THE EFFECTS OF A 7-WK HEAVY ELASTIC BAND AND WEIGHTED CHAIN PROGRAM ON UPPER BODY STRENGTH AND UPPER BODY POWER IN A SAMPLE OF DIVISION 1-AA FOOTBALL PLAYERS

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Jamie Ghigiarelli, M.S., ME.d.

Within recent years, strength training involving the modalities of heavy elastic bands and weighted chains has received widespread recognition and increased popularity. PURPOSE: The purpose of this study was to explore the effects of a seven week heavy elastic band and weighted chain program on maximum muscular strength and maximum power in the bench press exercise. METHODS: Thirty six (n=36) healthy males 18-30 years old from the Robert Morris University football team volunteered to participate in this study. During the first week, predicted one repetition maximum (1RM) bench press and a five repetition (5RM) maximum speed bench press tests were conducted. Subjects were randomly divided into three groups (n=12): elastic band (EB), weighted chain (WC) and control (C). Subjects were oriented to the elastic band (EB) and chain weighted (WC) bench press prior to pre testing. During weeks 2 through 8 of the study, subjects were required to follow the resistance training program designed for using the EB and WC for seven weeks. All other components of normal spring training and conditioning remained the same. Means and standard deviations of the predicted 1RM bench press and 5RM speed bench press were computed in the first and ninth week of the program. A two factor (method X time) analysis was applied to identify significant differences between the training groups. Statistical significance was set at $\alpha = 0.05$. RESULTS: Results indicated a significant time ($*p < 0.05$), but no group effect for both predicted 1RM (kg) and 5RM peak power tests (watts). Although not significant, results did show greater improvements in the EB and WC groups compared to control when the two highest and greatest values were selected regarding peak power. CONCLUSION: This study suggests that the use of EB and WC in conjunction with a general seven week off season strength and conditioning program can increase overall maximum upper body strength in a sample of Div 1-AA football players. PRACTICAL APPLICATION: The implementation of heavy elastic bands and weighted chains into a strength and conditioning regimen may result in potential gains in muscular strength and power. These types of training modalities add a unique training style and more flexibility in respect to exercise prescription for athletes and strength practitioners.

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1.0 INTRODUCTION

Within recent years, strength training involving the modalities of elastic bands and weighted chains has received widespread recognition and increased popularity (Ebben, 2002; Cronin, 2003; Newton, 2002; Wallace, 2006; Andersen, 2005; Berning, 2004; Winters, 2006; Waller, 2003; Simmons, 1999). When traditional weight training uses a constant external load throughout an exercise, skeletal muscle exerts varied forces due to the internal torque-joint angle relationship (McGinnis, 1999). With the introduction of nontraditional training modes, external resistance may be altered in many ways to target particular neuromuscular traits and thereby change the "transfer specificity" of a given training program. Transfer specificity (Kraemer, 2002; Newton, 2002) relates to the percentage of carryover to other activities. This may be accomplished by changing the resistance training mode in an attempt to specifically match the strength curve of the exercise movement (Zatsiorsky, 1995; Fleck & Kraemer, 2004).

Attempts to design variable resistance equipment that match strength curves of a given movement have allowed muscles to exert maximal force throughout a range of motion (i.e. Nautilus Equipment) (Zatsiorksy, 1995). However, few studies have explored effects of this type of variable resistance training (VRT) in dynamic free weight exercises. Through the addition of hanging chains to the ends of a barbell, free weight exercise models those characteristics similar to variable resistance exercise. The functions of VRT training using a free weight exercise are two-fold: 1) Load will increase where the muscle joint has more leverage, such as in the early phases of a lift and; 2) a decreasing load will follow where the muscle joint has little leverage, such as in the later phases of a lift (i.e. the deep squat position). It is hypothesized that VRT may be a beneficial modality in strength training based on the theoretical concept of the muscle-joint relationship. In this example, the weighted chain system is accommodating a load at weaker joint angles. Practitioners have also reported additional benefits from weighted chains oscillating and swinging throughout the range of motion including the increased use of stabilization muscles (Berning, 2004; Simmons, 1999).

Historically, elastic bands have been used primarily in rehabilitation settings (Simoneau, 2001; Treiber, 1998) or for exclusive sports specific objectives such as improving strength and power in racquet sports (Behm, 1988). Recently, elastic bands have been applied to both structural and power movements in an effort to induce greater strength gains (Cronin, 2003; Andersen, 2005; Wallace, 2006; Newton, 2002; Simmons 1999). Due to the tendency of the elastic bands to pull a barbell down during early phases of a lift, an increased eccentric loading phase occurs which may explain how higher eccentric velocities could be associated with this type of training.

Eccentric training is considered a viable stimulus because it is more metabolically efficient than concentric contraction, as well as capable of generating higher forces (Asmussen, 1974; Hakkinen, 1983; Bobbert, 1987; Kaneko, 1983; Rodgers & Berger, 1974). It has also been reported that eccentric compared to concentric exercise tends to produce greater and more rapid increases in muscle strength and hypertrophy (Hortobagyi, 2000) due to the result of greater tissue damage produced under eccentric conditions. As a greater magnitude of muscle is stretched, the more elastic energy it will store (Bobbert, 1987), and consequently, a greater resultant concentric force will result.

Eccentric training may be implemented in two ways: (1) By increasing the load on the barbell (Doan, 2002; Siff, 1999); or (2) increasing the velocity of stretch in the respective movement (Bobbert, 1987; Cavagna, 1968). The attachment of heavy elastic bands is an attempt to increase velocity of stretch which may cause selective increases in the tensile strength of tendons and other series elastic components of the muscle. Modifying bands to a strength training apparatus in such a way that the return velocity and force needed to decelerate the load (at the end of the eccentric phase) has reported promising results (Cronin, 2003; Andersen, 2005; Wallace, 2006; Newton, 2002) and warrants further investigation.

Literature suggests the implementation of high speed, high force movements in a weight training program results in increased power and strength gains (Newton, 1994; Harris, 2000; Lyttle, 1996). Performing these types of movements using uncommon modalities of resistance training may hold promise of an improved ability to transfer benefits directly from the weight room to the athletic arena. By performing the chain and elastic band bench exercise as instructed, subjects may potentially increase maximum bench and speed bench press, due to increased upper body strength and power. To a vast majority of athletes, information regarding increases in strength and power is of high practical value.

The emphasis on strength and conditioning is apparent (Latin, 2004) in Division I college athletes which is why it is important to explore research using alternative forms of free weight exercise. The results of the study can assist coaches or physical education teachers to implement and educate young athletes on a new and safe technique to improve muscular strength and power. In addition, these modalities could allow the strength and conditioning professional more flexibility in exercise prescription with respect to exercise variety.

1.1 STATEMENT OF PURPOSE

The purpose of this investigation was to explore the effects of heavy elastic bands and weighted chains on upper body maximum strength and power in a seven week off-season strength and conditioning program using a sample of Division 1AA football players.

1.2 HYPOTHESES

It was hypothesized that:

1. Incorporating weighted chains (WC) into a seven week off-season strength and conditioning program would increase maximum upper body strength compared to control group (traditional weight training group).
2. Incorporating weighted chains (WC) into a seven week off-season strength and conditioning program would increase maximum upper body power compared to control group (traditional weight training group).
3. Incorporating elastic bands (EB) into a seven week off-season strength and conditioning program would increase maximum upper body strength compared to control group (traditional weight training group).
4. Incorporating elastic bands (EB) into a seven week off-season strength and conditioning program would increase maximum upper body power compared to control group (traditional weight training group).

2.0 REVIEW OF LITERATURE

2.1 INTRODUCTION

The purpose of this review will be to explore previous literature related to neuromuscular adaptations as a result of traditional resistance training and power training. This review will also discuss how methodology of power training may be coupled with non traditional methods of training for power development. It is important to note that the intervention proposed in the present study was seven weeks long. Previous literature has suggested that hypertrophic effects are not typically observed in this short period of time, therefore effects of power training on muscle hypertrophy will not be discussed.

2.2 NEURAL ADAPTATIONS TO RESISTANCE TRAINING

2.2.1 Electromyographic studies (I EMG)

A motor unit (MU) consists of a motorneuron and the muscle fibers it innervates. The recording of integrated electromyographic (IEMG) activity is a common method to monitor neural adaptations, i.e. changes in motor unit activation during strength training (Hakkinen, 1989). Electromyographic studies are well documented and have provided the most direct assessment of neural adaptation to training (Hakkinen, 1985, 1983, 1987, 1989, 1990, 2001; Komi, 1972; Higbie, 1996; Moritani, 1979; 1985; Thorstensson, 1976,). Surface electrodes are used to measure motor unit activity in the prime mover muscles during brief periods of isometric (Hakkinen 1985, 1983), isokinetic (constant velocity) (Komi, 1972), and explosive actions (Hakkinen, 1985, 2001). The recorded motor unit activity is quantified as the IEMG.

The level of integrated electromyogram (IEMG) attained during maximal voluntary contraction (MVC) is a measure of the maximal activation of the muscle under voluntary contraction (Moritani, 1979). Sustained MVC's show a progressive decline in the amplitude of surface IEMG spikes, and may to a great extent account for a progressive reduction of MU activity (Moritani, 1979, 1985). Objectives of early research were to observe the neural adaptation of resistance training in longitudinal studies. Moritani (1979) recruited fifteen healthy subjects to perform a strength training program using a progressive resistance in dumbbell exercises (elbow flexion) of ten repetitions at 75% of one repetition maximum (1RM). Subjects were required to train twice a day three times per week for a period of eight weeks. Results showed a highly significant training effect (*$p < .002$) in muscle strength and IEMG activity for the trained elbow flexor muscle groups.

Hakkinen (1983) investigated the effects of a sixteen week combined concentric and eccentric strength training program followed by an eight week detraining period on human skeletal muscle as measured by IEMG. Fourteen males participated in a training program of three training sessions per week over sixteen weeks performing the back squat exercise. Training used progressive loads ranging from 70 to 100% of 1RM, and number of lifts increased from 18 to 30 contractions per training session. In addition, subjects performed 3-5 heavy eccentric contraction using loads 100-120% of 1RM. During the detraining period, strength training was completely terminated, but subjects were allowed to continue their normal daily activities. Maximal bilateral isometric force of the leg extensor muscles (rectus femoris, vastus medialis, and vastus lateralis) was measured by an electromechanical dynamometer. Hakkinen found an increase of 21.0% in maximal peak force during leg extension. Marked increases in force production mainly in the early part of the 16 week conditioning phase were observed. Following large initial changes, a marked decline in muscle force was observed during later training. Hakkinen attributed this to an increase in recruitment of synchronously-contracting motor units in early conditioning. It was speculated that the mechanism responsible was heavy resistance training reduced in inhibition from the Golgi tendon organ (GTO).

Hakkinen (1985) followed up with a similar study conducting a twenty four week investigation to examine the effects of strength training on isometric force, time, and relaxation time while varying type and intensity of training. Additional measurements were recorded after a 12 week detraining period. The experimental group consisted of eleven physically active males, which performed dynamic back squat exercise three times a week for twenty four weeks. The experimental group was tested on ten occasions during a 4 week interval. An electromechanical dynamometer was used to measure the maximal bilateral isometric force of the leg extensor muscles. Results from this study revealed the experimental group had an increase of 26.8% in maximal isometric force after the twenty four week training period followed by a significant decrease in ($p < .05$) in force production after the detraining period. It was concluded that neural factors may also be responsible for the improvement in strength during the course of very intensive strength training.

Hakkinen (1985b) conducted a separate study exploring the effects of explosive type strength training on IEMG data and muscle fiber characteristics via muscle biopsies. Ten male subjects went through progressive training which included primarily jumping exercises without extra load, and light weights three times a week for twenty four weeks. Subjects showed an increase of 10.8% from 4001 to 4434 (Newtons) in maximal isometric force during the twenty four week period. The IEMG results also showed significant shortening of contraction time to reach absolute force levels. In light of his findings, Hakkinen concluded that an explosive type strength training regimen may result in an increase in fast force production which is correlated with increases in neural activation of muscle fiber activity.

More recently, the effects of a six month resistance training program designed to develop both strength and power in a population aged 40 to 70 years was examined (Hakkinen, 2001). Using a sample size of forty subjects IEMG data was recorded in the knee extensors (vastus lateralis) on 1RM and maximal/explosive isometric strength. Following the six month training period, maximal isometric and 1RM strength values increased in the men and women 7% (*p < .001) and 14% (*p < .001), respectively. Explosive strength improved up to 41% in males and 45% in females.

2.2.2 Lack of Neural Adaptations to Resistance Training

Several studies have failed to show neural adaptation to resistance training based upon IEMG data (Hakkinen, 1987; Cannon, 1987; Thorstensson, 1976). Thorstensson (1976) explored the effects of an eight week systematic progressive strength training program on IEMG activity of the leg extensor muscles in eight healthy male subjects. The regimen consisted of three training sessions a week performing primarily squats, as well as vertical jumps and standing bread jump (3 sets of 6 repetitions). Results showed significant improvements in functional tests (1RM, broad jump, vertical jump). However there was no conclusive evidence of increased IEMG activity. Other studies (de Vries, 1968; Thorstensson, 1976) have also reported positive gains in functional testing but no increases in IEMG activity. This has been attributed to an increased desynchronization of motor units.

Hakkinen (1987) reported the effects of a one year training period on thirteen elite weightlifters performing Olympic lifts. During the twelve month period subjects were tested at four month intervals, performing three to four maximal contractions at the maximum rate of force development in the leg extensor muscles. IEMG data reflected modest alterations in maximal leg extension force (3.5%) and no significant change was seen when the mean maximum IEMG pre to post training were compared. These results demonstrated a limited potential for strength development in elite strength athletes, and suggest that magnitude and time periods of neural adaptations during training may differ from those reported for previously untrained subjects (Hakkinen, 1987).

Cannon (1987) found modest significance on the effects of a five week resistant training program on the adductor pollicis. Subjects were split into two groups: voluntary contraction (VOL) or stimulated contraction (STIM). Subjects underwent a training program consisting of fifteen contractions at 80% MVC three days per week for five weeks. Results revealed a small (9.5%) but significant (*$p < .05$) increase in MVC of the untrained muscle of the voluntary group but not the stimulated group. However, in both groups there was no change in maximal IEMG. It was concluded that after a strength training regimen using voluntary contractions, it is possible that there is a central motor adaptation as opposed to stimulated contractions might occur (Cannon, 1987).

2.2.3 Reflex potentiation

A second electromyographic technique used to monitor changes in motor unit activation has measured the degree to which certain reflex IEMG responses are potentiated by maximal voluntary contractions (Sale, 1983; Upton, 1975). Reflex potentiation is indicated by an increase in motor neuron excitability (Sale, 1982). Athletes with high reflex potentiation ratios may also have an ability to excite motor units more synergistically. In explosive athletes, muscle spindles are more sensitive to react to high speed movements, therefore an enhanced reflex contribution to force production during fast muscle contractions occurs (Ross, 2001).

Reflex potentiation has been explored in investigations using the thenar muscles of the hand because of the relative ease of measurement (Sale, 1982; Upton, 1975). Researchers speculated that greater reflex potentiation in the thenar muscles may be related to the importance of the thumb in skilled motor tasks. Therefore the thenar muscles might be in a relatively high "state of training," even in healthy non-athletes (Sale, 1983). If certain muscles groups underwent a training program to improve their "training state," there may be a concurrent increase in reflex potentiation.

Fourteen healthy subjects (Sale, 1983) underwent a strength training program consisting of isometric contractions using plantar flexion, elbow flexion with the forearm in the semi-pronated position, and flexion of the fifth metacarpal. Sale recorded an increase in potentiation by 49.7 and 38.9 % respectively after a period of strength training for nine to twenty one weeks. These findings indicate that training was responsible for an increased ability to raise motor neuron excitability during a voluntary effort.

Cross sectional studies have shown reflex potentiation to be enhanced in weight lifters and in elite sprinters (Sale, 1983; Upton; 1975). Sale (1983) observed electrophysiological measurements on the median-innervated thenar muscles and triceps surae in seventeen competitive weight trainers (bodybuilders and power lifters). In the thenar muscles, weight trainers possessed a significantly greater (8%) median motor nerve conduction velocity. In the triceps surae, weight trainers exhibited greater reflex potentiation (70%), peak twitch tension (10%), and contraction time (20%) which can be interpreted as an increased ability to activate motor units during maximal voluntary contractions.

2.2.4 Synchronization and Rate of Force Development

A third electromyographic method used to observe the effects of training is determining the degree of synchronization of discharge of motor units during voluntary contractions (Sale, 1988). Motor unit synchronization is a measure of the correlated discharge of action potentials by motor units, and is quantified by both time and frequency domain analyses from pairs of motor units (Semmler, 2002). Longitudinal studies have shown an increase in MU synchronization, and cross sectional studies have shown MU synchronization to be enhanced in weightlifters and in others who regularly perform brief maximal contractions (Milner, 1975). Milner-Brown found that motor unit synchronization increased after a six week strength training program in untrained control subjects and concluded that the increase in motor unit synchronization was due to the enhancement of the descending drive from the motor cortex and the cerebellum.

Increased motor unit synchronization may correspondingly increase the rate of force development (RFD), which is beneficial during performance contractions of fast velocities (Van Cutsem, 1998; Aagaard, 2002). Rate of force development is defined as the maximal rate of rise in muscle force during maximal contraction (Siff, 1999). Van Cutsem (1998) measured the activity of single motor units in the tibialis anterior muscle before and after twelve weeks of dynamic muscle training. Subjects performed ten sets of ten fast dorsiflexion contractions against a load of 30-40% 1RM for twelve weeks. Results showed an increase (*p < 0.05) of MVC (30.2%) and IEMG (19.6 %) activity. Van Custem's key finding suggested that earlier induced muscle IEMG activity would accompany an increase in maximal firing frequency of motor units. Motor units display a pattern of "*doublet discharges*" which may indicate different recruitment thresholds. Van Custem deduced that this muscle adapted itself and exhibited the properties of faster muscles. It was concluded dynamic training increased the maximal rate of tension development, and this seemed to be related to an alteration in motor unit activation (Van Custem, 1998).

Aagaard (2002) examined the effect of a fourteen week heavy resistance training program on neural drive and rate of force development. The training regimen consisted of lower body exercises (hack squats, incline leg press, leg extension) for the duration of fourteen weeks. Fifteen male subjects were tested on MVC before and after training. Aagaard found a significant increase 15% (*p < 0.05) in RFD post training. Aagaard concluded that increased explosive muscle strength (contractile RFD and impulse) were explained by enhanced neural drive. Marked increases in IEMG signal amplitude and rate of IEMG rise in the early phase of muscle contraction support these findings. The most likely functional role of motor unit synchronization is to increase the (RFD) during rapid contractions, or as a mechanism to coordinate the activity of multiple muscles to promote skilled muscle synergies (Semmler, 2002).

2.2.5 Practical Application and Summary

Investigators have repeatedly shown neural adaptations occur with resistance training. Greater improvements in maximal force production, force time curves, and contraction velocities are some of the marked benefits athletes can achieve. In summary, it can be concluded that heavy resistance and explosive type strength training regimens result in specific changes in voluntary neuromuscular performance capacity. An increase in MU activation during maximal contractions, as indicated by an increase in IEMG data, supports this theory.

