100, 100%
C1. Front Squat	6 x 1	120s	90, 95, 95, 98, 100, 100%
D1. Incline DB bench	3 x 6	60s	Moderate
D2. Seated Row	3 x 6	60s	Moderate

Exercise	Set/Rep	Rest	Intensity
A1. Deadlift	6 x 1	120s	90, 95, 95, 98, 100, 100%
B1. Back Squat	6 x 1	120s	90, 95, 95, 98, 100, 100%
C1. Trap Bar Jump	6 x 1	120s	90, 95, 95, 98, 100, 100%
D1. DB shoulder press	3 x 6	60s	Moderate
D2. Pull up	3 x 6	60s	Body weight

Exercise	Set/Rep	Rest	Intensity
A1. Clean	6 x 1	120s	90, 95, 95, 98, 100, 100%
B1. BB RDL	6 x 1	120s	90, 95, 95, 98, 100, 100%
C1. MB golfer swing	3 x 6	90s	Explosive
C2. MB OH throw	3 x 6	90s	Explosive
D1. MB side toss	3 x 6	90s	Explosive
D2. Plate sit-up	3 x 6	60s	Heavy

Appendix D

Regular Off Season Training Program for Adams State University Men's and Women's Golf Team: Note: ROM equals range of motion

Weeks 1-2

Monday *ROM=Range of motion

Exercise	set/rep	rest	Emphasis
A1. DB HE Front Squat	4 x 8-10	45	Control Weight
A2. BW Piston Squat	4 x 6-8	30	Control Weight
B1. DB RDL	3 x 8-10	45	ROM
B2. Leg curl	3 x 8-10	30	ROM
C1. Plate sit-up	3 x 10-12	30	Control Weight
C2. MB twist	3 x 8-10	30	ROM

Wednesday

Exercise	set/rep	rest	Emphasis
A1. Pull up/Pull down	4 x 8-10	45	ROM
A2. Cable 1 Arm Row	4 x 6-8	30	Control Weight
B1. DB 1 Arm Bench	3 x 8-10	45	Control Weight
B2. Band pull apart	3 x 8-10	30	Control Weight
C1. Face pulls	3 x 10-12	30	Control Weight
C2. MB golf swing	3 x 8-10	30	Control Weight

Friday

Exercise	set/rep	rest	Emphasis
A1. MB walking lunge	3 x 4-6	30	ROM
A2. MB RDL	3 x 4-6	30	ROM
B1. Cable Int. Rotation	3 x 8-10	30	ROM
B2. Cable golf chop	3 x 8-10	30	ROM
C1. MB sit up	3 x 8-10	30	ROM
C2. 1 Arm Back Ext.	3 x 8-10	30	ROM

Weeks 3-4

Monday

Exercise	set/rep	rest	Emphasis
A1. DB HE Front Squat	4 x 6-8	45	Control weight
A2. BW Piston Squat	4 x 8-10	30	Control weight
B1. DB RDL	3 x 6-8	45	ROM
B2. Leg curl	3 x 6-8	30	ROM
C1. Plate sit-up	3 x 10-12	30	Control weight
C2. MB twist	3 x 6-8	30	ROM

Wednesday

Exercise	set/rep	rest	Emphasis
A1. Pull up/Pull down	4 x 6-8	45	Control weight
A2. Cable 1 Arm Row	4 x 8-10	30	Control weight
B1. DB 1 Arm Bench	3 x 6-8	45	ROM
B2. Band pull apart	3 x 6-8	30	ROM
C1. Face pulls	3 x 10-12	30	Control weight
C2. MB golf swing	3 x 6-8	30	ROM

Friday

Exercise	set/rep	rest	Emphasis
A1. MB walking lunge	3 x 6-8	30	ROM
A2. MB RDL	3 x 6-8	30	ROM
B1. Cable Int. Rotation	3 x 8-10	30	ROM
B2. Cable golf chop	3 x 8-10	30	ROM
C1. MB sit up	3 x 8-10	30	ROM
C2. 1 Arm Back Ext.	3 x 8-10	30	ROM

