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Comparing the acute effects of elastic resistance bands on kinetics and kinematics during the bench press exercise

Blake Baxter
Eastern Washington University

Comparing the Acute Effects of Elastic Resistance Bands on Kinetics and Kinematics During the Bench Press Exercise

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Blake Baxter

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DR. GARTH BABCOCK, GRADUATE STUDY COMMITTEE DATE

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Abstract

Comparing the Acute Effects of Elastic Resistance Bands on Kinetics and Kinematics During the Bench Press Exercise

Elastic resistance training is becoming very popular in the strength and conditioning realm and is used at the collegiate and professional levels for various sports. Elastic resistance training has been shown to increase the force, velocity, and power compared to traditional free weight movements. The purpose of this study was to determine if a specific loading condition could increase both kinetic and kinematic variables within a bench press. To test this, two loading conditions (15% and 25% of 1RM) were used and each resistance load was added to a base of 60% of 1RM free weights.

Twelve recreationally trained male athletes participated. They were familiarized with the elastic resistance bands before measurements were taken. Each participant performed one set (three repetitions) at each specific intensity level. A GymAware analyzer measured the variables of force, velocity, and power during each full lift.

A 2x3 repeated measures ANOVA was used to determine if there was a significant difference in force, velocity, and/or power between groups ($p \leq .05$). Both mean velocity and mean force were significantly different between elastic resistance loads. Results indicated that neither elastic resistance intensity was more effective at increasing power output production than the other. The force and velocity relationship between the elastic resistance loads mimicked the expected free weight load outcome, lighter equals greater velocity and heavier greater force.

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Tables and Figures

Table 1.

Combined Repetition Averages for Peak and Mean Force, Power, and Velocity, for the Heavy and Light Lifting Intensities.

Resistance	Mean Force (newtons)	Mean Power (watts)	Mean Velocity (m/s)	Peak Force (newtons)	Peak power (watts)	Peak velocity (m/s)
85%1RM	985.94 ±62.90*	482.93 ± 38.78	.49 ±.02	1877.51 ±141.44	782.47 ± 233.58	.69 ± .11
75%1RM	878.27 ±55.30	500.22 ±40.56	.582 ±.02 *	1774.77 ±125.24	737.80 ±52.86	.74 ±.12

Note. * Denotes a significant difference (P=<.05)

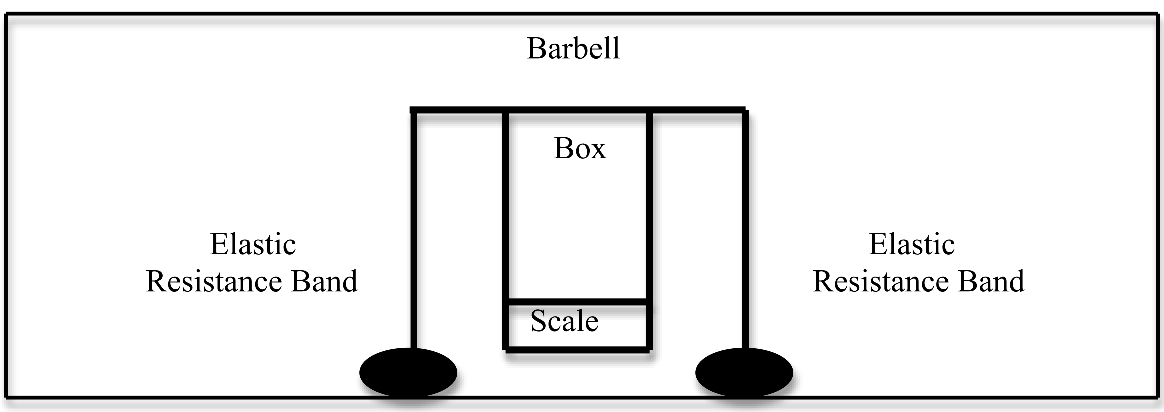

Figure 1. Elastic resistance band model used to evaluate and determine elastic training loads of 15% and 25% 1RM.

Chapter 1

Introduction

History of Strength Training

Sports performance enhancement and strength and conditioning are an essential part of athletic development. Early strongmen and weightlifters were used as a source of entertainment; their brute strength often impressed and drew large audiences at the circus and other public gatherings (Morgan, 2003). Strongmen trained and lifted by using the principal of overload. Increasing the amount of weight subsequently augmented the amount of force, which could be produced (Siff, 2003). They trained on their own, with no strength and conditioning coaches, and through trial and error increased strength. This overload principle-was discovered early on by European researchers and was a cornerstone of training during the 1800's with the focus of the application for athletes who lifted weight for-their sport (Siff, 2003).

In the 20th century the purpose of weightlifting shifted to sports performance rather than just lifting weights, but early within the century training was still mostly trial and error. This changed once the technology caught up with the ways to measure and evaluate the physiological changes that allowed for increased strength (Kraemer & Hakkinen, 2002). The macro and microscopic changes within the structural and contractile components could be measured and evaluated (Kraemer et al., 2002). Research continued and shifted to how different training principles influenced the adaptive process regarding strength and hypertrophy. Different resistance implements were designed to assist in physical development and strength adaptation. Such implements included Indian clubs, kettlebells, dumbbells, and loadable barbells (Morgan, 2003). As implementations and training innovations improved, European scientists and scholars started to look at how the training principles of progression, overload, specificity, training status, and recovery influenced the adaptations of the athlete in terms of strength and hypertrophy (Siff, 2003).