Strength gains have been attributed to neural adaptations such as alterations in recruitment, rate coding, and synchronization of motor units, reflex potentiation, and synergistic muscle activity (Behm, 1995). Additional evidence, such as increased voluntary strength without concurrent increases in muscle hypertrophy, suggest that adaptation occurs within the nervous system as an early response to training (Sale, 1987).

For optimal strength and power gains, resistance training programs advocating high intensity (high resistance), low volume (less than 6 reps) should be implemented. Emphasis should be placed on both eccentric and concentric contractions to ensure utilization of high threshold motor units and stress maximal muscle activation (Behm, 1995). Prior research (Hakkinen & Komi, 1983, 1985, 1987, 2001) provides the foundation that initial strength gains are attributable to the increase in voluntary neural drive. Hypertrophy, while possibly occurring simultaneously with these neural adaptations, does not become the predominant cause of strength gains until three to five weeks into a training regimen.

2.3 NEURAL ADAPTATIONS TO POWER TRAINING AND OPTIMAL LOADING FOR POWER OUTPUT

Sports involving movements that require generation of force over a short period of time demonstrate elements of muscular power (Mcbride, 1999; Newton, 1994; Kawamori, 2004; Haff,

2001) and are required in activities such as throwing, jumping, striking, and those that require a change of direction. Power is the main determinant of performance (Baker, 2001; Haff, 2001; Newton, 1994.), therefore it seems reasonable that resistant training programs that enhance muscular power are desirable (Kawamori, 2004).

Mechanical power can be defined as the product of force and velocity (McGinnis, 1999) However, force and velocity are not solely independent relative to in muscle actions; as the velocity of movement increases, the force that muscle can produce decreases during concentric movements. Consequently, maximum power is achieved at a compromised level of either maximal force or a maximal velocity (Siegel, 2002)

Generally, neural factors that contribute to high power output include motor unit (MU) recruitment, rate coding, and MU synchronization (Kawamori, 2004). High threshold units, typically composed of type II muscle fibers, need to be recruited for high power outputs. Subsequently, training programs emphasizing recruitment of high threshold motor units can theoretically improve power-producing capability. Typically motor unit recruitment will follow the size principle (i.e. smaller units recruited first then larger units) however; a contradiction has been presented in ballistic movements which focus on movement speed (Haff, 2001; Sale, 1992). It has been suggested that in large multijoint eccentric movements, larger motor units may be recruited first. If not exposed to a power specific training regimen, however athletes may be unable to recruit high threshold units.

Another neural adaptation from power training may be an increase in rate coding. Rate coding is defined as motor unit frequency (Kawamori, 2004). An increase in motor unit frequency will increase the force output up to a certain point (Sale, 1992). When motor unit frequency exceeds the level of maximum force, a further increase in firing frequency contributes to rate of force development (RFD) (Sale, 1992). RFD has been considered a crucial factor in high power production because time to exert force is usually limited in powerful muscle actions (Newton, 1994; Zatsiorsky, 1995).

2.3.1 Silencing Period

In addition to increases in efficiency of MU recruitment and rate coding, MU synchronization has been observed as a result of high power training programs. The initiation of rapid movements is not characterized by activation, but rather the depression or silencing of IEMG activity, called pre-movement silencing period (SP) (Conrad, 1983; Mortimer, 1984).

Conrad et. al. recruited eight healthy subjects to perform maximal horizontal elbow flexion at various angles. Results indicated that in this type of ballistic movement, a positive relation between the extent of pre-movement depression of tonic activity and subsequent phasic innervation occurs. Conrad (1983) suggests that tonically active motor neurons in high-speed movements where a maximal number of motor units have to be recruited must be released from tonic activity and simultaneously depressed for optimal synchrony. SP would bring all motor neurons synchronously back to a refractory period, enabling all available neurons to be ready to fire at the same moment for optimal power production.

Mortimer (1984) found similar findings to support this theory. Eleven healthy subjects performed rapid forearm flexions and extensions, it was determined that an electromyographic silent period preceded the initial agonist burst. Pre-movement SP was greater in those muscles involved in the intended movement than the reaction time paradigm. Mortimer (1984) concluded that pre-movement silence might increase peak muscular force by bringing motor neurons into a non-refractory state prior to their activation. The fact that SP manifests a variable duration from trial to trial, and that some subjects appear to be more capable of producing SP than others, suggests that SP may be a learned motor response rather than an automatic component of the movement program (Moritani, 1993). However, studies show this clearly is a neurological adaptation to exercises emphasizing high-speed movements, which may be why top world sprinters and jumpers demonstrated considerable shorter SP than a group of physical education students (Kawahatsu, 1981).

2.4 OPTIMAL LOADING FOR HIGHEST POWER OUTPUT

On the basis of muscular power development, training at the load that maximizes mechanical power output is recommended to improve maximum muscular power (Kawamori, 2004). Although there are various methods one can use to enhance dynamic performance, there appears to be three distinct schools of thought: traditional weight training, plyometric weight training, and dynamic weight training. In traditional weight training, heavy loads (80-90% maximum) with few repetitions (4-8) are used. During plyometric training acceleration of body weight is used as the overload in dynamic activities such as depth jumping and broad jumping. Dynamic weight training involves lifting relatively light loads (30% maximum) at high speeds (Wilson, 1993).

While it is fairly well established that using resistance training will improve power development, the exact quantity of the resistance is less clear. Several researchers (Kaneko, 1983; McBride, 2002; Moss, 1997; Newton, 1997) have shown that 30-45% of 1RM elicits the highest power output, while others (Baker, 2001; Cronin, 2001; Mayhew, 1997) have found that the load should be heavier (50-70% maximum). The particular intervention that will be given to the subjects in the present proposed study will emphasize enhancement in upper body power using a multijoint exercise (bench press). Therefore this review of literature will focus solely on studies that are germane to upper body power enhancement.

2.4.1 30-45% Maximum

A study by Kaneko (1983) examined how concentric contractions with different load conditions influenced the force-velocity relationship, and the resultant power output in human elbow flexor muscles. Twenty subjects performed ten maximum contractions a day, three days a week, for twelve weeks. Subjects were divided into four groups according training intensity, which was prescribed by a percentage of maximum isometric strength with the elbow flexed at 90^o. Power output measures were tested at 0, 30, 60, and 100% maximum isometric strength. Results showed that different training loads brought about specific modifications of the P-V relationship, and that the load of 30% maximum was the most effective in improving maximum mechanical power output (Kaneko, 1983).

Moss et. al. (1997) examined the effects of maximal effort strength training with different loads on maximal strength and the P-V relationship in elbow flexion. Thirty subjects were divided into three groups varied by intensity of 15, 35, and 90% of 1RM. Training consisted of three to five sets performed three times a week for nine weeks. Measures for power output were tested at 15, 25, 35, 50, 70, and 90% of 1RM. Moss reported that training at each of the three intensities produced significant increases (*$p < .001$, *$p < .001$, *$p <.05$, respectively) in maximum strength. In addition power output increased from training over a wide load range (35-90% of 1RM), along with a strong correlation ($r = 0.93$, $p <.0001$) between 1RM and maximal power, and 1RM and power at light loads (< 15%) There is a high correlation between maximal power training and successful performance at lighter loads.

Newton (1996) investigated the kinematic, kinetic, and electromyographic differences between an explosive bench press throw in which the load was actually released towards the end of a motion (classified as a "ballistic" exercise) (Newton, 1994; Haff, 2001), and a traditional bench press performed explosively. Seventeen male subjects underwent two testing sessions performed four days apart. The initial session consisted of subjects performing bench press throws using 45% of 1RM. Subjects were instructed to lower the barbell to the chest and immediately explode it upward in an attempt to project the bar for maximal height. In the second session, subjects were instructed to explode the bar upward from the chest and stop the bar at arm's length. Newton found that ballistic loading movements, where the resistance was accelerated throughout the entire movement, results in greater velocity, force output, and IEMG activity than non-ballistic (1996).

To determine the optimal load in ballistic exercises, Newton (1997) studied seventeen male subjects. Subjects performed stretch shortening cycle (SSC) and concentric only (CO) bench throws using loads of 15, 30, 45, 60, 75, 90, and 100% of their previously determined 1RM. Bench press throws are defined as accelerating the barbell as fast as possible during the concentric phase of the lift then projecting the barbell as far away from the hands as possible. The displacement, velocity, acceleration, force and power output, and IEMG activity from pectoralis major, anterior deltoid, and triceps brachii were recorded. Highest power output was produced at 30% and 45% loads during the SCC throws and the highest peak and average power outputs were produced at 15-30% and 30-45% of 1RM.

Izquierdo (2002) explored the effects of different loading conditions on maximal strength and power output in athletes from various sports. Maximal strength (1RM) and P-V relationships were examined in the bench press exercise using a wide range of loads, (30 to 100% 1RM). Seventy subjects were divided into four groups by sport (weightlifters, handball players, cyclists, middle-distance runners), as well as a control group. It was determined that power output was maximized at 30% for the weightlifters and handball players, and at 45% for the middle-distance runners, cyclist, and control. Izquierdo (2002) concluded that the magnitude of differences in strength and/or muscle power output among groups may be explained by multiple factors, such as fiber type distribution, biomechanical issues, and training background.

2.4.2 50-70% Maximum

During more non-ballistic lifts (e.g. bench press or squat) power is maximized at loads of 60% or higher (Hatfield, 1989). Research has shown that in multijoint exercises, power output tends to be slightly higher at heavier loads (Baker, 2001; Mayhew, 1997; Siegle, 2002). Siegel (2002) recruited fifteen males to measure maximal power output at different loading conditions (30, 40, 50, 60, 70, 80, and 90% of 1RM) in the bench press exercise. Peak power output was recorded at 40-60% of 1RM for the bench press. Mayhew (1997) measured bench press power (BPP) using different loading conditions and seated shot put press (SSP). Twenty-four college men were trained two times a week for twelve weeks. Groups were assigned according to load (30, 40, 50, 60, 70, and 80%). Results showed an upward shift in the power curve by 13.6 %, and a 9.1% increase in 1RM. Peak power was produced at 40-50% on the 1RM before and after training.

Baker (2001) demonstrated that optimal loads are achieved at 50-60% of 1RM during ballistic exercises, such as bench press throw and jump squat. Thirty-one rugby players were tested for maximum upper body strength (1RM bench press) and power output using various barbell loads. Maximum upper body power was tested using absolute loads representing 31, 39, 46, 54, and 62% of 1RM in the bench press throw exercise. Baker found that mechanical power was highest when using loads of 55% of 1RM. In a similar study using the same subjects who performed the jump squat exercise, Baker investigated highest power output using loads ranging from 24-75% of 1RM. Results from this study suggested that loads representing 55-59% 1RM evoked the highest average mechanical power output during the concentric phase of the jump squat exercise (Baker, 2001).

2.5 SUMMARY

Previous research suggests that exercises using lighter resistances (30-45%) will produce optimal power outputs (Newton, 1996; Mayhew, 1997; Kaneko, 1983). However Baker challenges this theory with his current work. The upward trend in the amount of resistance required to attain Pmax may reflect subjects selected with a longer history of intense training. It is concluded that the power responses of an elite power athlete is clearly affected by the acute and long term manipulation of variables such as exercise selection, volume, and training experience (Baker, 2005) . Athletes who trained for both maximum strength and power may generate maximum power outputs at a higher percentage of 1RM compared to athletes who train solely for strength.

Frequent measurements and determination of power using optimal loads may be necessary to provide appropriate stimuli to the neuromuscular system and provide useful information about the effects of training paradigms and training status of athletes. Athletes and coaches are strongly encouraged to incorporate the idea of periodization and combined training strategy into their training programs (Kawamori, 2004).

Below are comparisons and conflicts of previous studies involving increases in muscular power using varying load and exercise selection.

Table 1. Exercise Selection and Loading Requirements

Type of exercise	**Optimal Load**	**Reference**
Upper-body and single-joint exercise	30% of MVC	Kaneko 1983
Elbow flexion	35-50 % of 1 RM	Moss 1997
Elbow flexion		
Upper-body and multijoint exercise		
Bench press	40-50% of 1RM	Mayhew 1997
Bench press	30-45% of 1RM	Izquierdo 2001, 2002
Bench press and bench throw	50-70% of 1RM	Cronin 2001
Bench throw	55% of 1RM	Baker 2001
Bench throw	15-45% of 1RM	Newton 1997
Lower-body and multijoint exercise		
Jump squat	55-59% of 1RM	Baker 2001
Squat Jump (static and countermovement)	10% of 1RM	Stone 2003
Half-squat	60-70% of 1RM	Izquierdo 2001, 2002
Half-squat	45-60% of 1RM	Izquierdo 2001, 2002
Smith machine squat	60% of 1RM	Siegel 2002
Double-leg press machine	60% of 1RM	Thomas 1996

2.6 PROGRAM DESIGN AND CONSIDERATIONS FOR MUSCULAR POWER DEVELOPMENT

It is well documented that the use of explosive type resistance training improves muscular power and dynamic athletic performance (Adams, 1992; Harris, 2000; McBride, 2002; Jones, 1987; Kaneko, 1983; Moss, 1997). However, practitioners in strength and conditioning endorse the philosophy of varying workouts to prevent staleness or overtraining. Chronic power training, which uses the same relative intensity (a percentage of 1RM) and the same exercise over a long period of time without any variation, could result in deterioration of athletic performance due to overtraining. Consequently, periodization of training programs is important for the optimum muscular-power development. Periodzation may be defined as the "overall long term cyclic structuring of training and practice to maximize performance to coincide with importation competitions" (Siff, 1999). Several researchers (Harris, 2000; Stone, 1991, 1993; Stowers, 1983; Lyttle, 1996) have explored emphasizing strength development in the early stages of a training regime followed by a period of power development.

Stowers et al. (1983) examined the effects of three short term weight training programs on multiple dependent measures: body weight, 1RM bench press, 1RM squat, and vertical jump. Eighty-four subjects were randomly assigned to three groups. Group 1 used a standard periodization program, group 2 trained with one set until exhaustion, and group 3 trained used three sets to exhaustion. Each group trained three days a week for seven weeks. Stowers found the periodization group showed significant improvements in the squat exercise and vertical jump compared to groups 2 and 3. It was suggested that periodization may produce superior results in strength and power compared to protocols using multiple sets to exhaustion. This initial study was the impetus for further studies examining the ability of periodization to enhance power and strength.

In addition to periodization training, a combined training method may help develop muscular power in a wide variety of athletic performances (Harris, 2000; McBride, 1999; Lyttle, 1996; Newton, 1994, 2002). Harris (2000) examined the effects of three different resistance training methods on a variety of performance variables representing different portions of the force-velocity curve, ranging from high force to high speed movements. Forty-two men recruited were divided into three groups: high force (HF), high power (HP), and a combination training group (COM). Each group trained four times a week for nine weeks. HF trained at loads of 80-85% of 1 RM, HP trained at 30% of peak isometric force and the COM used a combination training protocol. Subjects were tested pre and post training on multiple variables such as: 1RM squat, 1RM mid thigh pull, vertical jump, Margaria-Kalamen test, 30meter sprint, 10 yard shuttle run, and standing long jump. Harris found the 1RM squat and vertical jump improved only in the HF and COM groups. In the 10 yard shuttle run only the COM group improved significantly and only the HP showed significant improvement in the standing long jump. It was concluded that a training program that combines heavy strength training and high power exercises may increase a variety of performance variables related to maximum strength and power (Harris, 2000).

Lyttle (1996) examined the effects of two forms of performance training: maximal power training, and a combined weight and plyometric program. Thirty-nine subjects were recruited and randomly assigned to one of three groups: combined weights and plyometrics; maximal power training; or control group. The maximal power group performed weighted jump squats and bench press throws using a load that maximized the power output of the exercise. The combined group underwent traditional weight training- such as heavy squats, bench press, along with plyometric training exercises such as depth jumps and medicine ball throws. Subjects trained two times a week for eight weeks. Lyttle found that both types of training showed significant ($p < 0.05$) improvements in the testing measures after the short term weight training regimen. Lyttle concluded that although both methods were effective, the combined weight and plyometric protocol produced superior results over the maximal power training, especially in stretch shortening cycle (SCC) activities.

The superiority of a combined training method is further supported by a cross sectional study. McBride (1999) compared strength and power characteristics of Olympic lifters, power lifters, and sprinters considered to be involved in high force/high velocity, high force/low velocity, and low force/high velocity training protocols, respectively. Olympic lifters who used both heavy resistance training and explosive type resistance training achieved better results in jump height and muscular power measures than power lifters who used only heavy resistance. Newton and Kraemer (2002) examined the effects of a periodized training program composed of a combination of exercises to increase muscle size, maximal force, and power. This mixed method approach supports the theory that to simultaneously train for the three dimensions of muscle characteristics hypertrophy, maximal force production, and maximal power. It is critical for an athlete to address volume, exercise selection, and load when preparing for training.

2.7 UNCOMMON METHODS OF TRAINING FOR POWER

Strength development and physical fitness conditioning have played a significantly larger role in the planning of an athletes training season (Secora, 2004). Today's collegiate athlete participates in year round conditioning intended to enhance athletic performance. As reflected in this review, there are several types of training paradigms available to athletes and strength and conditioning coaches. The final section of this review focuses on uncommon modalities and methods in strength and conditioning. To maximize gains in size, speed, and strength, coaches can potentially utilize alternative methods of training (Adams, 2004).

2.8 VARIABLE RESISTANCE TRAINING USING ELASTIC BANDS AND WEIGHTED CHAINS

Recently strength training with nontraditional modes of resistance has become increasingly popular (Hedrick, 2003; Waller, 2003). The use of elastic bands and weighted chains on the barbell have gained wide recognition of late in both lay journals (Simmons, 1999) and in peer reviewed journals (Ebben, 2002; Cronin, 2003; Claxton, unpublished report, Andersen, 2005; Newton, 2002; Siff, 1999; Wallace, 2006; Berning, 2004). The main idea of variable resistance is to accommodate a load to the human strength curve throughout a complete range of motion (Zatsiorsky, 1995). In machines similar to Nautilus equipment, resistance is applied in concert with the human strength curve. Due to the odd shaped cams on these machines, the lever arm of the resistance force or applied force is variable so that the load varies throughout the entire range of motion (Zatsiorsky, 1995; Fleck, 2004).

In traditional weight training the external load remains constant throughout an exercise. With the introduction of some nontraditional training modes, resistance can be altered in several ways to target explicit neuromuscular traits and thereby change the transfer specificity of a given training program. Transfer specificity (Kraemer, 2002, Newton, 2002) relates to the percentage of carryover to other activities (Fleck & Kraemer, 2004). A way to achieve this is to change the resistance training mode in an attempt to specifically match a given movement strength curve (Adams, 2005).

2.8.1 Weighted Chains

Weighted chain training transforms a free weight, dynamic exercise to a variable resistance exercise. When performing an exercise such as squat or a bench press exercise, force production is directly related to the angle of the joint and the mechanical advantage the muscle has over resistance force. The greatest muscle force is produced at the top portion of the lift whereas at the bottom of the movement, muscle force production is at its least. Theoretically, a variable resistance system provides a lower resistance at the point when the muscle is at a mechanical disadvantage (the bottom of the lift). Greater resistance at the point when the angle joint can create the most muscular force (top of the movement) is considered advantageous. The systematic set-up of chains allows for this. When a lifter begins to descend to the floor during the weighted chain back squat, the barbell is lowered and additional chain links accumulate on to the floor, decreasing the overall weight of the load. During ascent or the concentric portion of the lift, additional chain links leave the floor and progressively adds resistance throughout the lift. It has been hypothesized that by matching the ascending strength curve to produce near maximal force through the full range of motion along with an increase in stabilization activity (controlling the chains from swaying), a transfer specificity to a given dynamic task would be achieved.