Weeks 5-6

Monday

Exercise	set/rep	rest	Emphasis
A1. DB step up	4 x 8-10	45	Control weight
A2. BW Bulg. Split Squat	4 x 6-8	30	Control weight
B1. DB RDL	3 x 8-10	45	ROM
B2. Leg curl	3 x 8-10	30	ROM
C1. Plate sit-up	3 x 10-12	30	Control weight
C2. MB twist	3 x 8-10	30	ROM

Wednesday

Exercise	set/rep	rest	Emphasis
A1. Pull up/Pull down	4 x 8-10	45	ROM
A2. Cable wide grip Row	4 x 6-8	30	Control weight
B1. DB Incline Bench	3 x 8-10	45	Control weight
B2. Band pull apart	3 x 8-10	30	Control weight
C1. Face pulls	3 x 10-12	30	Control weight
C2. MB golf swing	3 x 8-10	30	Control weight

Friday

Exercise	set/rep	rest	Emphasis
A1. MB reverse lunge	3 x 4-6	30	ROM
A2. MB SLRDL	3 x 4-6	30	ROM
B1. Cable Int. Rotation	3 x 8-10	30	ROM
B2. Cable golf chop	3 x 8-10	30	ROM
C1. MB sit up	3 x 8-10	30	ROM
C2. 1 Arm Back Ext.	3 x 8-10	30	ROM

Weeks 7-8

Monday

Exercise	set/rep	rest	Emphasis
A1. DB step up	4 x 6-8	45	Control weight
A2. BW Bulg. Split Squat	4 x 8-10	30	Control weight
B1. DB RDL	3 x 6-8	45	ROM
B2. Leg curl	3 x 6-8	30	ROM
C1. Plate sit-up	3 x 10-12	30	Control weight
C2. MB twist	3 x 6-8	30	ROM

Wednesday

Exercise	set/rep	rest	Emphasis
A1. Pull up/Pull down	4 x 6-8	45	Control weight
A2. Cable Wide grip Row	4 x 8-10	30	Control weight
B1. DB Incline Bench	3 x 6-8	45	ROM
B2. Band pull apart 3 way	3 x 6-8	30	ROM
C1. Face pulls	3 x 10-12	30	Control weight
C2. MB golf swing	3 x 6-8	30	ROM

Friday

Exercise	set/rep	rest	Emphasis
A1. MB reverse lunge	3 x 6-8	30	ROM
A2. MB SLRDL	3 x 6-8	30	ROM
B1. Cable Int. Rotation	3 x 8-10	30	ROM
B2. Cable golf chop	3 x 8-10	30	ROM
C1. MB sit up	3 x 8-10	30	ROM
C2. 1 Arm Back Ext.	3 x 8-10	30	ROM

Appendix E

Adams State University

Request to obtain approval for the use of human participants – expedited review

Date:

To: **Adams State University**

Request to obtain approval for the use of human participants – expedited review

Date:

To: Rob Demski, ASU Institutional Review Board

Name: Jason Mannerberg
Email: mannerbergjm@grizzlies.adams.edu
Mailing Address: 230 Calle Buena Alamosa, CO 81101

Phone: 720-387-1295

Responsible Faculty Member

Chair of Thesis Committee: Tracey Robinson, Ph.D.
Email: tlrobins@adams.edu
Phone: 719-587-7663

Subject: Strength and Power Training and its effects on club head speed in male and female collegiate golfers (Master's thesis project).

Others in Contact with Human Participants:

Research Assistants: Possible undergraduate students.

The title of the research: Effects of an 8-Week Combined Strength & Power Training Program on Club Head Speed in Collegiate Golfers.

Objectives of the research: Golf ranks among the top ten most popular sports and recreational activities in the United States with over 26.4 million golfers nationwide. This intermittent sport appeals to both male and female populations as well as people of various skill levels, and age. With an increase in popularity there has been a rising interest in studying factors associated with increasing golf performance. Few Studies have investigated the effects of resistance-training on golf performance measuring club head speed. The research on collegiate golfers is very limited and must be expanded upon. The purpose of this study is to identify if an 8-week strength and power intervention produces an increases in the club head speed of division II collegiate male and female golfers.