As research continued, the methods were finally applied to athletes to further develop sport capabilities. The first sport to incorporate strength and conditioning was men's track and field in the 1950's and 1960's. Soon after football began to incorporate strength training into its yearly cycle (Silvester, 1992). During this period, the focus was still on building strength, not looking at weight training as a direct way to increase athletic performance, but a means to add mass and increase physical strength (Kraemer et al., 2002). Finally in the 1970's research began tying strength development to sport specific goals. Athletes no longer had to rely on popular-press magazines that showed pictures of muscle transformations. In 1978 the National Strength and Conditioning Association (NSCA) was founded and began publishing *The Journal of Strength and Conditioning* in 1987 (Kraemer et al., 2002). This was the first and only peer-reviewed publication to exclusively look at how strength training concepts and principals influence athletic enhancement/performance (Kraemer et al., 2002).

This research focus has also become refined. Because just strength or hypertrophy does not directly lead to improved performance the research focused on specific modes of training which influence power, acceleration, and velocity, along with the biomechanical components of force production related to specific sports or activities, became the research focus. Some of the training modes and methods include plyometrics (Clark, Bryant, & Pua, 2010), multijoint movements (Farup et al, 2012), and sport specific techniques (Wallace, Winchester, McGuigan, 2006). Research has shown that strength is one component of performance training that needs to be combined or supplemented with other methods to get optimal results for sport enhancement (Harris et al., 2000). The goal of training is dependent on the sport and the mechanical, physiological, and metabolic aspects it entails.

The type of athletic event, in terms of force and velocity profiles, dictates the type of training used for enhancement. Power and the rate of force development are the greatest predictors of sports performance, which are determined by force and velocity outputs. Heavy resistance strength training and power have different acceleration and force profiles, which influence the training characteristics and adaptations. Heavy resistance training must be supplemented or combined with other methods in order to fulfill all aspects of the force velocity spectrum.

Heavy strength training does not directly influence power and acceleration because of the movement mechanics of the lift. In accordance with the force velocity relationship, heavy resistance training is performed under slow speeds (Fry et al., 2003). When heavy resistance training (85-100% of 1RM) is done the sticking point of the movement, the point of least mechanical advantage, limits force, power, and acceleration at that specific joint angle (Anderson, Sforzo, & Sigg, 2008; Fry et al., 2003; Israetel, Mcbride, Nuzo, Skinner, & Dayne, 2010). The sticking point therefore determines the subsequent load which limits speed and power production due to the length tension and force velocity relationship (Clark, Adam, Bryant, & Humphries, 2008; Tillar & Ettema, 2009). This specific form of training can be effective for building strength, but is incompatible for developing power, which requires speed of movement through the whole ROM.

Power training is designed to influence the rate component of movement, in terms of acceleration and velocity, which influences the absolute speed and subsequent rate of force development (RFD) (Cronin, McNair, & Marshall 2000). Power training has distinctly different force and movement profiles compared to strength training in terms of the force velocity relationship. Power training is performed with faster velocities and lower intensities (30-60% 1RM), which limits the transferability to strength or force development, due to the decreased loads and decreased times under tension (Newton et al., 1997). Due to the characteristics of athletic movements, increasing the RFD compared to overall force development is a better predictor of performance (Newton & Kraemer, 1994). This is due to the limited movement times, which limit the total amount of force that can be applied during dynamic movements. Due to this relationship power training and the adaptations are necessary to reach performance potential.

Certain sports require dynamic movements and a limiting factor for ideal performance is the rate at which force can be applied. In order to apply maximal concentric force 700ms are required in order to recruit the maximal amount of muscle tissue. During dynamic movements, force application times are limited between 50-250ms due to the faster contraction rates associated with running and upper body movements in athletic movements (Baechle & Earle, 2008). The rate at which force can be applied becomes the limiting factor during athletic movements, rather than the absolute amount of force produced. Specific upper body movements that are performed explosively occur in-combat sports, basketball, track and field throwing events, and certain components of football. A key component to all of the movement is maximal elbow extension and shoulder adduction during the concentric range of motion being applied in a similar manner during the bench press (Delavier, 2010). Therefore to increase the specificity and contractile characteristic of the athletic movement, the bench press would be a suitable exercise for performance enhancement when performed under optimal conditions, which promote maximal force production through elbow extension.

When developing sport specific exercise techniques, including movements with maximal dynamic elbow extension, traditional barbell and medicine ball exercises are not appropriate. The biomechanics and movement characteristics of power training do not have sticking points like heavy strength training, but do have deceleration epochs near the lockout (maximal elbow extension) which inhibit excessive force development (Cronin et al., 2000; Madsen & McLaughlin, 1984; Newton et al., 1997; Tillar, Saieterbakken & Ettema, 2012). During the end of the lift a decrease in force and acceleration occur by decreasing neural recruitment in order to protect the shoulder and elbow from a forceful lockout (Tillar et al., 2012). If movement rates were maintained throughout the entire range of motion, the integrity of the shoulder joint could be compromised and exposed to injury. The biomechanical flaw at the lockout reduces the ensuing force production and effectiveness of the overall lift by decreasing the force and acceleration during the later portions of the movement.