Figure 1. Weighted Chain System

Kraemer (2002) suggested optimal training for sport must maximize the transfer of trainable characteristic (e.g. power) to the specific activity or sport targeted. Ebben et. al (2002) used chains to assess the motor unit activation, rate of force development (RFD), and peak force development of variations of the back squat exercise. Eleven Division I athletes were recruited to examine the integrated electromyographic activity (IEMG) for the lower body under three conditions : (1) traditional back squat, (2) squatting with plates plus weighted chains suspended from the top to replace approximately 10% of the squat load, and (3) squatting with elastic resistance bands replacing 10% of the load. Testing consisted of a one-day session with the subjects performing three sets of five repetitions under different loading conditions (50 and 80% of 1RM). Results revealed no significant difference in IEMG and ground reaction forces for any of the three squat conditions. Ebben suggested a longitudinal study of 8-10 weeks would reveal differences in the modalities.

2.8.2 Elastic Bands

Elastic bands similar to weighted chains, offer an alternative method to vary resistance throughout the range of motion during exercise. Attaching elastic bands to the barbell and anchoring them to the floor offers maximum tension due to the bands being pulled taut at full extension (See Figure 2). For example, as the lifter begins to descend to the floor during a squat, the tension of the elastic bands will reduce decreasing the overall load of the barbell. There is greater evidence supporting the benefits of elastic bands than weighted chains, and results have been promising (Cronin, 2003; Newton, 2002; Wallace, 2006; Andersen, 2005; Claxton, unpublished report). Elastic bands add an eccentric loading component that is not present in traditional weight training.

Eccentric training is superior to concentric training relevant to regarding improvements in strength gains, recovery, and muscle hypertrophy (Hortobagyi, 2000; 1996; Dudley, 1991; Hather, 1991; Booth, 1991). However it remains unclear whether this unique aspect of training involves fatigue resistance, greater muscle efficiency, dissipation rather than generation of potential energy, or specific motor recruitment (Hortobagyi, 2000).

Eccentric training is also shown to be a viable method of training for power (Doan, 2002; Bobbert, 1987). Similar to the action of a stretched elastic band, the stretched parallel and series musculotendinous complex found in an eccentrically contracted muscle is followed by a recoiling, which contributes to force in the opposite direction (Bosco, 1979; Giovanni, 1968) or concentric contraction. Research suggests that the faster a muscle is eccentrically loaded or lengthened, the greater the resultant concentric force produced (Asmussen, 1974; Bosco, 1979; Cavagna, 198.). The magnitude of this stored elastic energy increases with the speed of the eccentric action (Bobbert, 1987). Cronin (2003) suggested higher eccentric velocities are associated with elastic band training suggesting that this type of training may offer an effective means to enhance strength and functional performance.

Newton (2002) examined the effects of heavy elastic bands in the back squat on force, velocity, and power output. Ten subjects performed the back squat exercise under three different conditions: (1) bands top (BT) condition (elastic bands were attached, and the load on the bar was reduced until the total load on the subject when standing erect was equal to 6RM); (2) bands bottom (BB) (weight on the barbell was adjusted in the same manner until the total load was equal to 6RM when subject was in parallel squat position); (3) and control group. It was found bar velocity and power output was significantly higher in the BT condition for the initial 50% of the concentric movement compared to BB and control groups. Additionally, subjects were able to produce greater velocity and power over the lower phase of the lift in BT condition. Newton felt this supported anecdotal evidence that the use of bands allows a lifter to "explode" more out of the bottom portion of a lift since bands and not the subject slows the bar down, eliminating the fear of possible injury. The BT condition may allow greater transfer specificity over traditional squat exercises, and translate to better sports performance, specifically vertical jump and ballistic performance outcomes (Newton, 2002).

Cronin (2003) examined the IEMG and kinematic characteristics of three different squat techniques in ten male volunteers: (1) traditional squat, (2) non-elastic band jump squat, (3) and elastic band jump squat. Subjects underwent ten weeks of ballistic weight training and were pre and post tested on various kinematic variables and tests of multidirectional agility, lunge ability, and single leg jump performance. Significantly greater IEMG activity was observed during both the elastic band and non-elastic band jump squats throughout the entire concentric phase compared to the traditional squat. The group performing the elastic band squat also improved in lunge performance compared to non-elastic band and control groups. Cronin concluded that in light of the significant findings in his study, further investigation using this training technique is suggested.

Encouraging results (Wallace, 2006; Andersen, 2005 Claxton, unpublished report) on elastic band training have been reported. However, these studies are primarily abstracts and not yet published in a peer review journal and considered speculative. Wallace (2006) investigated the effect of elastic bands on peak force (PF), peak power (PP), and peak rate of force development (RFD) during a back squat exercise. In ten recreationally trained subjects, 1RM was tested under three loading conditions: no bands (NB), band condition 1 (B1), and band condition two (B2). B1 constituted approximately 80% of the resistance from free weights and 20% from bands; and B2 included approximately 65% of the resistance provided by free weights and 35% from bands. After 1RM was achieved, subjects performed two sets of three repetitions on two different testing days using 60% and 85% 1RM, respectively. It was found that a significant (*p < .05) increase in PP and PF occurred between the NB (16%) and BI (24%) respectively. Results suggested that the use of elastic bands coupled with dynamic free weight training may significantly increase PF and PP during the back squat exercise.

Andersen (2005) examined the effects of elastic band training on different strength and power adaptations compared to traditional weight training. Forty-four (22 males, 22 females) Division I collegiate athletes were recruited and randomly stratified into groups by their respective sport. Subjects were tested prior to and after seven weeks of resistance training on multiple dependent measures: 1RM back squat, 1RM bench press, average power (AP), and peak power (PP) output in the vertical jump. Results indicated significant differences between the experimental group (subjects which trained with elastic bands for 7 weeks) and control group (no bands for seven weeks) in power measurements. Effects were three times greater for the BS (16.47 ± 5.67 vs. 6.84 ± 4.42), two times greater for the BP (6.68 ± 3.41 vs. 3.34 ± 2.67) and three times greater for AP (68.55 ± 84.35 vs. 23.66 ± 40.56 watt increase). Andersen concluded that training with elastic bands combined with free weight resistance training might be better for developing lower body strength, upper body strength, and lower body power compared to using traditional weight training alone (Andersen, 2005).

Figure 2. Elastic Band System

2.9 MEASURING MUSCULAR POWER

Although conditions can be well controlled in laboratory settings, field tests are considered to be more practical, ready available, and cost effective. A device to measure muscle power (Refer to Fitrodyne in **Figure 3M of Methods chapter**) (Fitronic Bratislava, Slovakia) recently became commercially available and has been used in several investigations, but not yet validated (Jennings, 2005; Coelho, 2003, 2002). The Fitrodyne attaches to conventional resistance training equipment and measures the speed of muscle contraction. Advantages of this device are, it is relatively inexpensive, versatile, portable, and could be used to test a variety of muscles and movement patterns (Jennings, 2005). This device has also shown to have a strong degree of reliability for measuring muscular power (Jennings, 2005). Jennings (2005) examined the repeatability of this device during the squat jump and bicep curl exercises. Thirty men performed three bicep curls and three squat jumps at six different loads (90, 80, 60, 40, 20, 0%) on three different testing days. The average of the closest two values for each load for the curls and jumps was used the analysis. The intraclass correlation coefficient for between the Fitrodyne measures was r = 0.97.

In an effort to maximize training efficiency in athletic populations, knowledge of bar velocity using different amount of loads can be helpful when trying to train for power. The use of the Fitrodyne can give immediate coach-to-athlete feedback and inform athletes if they are moving the bar too slow or fast. It is also useful for examining pre-post differences in multiple power measurements after a particular training program has been implemented. This allows coaches to evaluate the effectiveness of different training programs in strength and conditioning.

Though the Fitrodyne has the potential to be a useful tool for measuring muscular power because it is reliable and can be used with conventional resistance training, future work on the validity of this device is warranted.

2.10 SUMMARY

Dynamic variable resistance training has shown to be a viable mode of resistance exercise (Newton, 2002; Cronin, 2001; Wallace, 2006; Claxton, unpublished report). Although the exact neurological and musculoskeletal adaptations of VRT compared to traditional resistance exercise are not completely understood, such uncommon modalities do seem promising. A limitation of traditional resistance exercise is that a substantial portion of the lift involves a period when the bar is decelerated prior to achieving zero velocity at the end of the concentric movement (Elliot, 1989). Also, to avoid injury a lifter has to be aware of stopping the bar at the end of the concentric movement. With bands, a lifter can attempt to accelerate the bar throughout the entire concentric phase since bands will arrest the bar, and decrease the risk of injury. Increased eccentric loading also occurs with the use of elastic bands (Cronin, 2003). Eccentric loading has been associated with an increase in upper body strength (Doan, 2002). The increased tension at the top portion of a lift will cause the lifter to accelerate faster during the eccentric portion of the lift, therefore creating more stored elastic energy to enable a lifter to produce increased explosive power transitioning from the eccentric to concentric phase.

To perform optimally in sports, muscular strength and power are required. Chains and bands offer a safe and effective mode of training as well as hold the possibility of an improved ability to transfer benefits directly from a weight room to an athletic arena. This may also contribute to national efforts on improving important components of physical fitness and healthy living in colleges and schools throughout the country.

3.0 METHODS

3.1 EXPERIMENTAL DESIGN

A repeated measures experimental design compared the pre-training and post-training means for strength and power measures as a result of a 7-week strength training program in a sample of college male I-AA football players. Subjects were selected using a randomized blocking design with the blocking variable being relative bench press strength ($BP \cdot BW^{-1}$). The top thirty six of ninety two scores with respect to $BP \cdot BW^{-1}$ were randomized into three groups of twelve subjects: Elastic Band (EB) (n=12), Weighted Chain (WC) (n=12), and Control (traditional weight training) (C) (n=12). All groups performed the same off-season training program with the exception of the bench press exercise, which served as the training intervention. The traditional weight training group (C) assumed a typical bench press regime, while the treatment groups included either elastic bands (EB) or weighted chains (WC).

Dependent variables included the following: 1) Multiple 5-7 RM maximum bench press test (weight in kilograms) to predict one repetition (1RM) maximum (Baechle and Earle, 2000); 2) Five repetition maximum (5RM) speed bench press test as determined by the Fitrodyne (units of measure included maximum power (Watts) and maximum velocity ($m \cdot sec^{-1}$); and 3) Percent body fat as determined by the skinfold method of body composition. Independent variables were Method (EB, WC, C) and time (seven weeks). Dependent measures were conducted prior to and following the exercise intervention.

3.2 SUBJECT CHARACTERISTICS

Thirty-six Division 1AA football players from Robert Morris University participated in this investigation. All participants were voluntary and had the support and approval of the Robert Morris Department of Athletics head football and head strength and conditioning coaches. To be eligible to participate, subjects were: (1) healthy; (2) non-obese (defined by <25 % fat); (3) advanced level weight lifters (currently lifting weights a minimum of 4-5 days a week for the past 2 years) and; (4) able to bench press at least a weight greater than or equal to 1.1 times their body weight. Exclusion criteria included: (1) responding "Yes" to one or more questions on the PAR-Q & YOU; (2) presence of a serious or unstable medical illness within the past 12 months, e.g. myocardial infarction; (3) any clinical, musculoskeletal, and metabolic contraindications to exercise; (4) currently being treated for any serious psychological disorder or having received treatment (e.g. hospitalization or emergency room visit) within the previous 6 months; (5) knowingly taking any performing enhancing substances, including creatine, androsteindione, or any other anabolic enhancer; and (6) unwilling to perform or participate the prescribed intervention training program.

Subjects completed the Physical Activity Readiness Questionnaire (PAR-Q & YOU) as well as team physician waiver in order to participate in the upcoming football season. Potential risks and benefits and underlying rationale for the investigation were explained to all subjects where upon their written consent to participate was obtained (Appendix D).

3.3 PROCEDURES

Subjects reported for pre-testing during the Week 1 where the multiple 5-7RM bench press, 5RM speed bench press, and body composition tests were conducted each on separate days. Weeks 2 through 8 consisted of the training intervention. Subjects reported for follow up testing during Week 9. The proposed testing schedule included the following:

Week 1

- Day 1 IRB consent obtained
  - -Orientation sessions conducted
  - -Body composition assessment
- Day 2 Pre-testing sessions (T_1) for predicted 1RM bench press
- Day 3 Pre testing sessions (T_1) for 5 RM speed bench press

Weeks 2 and 8

- Training intervention

Week 9

- Day 1 Post testing sessions (PST_1) for predicted 1RM bench press
- Day 2 Post testing sessions (PST_1) for 5 RM speed bench press
- Day 3 Post testing sessions (PST_2) for 5 RM speed bench press

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3.4 ORIENTATION SESSION

On the first day subjects were provided an overview of the study where IRB consent was obtained. Potential subjects also had the opportunity to ask questions regarding the tests they would be performing (1RM predicted bench press and 5RM speed bench press). After reviewing IRB consent, all subjects underwent an orientation session where procedures were explained, and demonstrations were provided on the 1RM predicted bench press and 5RM speed bench tests. Immediately following, subjects were allowed to practice and feedback was provided for safe and correct technique for their lifts.

3.5 BODY COMPOSITION

Subject's height and weight were obtained using a standard scale calibrated regularly.

Percent body fat was determined by using the skinfold method of body composition. This procedure is highly correlated (r = 0.70 - 0.90) to hydrostatic weighing (ACSM, 2000). The Siri equation (% of fat = ({4.95/Db} – 4.5) x 100) was used to determine body fat percentage from chest, abdomen, and thigh locations using a Lange skinfold caliper (Pollack, Schmidt, & Jackson, 1980). All measures were taken on the right side of the body. Skin fold calipers were placed 1 cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and base of the fold. The mean of three measures was taken at each site, and subjects were retested if measures were not within 1 to 2 mm (ACSM, 2000).

3.6 1 RM PREDICTED BENCH PRESS

It is well documented that multiple RM prediction models are a safe, valid, and reliable method to predict 1RM maximum testing (Epley, 1985; Brzycki, 1993; Ware, 1995; Chapman, 1998). During week 1 subjects performed a multiple 5-7RM bench press test (*to failure*) using a prediction chart (Baechle & Earle, 2000) to predict their 1RM maximum. Based on the number of repetitions completed and the particular load (weight on the barbell) used, the subject's predicted 1RM bench press may be calculated. Multiple 1RM prediction models are considered a safer method with a higher applicable value in the athletic setting compared to 1RM testing (Ware, 1995; Whisenant, 2003). Research has documented the validity of these equations to be accurate, reporting correlation values ranging from r = 0.84 - 0.92 (Whisenant, 2003).

Subjects followed the warm-up (ACSM, 2000) and testing protocol reported by Ware (1995). Bench press repetitions followed the standard "touch and go" protocol:

1) The bar was required to touch the chest before pressing to "full arms" extension;

2) Subjects placed hands slightly wider than shoulder width grip on the barbell, and feet were placed on the ground during all sets.

3. Subjects performed a warm-up lift of 5 to 10 repetitions at 40 to 60% perceived maximum exertion.
4. Following a 1-minute rest with light stretching; the subjects completed 3 to 5 repetitions at 60 to 80% of perceived maximum exertion.
5. Following a 3-5 minute rest; a weight that was approximately 85% of their probable 1RM loaded on to barbell.
6. Using the selected weight, subjects performed as many correct repetitions-to-failure as possible. The final number of valid repetitions was recorded.

7. Based on the number of repetitions performed, a prediction equation was used (1RM = (0.033 rep wt)* repetitions + rep wt) (Epley, 1985)

3.7 5 RM SPEED BENCH PRESS TEST

The 5RM speed bench press was used to determine and evaluate upper body muscular power for each subject. The 5RM speed bench press testing was performed 1 day after the predicted 1RM test. Subjects completed the following sequence:

1. Following the warm-up; subjects used 50% of the load from their 1RM test and placed it on the bar.

2. Subjects were instructed to lower the barbell as fast and controlled as possible (approximately one second tempo during lowering followed by maximal acceleration during raising), while maintaining proper form. After the barbell touched the chest, subjects were instructed to accelerate the barbell upwards as fast as possible until arms reached full extension. Subjects performed 2 sets of 5 repetitions using this technique.

3. Average and peak velocity ($m \cdot sec^{-1}$) and average and peak power values (Watts) were recorded across both sets using the Fitrodyne device (discussed in Instrumentation section, page 8).

4. The highest mean value from both sets was used for Fitrodyne analysis.

3.8 POST TESTING FOR 5RM SPEED BENCH

Subjects were post-tested in the speed bench press test on two separate occasions. The first day (PST1) consisted of testing each subject at 50% of their original pre-test predicted 1RM maximum. The second day (PST2) consisted of testing each subject at 50% of their *new* predicted 1RM maximum, which was calculated from the post 1RM predicted test. According to the literature, optimal loading for power output in this particular exercise (*non-ballistic*) is approximately 50-55% of subjects 1RM (Baker, 2001; Mayhew, 1997; Siegle, 2002). Therefore subjects were tested at their post-test 1RM in addition to their pre test 1RM to be optimally loaded for highest power output

3.9 TRAINING INTERVENTION

Following the orientation and pre testing sessions, a seven week training intervention was conducted as part of an off-season conditioning program. All training sessions were performed at Robert Morris University athletic weight training facility under the supervision of the head strength and conditioning coach. The weight room was fully equipped with ten bench press stations and ample space to train and test multiple groups concurrently.

The off-season program consisted of lifting sessions conducted four days a week for seven weeks. All subjects performed lower body exercises on Mondays and Thursdays and upper body exercises on Tuesdays and Fridays. Subjects typically performed ten to twelve exercises on a given session primarily focusing on dynamic free weight exercises. Training incorporated all major muscle groups involved such as dynamic bench press, dumbbell bench press and tricep extensions. Lower body exercises typically consisted of dynamic squat, one legged lunges, hip extension/flexion, and leg curls. A more detailed description of the training conducted is provided in Appendix A.

The specific training intervention occurred on the subject's second upper body day (Fridays). For the bench press exercise treatment, groups included elastic band (EB), weighted chain (WC), and traditional bench (C) groups.

3.9.1 Volume

Similar to methods from previous studies, proper loading for the second upper body day of the week in the bench press exercise for the weighted chain elastic band and control groups consisted of the following: EB, 40% of 1RM; WC, 50% of 1RM; Control, 60% of 1RM. The variance in weight loaded was an attempt to have the load on the barbell be equal for all groups when subjects are at full lockout position at the start of the eccentric phase. Subjects performed six sets of three repetitions for each set, with instructions to accelerate the barbell as fast as possible during the concentric phase of the movement.

3.10 INSTRUMENTATION

3.10.1 Weighted Chains

Three chains (Topper Supply, Figure 1) were attached to each side of a barbell, for a total of six chains on the bar. Four chains consisted of *training* chains (two on each side), and two were considered *support* chains (one on each side). A training chain was five feet long and weighed twenty pounds. Each five foot support chain weighed four pounds. The combined weight of all chains used was approximately 85-90 lbs. The two support chains were used to attach the training chains to the barbell. The attached chains were lowered to the ground during work sets (depicted in **Figure 1 of Literature Review chapter**).