Benefits

The benefits of this study include, but are not limited to: increased club head speed and increase in strength and power production. Identifying specific exercises that cause an increase in strength and power to produce increase in club head speed will also be beneficial. It is crucial to determine exercises and improve knowledge that will potentially improve performance for male and female collegiate golfers.

Risks and Discomforts

There are possible risks associated with the study that include the potential for injury, that are associated with any lifting program. These include: muscular damage, delayed onset muscle soreness (DOMS), and possible structural damage. To minimize the potential of injury, the exercises will be instructed and supervised by the primary researcher and Matt Gersick (Head Strength and Conditioning Coach). Every professional effort will be made to minimize any risks involved in this study. Participants may also experience sore muscles due to the training programs. The risks of participating in a resistance training program are less than that of playing the actual sport.

Methods of procedure:

Permission for this research study will be obtained from the Institutional Review Board (IRB) for human subject research at Adams State University. All participants will perform their pre/post tests and resistance training program under supervision of the researcher, at all times. The researcher is a certified strength and conditioning specialist (CSCS) and has written all of the resistance training programs. The CSCS is certified by the National Strength and Conditioning Association. These measures will be taken to ensure that the training protocols and exercises will be followed safely and appropriately.

The Setting: The study will take place at Adams State University, Alamosa, Colorado. All participants will complete pre and post-test measures of bat swing velocity in the Plachy Hall Athletic Field House. The resistance training program will take place in the Adams State University athletic weight room, located in Plachy Hall room 105B.

Participants: A group of twelve male and female golf athletes from Adams State University will volunteer to participate in the study. Adams State University head golf coach John Antencio has given permission for his team to participate in the eight week training program. The participant's ages will range from 18-23 years old. Right handed and left handed golfers will both be used.

Pre-test: Consent forms will be signed and collected from all participants prior to the beginning of the study. There will an initial meeting with the subjects to stress the importance of adherence to the training program and testing protocol to ensure safety as well as accuracy. The initial meeting will also allow subjects to fill out a questionnaire for the researcher to measure their characteristics. Following the initial briefing, the subjects will be randomly assigned into either an experimental group (N=6) or control group (N=6) and will be tested to obtain pre-treatment measures.

Testing will consist of:

1. Club head swing speed measured by the BatMaxx 500. Each participant will be allowed 3 practice swings followed by 5 minutes rest and then 3 measure maximal effort swings with 60 seconds rest between attempts. The peak and average swing velocities will be recorded and analyzed by the researcher. The subjects will be instructed to use their natural swing with maximal effort during the measured efforts.

2. The participants' strength will be measured by administering a 1RM test in the back squat, deadlift, and power clean. Each exercise will follow the exact same protocol when testing 1RM. The protocol is as follows:
    a. Prior to the 1RM test, the subjects will be instructed to warm up with light resistance that easily allows 5 to 10 repetitions followed by a 1 minute rest period.
    b. An estimated warm-up load is then selected by the strength and conditioning specialist that will allow the subjects to complete 3 to 5 repetitions followed by a 2 minute rest period.
    c. Next, an estimated near maximal load will be selected by the strength and conditioning specialist that will allow the subjects to complete 2 to 3 repetitions followed by a 2-4 minute rest period.
    d. The load is then increased to a perceived maximal effort and attempted by the subjects for 1 repetition. If the repetitions is successful, the subjects will take another 2-4 minute rest, increase the load 5-10% for upper body and 10-15% for lower body and repeat a maximal effort attempt. If any subject fails at their first attempt of a 1RM the load will be decreased by 2.5-5% for upper body exercises and 5-10% for lower body exercises after a 2-4 minute rest period.

3. Lastly, the participants will then measure power by measuring vertical jump height via the "Just Jump" mat (Probotics INC.).
    a. Each subject will be instructed to warm up by completing ankle jumps for 2 sets of 10 repetitions.
    b. The participants will then stand in front of the "Just Jump" mat until instructed to step onto the device, where they will then perform a maximal effort jump landing back on the "Just Jump" mat resting for 2 minutes in between attempts.
    c. Each participant will repeat this process a total of three time.

Procedures: The actual study will consist of an 8-week resistance training program. The participants will train three days a week on Mondays, Wednesdays, and Fridays. Each participant will be given printed out copies of the resistance program with instructions on how to record volume and intensity for each exercise. The primary exercise intensities will be based off the 1RM test results.