New techniques have been developed that combine traditional barbell training and plyometric training. Using elastic resistance bands enable high force outputs to be applied dynamically through maximal elbow extension. Elastic band training changes the traditional force velocity relationship of barbell training, so that higher velocities can be reached with increased loads. The characteristics of the elastic bands allow a progressive overload in accordance with the length tension relationship (Richards & Dawson, 2009). This maximizes the strength curve by reducing the sticking point and maximizing the load at lockout, negating the biomechanical flaws of both heavy resistance and power training (Stevenson et al., 2010; Wallace et al., 2006).

Elastic band training has been shown to be superior to both plyometric and barbell modes in terms of dynamic force application (Baker & Newton, 2009; Joy, Lowery, Oliveira De Souza, & Wilson, 2013; Shoepe, Ramirez, Rovetti, Kohler, & Almstedt, 2011). Research regarding elastic resistance training has not yet found an ideal training range that can affect both kinetic and kinematic variable output. Elastic resistance loads for the squat and bench press have looked at different loading intensities ranging from 11% 1RM to 30% 1RM and have failed to show a potentiating effect in terms of power output. Elastic resistance bands have failed to look at moderate intensity loads in acute setting for the bench press exercise. Therefore there are no set training ranges for power, acceleration, or force like traditional barbell or plyometric training. Due to the altered loading patterns, in terms of the force velocity and length tension curve, loading percentages differ compared to barbell loads. In order to optimally plan and train with elastic resistance bands, loading ranges need to be established

Purpose

While there has been research conducted with resistance bands, most of the studies have simply picked a resistance level and trained with them (Stevens, 2010; Wallace et al., 2006). The results have varied, but generally the outcomes have been increased strength or power measures (Baker, Nance, Moore, 2001; Baker et al., 2009;

Lawrence, 2010), but the range of elastic resistance loads that have been used (0% to 85%) have not been compared acutely to determine their effect on the variables of force, velocity, and power to see if there are optimum resistance loads for any of the variables for the bench press. Therefore, the purpose of this study was to determine the acute effects of elastic resistance loads of 15% and 25% (1RM) in terms of force, velocity, and power production.

Null Hypotheses

- There will be no significant difference in power, force, or velocity when using elastic resistance loads of 15% or 25% of 1RM added to 60% of 1RM of free weights during a bench press with the alpha level set at $p \leq .05$.

Operational Definitions:

The primary variable being measured was power with the secondary variables being force and velocity. Power is made up of two distinct components, force and velocity. All variables were measured with the GymAware analyzer, which is a linear transducer or optical encoder that tracks several measures. The variables included force, velocity, work, and power. The GymAware system attaches to the barbell, in the form of a tether, and measures the displacement and time of the bar movement.

Assumptions

- Participants will refrain from exercise the day of testing to avoid any fatigue, which could influence performance.

Delimitations

- Twelve participants will be between the ages of 18-30 with at least six months of resistance training history volunteered to be in the study.

- A power analysis performed on G Power determined a minimum of 10 participants was required to achieve significance at an alpha level of $p \leq .05$.
- Participants had their appropriate grip on the bar measured during the familiarization session and the grip with was used on the day of testing to assure consistent measurement for each participant.

Significance

To date these elastic loads of 15% and 25% of the 1RM have not been compared in acute settings in terms of force, power, and velocity. Differences associated with the elastic loads (15 and 25%) in terms of force, power, and velocity may alter the physiological adaptations and subsequent performance goals if used in a comprehensive training program. The performance variable outputs may give necessary insight into how variable elastic resistance loads influence the force- velocity relationship in terms of force, power, and velocity. This information will allow for an accurate and specific training program to be based off of elastic resistance and designed for specific athletic needs and goals. The differences between testing groups, in terms of variable outcomes, will help athletes tailor resistance training programs based on athletic performance and movement needs.

Summary

Strength training has progressed from its origin of heavy resistance lifting, into more sport specific methods. In addition to strength sport specific training deals with power, force, and velocity, depending on athletic and movement needs. Literature states that elastic resistance training due to the biomechanical alterations creates a more dynamic and forceful movement compared to traditional barbell loads.

The research regarding the acute loading patterns, in terms of elastic resistance, has not been explored extensively. In order to establish how different training intensities alter performance variables, data needs to be produced to give insight.

Chapter 2

Review of Literature

Introduction

The purpose of the study was to determine the acute effects of elastic resistance loads of 15% and 25% (1RM) in terms of force, acceleration, and power production. The literature regarding the history of strength training and the specific techniques are reviewed in this chapter. The use of elastic resistance band training is also explored.

Heavy Resistance Training

Heavy resistance training is a specific subtype of training that uses heavy loads ranging from 85%-100% 1RM (Duchateau, Semmler, & Enoka, 2006). Its primary focus is to increase the amount of force, which can be produced through a specific range of motion (Crewther, Cronin, & Keogh, 2005). There are several different variations in which intensity can be manipulated which are used by athletes and strength and conditioning professionals. Some of the different variations include heavy negatives, contrast methods, lightened methods, and reactive methods. All the methods have one thing in common, increasing the amount of force that can be produced during the movement.