3.10.2 Elastic Bands

Elastic bands (Iron Woody Fitness, Olney, MT) progressively increase overall resistance during the concentric portion of each repetition. Conversely, during the eccentric portion of each repetition, resistance progressively decreased (depicted in **Figure 2 of Literature Review chapter**). The elastic bands were anchored down on the bottom of the bench press apparatus creating maximum tension at the top of the lift with lowest tension at the bottom.

3.10.3 Fitrodyne

The Fitrodyne is a Weightlifting Analyzer System (Version V-104 from Sports Machines-Ing, Slovak Republic) (Jennings, 2005; Coelho, 2002, 2003) consisting of two components (Figure 3): 1) a velocity sensor unit, 2) and a microcomputer. The velocity sensor unit is connected to the weight by a kevlar cable with strap and Velcro. Using mass (input prior to exercise), the system calculated the following dependent variables: average velocity ($m \cdot sec^{-1}$), peak velocity ($m \cdot sec^{-1}$), average power (W), and peak power (W) for each repetition in the concentric phase of the exercise.

Figure 3. Fitrodyne Unit

The sensor unit is placed where the cable is perpendicular with the floor

3.11 DATA ANALYSIS AND STATISTICAL CONSIDERATIONS

Data analysis was performed using SPSS version 14.0 for windows statistical software. Descriptive data for subject characteristics and experimental variables were calculated as means and standard deviations. A 2 X 2 factorial (Method X Time) ANOVA was computed for pre and post predicted 1RM bench press and 5RM speed bench press. A dependent t-test was calculated for pre and post body fat measures. Statistical significance was set at $\alpha = .05$.

4.0 RESULTS

The purpose of this investigation was to observe the effects of heavy elastic bands and weighted chains on maximum upper body strength and upper body power in a 7-week off season strength and conditioning program. It was hypothesized that incorporating heavy elastic bands and weighted chains into an off-season strength and conditioning program would increase maximum 1RM bench press and maximum 5RM speed bench press tests compared to a control group (traditional bench press).

Thirty six members of the Robert Morris football team participated in this investigation. An attrition rate of two percent was observed with one subject being lost due to resignation from the team. Thirty six out of the ninety two players were selected using a blocking variable which was relative bench press strength. Following selection, subjects were divided into one of three groups; Elastic Band (EB), Weighted Chain (WC) and Control (C). Subject characteristics are presented in Table 1. Each player was classified as either a skill player or a line player. Skill position players consisted of quarterbacks, running backs, receivers, linebackers, and defensive backs, and line players consisted of offensive and defensive lineman.

Table 2. Subject Descriptive Data

Variable	Group Total	Chains	Bands	Control
Age (yrs)	19.9 ± 1.03	20.27 ± 1.1	19.6 ± .9	20 ± 1.1
Height (cm)	180.8 ± 6.24	181.6 ± 6.1	179.3 ± 4.82	181.6 ± 7.8
Weight (kg)	96.4 ± 15	94 ± 12.9	90.9 ± 17.1	104.1 ± 15
Pre BF (%)	13.7 ± 6.06	12.4 ± 6.2	11.2 ± 5.8	17.7 ± 6.2
Post BF (%)	13.9 ± 6.4	13 ± 6.8	11 ± 5.8	17.5 ± 6.6
BP·(Body wt)$^{-1}$	1.38 ± .12	1.38 ± .09	1.41 ± .13	1.37 ± .14
Position	23 skill; 13 line	8 skill; 4 line	10 skill; 2 line	5 skill; 7 line

Values are means ± SD
N = 36: 23 (Skill players), 13 (Lineman)

Following anthropometric measurements, subjects were tested on the two dependent variables: 1RM predicted (5-7RM) bench press and 5RM maximal speed bench press. Based on the load and number of repetitions on the multiple 5-7RM bench press test, a prediction equation was used (Baechle, 2000) to predict maximal 1RM bench press. The rationale for using the sub maximal 1RM testing was enforced by the strength coach because of issues around safety and risk of injury of players participating in a 1RM test. Pre and post-test results of the 1RM predicted and 5-7RM tests are presented in Table 2.

Table 3. 1 RM Predicted Max and 5RM Speed Bench Results

Variable	Group Total	Chains	Bands	Control
Pre test 1RM (kg)	133 ± 21	129.5 ± 15	127.7 ± 25	141.8 ± 23
Post test 1RM (kg)	141.9 ± 20	138.6 ± 14	137.7 ± 25	149.5 ± 23
Pre-test Peak Power 5RM speed bench (W)	837 ± 155	823 ± 153	812 ± 171	877 ±142
Post-test$_1$ Peak Power 5RM speed bench (W)	831 ± 153	823 ± 134	812 ± 174	858 ± 153
Post-test$_2$ Peak Power 5RM speed bench (W)	845 ± 146	815 ± 101	835 ± 181	885 ± 157
Pre-test 5RM peak velocity ($m \cdot sec^{-1}$)	1.29 ± .11	1.29 ± .136	1.29 ± .096	1.26 ± .121
Post test$_1$ 5RM peak velocity ($m \cdot sec^{-1}$)	1.29 ± .13	1.32 ± .134	1.33 ± .12	1.26 ± .14
Post test$_2$ 5RM peak velocity ($m \cdot sec^{-1}$)	1.2 ± .11	1.19 ± .08	1.24 ± .104	1.19 ± .152

kg = kilograms
W = watts
Post-test$_1$ = conducted using original pre-test 1RM
Post-test$_2$ = conducted using 1RM from post-test$_1$

4.1 PREDICTED 1RM BENCH PRESS

Results showed significant main effect by time (*p <.05) within all groups. The WC, EB, and control groups increased their predicted 1RM maximum bench press by 9.6 kg (7%), 10 kg (8%), and 7.7 kg (5%) respectively (Figure 1 and Figure 2). Furthermore, a partial eta squared of .747 was observed indicating a large effect size. However, no significant group effects were reported.

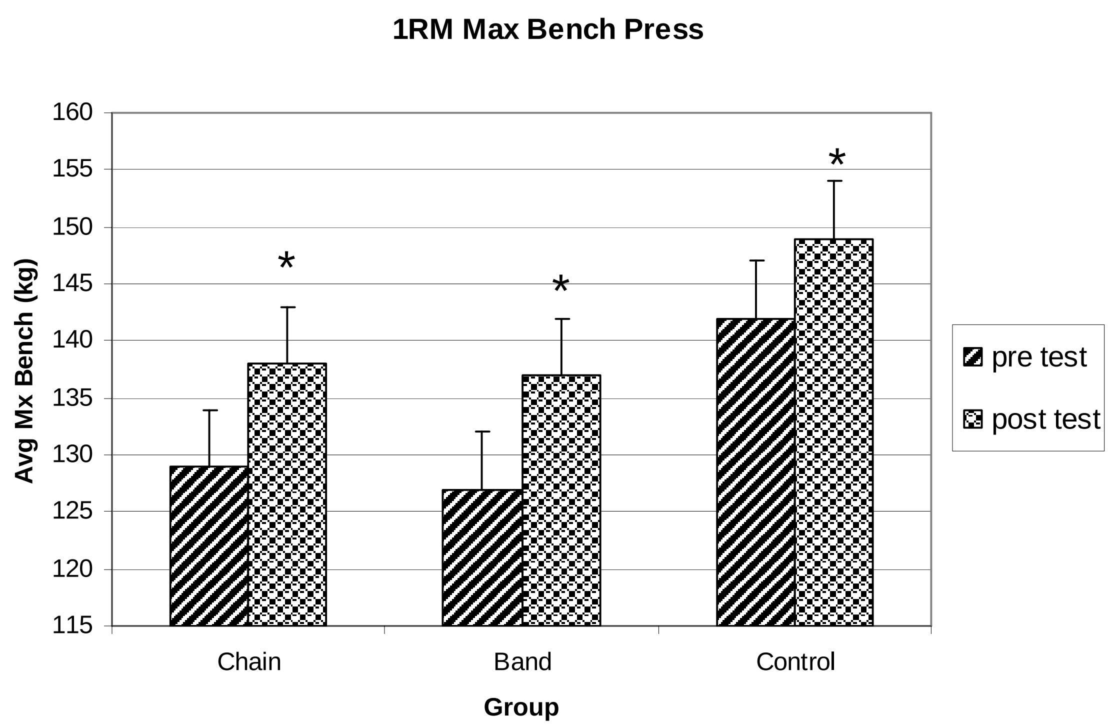

Figure 4. 1RM Predicted Max

Change in 1RM bench press pre and post test following the 7-week strength and conditioning program.
* = significant time effects for pre and post test (*p < .05)

Figure 2 represents 1RM predicted relative max bench press. Due to the method of selection via the blocking variable ($BP \cdot BW^{-1}$), data was formatted to calculate relative strength per body weight. Results showed statistical significance (*$p < .05$) for time and no significance for between group variance.

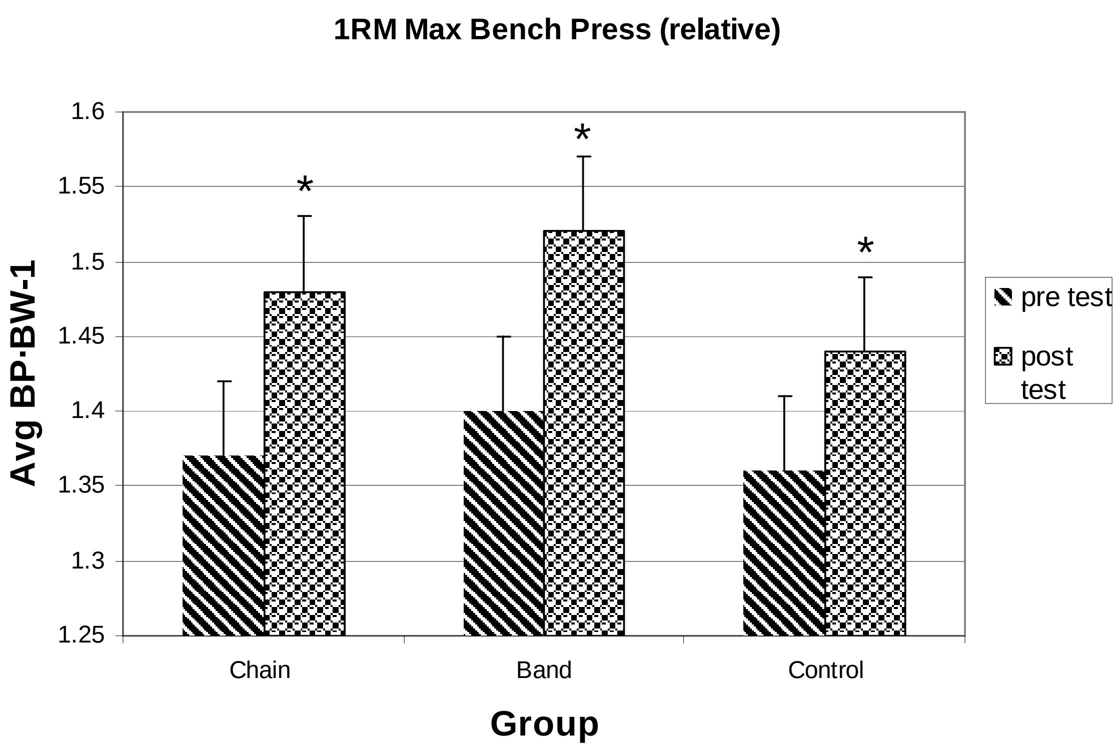

Figure 5. 1RM Predicted max Relative
Change in 1RM bench press relative to body weight ($BP \cdot BW^{-1}$).

4.2 5RM PEAK POWER TEST

Subjects performed the 5RM speed bench press test in which peak power (Watts) was measured using the Fitrodyne device. Figure 3 represents the average peak power values across all groups for the three testing days. Subjects were tested over three sessions; pre-test (PRE), post-test 1 (PST1), and post-test 2 (PST2) at 50% of pre test 1RM maximum. The first post testing session consisted of subjects performing 5RM speed bench press at 50% of the subjects original pre test max. The second post testing session was performed at 50% of the subjects *new* 1RM max.

Subjects performed two sets of five repetitions for each set. The overall mean of the peak power values (W) recorded from each set was calculated (the highest of average peak power value between both trials was recorded). Results showed no significant differences for between or within group effects.

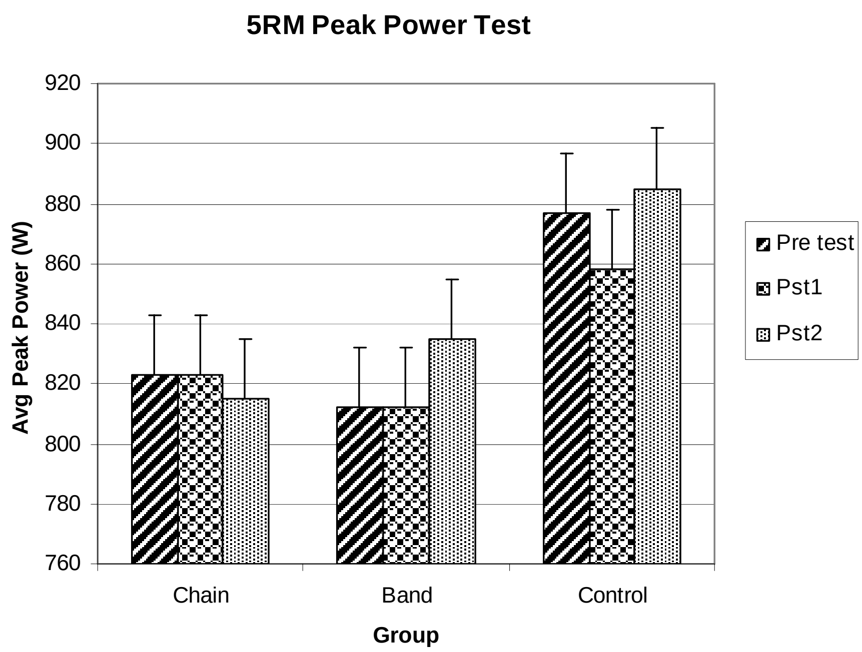

Figure 6. 5RM Peak Power Test

Change in peak power expressed in Watts in the 5RM
speed bench press test following the off season conditioning program.

Figure 4 represents the change in peak velocity values across all groups for the three testing sessions. On PST2 subjects performed the 5RM speed bench press at their *new* 1RM's recorded from the post test 1RM sessions. Results indicated a significant effect (*p < .05) for decreasing velocity between PST1 and PST2.

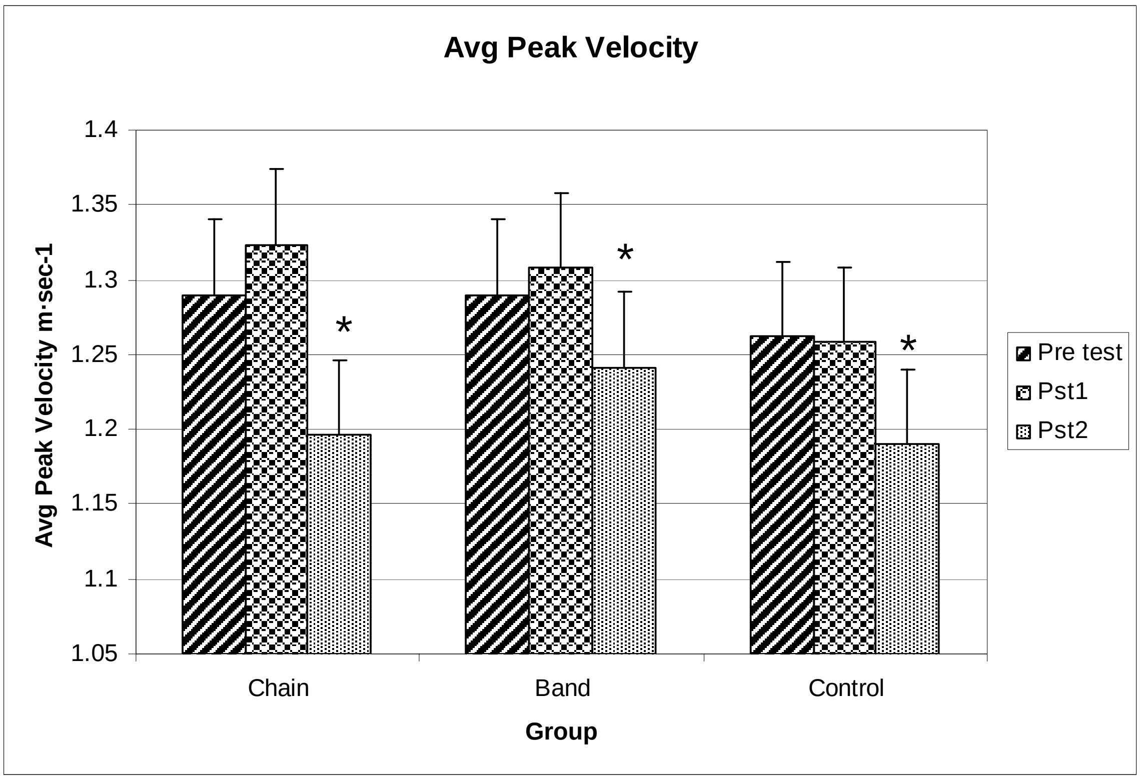

Figure 7. Average Peak Velocity

Change in peak velocity expressed in meters per second in the 5RM speed bench press test following the off season conditioning program. * = significant time effects for pst1 and pst2 (*p < .05).

4.3 2 RM PEAK POWER TEST FROM 5RM TEST

The investigators filtered the data by taking the average of the top two repetitions for the selected trial on the 5RM peak power test. Peak power values for all participants were recorded between repetitions one and five. Figure 5 represents the average of the two highest peak power values recorded between repetitions one and three. The WC and EB increased 2 RM peak power from, 849W to 856W, and 836W to 870W respectively, while the control decreased from 910W to 902W. This method of data analysis was an attempt to detect greater variability by choosing the top repetitions within each set. However, no significant differences for within or between group variance were observed.