Prior to each training session, the experimental group will perform a general warm up consisting mobility drills and dynamic stretches. The warm up consist of five movements completed for 1 set of 8-10 repetitions per movement. Warm up movements include: supine hip cross-overs, prone single leg cross-over, body weight lunges, inverted hamstring stretch, and 5lb. plate Cuban press.

The control group will perform their normal 8-week off-season training program provided by the Adams State University strength and conditioning staff.

After 8 weeks, the subjects will be allowed adequate rest of 48 to 72 hours as outlined by (Baechle & Earle, 2008).

Post-test: The experimental and control group will then be tested post-treatment for club head swing speed; 1RM back squat, deadlift, power clean; and vertical jump, using the same protocol mentioned for pre-testing.

Research Design: Data will be analyzed using SPSS statistical analysis software. The independent variables in this study will be the treatment groups, (experimental and control 8-week resistance-training program), and time of measurement (pre and post training program); the dependent variables will be the peak and average club head velocity, and 1RM in the deadlift, squat, and power clean, and vertical jump height.

Protection Measures

Participation is voluntary and will be held confidential. Participants may choose not to answer any question they do not want to answer and/ or may withdraw from participation at any time without penalty. Names will not be used in the study, participants will be assigned a number and group data will be reported. Data will be locked under a password protected computer for five years in which the researcher only has the password. Adams State University reserves the right to use the results of this study for future research and/or presentation of results. In such cases, participants will be asked to sign a release form freeing all collected information prior to its use by the institution or researcher. If research is used in a public forum, data will be reported as a group without individual or school identification.

Consent: Participants will be asked to read over and sign the consent form before any testing begins. The informed consent is attached separately.

Changes: If any changes are made to the research I will contact the IRB immediately and fill out the needed paperwork.

____

Signature of Department Chair or Appropriate Person Date

____

Signature of IRB Chair Date

Appendix F

Informed Consent for Resistance Training Intervention Research Study

The Effects of an 8-week Combined Strength and Power Training Program on Club Head Speed in Collegiate Division II Golfers

Jason Mannerberg
Adams State University Human Performance and Physical Education

The purpose of the study is to determine the effect that specific strength and power resistance training has on club head speed in collegiate golfers. The secondary purpose is to identify the specific exercises that contribute to an increase in club head speed. You have been identified by the researcher as a potential volunteer for this study because you met the criteria of being a Division II, collegiate golf athlete at Adams State University.

Procedures

This study will utilize 12 participants, who will be randomly assigned to one of two groups: control (regular in-season lifting) and experimental (8-week strength and power resistance training program) lifting and sport specific medicine ball training program). Randomization of the two groups will be performed equally, based on collegiate golf experience, age, and gender.

Specific Laboratory Tests Include:

All tests listed below will be performed both before the training program, and after the conclusion of the training program.

1. You will be asked to fill out a short survey asking about your demographics (age, weight, height, and collegiate golf experience) before testing. All pre and post testing will be performed in the Human Performance lab at Adams State University.
2. A one repetition maximal (1RM) effort in the back squat, deadlift, and power clean will be tested in the Plachy Hall weight room.
3. You will perform 3 maximal effort jumps for vertical height using the "Just Jump" mat and will be tested in the Plachy Hall weight room.
4. You will then be asked to perform five swings using your personal driver with maximal effort. All participants will use their own personal club. Club swing velocity will be measured using a BatMaxx 500, vertical computerized photosensing timer.

Training Program:

The program must be followed strictly as outlined for 8 weeks. This program is based on strong empirical evidence and will be targeting strength and power specific to the vital aspects of the golf swing. Any lapse in training or alteration of the training program design will result in your being asked to leave the study.

The 8-week training program will be performed in the Plachy Hall weight room, under the supervision of Jason Mannerberg (Primary Researcher) and Matt Gersick (Head Strength and Conditioning Coach).