Increasing force production is critical for several types of athletes. Specifically football, wrestling, and combat sports all need to apply high amounts of force during the sporting contest (Duchateau et al., 2006). In order to overcome a resistance (opponent) a net force must be applied that's greater than the opposition. If the net force is greater than the opposing force, positive work will be produced. Increasing the net force will have a direct influence on the speed of an object, in terms of acceleration and velocity (Knudson, 2007). As the load increases and subsequent force output remains constant, the overall velocity of the movement will be sacrificed and movement times will increase (Baechle et al., 2008; Fry et al., 2003). Heavy resistance training adaptations are based on the movement velocities and force outputs applied during a specific task.

One of the main characteristics of heavy resistance training is the speed and force components of the lift. This principle is known as the force velocity relationship. Heavy resistance training, in terms of this relationship, is skewed towards the force side, producing little velocity and acceleration (Newton et al., 1997). Due to this relationship, the muscle performs more work under a greater amount of stress due to increased times under tension (Crewther et al., 2005). Increasing the times under tension makes specific adaptations to the structural (Farup et al., 2012; Kongsgaard et al., 2007), neurological (Cutsem, Feiereisen, Duchateau, & Hainaut, 1998; Duchateau et al., 2006), and mechanical properties (Kadi et al., 2004; Schoenfeld, 2010; Smilios, Pilianidis, Karamouzis, & Tokmakidis, 2002) in order to increase absolute force production and strength.

Heavy resistance training overloads the muscle causing damage and stress within the muscle contractile components. Decreasing the speed of the movement allows greater time for actin-myosin interaction through cross bridge formation. Increasing actin-myosin cross bridge interaction will allow for maximal tension development (Crewther et al., 2005). The stress and damage from the force and tension within the movement creates alterations to the contractile elements, which is known as hypertrophy. The muscle adapts to stress by increasing the cross sectional area of the myofibrils allowing for increased tension development (Farup et al, 2012). Increasing the size of the contractile units allows increased force production and subsequent increases in strength development (Blazevich, Cannavan, Coleman, & Horne, 2008). Hypertrophy is regulated and controlled by several different factors. These factors include satellite cell recruitment from acute micro trauma (Barton-Davis, Shoturma, & Sweeney, 1999; Toigo & Boutellier, 2006), acute increases in testosterone/IGF-1 levels (Schoenfeld, 2010; Smilios, Pilianidis, Karamouzis, & Tomakidis 2003; Suga et al., 2009), and increases in protein synthesis.

Heavy resistance training not only increases hypertrophic adaptations but neurological ones as well. Increases in motor unit recruitment and rate coding are primary neurological adaptation when lifting with loads between 85%-100% 1RM (Cutsem, et al., 1998; Duchateau et al., 2006). Rate coding increases the speed and efficiency of neural impulses associated with muscle recruitment. This allows more muscle to be recruited at a faster speed. Increasing muscle recruitment maximizes tension and subsequent force production. Both the neural and hypertrophic adaptations related to heavy resistance training are related to force development rather than movement velocity (Blazevich et al., 2008). Adaptations based on speed and velocity are not seen during heavy resistance training due to the biomechanical limitations and subsequent heavy loading ranges (Schmidtbleicher, 1993).

The drawback to heavy resistance training is the lack of specificity in terms of kinematic or movement development. Athletic movements are dynamic in nature (throwing, passing a ball, combat sports, and blocking aspects of football) and are associated with rate of force development (RFD) and acceleration compared to absolute force development (Blazevich et al., 2008; Haff et al., 1997; Stone, 1993). Due to the biomechanics of heavy resistance training and subsequent loads, adaptations related to velocity and acceleration are sacrificed due to the emphasis on force.

When performing the bench press with heavy loads, biomechanical restraints limit the amount of power, velocity, and force that can be produced (Clark, Adam, Bryant, & Humphries, 2008). This point occurs directly after the eccentric-concentric transition, near the beginning of the range of motion, and is referred to as the sticking point. The sticking point occurs when the mass of the bar exceeds the amount of force the body can produce, due to the mechanical disadvantage in terms of the length tension relationship (Tillar et al., 2009). The sticking point occurs early in the range of motion approximately at .2 seconds into the lift. The point where the sticking point starts, ultimately limits the amounts force that can be produced during the more biomechanically advantageous parts of the movement in terms of the length tension relationship (Madsen et al., 1984; McCarthey, Wood, Bolding, Roy, & Hunter, 2012).

In order to create adaptations that cater to velocity, acceleration, and power higher movement velocities must occur. Decreasing the loading intensities shifts the focus from kinetic energy, the amount of energy needed to accelerate the limb to the stated velocity, to kinematic or movement enhancement. By decreasing the load you minimize the sticking point, which allows for the speed and power to be maintained through the full range of motion.

Power Training

Power training is inversely related to heavy resistance training in terms of the force velocity relationship. Power training is performed with 30%-60% 1RM, which allows for increased amounts of acceleration, velocity, and power (Clark et al., 2008;

Tillar et al., 2012). Power training unlike heavy resistance training, focuses on the velocity or speed aspect of the movement, rather than force development (Newton et al., 1994). Power training is designed to increase power, by manipulating the components of acceleration, velocity, and RFD.

There are several ways to increase power and it is dependent on the type of training performed. There are three distinct methods that increase power, specifically plyometrics, ballistic barbell training, and resisted plyometrics. The three techniques are important for sports performance training due to the correlation associated with sport specific power output (McBride, Triplett-Mcbride, Davie, & Newton, 2002; Stone, 1993). Most athletic movements are related to power more than absolute strength due to the limited time for force application in most of the movements required (Newton et al., 1994; Haff et al., 1997). Therefore kinematic power adaptations better suit dynamic athletic needs compared to absolute strength development.