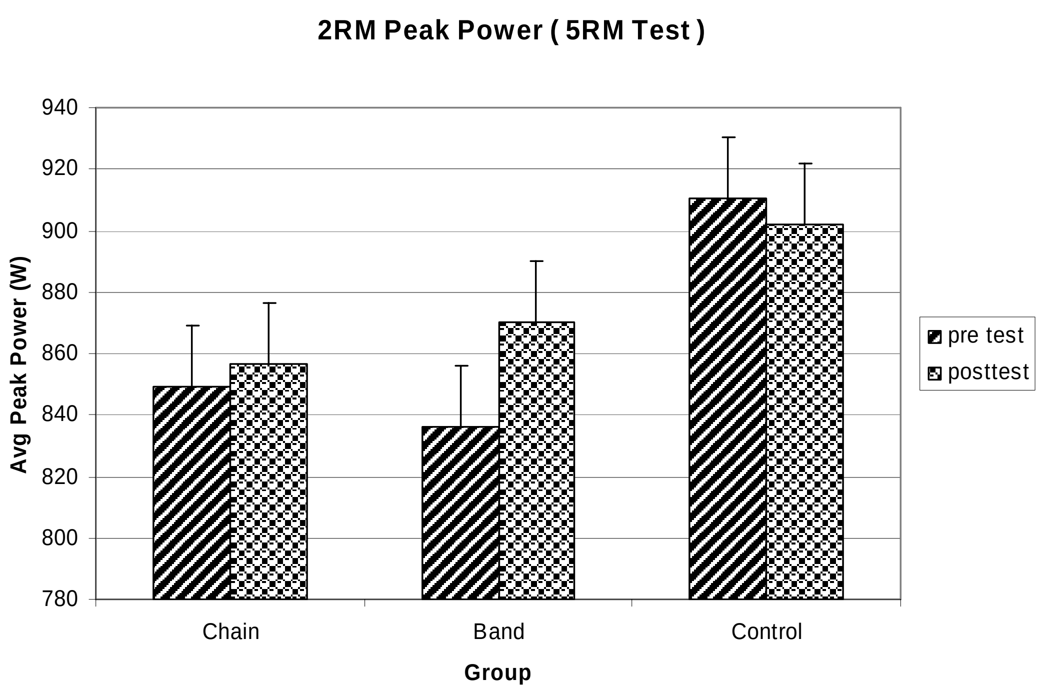

Figure 8. 2RM Peak Power (5RM Test)

Change in peak power by selecting the top two repetitions from the 5RM peak power test.

4.4 1 RM PEAK POWER TEST FROM 5RM TEST

Data was filtered a second time by taking the top repetition of the best trial. Although not significant, the band condition increased their highest repetition value from an average of 848W to 883W. The chain group increased from 856W to 878W and the control group decreased from 928W to 918W. The band group also recorded the highest relative to BW power increase from 4.24 to 4.43, while the chain group increased from 4.13 to 4.26, and the control group decreased from 4.05 to 4.02.

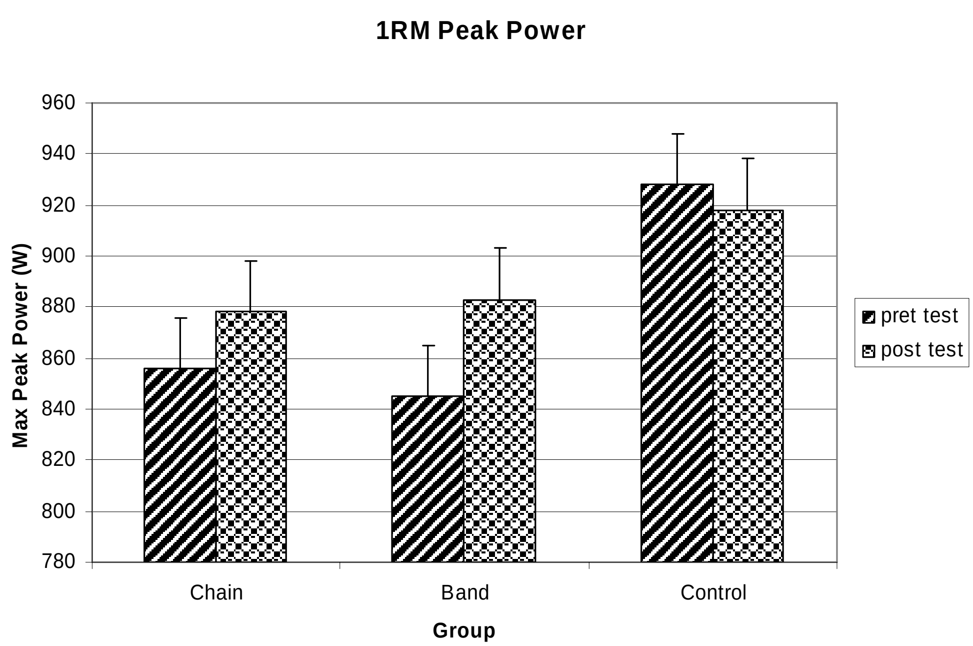

Figure 9. 1RM Peak Power

Change in peak power by selecting the top repetition from the 5RM peak power test.

4.5 1RM PEAK POWER TEST FROM 5RM TEST (RELATIVE)

The 1RM peak power filtering process from the 5RM test was not significant for within or between group effects, however did show greater variability in the EB group. The top repetition was selected and converted to relative power. Figure 6 represents the maximum peak power repetition relative to body weight for all groups.

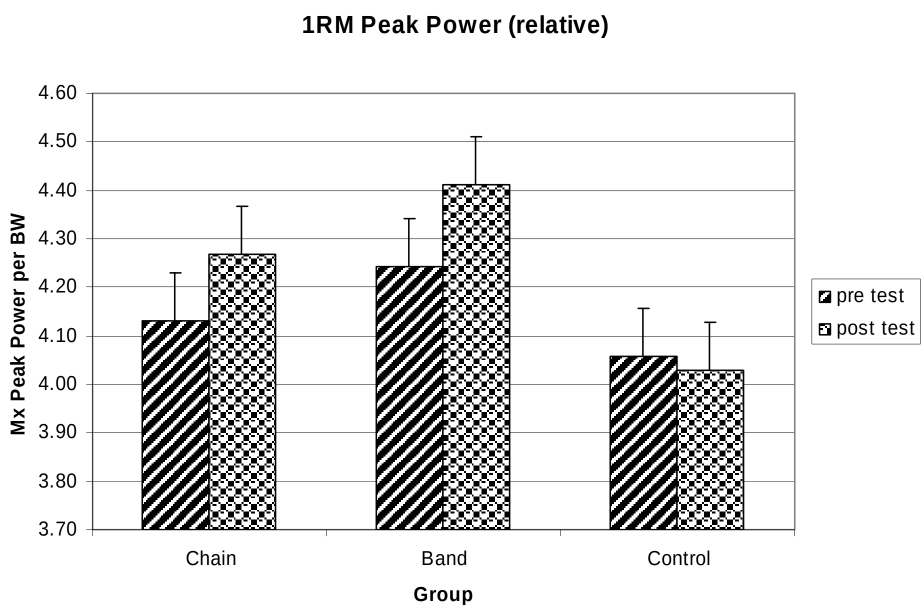

Figure 10. 1RM Peak Power from 5RM Test (Relative)

Change in relative peak power by selecting the top repetition from the 5RM peak power test.

4.6 BODY COMPOSITION

Overall body fat percentage for all subjects using the 3-site skinfold caliper measurement showed no significant differences from pre to post training intervention (13.7% vs. 13.9%).

4.7 INTRACLASS RELIABILITY

The peak power measurement in the bench press exercise using the Fitrodyne device had an average Cronbach's intraclass correlation coefficient (ICC) of $R = 0.981$. ICC was 0.988, 0.981, and 0.984 for the pre test, post test 1, and post test 2 sessions respectively. Figure 7 represents the range of the average peak power values for each subject over three trials (pre test, pst1, and pst2). For each column, three intra reliability correlations were calculated for each trial for each subject then averaged together. The thirty five ICC's were average to produce an overall ICC (r = 0.98).

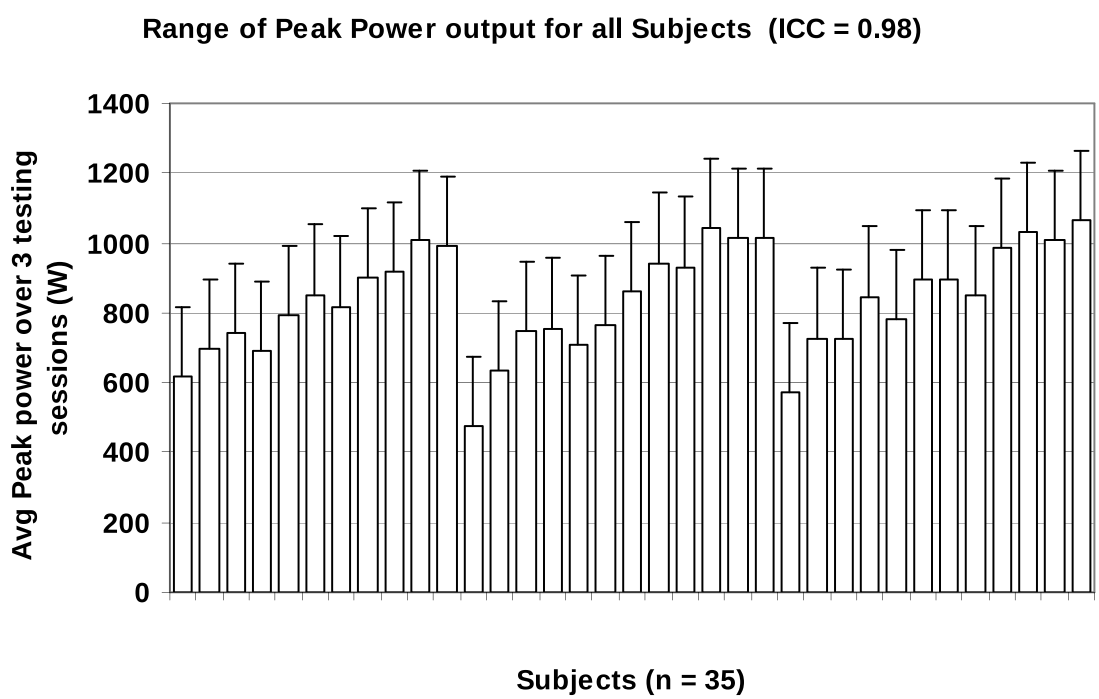

Figure 11. Range of Peak Power output for all Subjects (ICC = 0.98)

The average peak power output ± *SD* for each of the 35 subjects during the speed bench press exercise repeatability trial.

4.8 SUMMARY

Results of the seven week intervention using weighted chains, elastic bands, and traditional bench press exercise showed a significant time, but no group effect for both predicted 1RM (kg) and 5RM peak power tests (watts). After filtering the data with the selected highest peak power values, the chain and band groups showed slightly non-significant greater values when the two highest and greatest values were chosen. There were no significant improvements in body composition for all subjects over the seven week training period.

5.0 DISCUSSION

The purpose of the present study was to explore the effects of heavy elastic bands and weighted chains implemented into an off season strength and conditioning program on strength and power measures. To date, a lack of information pertaining to weighted chains exists (Ebben, 2002; Berning, 2004; Baker, 2005), while a limited number of studies using elastic bands have shown equivocal results (Andersen, 2005; Ebben, 2002; Newton, 2002; Cronin, 2003; Wallace, 2006; Winters, 2006; Claxton, unpublished report).

Specifically, elastic bands are reported to provide greater peak power and peak force output due the increase in the velocity of eccentric muscle contraction from the bands pulling the barbell downward at the start of the eccentric phase (Andersen, 2005; Wallace, 2006; Cronin, 2003). Although the effectiveness of elastic band training remains unclear, recent studies have shown gains in muscular power and maximal force production (Newton, 2002; Cronin, 2003; Wallace, 2006; J. Claxton, unpublished report 2005). Likewise, the cumbersome and heavy nature of the weighted chains has prohibited investigators from examining effects of weighted chain training interventions. Thus the present study is the first to explore weighted chain training in an off season conditioning program. It was hypothesized that elastic bands and weighted chains would provide optimal resistance through the entire range of motion by accommodating to the changing length-tension relationship of the musculoskeletal system (Ebben, 2002; Newton, 2002; Simmons, 1999; Zatsiorksy, 1995; Baker, 2005).

5.1 DESCRIPTIVE CHARACTERISTICS

The present study provided descriptive data on a sample of Division 1-AA football players. The average body composition, 1RM values, and upper body power measures were comparable to other Division 1 and Division 1-AA college football players (Black, 1994, Barth, 2003, Jennings, 2005). Subjects in the present study were considered moderate to highly trained, as reflected by the group's predicted 1RM BP·BW^{-1} ratio (1.38) and predicted 1RM bench press (142 kg) (Baechle, 2000). Based on the high levels of relative strength scores and low body fat percentages, the sample recruited for the current study was representative of Division 1-AA football players.

5.2 PREDICTED 1RM BENCH PRESS

The overall mean of the 1RM predicted bench press significantly increased within each group over the seven week time period. However, there was no significance for between group interactions. It was unclear as to whether the increases were specifically due to the treatment (training program with bands and chains), or to the general conditioning adaptation that would typically occur in an off season training program. All subjects underwent an advanced training program, which consisted of training 4-5 days per week, performing multijoint exercises loaded at 85% of 1RM for strength gains, and 50% 1RM for muscular power enhancement. It is well documented that this type of intervention is recommended to elicit these particular performance gains similar to a dose response relationship in advanced athletes (Kraemer, 2002; Pertesen, 2004). Although not significant, the band and chain groups appeared to respond better to the treatments through increased 1RM bench press scores compared to the control group (8% and 7% vs. 5%). This supports recent evidence that elastic band training increases maximal force production (Wallace, 2006; Andersen, 2005). The elastic band and weighted chain methods acted as a new training stimulus, and strength coaches assumed a conservative approach by keeping the frequency of training minimal to one day per week. As a result there is concern regarding the effectiveness of training frequency as a training stimulus for power and strength development.

While this study had less duration compared to other short term interventions (11-16 wks) previously reported, it was of sufficient time to observe strength and power gains (4-6 wks) (Kraemer, 2002). The present study trained with elastic bands and weighted chains one session per week for seven weeks for a total of seven sessions. Other training studies have prescribed the duration of training to as long as ten weeks, with the frequency of training being 1-2 days per week (Ebben, 2002; Wallace, 2006; Cronin, 2003; Andersen, 2005). In a ten week study by Cronin et. al, subjects trained twice a week for a total of twenty sessions (Cronin, 2003). In each session, subjects performed three sets of ten repetitions using elastic bands, for a total of six sets a week. In the present study, while the weekly number of sets was equal to the Cronin study, total volume (frequency x sets x repetitions) remained less. Therefore, it is likely that the total time under treatment may have not been sufficient.

5.3 5RM SPEED BENCH PRESS

Although no significance was found in the 5RM peak power test using the average of five repetitions, the results indicated greater improvements in the band and chain groups compared to control when the two highest and single highest peak power repetitions were selected. Since subjects were producing their highest values earlier in the performance set investigators filtered the data by selecting the top (repetitions 1 and 2) power values. Furthermore, supporting evidence has reported that the highest motor unit efficiency power outputs occur at low fatigue levels that correspond to the first few repetitions of a set (Baechle, 2000; Zatsiorksy, 1995; Fleck and Kraemer 2000).

Increases in power values for repetitions one and two in the experimental groups compared to the control as form of variable resistance training may have reflected increases in reversible strength. Reversible strength is defined as "the ability to accelerate a force in the opposite direction in a stretch shortening cyclic action" (Zatsiorsky, 1995; Siff, 1999). In this investigation, subjects were instructed to perform the traditional bench press exercise "explosively" which required them to accelerate the barbell as fast as possible from eccentric to subsequent concentric contraction. Due to the decreasing load taken off the bar at the end of the eccentric phase during the weighted chain exercise, experimental groups were able to accelerate the barbell faster during the concentric portion of the lift resulting in higher peak power values. It has also been suggested that elastic band training allows a player to be in longer state of acceleration during the concentric phase due to increasing force towards starting position (J. Claxton, unpublished report).

Another possible explanation for the lack of significance in overall peak power measures is exercise selection. One of the limitations of traditional bench press is the large deceleration period at the end of the concentric phase (Newton, 1996; Elliot 1989). Research suggests that ballistic training is utilized to compensate for this (Newton, 1997; Kraemer, 2002). Ballistic training occurs when the lifter attempts to accelerate the barbell throughout an unlimited range of motion, which usually results in either a jumping motion or the release of the barbell from the hands (Siff, 1999). This type of training has been shown to induce greater power outputs compared to traditional weight training (non-ballistic) (Haff, 2001; Mcbride, 2002). Although subjects in this investigation were instructed to accelerate the barbell throughout the range of motion, they were not allowed to release the barbell at the end of concentric movement, therefore performing a more traditional bench exercise. Previous studies have supported that in order to develop explosive power, using light loads by performing traditional resistance training may not be beneficial because of the large amount of time the barbell spends in the deceleration phase (Wilson, 1993). In the present study, investigators did not have access to a Smith machine or machine type apparatus which would have allowed ballistic training to be performed.

5.4 5RM PEAK VELOCITY RELATIVE TO PEAK POWER

Subjects performed two post testing sessions in the 5RM speed bench press test. Loading for the first session (PST1) was 50% of their predicted 1RM pre test score, while loading for the second (PST2) was 50% of their predicted 1RM post test score. There was a significant difference between PST1 and PST2 where peak velocity was lower for PST2 (1.2 $m \cdot sec^{-1}$) than PST1 (1.29 $m \cdot sec^{-1}$). However, although peak velocity decreased, peak power increased in PST2 and subjects produced greater power outputs in PST2 (845W) than PST1 (831W). This may be due, in part, to subjects being more optimally loaded during PST2, which consequently resulted in higher power outputs.

It is suggested that due to the increases in predicted 1RM pre to post test, subjects completing PST1 for the speed bench were using too “light” of a load. This was apparent from both the observed deterioration of form and technique (i.e. back coming off bench) as well as low peak power scores. The PST1 load was based on the subject’s pre test predicted 1RM bench at the start of the training program. From the increase in the predicted 1RM values, subjects were loaded at approximately 40-45% of their predicted 1RM. During PST2, using 50% of the predicted 1RM post test scores, subjects were loaded with approximately 50-55% of their predicted 1RM which deemed a more optimal weight for peak power as observed with the peak power values. It is reported that in well trained athletes, proper loading for upper body power in the bench press exercise is recommended at 50-55% (Baker, 2005), and this was supported in the present findings.

5.5 FITRODYNE

The Fitrodyne has been commercially available and reliable measurement in published research (Weiss, 2006; Jennings, 2005; Coelho, 2002, 2003). Similar to previous studies the average test-retest reliability coefficients in this investigation was r = 0.98. From these conclusions, it can be suggested that while costly, the Fitroydne is a feasible and reliable measurement for power output. Recently this device has been validated in which the findings were less desirable; however this is the only study to date examining this research question (Weiss, 2006).

5.6 LIMITATIONS

As mentioned previously throughout the discussion, the present study contained several limitations which may have contributed to the results observed:

1. *Training frequency for treatment groups*: In the present study subjects in the elastic band and weighted chain groups trained with the variable resistance modalities only one day per week. Based on the improvement outcomes observed in all three groups, it's plausible to suggest the training stimulus was insufficient in frequency and total volume trained.
2. *Duration of intervention*: A review of literature states the typical strength and conditioning regimen intended to elicit strength and power gains should be approximately eleven to sixteen weeks. However, depending on the level of initial training status, frequency, and volume of training these recommendations may vary. While neurological strength gains are observed in the early stages (4-6 wks), the present study incorporated a seven week training intervention. It is possible the duration of this intervention contributed to less of a physiological effect on the development of power and strength.
3. *Inability to determine if training effects were due to improvements in overall conditioning vs. specific effects of the elastic bands and weighted chain training*: Though it's suggested the length of the training intervention may have been insufficient, the particular program design in the present study was of proper loading, exercise selection, and volume that would elicit strength and power gains. Due to the fact the control group in addition to the treatment groups received this intervention, it was difficult to differentiate whether gains observed were due to

the general off season conditioning program or to the variable resistance techniques assigned.