If you are randomly selected to participate in the control group, you will perform your regular, off-season lifting program 3 days per week (Monday, Wednesday, Friday). Exercises include: DB front squat, BW piston squat, RDL, pull down, cable row, DB bench, band pull-a-part, face pull, MB back extension, MB golfer swing, MB lunge, MB Russian twist, and cable chops.

If you are randomly selected to participate in the experimental group, you will perform a 8-week strength and power resistance program, 3 days a week (Monday, Wednesday, Friday). Exercises for the experimental group include: hang clean, push press, front squat, incline bench, deadlift, back squat, trap bar jump, DB shoulder press, pull-up, clean, RDL, MB golfer swing, MB OH throw, MB side toss, and weighted sit-up.

Benefits:

The training program is based on empirical evidence and targets variables known to be responsible for a statistically significant increase in club head swing speed and thus improved performance can be expected.

Attendant Risks and Discomforts:

As with any training program there is an inherent risk for injury. The resistance training program is based on empirical evidence and will be supervised by a certified strength and conditioning specialist. All known precautions to prevent injury during the training program will be taken. However, all exercise regardless of measures taken has some risk for injury. This program may also cause muscular discomfort or soreness that is associated with resistance training that targets strength and power. These are very common side effects and each participant will be closely monitored by the certified strength and conditioning specialist for safety throughout the duration of the resistance training program. If needed an athletic trainer will be consulted for safety.

Inquiries:

Any questions about the procedures used in the study or the results of the study are encouraged. If you have any concerns or questions, please ask us for further explanation.

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Use of Medical Records:

The information that is obtained during the study will be treated as privileged and confidential. All information will be secured in a locked draw only accessible by the researcher. It is not to be released or revealed to any person except your personal physician without your written consent, or in the case of an emergency. The information obtained, however, may be used for statistical analysis or scientific purposes with your right to privacy retained. All individual data will be kept confidential and results will be reported only as group data.

Freedom of Consent:

> I hereby consent to voluntarily engage in this study to determine the efficacy of the resistance training program outlined. My permission to participate in this research is voluntary. I understand that I am free to stop participating at any point, if I so desire with absolutely no detriment to my sport or academics at Adams State University. I understand that this research will be monitored by a certified strength and conditioning specialist and a certified athletic trainer. I also understand that all records concerning my involvement in this study will be kept in a locked storage area and only available to the researchers.

I have read this form, and I understand the procedures that I will perform and accept the risks and discomforts. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this study.

_______________________________ ____________

Printed name of participant Date

____

Signature of participant

_______________________________ ____________

Signature of researcher Date

Appendix G

Participant Questionnaire for Club Head Speed Research

1. Full name, DOB, height, weight, age.

2. Years of playing golf? Only include years played at collegiate level.

3. Any current injuries or health related concerns? Include all past treatments received from physical therapist or athletic trainers.

4. Any Major surgeries or injuries in the past 12 months?

5. Height and weight measured by the research team (centimeters and kilograms)

6. List any medications or supplements you are currently taking

Appendix H

Dynamic Warm-up, completed prior to each training session:

Warm-Up Movement	Set/Rep	Rest
A1. Hip Cross-overs	1 x 8-10	15sec
A2. Prone Single Leg Cross-overs	1 x 8-10	15sec
A3. BW Lunges	1 x 8-10	15sec
A4. Inverted Hamstring Stretch	1 x 8-10	15sec
A5. 5lb. Plate Cuban Press	1 x 8-10	15sec

Appendix I

Independent samples t test and Leven's test for equality of variances

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
post CHS minus pre CHS (average - mph)	Equal variances assumed	4.273	.066	3.784	10	.004	7.03333	1.85870	2.89188	11.17478
	Equal variances not assumed			3.784	6.566	.005	7.03333	1.85870	2.79592	11.27075
post VJ minus pre VJ (average - inches)	Equal variances assumed	.058	.814	2.657	10	.024	2.03333	.76536	.32800	3.73866
	Equal variances not assumed			2.657	9.631	.024	2.03333	.76536	.32401	3.74266
post backsquat minus pre back squat	Equal variances assumed	3.915	.076	2.091	10	.063	30.00000	14.34689	-1.96687	61.96687
	Equal variances not assumed			2.091	6.734	.076	30.00000	14.34689	-4.19813	64.19813
post deadlift minus pre deadlift	Equal variances assumed	.312	.589	1.611	10	.138	14.16667	8.79552	-5.43097	33.76430
	Equal variances not assumed			1.611	9.783	.139	14.16667	8.79552	-5.49011	33.82344
post clean minus pre clean	Equal variances assumed	2.470	.147	2.510	10	.031	8.50000	3.38707	.95314	16.04686
	Equal variances not assumed			2.510	9.257	.033	8.50000	3.38707	.87024	16.12976