One of the most important factors in developing power is the relationship between force and velocity. Power is the product of both force and velocity (P= F x V). In order to maximize power outputs, loads must be lifted at maximal or near maximal speeds (Sakamoto & Sinclair, 2006). Speed and resistance are inversely related, so the heavier the load (>60% 1RM) the slower acceleration and velocity due to increased times under tension (Baechle et al., 2008). A similar relationship exists with speed, lighter loads (<30% 1RM) are correlated with faster velocities, but have reduced absolute force outputs due to decreased times under tension and sub maximal intensities (F= M x A)(Knudson, 2007). If the load is too heavy or too light, the respective force or speed component is minimized decreasing the overall power output. In order to maximize power outputs moderate loads must be moved at maximal or near maximal velocities (Clark et al., 2008). Training with the intent to increase movement speed and power make specific alterations within the mechanical, neural, and structural tissues.

As with the development of strength, there are adaptive responses that occur with power training. Mechanical alterations involve more efficient cross bridge interactions between actin and myosin, which in an untrained state is a limiting factor for developing power and acceleration (Baker et al., 2001). Increasing contraction rates enable faster movement velocities throughout the movement, which increases power outputs (Malisoux, Francaux, Nielens, & Theisen, 2005; Sakamoto et al., 2006). Elastic resistance training has been shown to alter myosin heavy chains, due to the increased recruitment of high threshold motor units during both the eccentric and concentric contractions (Campos et al., 2002; Raue et al., 2005). The increased muscle fiber recruitment and stimulation increase muscle hypertrophy in the myofibrils which increase force and strength development, much like heavy resistance training (Hoffman, Cooper, Wendell, & Kang, 2004). Neural alterations include increasing motor unit synchronization, motor unit firing rate, and faster recruitment of type two fibers (Cutsen et al., 1998; Harris, Stone, O'Bryant, Proulx, & Johnson, 2000; Malisoux et al., 2005; Toji, Suei, & Kaneko, 1997). All of the same neural adaptations that allow for increases in relative force allow for greater power production.

Several structural adaptations occur in the tendon that increase and potentiate muscle contraction. Increased tendon stiffness is altered by power training as a protective mechanism for the muscle attachment on the bone, which allows the greater speed required to increase power, force, and acceleration (Cutsem, et al., 1998; Keough, Wilson, & Weatheby, 1999; Malisoux et al., 2005). Increasing the stiffness of the tendon structure also allows for an increased amount of elastic energy to be stored and released during the concentric motion (Malisoux et al., 2005; McCarthey et al., 2012).

Power training with weights has limitations, similar to heavy resistance training, that decrease its transferability to sporting movements due to biomechanical limitations and tension development restrictions. During a bench press with sub-maximal loads, there is a deceleration epoch at the end of the movement. The deceleration is for protection of the elbow and shoulder joints, but the reduction in speed, limits force, power, and velocity development through the end of elbow extension (Cronin et al., 2000; Madsen et al., 1984; Newton et al., 1997; Van Den Tillaar et al., 2012). Sports events that require fast movement velocities and high amounts of force through the full range of motion, will not accurately meet athletic movement profiles with either strength or power upper body training.

Another limiting factor of power training is tension development due to the force velocity relationship. Sub-maximal loads when lifted exceed the force of gravity and as a result tension development is reduced. As acceleration and velocity increase, force and time under tension decrease, which subsequently limits crossbridge formation compared to maximal loads. By reducing crossbridge interaction, subsequent muscle tension development is reduced and force is sacrificed compared to maximal resistance loads. Increased rates of contraction also limit muscle interaction, which reduces overall force production and strength development (Baechle et al., 2008; Newton et al, 1997; Sakamoto et al., 2006).

In order to fully develop a complete athletic profile of both optimum strength, and optimum speed, both power and heavy strength training are necessary. A new method of training called variable resistance training or elastic band training is a combination of both power and heavy resistance modes. Elastic band training is thought to make both kinetic energy and kinematic adaptations in a more sport specific way compared to both heavy resistance and power training.

Elastic Resistance Training

Elastic resistance training is a hybrid method, which utilizes a loaded barbell and elastic resistance bands. Elastic resistance training is used to increase power, acceleration, and velocity at higher loading intensities, making the movement more dynamic and sport specific compared to traditional barbell methods. The recommended ranges for elastic resistance vary from 15%-25% 1RM used in conjunction with 40-60% 1RM in barbell weight (Baker, 2008; Simmons, 1999). Elastic loads that exceed 25% 1RM reduce the ability to accelerate through the full range of motion, reducing the velocity and acceleration of the movement. Lighter elastic resistance loads (<15% 1RM) do not overload the muscle enough to create increases in force due to reduced loading intensities and increases kinematics that reduce crossbridge interaction and tension development.

It has been shown that using elastic resistance bands changes the biomechanics and length tension relationships of traditional barbell training (Baker et al., 2009; Bellar et al., 2011; Wallace et al., 2006). Elastic resistance alters the force velocity relationship by loading with the strength curve enabling greater loads to be handled at the stronger portions of the lift. By loading progressively through the range of motion, you eliminate the points of least mechanical advantage, enabling kinematic and kinetic strengths of both power and heavy resistance training into one movement.