4. *Exercise selection when testing for muscle power*: Evidence suggests that the traditional bench press exercise is a poor choice regarding exercise selection when testing for muscle power due to the large deceleration phase at the end of the concentric phase. The concept of ballistic exercise (i.e. releasing the barbell at the end of the concentric phase) is currently implemented to solve this problem. Due to lack of available equipment, the present study instructed subjects to perform the traditional bench press at maximal movement speed. This may have lacked precision and accuracy for assessing muscle power.
5. *Physiological Ceiling effect*:

   The inability to see increases in strength and power between the groups may have been due to the highly trained state of the subject pool. The rationale for selecting this type of population was due to the advanced training methods implemented. It should be noted a lesser trained population may have allowed the investigators to see improvements for between the groups.
6. *Time issue using the Fitrodyne*: The investigators had the intention of performing three sets of five repetitions when testing the subjects in the 5RM speed bench press using the Fitrodyne. However, due to time constraints and lack of equipment (i.e. only one Fitrodyne device), subjects had to be tested on two sets of five repetitions. Performing more testing sessions may have provided a more accurate score for peak power in the 5RM test.
7. *Technical issue using the Fitrodyne* Technical difficulties pertaining to this device

were minimal, however problems did occur if the subjects did not come to complete lockout position when performing the speed bench repetitions. To allow the Fitrodyne to record power output values, subjects should return the barbell to complete lockout position at the end of the concentric phase, and take a one second pause before performing another repetition.

5.7 CONCLUSION

The main findings of this study suggests that the use of elastic bands and weighted chains in conjunction with a general seven week off season strength and conditioning program can increase overall maximum upper body strength in a sample of Div 1-AA football players. Elastic bands and weighted chains should be considered as potential training methods for increasing maximum force production. This information may be beneficial for training athletes whose primary goal is to increase maximal force and maximal power for enhanced athleticism in their respective sport. Furthermore, these methods could be intermittently used as a separate training tool during an off-season training cycle from which the athlete could achieve performance gains in specific exercises such as vertical jump and ballistic performances (Newton 2002). In addition, variable resistance training also gives the athlete and strength and conditioning practitioner greater flexibility in exercise prescription.

5.8 RECOMMENDATIONS FOR FUTURE RESEARCH

Based upon the finding of this investigation, future research involving the use of weighted chains and elastic bands into strength and conditioning regimen should consider the following:

1. Lengthen the time of the training program. The duration of the training program in this investigation was approximately seven weeks. It would be of interest to explore the effects of these modalities if subjects were exposed to more training sessions using these methods. Subjects in the elastic band and weighted chain groups had not participated in this type of training prior and showed a high adherence rate to the treatment days. However, the lack of change between groups may have been due to subjects' pre existing high level of training state. Therefore, based on the encouraging trends of the elastic band group, a longer training program is warranted (i.e. 10-12 weeks).

2. If time is a prohibitive factor, an increase in the frequency of training sessions using elastic bands or weighted chains should be implemented. Subjects in this investigation were exposed to the training one day per week. It would be of interest to explore the effects increasing the frequency of use to two times per week.

3. Change the exercise selection when testing for muscular power. In this investigation subjects performed the traditional bench press exercise "explosively" when tested on the Fitrodyne device. Though instructing the athlete to accelerate lighter loads as fast as possible may have neurological benefits, suboptimal gains in traditional weight training could result due to the large amount of time subjects spend decelerating the bar. It would be of interest to explore the upper body power outputs performing the bench press exercise "ballistically," which would require subjects to release the bar at the end of the concentric phase.

4. It would be of interest to conduct a validation study using the Fitrodyne device. The

Fitrodyne is portable, feasible, reliable, and relatively inexpensive compared to other measures of muscular power. However, the validity of this device needs to be further examined. One possible method of validation would be to concurrently use the Fitrodyne with a high speed digital camera system while performing the speed bench press exercise.

APPENDIX A

DATA SHEET FOR 1RM PREDICTED BENCH PRESS

ID	Group	5-7 RM Test Pre (Weight X # of repetitions)	5-7 RM Test Post-test	Predicted 1RM
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	WC			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	EB			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			
	Con			

APPENDIX B

DATA SHEET FOR 5RM SPEED BENCH PRESS

ID

Body weight ______________
Pred 1RM ______________
Test weight ______________

Trial 1	Avg Power (Watts)	Avg Velocity (m/s)	Peak Power	Peak Velocity
Repetition				
1				
2				
3				
4				
5				

Trial 2	Avg Power (Watts)	Avg Velocity (m/s)	Peak Power	Peak Velocity
Repetition				
1				
2				
3				
4				
5				

ID

Body weight ______________
Pred 1RM ______________
Test weight ______________

Trial 1	Avg Power (Watts)	Avg Velocity (m/s)	Peak Power	Peak Velocity
Repetition				
1				
2				
3				
4				
5				

Trial 2	Avg Power (Watts)	Avg Velocity (m/s)	Peak Power	Peak Velocity
Repetition				
1				
2				
3				
4				
5				

APPENDIX C

DATA SHEET FOR BODY COMPOSITION

ID __________

Pos ___________

Height ______________

Weight __________

Site 1 (chest)

__________ _________ __________

Site 2 (AB)

__________ __________ __________

Site 3 (Quad)

__________ __________ __________

APPENDIX D

INSTITUTIONAL REVIEW BOARD PROTOCOL

Project Title

The Effect of Heavy Elastic Bands and Weighted Chains on Upper Body Strength and Power in a Sample of Division IAA College Football Players.

Abstract

The purpose of this study is to explore the effects of heavy elastic bands and weighted chains on maximum muscular strength and maximum power in the bench press exercise. Thirty six healthy males 18-30 years old from the Robert Morris University football team will volunteer to participate in this study. During Weeks 1 and 9 of the study a one repetition maximum (1RM) and a five repetition (5RM) speed bench press maximum will be determined for the subjects in the bench press exercise. Thirty six subjects will be randomly divided into three groups (n=12): elastic band (EB), weighted chain (WC) and control. Subjects will be oriented to the elastic band (EB) and chain weighted (WC) bench press prior to pre testing. Subjects will be taught how to attach the EB and WC on to the barbell as well as how to perform the bench press exercise using them. During weeks 2 through 8 of the study, subjects will be required to follow the resistance training program designed for using the EB and WC two times a week for seven weeks. All other components of normal spring training and conditioning will remain the same. Means and standard deviations of 1RM bench press and 5RM speed bench press will be computed in the first and ninth week of the program. A two factor (method X time) analysis will be applied to identify significant differences between the training groups. Statistical significance will be set at the $p<0.05$ level. It is hypothesized that a seven week resistance training program using the heavy elastic bands and weighted chains for upper body presses will increase 1RM and 5RM speed bench press in a sample of collegiate football players.

Objective and Specific Aims

1. The primary aim of this study is to investigate the effects of using heavy elastic bands and weighted chains in a seven week bench press program to increase 1RM and 5RM speed bench press.

Background/Significance

The desire for most athletes, recreational lifters and bodybuilders is to increase muscle strength and build muscle size. Current evidence suggests the use of chains in a resistance training regimen will benefit the strength/power athlete (Simmons, 1999).

Chains

Weighted chains are attached to the end of a barbell so as the lifter ascends during an exercise such as a squat, an increasing load is systematically increased as the chain is lifted off the floor. Simmons (1999) suggests that with the use of the chains one's mechanical advantage of the exercise increases. This is due to the chains accommodating the load on the bar during weaker points of the biomechanical movement of the squat exercise.

The weighted chain system matches the length-tension relationship of the muscle by using heavier loads at the top portion of the squat exercise where the lifter is at their strongest position and decreasing the load at the bottom of the squat where the lifter is at their weakest position. As one begins to descend the muscles of the knee extensors and hip flexors begin to lengthen, however the weight is being decreased from the bar because of more chain links gathering on the ground. This matching or accommodating system may allow lifters to use more load during weight training exercises especially at the top portion of the lift.

Once the lifter begins to ascend into the concentric phase, the load of the bar increases. However the distance from the working muscle joint to the bar decreases, thus providing less torque on the working muscle joints positioning the lifter in a stronger position. This potential advantage can transfer into the overload principle. To bring about positive changes in the athlete's state, an exercise overload must be applied. The training adaptation takes place only if the magnitude of the training load is above the habitual level (Zatsiorsky, 1995).

Another positive attribute of this mode of training pertains to Newton's Laws of Acceleration. Newton's laws indicate that the instant of minimum vertical bar acceleration is also the instant at which the lifter is exerting minimum force on the bar (Madsen, 1984). Madsen et. al. stated this point is typically 0.12 m off the chest, also known as the "sticking point". Other research (Wilson, 1989) found similar findings. When the weight becomes lightest at the bottom of the lift due to the weighted chain system, it is hypothesized the lifter can change the direction of the bar much quicker. By shortening the time it takes to change vector direction an increase in force will occur. This is due to the impulse-momentum relationship; $F = (\text{mass} * \text{change in velocity}) / (\text{change in time})$ (McGinnis, 1999). Instructing the lifter to accelerate the bar as quickly as possible at the bottom of the lift utilizes this relationship and could possibly help train them through these "sticking points."

The acceleration of the bar through the concentric phase focuses on training for power. Siff (2003) describes this as speed strength training. Accelerating lighter loads at faster rates through the concentric phase will condition the nervous system to stimulate a muscular response (Siff, 2003).

Ebben et al (2002) found the use of chains to be insignificant. While conducting a study observing the neurological effects in the lower extremity during the squat exercise his sample was divided into three groups consisting of squatting with the chains (chain squat), band squat and traditional squat (no bands or chains). Results revealed no significant difference in any of the three conditions (Ebben 2002). It was suggested that future studies are warranted potentially using a different protocol. Currently there is no knowledge of research investigating the use of chains in a longitudinal (6-8 weeks) resistance training study.

Elastic Bands

Historically, elastic bands have been used primarily in rehabilitation settings (Simoneau 2001, Treiber 1998) or for exclusive sports specific objectives such as increasing strength and power for racquet sports (Behm 1988). Recently, elastic bands have been applied to both structural and power movements in an effort to induce greater strength gains (Cronin 2003, Andersen 2004, Wallace 2004, Newton 2002, Simmons 1999). Due to the tendency of the elastic bands to pull a barbell down during early phases of a lift, an increased eccentric loading phase occurs which may explain how higher eccentric velocities could be associated with this type of training.

Eccentric training is considered a viable stimulus because it is more metabolically efficient than concentric contraction, as well as capable of generating higher forces (Asmussen 1974, Hakkinen 1983, Bobbert 1987, Kaneko 1984, Rodgers 1974). It has also been reported that eccentric compared to concentric exercise tends to produce greater and more rapid increases in muscle strength and hypertrophy (Hortobagyi 2000), due to the result of greater tissue damage produced under eccentric conditions. As a greater magnitude of muscle is stretched, the more elastic energy it will store (Bobbert 1987), and consequently, a greater resultant concentric force will result.

Eccentric training may be implemented in two ways: by (1) increasing the load on the barbell (Doan 2002, Siff 1999), or (2) increasing the velocity of stretch in the respective movement (Bobbert 1987, Cavagna 1968). The attachment of heavy elastic bands is an attempt to increase velocity of stretch which may cause selective increase in the tensile strength of tendon and other series elastic components of the muscle. Modifying bands to a strength training apparatus in such a way that the return velocity, and force needed to decelerate the load (at the end of the eccentric phase) has reported promising results (Cronin 2003, Andersen 2004, Wallace 2004, Newton 2003) and warrants further investigation.

The most common method of assessing muscular strength is the one repetition maximum (1RM) test (LeSuer 1997). A traditional test to measure upper body strength is the 1RM bench test. Performance of the bench press exercise involves initially taking a barbell at arm's length while lying on a bench then lowering the bar to the chest and raising it to starting position (Madsen 1984). A common method for testing upper body power is the 5RM speed bench press test (Newton 1997). Instructing the athlete to accelerate light to moderate loads ranging from 40-70% 1RM at high velocities is a well documented method to train and test for muscular power (Kaneko 1983, McBride 2002, Moss 1997, Newton 1997, Baker 2001). A dramatic increase in neural factors contributing significantly to strength gains during the time course used for most resistance training studies is 6 to 10 weeks (Sale 1988).

The majority of sample populations in past research studies similar to this one were predominantly males. Collegiate male athletes 18-30 years of age were chosen so the investigators would be able to be able to generalize their results to that specific target population.

Experimental Design and Methods

Experimental Design: This study will employ an experimental randomized repeated measures design. Thirty six male NCAA Division IAA football players from Robert Morris University 18-30 years old will volunteer to participate in this study. Subjects will be selected using a randomized blocking design with the blocking variable being bench press (BP) per body weight (BW). The top thirty six out of ninety two players in respect to BP/BW will qualify for participation and be randomized into three groups of twelve. All subjects will be; (1) male (2) age 18-30, (3) non-obese (defined by <25 % fat), (4) advanced level weight lifters (currently lifting weights a minimum of 4-5 days a week for the past 1.5 to 2 years) (5) must be members of the Robert Morris University football team and have passed the team physical (6) non-obese (<25% body fat), which will be determined by self-reporting and (7) able to bench press at least 1.3*body weight (a weight greater than or equal to 1.3 times their body weight). All subjects will have a pre-participation clearance in the form of the Physical Activity Readiness Questionnaire (PAR-Q & YOU) as well as team physician clearance to participate in the football season. All procedures will receive approval from the Institutional Review Board at the University of Pittsburgh prior to the study. After approval all procedure will undergo IRB approval at Robert Morris University as well.

Prior to the first week of the study subjects will be informed of the details in an introductory meeting by the head strength and conditioning coach. This meeting is designed to determine if the subject is eligible for the study and to introduce the strength program they will be following. After been given study information, subjects still showing interest will contact the principal investigator for an interview and to set up one orientation session. This interview is designed to screen the subjects further for specific medical conditions and to garner knowledge of their training background. Subjects' still expressing interest in the study will set up an orientation session appointment. Following completion of consent form subjects will perform a 1RM bench press test to distinguish if they qualify to be in one of the thirty six selected to be divided into three groups. The rationale for this is to establish greater homogeneity of the sample size and to increase design sensitivity. All testing, orientation, and training sessions will be conducted at Robert Morris University.

The total duration of this study is nine weeks. Subjects will follow the training protocol for the middle seven weeks with weeks 1 and 9 scheduled for pre and post testing sessions.
The projected timeline is:

- Week 1 — Pre-testing session (T_1)
- Week 2 and 8 — Lifting sessions using the designed program (Appendix A)
- Week 9 — Post-testing sessions (T_2)

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Procedures

Screening

Subjects will be screened by Jamie Ghigiarelli (exercise physiology doctoral student) who is certified as a strength and conditioning specialist and is experienced in developing strength and conditioning programs for various populations. All subjects will be healthy, non-obese (Body Fat < 25%) and will have pre-participation clearance in the form of the Physical Activity Readiness Questionnaire (PAR-Q and YOU). The PAR-Q & YOU will assess the subject's readiness for physical activity and identify potential subjects for whom the physical activity may be inappropriate and includes seven questions inquiring about a subject's current health status as it relates to physical activity/exercise (i.e. Has your doctor said that you have a heart condition and that you should only do physical activity recommended by a doctor?; Do you feel pain in you chest when you do physical activity?; Do you lose your balance because of dizziness or do you ever lose consciousness?).

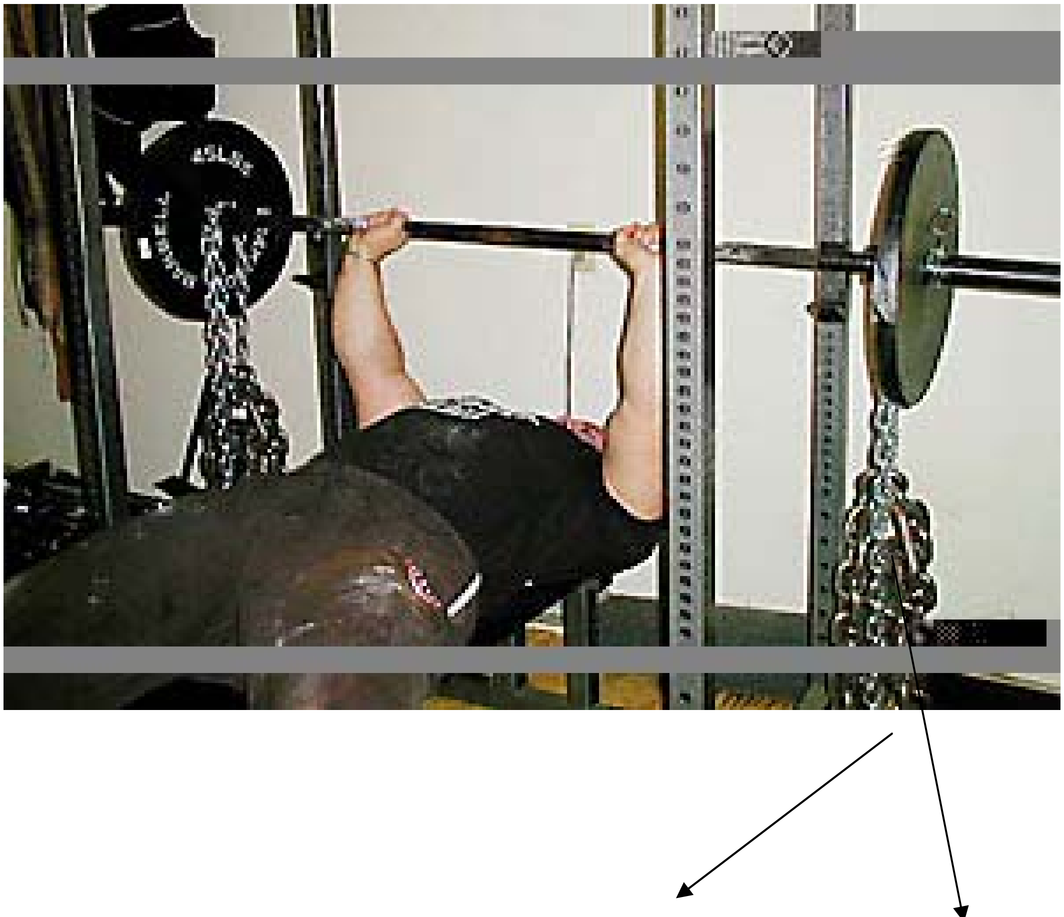
Prior to administration to any research procedures, including comprehensive screening of eligibility informed consent will be signed and obtained by the principal investigator. The interview will examine the subject's current, past, and the assigned workout regimen. Other information obtained from the interview will be to assess if the subject has any orthopedic limitations including surgeries or pre-existing limitations.

Instrumentation

Weighted Chain Exercise

Two chains (Topper Supply, Figure 1) will be attached to each side of a barbell, for a total of four chains on the bar. Two chains will be *training* chains and two will be *support* chains. Each training chain weighs twenty pounds and is five feet long. Each support chain weighs four pounds and is also five feet long. Total weight of all chains used will be approximately 55 lbs. The two support chains are used to attach the training chains to the barbell. The attached chains will be suspended down to the ground during work sets.

Figure 1



Chain bench press exercise

Elastic Bands

Elastic bands (Jump-Stretch, Columbus, OH) are considered to progressively increase overall resistance during the concentric portion of each repetition. Conversely, during the eccentric portion of each repetition resistance progressively decreases (See Figure 2). The elastic bands will be anchored down on the bottom of the bench press apparatus creating maximum tension at the top of the lift while lowest tension at the bottom.