Appendix J

Pearson Correlation test tables and graphs

Correlations

		BackSquatpost	CHSpost
BackSquatpost	Pearson Correlation	1	.640*
	Sig. (2-tailed)		.025
	N	12	12
CHSpost	Pearson Correlation	.640*	1
	Sig. (2-tailed)	.025	
	N	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

Correlations

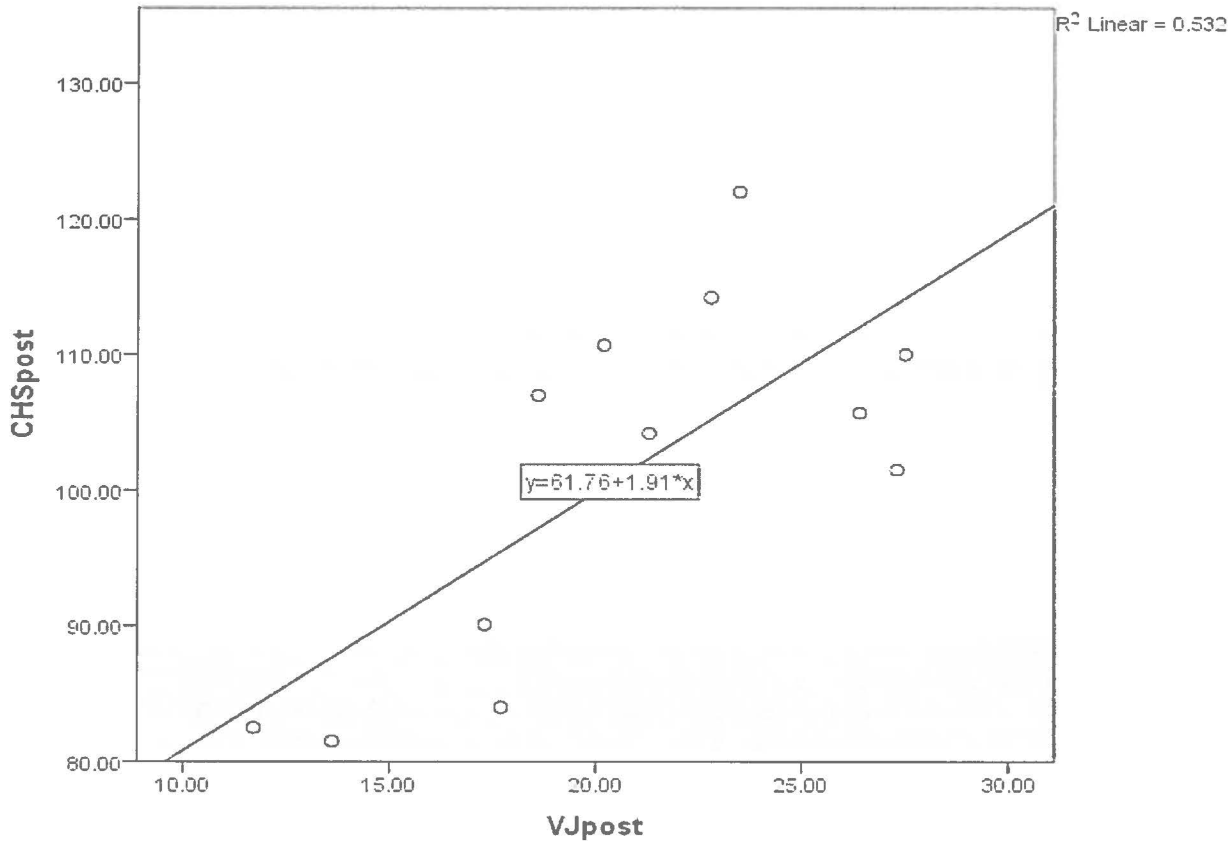
		Deadliftpost	CHSpost
Deadliftpost	Pearson Correlation	1	.542
	Sig. (2-tailed)		.069
	N	12	12
CHSpost	Pearson Correlation	.542	1
	Sig. (2-tailed)	.069	
	N	12	12