Research using elastic resistance training both long and moderate term periodized resistance programs have been developed to look at performance measures compared to traditional free weight methods (Joy et al., 2013; Bellar et al, 2011; Garcia-Lopez et al., 2014; Shoepe et al., 2011). In all cases the elastic resistance training was significantly better than free weights on measures of power and strength, including an isokinetic assessment. The shortest study was only five weeks long (Joy et al., 2013) and the longest was 24 weeks (Shoepe et al., 2011). The degree of resistance varied across all the studies and some varied the amount of elastic resistance over the length of the study with the range of resistance from a low of 15% to a high of 35%. Due to the nature of long term periodized studies, the acute effects of each loading intensity in was not tested therefore the effectiveness of each particular elastic load is not fully known.

One of the first times elastic resistance was recommended as a means of altering strength and power developed through free weights was in an article by Simmons (1999). It was simply an explanation of the protocols and how to use it, but it did make a recommendation that the optimum range for elastic resistance was 15% to 25% over the free weight base. This was not based on research and as can be seen in the significant results of more recent studies in the squat exercise (Stevens et al., 2010; Wallace et al., 2006), the optimum range given may not be accurate. There may be a ceiling of 30% 1RM elastic resistance (Wallace et al., 2006). They used varying amounts of resistance (Stevens et al., 2010; Wallace et al., 2006) and the highest resistance of 30% 1RM was found to be significantly higher for force output.

Exceeding this ceiling of 30% elastic resistance has been shown to significantly decrease force output compared to free weight only loads when using 50% and 75%

elastic resistance. The ceiling effect of 30% could possibly represent the maximum amount of resistance that can potentiate the movement in terms of kinetic and kinematic variable output. Excessive resistance reduces the amount of velocity and acceleration that can be maintained through the full range of motion, when the elastic resistance is fully engaged. Decreasing the kinematics during the later portions of the movement will decrease both kinematic and kinetic measures.

The two most common exercises studied with elastic resistance are the bench press and the squat (Baker et al., 2009; Lawrence., 2010; Stevens et al., 2010; Wallace et al., 2006). They are both multi joint exercises and both are regularly the focus for both strength and power exercises so if it is possible to combine the two aspects through the use of elastic resistance that would decrease the amount of time necessary in the weight room. These studies confirmed that there is a lower and higher end to the ranges for the addition of the bands. Below 15% was unable to develop power better than free weights (Stevens et al., 2010), and greater than 30% was unable to develop force better than free weights (Wallace et al., 2006). That is not to say they were not effective in developing velocity or force, but just that they were no better than free weights. Unless there is some other mechanical advantage of using the elastic resistance bands, there is no additional benefit outside of 15% and 30%.

Based on the acute and long-term effects of the training protocols, researchers became interested in how elastic resistance bands influenced the biomechanics of the lift. One of the major advantages of elastic resistance is the altered loading pattern compared to free weights (Baker et al., 2009; Wallace et al., 2006). The elastic resistance movements altered the loading pattern. This allowed the movement to load progressively through the range of motion, avoiding the points of least mechanical advantage, associated with light and heavy free weights (Murphy, Wilson, Pryor, & Newton, 1995; Bellar et al., 2011). Progressive loading accomplished by the bands along the strength curve, subsequently avoids the sticking point and deceleration epochs with free weights, allowing for higher power, velocity, and force outputs (Baker et al., 2009; Rhea et al., 2009).

The elastic resistance bands also significantly alter the eccentric recruitment pattern. Elastic resistance bands increase eccentric velocities, which potentiate the primary and secondary movers (Baker et al., 2009; Baker et al., 2001; Newton et al., 1997). The recoil of the elastic band creates the greater velocity that the primary movers contract against to slow and control the movement and the secondary movers are required to maintain the stability of the weight and bar as they move through the eccentric phase. Maximizing the load at lockout and selectively removing it during the decent, increases the neurological and mechanical state of the primary and secondary movers (Doan et al., 2002). Mechanically this maximizes cross bridge attachment/muscle tensions development, and increases elastic energy potential which allow for increased force, power, and acceleration measures during the succeeding concentric motion (Doan et al., 2002).

Based on the literature the consensus is that elastic resistance training is more effective than free weight resistance training for lifts that use elastic resistance between 15% and 30% of 1RM. Although the research fails to describe which specific elastic intensities are the most effective at potentiating specific kinetic energy and kinematic variables, especially power. Research needs to continue to explore the association between elastic resistance and power, velocity, and force by loading with moderate elastic resistance loads 15%-25% (Baker et al, 2008).

In order to establish the most effective elastic training loads for power, force, and velocity, elastic resistance intensities must be tested in acute settings. The acute responses will better assess the specific adaptive capabilities that each elastic resistance load produces. These acute responses can be applied to periodized resistance-training programs based on the specific characteristics that each elastic load produces (power, force, and/or velocity). All three forms of resistance training (heavy resistance training, power, and variable/elastic resistance training) develop specific adaptations that follow the force velocity relationship. Power and heavy resistance training need to be performed in conjunction with one another to fully develop both speed and strength measures. Elastic training may develop both force and speed characteristics making it more time efficient and transferable to sporting movements.

Summary

This chapter looked at both the characteristics of barbell and elastic resistance training methods. The benefits and drawbacks of free weight power and heavy load training were reviewed, which led into the introduction of elastic resistance training. The rational and benefits of elastic resistance training were analyzed and research regarding acute and long-term studies were compared.