Figure 2

Elastic Band bench press exercise

Elastic Bands attached to end of bench press apparatus

<u>Testing Sessions:</u>

Body Composition

Percent body fat will be determined by using skinfold measurements. This procedure correlates well (r=0.7-0.9) with body composition determined by hydrostatic weighing (ACSM, 2000). The principal investigator will use the 3-site formula taking vertical fold pinches at the chest, abdomen, and thigh. All measurement will be made on the right side of the body. The skin fold caliper will be placed 1 cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and base of the fold. Pinch will be maintained while reading the caliper. Duplicate measures will be taken at each site and will be retested if measurements are not within 1 to 2 mm (ACSM, 2000).

One Repetition (1 RM) Bench Press

The 1RM bench press procedure will follow the standard "touch and go" protocol in which the bar will be required to touch the chest before being pressed to 'full arms' extension (Ware, 1995). Subjects will follow 1RM testing standard procedures recommended by the American College of Sports Medicine (ACSM, 2000). The ACSM protocol below is a set design of sets and repetitions used to properly and safely estimate what a lifter's 1RM may be. This information will be needed in order to execute to training sets from Appendix A.

1. The subject performs a lift warm-up of 5 to 10 repetitions at 40 to 60% of perceived maximum. 1 RM testing will be performed during week 1 and week 10 of the training protocol.
2. Following a 1-minute rest with light stretching the subject does 3 to 5 repetitions at 60 to 80% perceived maximum.
3. The subject should be close to a perceived 1RM in Step 2. A small amount of weight is added, and a 1 RM lift is attempted. If the lift is successful, a rest period of 3 to 5 minutes is provided. The goal is to find the 1 RM within 3 to 5 maximal efforts. The process of adjusting the weight up to a true 1 RM can be improved by prior familiarization sessions that allow approximation of the 1 RM. Clear communication with the subject is needed to facilitate determination of the 1 RM. This process continues until a failed attempt occurs.
4. The 1RM is reported as the weight of the last successful completed lift.

5 RM Speed Bench Press Test

The 5RM speed bench press testing will be performed the day after the 1RM test. The 5RM speed bench press tested upper body power pre and post exercise intervention (Newton 1997).

1. After warm-up the subject will place 50% of the load from their 1RM test and place it on the bar.
2. Subjects will be instructed to lower the barbell as fast as possible, while keeping adequate form, to the chest. After the barbell has touched the chest, subjects will be instructed to accelerate the barbell upwards as fast as possible until arms reached full extension. Subjects will perform 3 sets of 5 repetitions using this technique. The highest value of the three sets will be recorded.
3. The highest velocity and power values between the 3 sets will be recorded.

<u>Fitrodyne</u>

The Fitrodyne will be a TENDO Weightlifting Analyzer Version V-104 from Sports Machines-Ing, Slovak Republic (Jennings 2005, Coelho 2002, 2003). The system consists of two components, a velocity sensor unit and a microcomputer. The velocity sensor unit is connected to the weight by a kevlar cable with strap and Velcro. Using mass (input prior to exercise); the system calculates average velocity, peak velocity, average power, and peak power of each repetition in the concentric phase of the exercise.

The sensor unit is placed where the cable is perpendicular with the floor.

Orientation Session

Prior to week 1 of the proposed study, an orientation session lasting approximately 35 minutes will be conducted by Jamie Ghigiarelli. J. Ghigiarelli is certified through the National Strength and Conditioning Association as a Certified Strength and Conditioning Specialist (CSCS). The CSCS is qualified to assess, design, and implement strength training programs to healthy individuals. J. Ghigiarelli is also certified through the American Red Cross in cardio pulmonary resuscitation (CPR).

For the orientation session subjects will be shown the proper way to perform the bench press exercise using the weighted chains and elastic bands. The written explanation will be as follows: *"The chains are attached so that approximately half the chain is on the ground at the start of the lift. When performing these repetitions, it is important you bring the bar down as fast and controlled as possible without bouncing it off your chest. When pushing the bar up, you must concentrate on moving the bar as fast as possible for maximum bar velocity."*
The bands are attached so the maximum tension is at the top portion of the lift. This is accomplished by anchoring the EB to the bottom of the bench press apparatus (See Figure 2). When performing these repetitions, it is important you bring the bar down as fast and controlled as possible without bouncing it off your chest. When pushing the bar up, you must concentrate on moving the bar as fast as possible for maximum bar velocity."

Training Sessions:

Following the pre testing sessions (Week 1) a seven week training intervention will be conducted that will include primarily free weight resistance exercise. Following the training intervention, post-testing sessions will be conducted during Week 9. All training sessions will be performed in the athletic weight room at Robert Morris University under supervision of the head strength and conditioning coach Tom Myslinski. The weight room is fully equipped with ten bench press stations and ample space to train and test multiple groups concurrently.

The training program will consist of lifting sessions four days a week for seven weeks. Subjects will perform lower body exercises on Mondays and Thursday and upper body on Tuesdays and Fridays. Subjects typically perform ten to twelve exercises on a given session primarily focusing on free weight dynamic exercises. The training sessions incorporate all major muscle groups involved such as dynamic bench press, dumbbell bench press and tricep extensions. Lower body exercises typically consist of dynamic squat, one legged lunges, hip extension/flexion, and leg curls. For a more detailed description of the training intervention see Appendix A.

All subjects will be performing the same workout with exception of the band and chain groups. On the subject's upper body days, the treatment groups will be using the EB and WC during the bench press exercise. The control group (traditional weight training group) will be performing the bench press the same way with exception of attaching the EB and WC to the bar.

In each of the subject's training sessions supervision will be provided during the workouts to ensure subject compliance. The supervisor present will either be the principal investigator or head strength and conditioning coach. Researchers will log in the number of reps and sets each subject completes with the chains as well as ensuring safety and proper technique.

Data Analysis and Statistical Considerations

Statistical Analysis: For this study, a sample size of 36 is projected to provide a power of (.90) for a large effect size (.8). A large effect size was established by observing a 6% increase in maximum bench press. Means and standard deviations will be computed for pre-test and post-test 1RM and 5RM speed bench press. A two way (method x time) factor ANOVA will analyze for statistical significance. A dependent t-test will be used to observe significance between body fat measurements. Statistical significance will be set at the $p<0.05$ level.

Human Subjects

1. Thirty six healthy, non-obese volunteer ranging 18-30 years of age will participate as subjects in this investigation.
2. Subjects will be members recruited from the Robert Morris University football team.
3. The rationale underlying the experimental measures, as well as the risks and benefits will be explained to the subject, whereupon the subject's written consent to participate will be obtained. Questions regarding the investigation will be answered at that time. All experimental procedures and related participation consent forms will comply with the American College of Sports Medicine's Guidelines for Exercise testing and Prescription. ACSM's Guidelines for Exercise Testing Prescription were developed by physicians, and exercise professionals in the field of exercise physiology and procedures for exercise testing and programming (ACSM 2000).
4. No exclusion criteria shall be based on race, ethnicity, or HIV status.

Inclusion Criteria

Subjects will be included in the study if they: (1) are male; (2) are aged 18-30 years; (3) must be members of the Robert Morris University football team and have passed the team physical (4) non-obese (<25% body fat), which will be determined by self-reporting (5) are an advanced weightlifter, which is classified by recently been weightlifting for 1.5 to 2 years; (6) must be able to bench press 1.3 times their body weight for 1 RM ; (7) are willing to consistently participate in the testing and training sessions over the period of nine weeks.

Exclusion Criteria

Exclusion criteria include: (1) responding "Yes" to one or more questions on the PAR-Q & YOU such as, Has your doctor said that you have a heart condition and that you should only do physical activity recommended by a doctor?; Do you feel pain in you chest when you do physical activity?; Do you lose your balance because of dizziness or do you ever lose consciousness?; (2) presence of a serious or unstable medical illness within the past 12 months, e.g. myocardial infarction; (3) any clinical, musculoskeletal, or metabolic contraindications to performing the bench press exercise; (4) are currently being treated for any serious psychological disorder or having received treatment e.g. hospitalization, emergency room visit within the previous 6 months; (5) knowingly taking any performing enhancing substances including: Creatine, Androsteindione (testosterone), Growth Hormone, Ephedrine, stimulants such as Methamphetamine, or any additional anabolic enhancer.

Recruitment Procedures

Subjects will be provided fliers with information and details about the study in a team meeting by the head strength and conditioning coach. Following the meeting those potential subjects, who fit the criteria and express interest in the study will be provided the name and phone number of the primary investigator so future contact can be made. Subjects who contact principal investigator will be asked to arrange a time so they may attend an orientation session. Prior to administration of any research procedures informed consent will be signed and obtained by the principal investigator. Orientation sessions are designed to further screen the subjects in respect to exclusion criteria and training background, and to answer any additional questions for the potential subject. Following signature of informed consent subjects will participate in a 1RM bench press test to distinguish if they qualify for the investigation. Participation in this study would be strictly voluntary and in no way affect the eligibility to participate in the upcoming football season. Each subject will be interviewed by the primary investigator to confirm that they fit the inclusion criteria for the study.

Waiver to document informed consent:

We have requested and obtained a waiver of the requirement to obtain signed informed consent for the screening process, which will take place over the phone. We believe we meet the following criteria: The respective research procedures present no more than minimal risk of harm to the involved subjects and involve no procedures for which written consent is normally required outside of the research context. We believe the information being obtained during the screening phone call is the same type of information that would be collected on patients setting up an appointment for their condition (history of medical problems in response to exercise). Please refer to **Appendix B** for the screening script and screening tool that will be utilized. If the subject does not meet inclusion criteria all the information collected during the screening process will be destroyed without identifiers and the subject will be notified of this. In addition written informed consent will be obtained at the screening visit prior to any research activities. The investigator or co-investigator will obtain written informed consent.

<u>Risk/Benefit Ratio</u>

As with any research study, there may be adverse events or side effects that are currently unknown, and it is possible that certain of these unknown risks could be permanent, serious, or life threatening.

The research protocol presents moderate risk to the involved subjects. All assessments will be conducted within the subject's own physical capabilities. Each subject may experience occasional delayed onset muscle soreness (DOMS). Incidence of DOMS along with moderate muscle strains and sprains is likely to occur when using advanced strength training techniques. DOMS can be treated by certain antioxidants and anti-inflammatory drugs such as pharmaceuticals, herbal remedies, and nutritional supplements (Connolly 2003). You may also experience minimal muscular tears and overall fatigue. Muscle tears occur when a muscle is stretched, which occurs when performing weight lifting exercises. Microfilaments of the muscle become damaged temporarily. However treatments such as the ones mentioned above will remedy this condition.

Although the weighted chain system does provide the lifter to use heavier weights in the maximally shorten position (standing straight up). The load being used as stated in Appendix A is 40-60% of the lifter's 1 RM. This load places the lifter at minimal risk during exercise. In addition, the occurrence of dropping the weights onto the subjects is very unlikely because of the certified personnel present (Hamill 1994) at the site of the training session and the sufficient weight lifting experience of the subjects recruited.

In order to minimize risks, a medical questionnaire, consent to participate form, and physical activity readiness questionnaire (PAR-Q & YOU) will be distributed at the orientation session to identify possible risks factors for injury. Subjects will be taught how to stretch and cool down after workouts.

The benefit of this study is that it will provide the subject with knowledge regarding their maximal strength capabilities, performed in a safe and controlled setting. The subject will also receive information regarding their 1RM and it's corresponding normative value as well as training technique education.

The potential likelihood of the following risks pertaining to this study:

<u>Weighted Chains Procedure</u>
Likely- expected to occur in more than 25% of people (more than 25 out of 100 people)
Muscle soreness- (Delayed Onset Muscle Soreness)

Common- expected to occur in 10-25% of people (10-25 out of 100 people)
Muscle strains or mild tendonitis

Infrequent- expected to occur 1-10% of people (1-10 out of 100 people)

Rare- expected to occur in less than 1% of people (less than 1 out of 100 people)
Major injury, such as weights dropping onto the subjects

Elastic Bands Procedure
Likely- expected to occur in more than 25% of people (more than 25 out of 100 people)
Muscle soreness- (Delayed Onset Muscle Soreness)

Common- expected to occur in 10-25% of people (10-25 out of 100 people)
Muscle strains or mild tendonitis

Infrequent- expected to occur 1-10% of people (1-10 out of 100 people)

Rare- expected to occur in less than 1% of people (less than 1 out of 100 people)
Major injury, such as weights dropping onto the subjects or elastic bands snapping or breaking.

Cost and Payments

There will be no charge to the subject or the insurance company for participation in this investigation.

Confidentiality

All records related to involvement in this research study will be stored in a locked file cabinet located in the Trees Hall Human Energy laboratory. The identity of the subject will be indicated by a case number rather than by name, and information linking these numbers with the subject's identity will be kept separate from the research records. All research records will be destroyed when such is approved as per university policy at 5 years following study completion.

Any information about the subject obtained from this research will be kept as confidential (private) as possible. The subject will not be identified by name in any publication of research results unless a signed release form is provided. In unusual cases, the research records may be inspected by appropriate government agencies or be released in response to an order from a court of law. It is also possible that authorized representatives of the University Research Conduct and Compliance Office may inspect the research records. If the researchers learn that the subject of someone, with whom the subject is involved, is in serious danger or harm, they will need to inform the appropriate agencies as required by Pennsylvania law.

Data Safety and Monitoring Plan

A data and safety plan will be implemented by the Principal Investigator (PI) to ensure that there are no changes in the risk/benefit ratio during the course of the study and that confidentiality of research data is maintained. Investigators and study personnel will meet weekly to discuss the study (i.e. study goals, and modifications of those goals; progress in data coding and analysis; documentation, identification of adverse events or research subject complaints; violations of confidentiality) and address any issues or concerns at that time. The PI investigator will be responsible for the monitoring, at least daily, of subject adherence during the entire study period. The PI will review confidentiality issues and complete a confidentiality agreement, prior to having contact with research subjects. The PI will provide a summary of cumulative adverse event data and external factors that may have an impact on safety of study participants or the ethics of the research study. The PI will immediately report any instances of adverse events to the University of Pittsburgh IRB.

Qualifications of Investigators

Jamie J. Ghigiarelli is a graduate assistant in the Health Physical Recreation and Education Department (HPRED) and doctoral student in exercise physiology. Mr. Ghigiarelli has had multiple experiences training athletes and designing strength training programs to increase muscular performance. Mr. Ghigiarelli is certified by the National Strength and Conditioning Association as a Certified Strength and Conditioning Specialist (CSCS).

Elizabeth Nagle, PhD, is Assistant Professor and Assistant Director for the Center for Health and Fitness research within the department of Health and Physical Activity, and formally served as Clinical Instructor/Director of Aquatics prior to Fall 1999. Dr. Nagle's focus of research has included prediction of human performance, overtraining, and assessment of body composition of athletes in both laboratory and aquatic settings. Dr. Nagle is certified as an American College of Sports Medicine Health and Fitness Instructor, and Advance Cardiac Life Support (ACLS) rescuer.

Robert J. Robertson, Ph.D. is Professor and Co-Director of the Center for Exercise and Health-Fitness Research within the Department of Health and Physical Activity at the University of Pittsburgh. Dr. Robertson's primary focus of research is in the areas of cardiovascular, metabolic, hemodynamic, and perceived responses to exercise stress. Dr. Robertson is certified by the American College of Sports Medicine as an Exercise Program Director.

Fredrick L. Goss, Ph.D. is Associate Professor and Academic Program Coordinator of the Center for Exercise and Health-Fitness Research within the Department of Health and Physical Activity at the University of Pittsburgh. Dr. Goss's primary focus of research is in the areas of cardiovascular, metabolic, sport performance, and sport nutrition in exercise. Dr. Goss is a Certified Program Director for Preventive and Rehabilitation Exercise Programs, American College of Sports Medicine

APPENDIX E

INSTITUTIONAL REVIEW BOARD INFORMED CONSENT

University of Pittsburgh

Institutional Review Board
Approval Date: 8/16/2005
Renewal Date: 8/16/2006
IRB Number: 0408120

CONSENT TO ACT AS A SUBJECT IN A RESEARCH STUDY

TITLE The Effect of Heavy Elastic Bands and Weighted Chains on Upper Body Strength and Power in a Sample of Division IAA College Football Players.

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Why is this research being done?
The University of Pittsburgh is conducting a research study to observe the effects of a seven week resistance training program using heavy elastic bands and weighted chains. The purpose of the study is to investigate whether a unique way of weightlifting will result in increased muscular performance.

Who is being asked to take part in the research study?
Thirty six male subjects 18-30 years old will be recruited from the Robert Morris University football team. You will be introduced to the details of the study from fliers handed out in a team meeting from the head strength and conditioning coach. You will be eligible if you meet the eligibility requirements stated on the flier. You will be eligible in the study if you: (1) are male; (2) are aged 18-30 years; (3) must be members of the Robert Morris University football team and have passed the team physical (4) non-obese (<25% body fat), which will be determined by self-reporting (5) are an advanced weightlifter, which is classified by recently been weightlifting for 1.5 to 2 years; (6) are be able to bench press 1.3 times your body weight for 1 repetition maximum (RM); (7) are willing to consistently participate in the training sessions over the period of seven weeks.

You will be asked to respond "yes" or "no" to one or more questions on the Physical Activity Readiness Questionnaire (PAR-Q and YOU) and questions regarding performance enhancing substances. Examples of such questions are; do you have presence of a serious or unstable medical illness within the past 12 months, e.g. myocardial infarction? Myocardial infarction is a serious medical condition commonly referred to as a heart attack, which occurs when there is an obstruction of blood flow to the heart. Do you have any clinical, musculoskeletal, and metabolic contraindications to exercise? A contraindication to exercise is any exercise or movement of an exercise that is deemed inadvisable. Are you currently being treated for any serious psychological disorder or having received treatment e.g. hospitalization, emergency room visit within the previous 6 months? Are you taking any performing enhancing substances, including creatine?

Following learning the details of the study, if you are still interested in participating you will be given the contact information for the principal investigator. After calling the principal investigator, an orientation session will be scheduled for you to attend. Orientation sessions are designed to confirm your eligibility, inform you with further details of the study, answer any additional questions you might have, and obtain your informed consent.

Following this portion, you will then be introduced to the elastic band and chain bench press exercises. Following informed consent you will perform a 1RM bench press test in which to distinguish if you qualify as one of the thirty six selected males to be divided into three groups. You will be ranked by the ratio of 1RM bench press to body weight.

In should be well noted that participation in this study would be strictly voluntary and in no way affect the eligibility to participate in the upcoming football season or academic status. Each subject will be interviewed by the primary investigator to confirm that they fit the inclusion criteria for the study. Identifiable private information will not be collected from respondents prior to informed consent

What procedures will be performed for research purposes?

Screening Procedures

You will be screened individually by Jamie Ghigiarelli who is certified and experienced in training programs for strength and conditioning. You are to be classified as healthy, non-obese and will have pre-participation clearance in the form of the PAR-Q and YOU. The PAR-Q & YOU will assess your readiness for physical activity and identify if physical activity may be inappropriate, and includes seven questions inquiring about your current health status as it relates to physical activity/exercise (i.e. Has your doctor said that you have a heart condition and that you should only do physical activity recommended by a doctor?; Do you feel pain in you chest when you do physical activity?; Do you lose your balance because of dizziness or do you ever lose consciousness?). "If you answer "yes" to any of the seven questions, you will be excluded from the present investigation." The interview will examine your current, past, and the assigned workout regime. Information obtained from the interview will be to assess if you have any other orthopedic limitations, such as shoulder impingement, when performing the bench press exercise. Shoulder impingement causes a lack of movement in the shoulder joint and could impair one's ability to perform the bench press exercise.