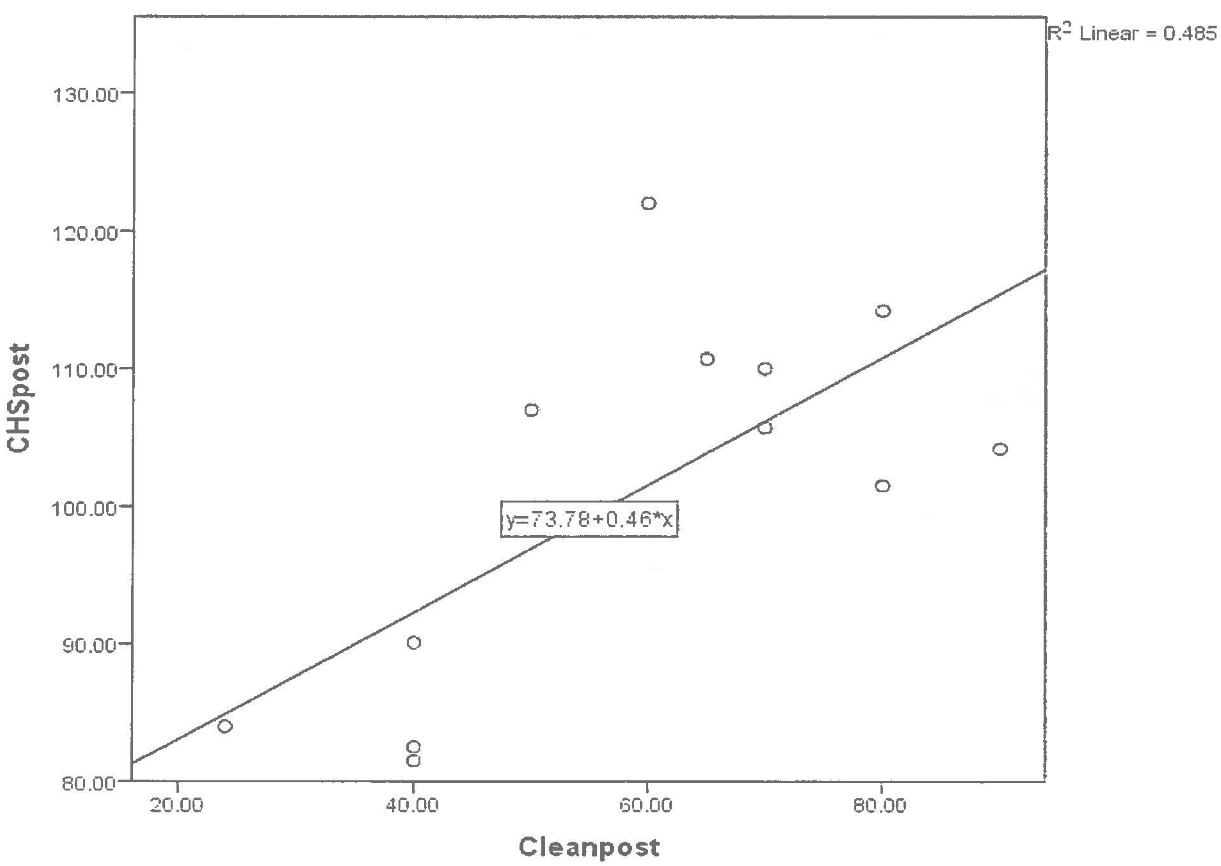
Correlations

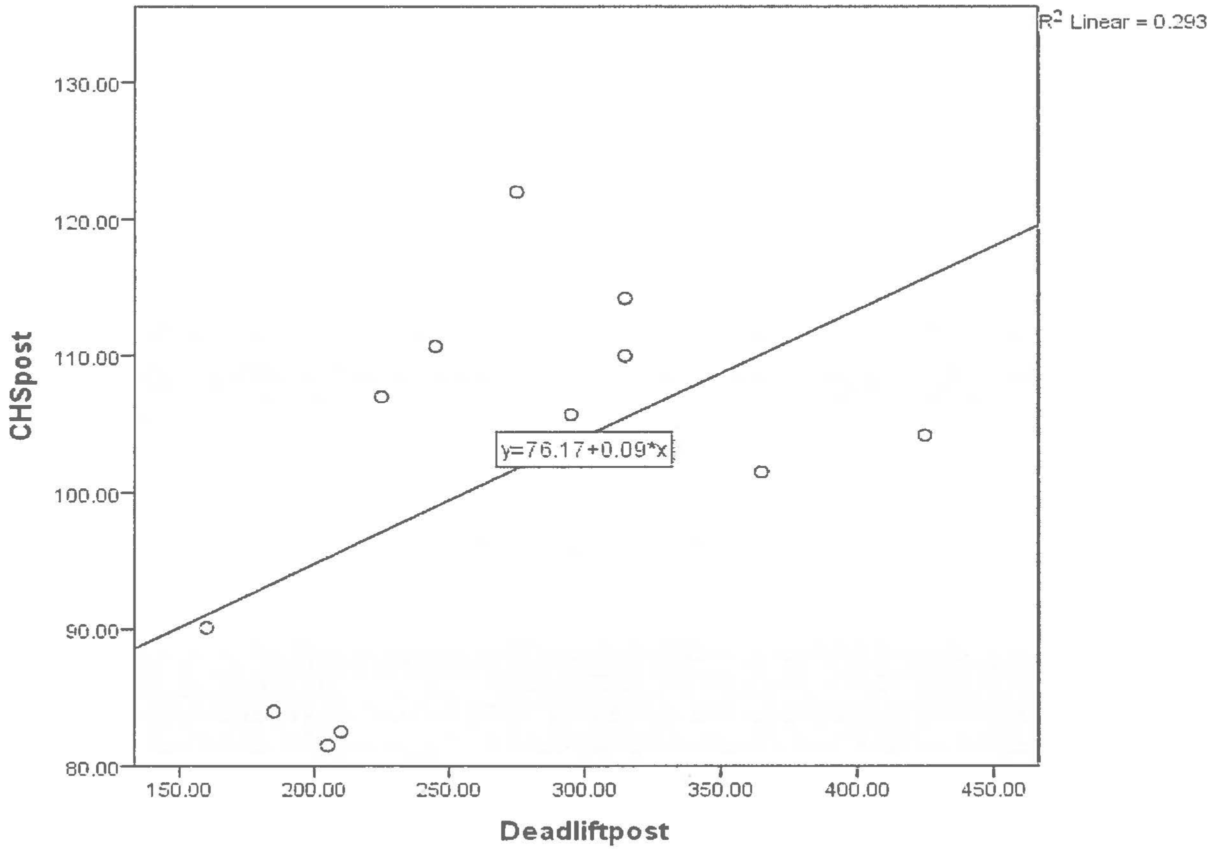
		CHSpost	VJpost	Cleanpost
CHSpost	Pearson Correlation	1	.729**	.697*
	Sig. (2-tailed)		.007	.012
	N	12	12	12
VJpost	Pearson Correlation	.729**	1	.726**
	Sig. (2-tailed)	.007		.007
	N	12	12	12
Cleanpost	Pearson Correlation	.697*	.726**	1
	Sig. (2-tailed)	.012	.007	
	N	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).


R2 Linear = 0.532
130.00
120.00
110.00
100.00
90.00
80.00
CHSpost
y=61.76+1.91*x
10.00
15.00
20.00
25.00
30.00
VJpost


R2 Linear = 0.485
130.00
120.00
110.00
100.00
90.00
80.00
CHSpost
y=73.78+0.46*x
20.00
40.00
60.00
80.00
Cleanpost


R2 Linear = 0.293
130.00
120.00
110.00
100.00
90.00
80.00
CHSpost
y=76.17+0.09*x
150.00
200.00
250.00
300.00
350.00
400.00
450.00
Deadliftpost