Chapter 3

Methods

Introduction

The purpose of the study will be to determine the acute effects of elastic resistance loads of 15% and 25% (1RM) in terms of force, acceleration, and power production. The participant selection process and inclusion/exclusion criteria will be explained. The instrumentation along with all of the variables will be outlined and defined. The methods and procedure will be outlined in a stepwise manner, from participant selection to the end of the testing period.

Participants

The participants in this study will be experienced weight lifters between the ages of 18-30. The participants will complete a form based on the participant inclusion criteria to determine eligibility. Questions will include injury history, resistance training history, and elastic/power training history (Appendix I). At that point, all potential participants will be given an informed consent form and will be instructed to read it and ask questions. When they return to the gym for testing they will bring the signed informed consent.

In order to determine the amount of participants for the study statistical analysis was run on G Power (3.1) with an effect size of .4(moderate). The minimal number of participants necessary for this study is 10, but more will be allowed to participate in order to increase the power and decrease the effect size to reach significance or the critical F value.

Inclusion Criteria

- Participants may be female or male and must be resistance trained for at least six months.
- Participants must be free of upper extremity injury for at least two months.

Instrumentation

All variables will be measured with the GymAware analyzer (Irmo, South Carolina). The GymAware analyzer is a linear transducer or optical encoder that tracts several measures which include force, acceleration, velocity, work and power. The GymAware system attaches to the barbell, in the form of a tether, and measures the displacement and time of the bar movement. The specific measurements in the study (force, velocity, and power) will be defined and related to the measurements that the GymAware analyzer provides.

There will be three variables measured during the testing process. Power will be the primary variable, which will be accompanied by velocity and force, the two secondary variables.

Velocity is vector quantity, which means it represents the speed and direction of a movement. It's defined as the rate of change in terms of speed from the start of a movement to the end. To find the average velocity of an object, you take the displacement and divide it by the time component ($\triangle$ displacement/time). Force is the product of mass and the change in velocity (Force x $\triangle$ velocity). Power (Force x Velocity) will be evaluated by taking the product of force and velocity.

Procedures

Before any testing begins the Institutional Review Board of Eastern Washington University will grant permission. The primary investigator will contact potential participants to see if they would be willing to partake in the study. Study procedures and outlines about the length and involvement will be reviewed and detailed. If permission is granted a meeting will be scheduled with all participants. A complete description of the study will be presented and any questions will be answered before the start of the procedures. To qualify for the study participants must answer all the questions on the test questionnaire and meet the inclusion criteria.

Participants will come to the gym on three different days separated by at least 48 hours. The first day will be used to determine the 1RM of each participant. Each participant's arm length (at lockout) will be measured at that time in order to measure elastic resistance. The second day will be for a familiarization period to get accustomed to the resistance bands. The third and final day will be the day of testing, where participants will perform three repetitions (1x3) of 75% and 85% 1RM, with 15% and 25% of the respective total coming from elastic bands.

The dates will be arranged in conjunction with the participant's schedule and will be performed in the morning at the same time for all three days. In order to remain consistent the participants will come in and perform the exercises each day in groups. Every group will have 30 minutes to complete the task for the day. Each group will remain the same for the three days and perform exercise routines in the same order. Each group will rotate in waves until all the participants have finished the procedures for the day.

In order to determine the sub maximal barbell loads associated with the testing and warm up session (60% 1RM) a 1RM max test will be performed. There are specific steps and procedures that need to be taken in order to successfully complete a 1RM bench press test. Participants will warms up with a light resistance, which enables 10-12 repetitions to be completed (reps). A one-minute rest period will be given and an additional 10-20 pounds will be added which should allow for three-five reps to be completed. After finishing the set, a two-minute rest period will be given and 10-20 pounds will be added which should allow two-three reps to be completed. Another two-four minutes of rest will be given and another 10-20 pounds will be added for a 1RM attempt. If the 1RM is successful a two-four minute rest period will be given and another 10-20 pounds will be added for another 1RM attempt. If the first attempt is a failure, two-four minutes of rest will be taken and 5-10 pounds will be reduced and another 1RM attempt will be attempted (Baechle & Earle, 2008).

After the completion of the 1RM protocol, measurements of the participant's lockout length will be taken. The measurement will start at the top of the participant's bench press position (lockout length) and will be measured to the anchor point of the elastic attachment (dumbbell)(2a). The lockout length will be used to calculate the respective percentages of elastic resistance for each exercise trial. Each person will have 15% and 25% of their 1RM in the form of elastic resistance. An additional load of 60% 1RM comprised of traditional barbell weight will accompany the elastic resistance bands. In total, loads of 75% and 85% 1RM will be used when measured at the lockout position. The respective elastic loads will be within 2.5% (1RM) of the actual load desired at 15% and 25% 1RM.

In order to determine the specific amount of elastic tension that make up 15% and 25% of the participant's 1RM in pounds (at lockout), plyometric boxes and an unloaded barbell will be placed on a scale to simulate the height of each participant's lockout measurement (2a). This will replicate the top of the movement from which the load is being measured and will accurately allow the elastic tension to be expressed in pounds. The plyometric boxes and barbell will be tarred in order to accurately gauge the elastic resistance. Bands will be applied to the ends of the barbell until the respective weights of 15% and 25% 1RM are reached in pounds. The elastic resistance bands will be attached to dumbbells on the ground in order to create an anchor point Figure 1).