All assessments, training sessions, and orientation sessions will be held at Robert Morris University Athletic Weight Room. Prior to week 1 of the proposed study, an orientation session lasting approximately 35 minutes will be conducted by Jamie Ghigiarelli. He will demonstrate how to use the elastic bands or weighted chains (i.e. how to attach them to the barbell, and proper form of doing the bench press exercise). Subjects will be randomized into one of three groups: elastic band (EB), weighted chain (WC) or control. The control group will not have to participate in the orientation sessions.

The total duration of this study is nine weeks. Subjects will follow the training protocol for the middle seven weeks with weeks 1 and 9 scheduled for pre testing and post testing sessions.

For the orientation session you will be shown the proper way to perform the bench press exercise using the bands and chains. The written explanation will be as follows: *The chains are attached so that approximately half the links are on the ground at the start of the lift. " When performing these repetitions, it is important you bring the bar down as fast and controlled as possible without bouncing it off your chest.*

When pushing the bar up, you must concentrate on moving the bar as fast as possible for maximum bar velocity." The bands are attached so the maximum tension is at the top portion of the lift. This is accomplished by anchoring the EB to the bottom of the bench press apparatus (See Figure 2). When performing these repetitions, it is important you bring the bar down as fast and controlled as possible without bouncing it off your chest. When pushing the bar up, you must concentrate on moving the bar as fast as possible for maximum bar velocity."

Testing Sessions:
One Repetition (1RM) Bench Press

There will be two testing sessions. One session is at week 1 and the second session is at week 9 of the training protocol. Each testing session will take approximately 45-50 minutes. The 1RM bench press procedure will follow the standard "touch and go" protocol in which the bar will be required to touch the chest before being pressed to full arms' extension (Ware, 1995). You will perform the testing sessions during Week 1 and Week 9 of the study and will follow 1RM testing procedures using American College of Sport Medicine procedures (ACSM, 2000). The ACSM protocol below is a set design of sets and repetitions used to properly and safely estimate what a lifter's 1RM may be. This information will be needed in order to execute the training sets from Appendix A.

1. The subject performs a lift warm-up of 5 to 10 repetitions at 40 to 60% of perceived maximum. 1 RM testing will be performed during week 1 and week 10 of the training protocol.
2. Following a 1-minute rest with light stretching the subject does 3 to 5 repetitions at 60 to 80% perceived maximum.
3. The subject should be close to a perceived 1 RM in Step 2. A small amount of weight is added, and a 1 RM lift is attempted. If the lift is successful, a rest period of 3 to 5 minutes is provided. The goal is to find the 1 RM within 3 to 5 maximal efforts. The process of increasing the weight up to a true 1 RM can be improved by prior familiarization sessions that allow approximation of the 1 RM.

Clear communication with the subject is needed to facilitate determination of the 1 RM. This process continues until a failed attempt occurs.
4. The 1-RM is reported as the weight of the last successful completed lift.

5 RM Speed Bench Press Test

The 5RM speed bench press testing will be performed the day after the 1RM test. The 5RM speed bench press tested upper body power pre and post exercise intervention (Newton 1997).
1. After warm-up the subject will place 50% of the load from their 1RM test and place it on the bar.
2. Subjects will be instructed to lower the barbell as fast as possible, while keeping adequate form, to the chest. After the barbell has touched the chest, subjects will be instructed to accelerate the barbell upwards as fast as possible until arms reached full extension. Subjects will perform 3 sets of 5 repetitions using this technique. The highest value of the three sets will be recorded.
3. The highest velocity and power values between the 3 sets will be recorded.

Body Composition

Body composition measures will be taken on a separate day during the screening procedure of Week 1 prior to 1 RM testing sessions. Percent body fat will be determined by using skinfold measurements. This procedure correlates well (r=0.7-0.9) with body composition determined by underwater weighing (ACSM, 2000). The primary investigator will use the 3-site formula taking vertical fold pinches at the chest, abdomen, and thigh. All measurements will be made on the right side of the body. The skin fold pincher will be placed 1 cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and base of the fold. The principal investigator will pinch the skin of the subject and place the caliper on the fold. A reading will be taken to measure the body fat on the specific site pinched. Pinch will be maintained while reading the caliper. Duplicate measures will be taken at each site and will be retested if measurements are not within 1 to 2 mm (ACSM, 2000).

Training Sessions

Following the pre testing sessions (Week 1) a seven week training intervention will be conducted that will include primarily free weight resistance exercise. Following the training intervention, post-testing sessions will be conducted during Week 9. All training sessions will be performed in the athletic weight room at Robert Morris University under supervision of the head strength and conditioning coach Tom Myslinski. The weight room is fully equipped with ten bench press stations and ample space to train and test multiple groups concurrently.

All subjects will be performing the same workout with exception of the band and chain groups. On the subject's upper body days, the treatment groups will be using the elastic bands (EB) and weighted chains (WC) during the bench press exercise. The control group (traditional weight training group) will be performing the bench press the same way with exception of attaching the EB and WC to the bar.

The training intervention will consist of lifting sessions four days a week for seven weeks. You will perform lower body exercises on Mondays and Thursday and upper body on Tuesdays and Fridays. You will typically perform ten to twelve exercises on a given session primarily focusing on free weight dynamic exercises. The training program incorporates all major muscle groups involved such as dynamic bench press, dumbbell bench press and tricep extensions. Lower body exercises typically consist of dynamic squat, one legged lunges, hip extension/flexion, and leg curls. For a more detailed description of the training intervention see Appendix A.

In each of the subject's training sessions supervision will be provided during the workouts to ensure subject compliance. The supervisor present will either be the principal investigator (Jamie Ghigiarelli) or head strength and conditioning coach. Researchers will log in the number of reps and sets each subject completes with the chains as well as ensuring safety and proper technique.

J. Ghigiarelli is certified through the National Strength and Conditioning Association as a Certified Strength and Conditioning Specialist (CSCS). The CSCS is qualified to assess, design, and implement strength training programs to healthy individuals. J. Ghigiarelli is also certified through the American Red Cross in cardio pulmonary resuscitation (CPR).

What are the possible risks, side effects, and discomforts of this research study?
As with any research study, there may be adverse events or side effects that are currently unknown, and it is possible that certain of these unknown risks could be permanent, serious, or life threatening.

The research protocol presents moderate risk to the involved subjects. All assessments will be conducted within your own physical capabilities. The risk of dropping the weights onto the subjects is very minimal because of the certified personnel present at the site of the training session. You may however experience occasional delayed onset muscle soreness (DOMS). Incidence of DOMS is likely to occur when using advanced strength training techniques. DOMS can be treated by certain antioxidants and anti-inflammatory drugs such as pharmaceuticals, herbal remedies, and nutritional supplements (Connolly 2003). You may also experience minimal muscular tears and overall fatigue. Muscle tears occur when a muscle is stretched, which occurs during a weight lifting exercise, and microfilaments of the muscle become damaged temporarily. However treatments such as the ones mentioned above will remedy this condition.

In order to minimize risks, a medical questionnaire, consent to participate form, and Physical Activity Readiness Questionnaire (PAR-Q and YOU) will be distributed to you at the orientation session to identify possible risks factors for injury. You will also be taught how to stretch and cool down after workouts.

Prior to the first training session you will be familiarized with the chains through an orientation session. You will be shown how to attach the chains on to the barbell as well as how to use them in a safe and proper manner for the bench press exercise.

The potential likelihood of the following risks pertaining to this study:
Likely- expected to occur in more than 25% of people (more than 25 out of 100 people)
Muscle soreness- (Delayed Onset Muscle Soreness)
Common- expected to occur in 10-25% of people (10-25 out of 100 people)

Muscle strains or mild tendonitis

Rare- expected to occur in less than 1% of people (less than 1 out of 100 people)
Major injury, such as weights dropping onto the subjects.

<u>Elastic Bands Procedure</u>
Likely- expected to occur in more than 25% of people (more than 25 out of 100 people)
Muscle soreness- (Delayed Onset Muscle Soreness)

Common- expected to occur in 10-25% of people (10-25 out of 100 people)
Muscle strains or mild tendonitis

Infrequent- expected to occur 1-10% of people (1-10 out of 100 people)

Rare- expected to occur in less than 1% of people (less than 1 out of 100 people)
Major injury, such as weights dropping onto the subjects or elastic bands snapping or breaking.

What are the possible benefits from taking part in this study?
There is no guarantee you will receive direct benefit from participation in this research. The benefit of this study is that it will provide you with the knowledge regarding your maximal strength capabilities, performed in a safe and controlled setting. You will also receive information regarding your 1RM and its corresponding normative value as well as training technique education. The corresponding normative value refers to the average performance in the 1RM bench press test for typical Division 1AA football players.

If I agree to take part in this research study, will I be told of any new risks that may be found during the course of the study?
You will be promptly notified if, during the conduct of this research study, any new information develops which may cause you to change your mind about continuing to participate.

Will my insurance provider or I be charged for the costs of any procedures performed as part of this research study?
Neither you nor your insurance provider will be charged for the costs of any of the procedures performed for the purpose of this research study (i.e., Screening Procedures, Experimental Procedures described above).

Will I be paid if I take part in this study?
There will be no charge to you, nor will you be paid to participate in this investigation.

Who will pay if I am injured as a result of taking part in this study?

University of Pittsburgh investigators and their associates who provide services at the University of Pittsburgh Medical Center (UPMC) recognize the importance of your voluntary participation to their research studies. These individuals and their staff will make reasonable effects to minimize, control and treat any injuries that may arise as a result of this research. If you believe that you are injured as the result of the research procedures being performed, please contact immediately the Principal Investigator listed on the cover sheet of this form. Emergency medical treatment for injuries solely and directly relating to your participation in this research will be provided to you by hospitals of the UPMC. It is possible that the UPMC may bill your insurance provider for the costs of this emergency treatment, but none of these costs will be charged directly to you. If your research related injury requires medical care beyond this emergency treatment, you will be responsible for the costs of this follow-up care unless otherwise specifically stated below. "There is no plan for monetary compensation. You do not, however, waive any legal rights by signing this form."

Who will know about my participation in this research study?

Any information about you obtained from this research will be kept as confidential (private) as possible. All records pertaining to your involvement in this research study will be stored in a locked file cabinet at the Center for Exercise & Health Fitness Research in Trees Hall. The identity of the subject will be indicated by a case number rather than by name, and information linking these numbers with the subject's identity will be kept separate from the research records. All research records will be destroyed when such is approved as per university policy at 5 years following study completion. You will not be identified by name in any publication of research results unless you sign a separate form giving your permission (release).

Will this research study involve the use of disclosure of any identifiable medical information?

This research study will not involve the use or disclosure of your identifiable medical information.

Who will have access to identifiable information related to my participation in this research study?

In addition to the investigators listed on this first page of this authorization (consent) form and their research staff, the following individuals will or may have access to identifiable information related to your participation in this research study:

The University of Pittsburgh Research Conduct and Compliance Office may review your identifiable research information for the purpose of monitoring the appropriate conduct of this research study.

However, in unusual circumstances, you understand that your identifiable information related to your participation in this research study may be inspected by appropriate government agencies or may be released in response to an order from a court of law. If investigators learn that you or someone with whom you are involved is in serious danger or potential harm, they will need to inform, as required by Pennsylvania law, the appropriate agencies.

For how long will the investigators be permitted to use and disclose identifiable information related to my participation in this research?

The investigators may continue to use and disclose, for the purposes described above, identifiable information related to your participation in this research study for a period of 5 years as required by University policy.

Is my participation in this research voluntary?

Your participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above, is completely voluntary. (Note, however that if you do not provide your consent for the use and disclosure of your identifiable information for the purposes described above, you will not be allowed, in general, to participate in the research study). Whether or not you provide your consent for participation in this research study will have no effect on your current of future relationship with the University of Pittsburgh. Whether or not you provide your consent for participation in this research study will have no effect on your current or future medical care at a UPMC or affiliated health care provider or your current or future relationship with a health care insurance provider.

Participation in this study would be strictly voluntary and in no way will any athlete be coerced to participate. It has been documented by the head strength coach and athletic director (see attachments) that refusal to this study will not affect the eligibility to participate in the upcoming football season or academic status. Each subject will be interviewed by the primary investigator to confirm that they fit the inclusion criteria for the study. Identifiable private information will not be collected from respondents prior to informed consent

May I withdraw, at a future date, my consent for participation in this research study?
You may withdraw, at any time, your consent for participation in this research study, to include the use and disclosure of your identifiable information for the purposes described above. (Note, however, that if you withdraw your consent for the use and disclosure of your identifiable information for the purposes described above, you will also be withdrawn in general, from further participation in this research study). Any identifiable research information recorded for, or resulting from your participation in this research study prior to the date that you formally withdrew your consent may continue to be used and disclosed by the investigators for the purposes described above.

To formally withdraw your consent for participation in this research study you should provide a written and dated notice of this decision to the principal investigator of this research study at the address listed on the first page of this form. Your decision to withdraw your consent for participation for this research study will have no effect on your current of future relationship with Robert Morris University. Your decision to withdraw your consent will have no effect on your current or future medical care at a UPMC or affiliated health care provider or your current or future relationship with a health care insurance provider.

If I agree to take part in this research study, can I be removed from the study without my consent?
It is possible that you may be removed from the research study by the researchers if, for example, you do not follow instructions provided by the investigators that were specifically established for research and your personal safety.

 Participant's Initials:___

VOLUNTARY CONSENT

All of the above had been explained to me and all of my questions have been answered. I understand that any future questions I have about this research study during the course of this study, and that such future questions will be answered by the investigators listed on the first page of this consent document at the telephone numbers given. Any questions I have about my rights as a research subject will be answered by the Human Subject Protection Advocate of the IRB Office, University of Pittsburgh (1-866-212-2668). By signing this form, I agree to participate in this research study.

____

Participant's Name (Print)

______________________ ______________

Participant's Signature Date

CERTIFICATION OF INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual, and I have discussed the potential benefits, and possible risks associated with participation. Any questions the individual has about this study have been answered, and we will always be available to address future questions as they arise.

_______________________ _____________________

Printed Name of Person Obtaining Consent Role in Research Study

_______________________ _________________

APPENDIX F

INSTITUTIONAL REVIEW BOARD RECRUITMENT FLYER

Robert Morris University Football Players

Research Subjects Needed

Study: Increasing 1 repetition maximum (RM) bench press and 5RM speed bench press using weighted chains and elastic bands during a 9-week resistance training program.

Recruitment and Location: The primary investigator will be recruiting football players from Robert Morris University. Training session will take place in the Robert Morris University Athletic Weight Room

Length: Approximately 9 weeks. The first and last week will be testing sessions (testing max bench press and speed bench press). The middle 7 weeks will be the training sessions.

"You must be:"

1. Male (18-30 yrs)
2. Not to have any major back problems and conditions pertaining to weightlifting exercises especially in the bench press exercise
3. Must be an advanced weightlifter (currently be lifting weights around 3-5 days per week for the past 1.5 to 2 years)
4. Preferably able to max bench press at least 1.3 times their body weight
5. Be willing to follow and participate in the training sessions over the 7 week period

If interested contact Jamie Ghigiarelli (jjg24@pitt.edu)
412-478-0437

APPENDIX G

INSTITUTIONAL REVIEW BOARD SCREENING SCRIPT

University of Pittsburgh *Bench Press Study*

Telephone screening script

Thank you for calling more about our research study. My name is Jamie Ghigiarelli and I am a researcher at the University of Pittsburgh in the Health and Physical Activity Department. The purpose of this study is to explore the effects of the heavy elastic bands and weighted chains on upper body strength and power in a sample of Division 1-AA football players.

Do you think you might be interested in participating in this study?

As part of our study we are asking subjects to answer a series of questions regarding their training background to be able to determine if they are eligible. You need to understand that the information I obtain from you including your name and identifying information will be strictly confidential and will be kept under lock and key. All information is needed to further assess whether or not you are eligible to participate. All information will be destroyed if you are not eligible to participate. If you are determined ineligible at any time during this screening process based on your answers, questioning will be stopped.

Do I have permission to ask these questions? (*if subjects answers yes continue with questioning*)

1. How would you categorize your general physical condition? ( ) Excellent ( ) Very Good ( ) Adequate ( ) Poor

Answering <u>NO</u> to questions 2 or 3 will determine the subject ineligible

	YES	NO
2. Are you a Robert Morris Football Player?	____	____
3. Have you passed a team physical?	____	____

Answering <u>YES</u> to questions 4, 5, 6, 7, or 8 will determine the subject ineligible

	YES	NO
4. Advice from a physician not to exercise?	____	____

5. Recent surgery? (Last 12 months) ____ ____
6. Muscle, joint, back disorder, or any previous injury still affecting you? ____ ____
7. Do you have any condition limiting your movement? ____ ____
8. Do you take any ergogenic aids or supplements specifically to improve athletic performance? ____ ____

9. Do you follow any specific diet? ____ ____

Please briefly explain if answered YES to question 9.

TRAINING BACKGROUND:

How often have you been currently weight training for the past 2 years?

How often are you currently weight training?

Have you ever used the modalities of weighted chains and elastic bands before?

Have you had any history of back problems or any major injuries that may affect your weight lifting performance, especially in the bench press exercise?

	YES	NO
Subject meets eligibility requirements	____	____

Based on this telephone screening, you (Are / Are NOT) eligible to participate in this study. If you are still interested, I would like to schedule a time for you to attend an orientation session to receive additional details about the study and obtain your permission to participate.

Scheduled Date and Time of Orientation Meeting

____

Subject Name: ____________
Phone number: ____________

APPENDIX H

ANOVA TABLES FOR 1RM PEAK POWER TEST

Descriptive Statistics

	GROUP	Mean	Std. Deviation	N
PRE RELATIVE PEAK POWER 2ND FILTER 1	CHAIN	4.1300	.68150	11
	BAND	4.2417	.65751	12
	CONTROL	4.0583	.48574	12
	Total	4.1437	.59902	35
POST RELATIVE PEAK POWER 2ND FILTER 2	CHAIN	4.2682	.60684	11
	BAND	4.4350	.74219	12
	CONTROL	4.0258	.62347	12
	Total	4.2423	.66494	35

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
factor1	Sphericity Assumed	.174	1	.174	2.071	.160
	Greenhouse-Geisser	.174	1.000	.174	2.071	.160
	Huynh-Feldt	.174	1.000	.174	2.071	.160
	Lower-bound	.174	1.000	.174	2.071	.160
factor1 * GROUP	Sphericity Assumed	.166	2	.083	.988	.383
	Greenhouse-Geisser	.166	2.000	.083	.988	.383
	Huynh-Feldt	.166	2.000	.083	.988	.383
	Lower-bound	.166	2.000	.083	.988	.383
Error(factor1)	Sphericity Assumed	2.682	32	.084		
	Greenhouse-Geisser	2.682	32.000	.084		
	Huynh-Feldt	2.682	32.000	.084		
	Lower-bound	2.682	32.000	.084		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1228.718	1	1228.718	1685.256	.000
GROUP	1.054	2	.527	.723	.493
Error	23.331	32	.729		

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