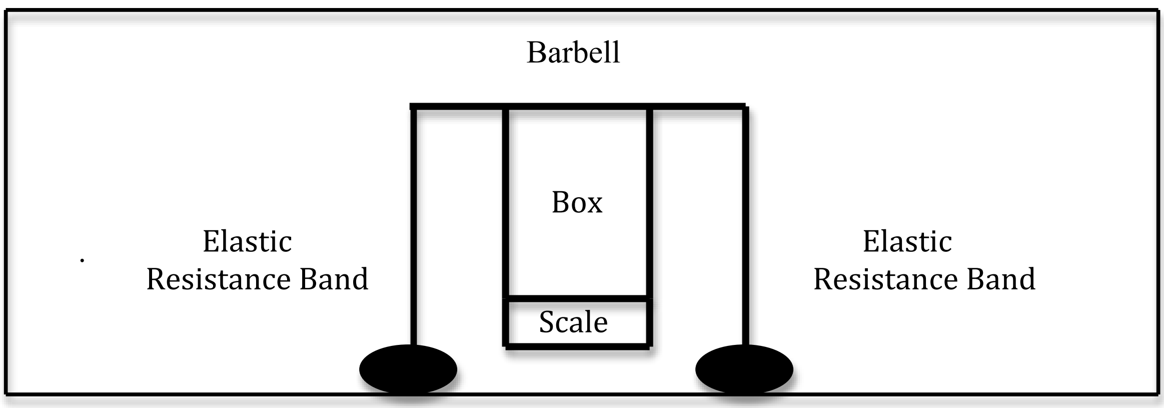

Figure 1. Elastic resistance band model used to evaluate and determine elastic training loads of 15% and 25% 1RM.

After the 1RM test has been completed the participants will have one familiarization period to get accustomed to the elastic resistance bands**.** During the familiarization session, the bands will be applied without any plate-loaded resistance. Having one familiarization session without the addition of any plate-loaded resistance reduces the chance of a learning effect or neurological adaptation. During the familiarization session participants will be using the same barbell and bench press during the testing session. The familiarization period and testing sessions will be separated by at least 48 hours. The third and final day will be the day of testing, where all the variables will be measured.

The third and final day participants will perform three repetitions (1x3) of 75% and 85% 1RM, with 15% and 25% of the respective total coming from elastic bands. When the participants enter the gym on the third day, three benches will be set. One bench which will be set up with 60% of the 1RM(warm up) and the two others at the 75% and 85% 1RM, with 15% and 25% of the respective loads coming from elastic resistance. Each participant will complete a warm up that consists of 12 repetitions at 60% 1RM. After the completion of the warm up, a two-minute rest period will separate the testing loads of 75% and 85% 1RM. The order in which the testing will take place will be determined at random and chosen by a coin toss. Each side of the coin will represent a particular intensity, 15% heads and 25% tails (elastic resistance). After the first exercise trial the participants will have two minutes to rest before the second trial is attempted at its respected bench. The only thing participants will be doing is moving from one bench to the next and waiting for the full two minutes to expire.

During the testing period each repetition should be completed as fast as possible using maximal exertion and must be continuous with no pause at the end of the eccentric down point, before beginning the return to the lockout position. Between each repetition, there should a brief pause at the top in order to ensure that the repetition is fully complete, through the lockout position.

To determine the differences between force, power, and acceleration, each repetition and the corresponding variables will be analyzed and compared. As well as analyzing the variables of each repetition, the highest repetition in terms of force, power, and acceleration will be compared.

Statistical Analysis

To determine the difference between the three variables of power, velocity, and force, a 2-way ANOVA repeated measures analysis would be run in SPSS (SPSS version 20, Armonk, New York). If there is a significance difference between groups, a Bonferroni post hoc analysis will be run, to see exactly where that difference is coming from.

Summary

Specific participant selection criteria as well as the purpose of the study shape the methodology. The methods are laid out in a progression manner in which they will actually happen. The methods entail the design and layout of the test administration process. The statistical analysis will evaluate the difference and subsequent significance between both testing procedures.

Chapter 4

Results

Introduction

The purpose of the study was to determine the acute effects of elastic resistance loads of 15% and 25% 1RM in terms of force, velocity, and power. To assess the differences between resistance loads a total of twelve recreationally trained athletes participated in the study. The results and statistical analysis of the study will be explained through this chapter.

Descriptive Statistics

A total of twelve recreationally trained participants partook in the study. During the study each participant performed three repetitions with two different loads (15% + 60% =75% 1RM and 25% + 60% 1RM=85% 1RM). For each repetition, power (peak/mean), velocity (peak/mean), and force (peak/mean) were calculated. The means of all three repetitions, for each measurement, were combined into an average that was analyzed. The heavy repetition group was labeled HR and the light resistance group was labeled LR. The numerical value represents the repetition number for both the heavy and light loads (LR2= light resistance repetition 2; HR1= heavy repetition 1).

The mean (M) and peak (P) values for the heavy resistance group (combined repetitions) were as followed: velocity (P=.69(m/s) ± .11(standard deviation); M= .498(m/s) ± .023), power (P=782.47(w) ± 233.58; M=482.933(w) ± 38.78) , and force (P=1877.5(n) ± 141.44; M=985.94(n) ± 62.90). The mean and peak values for the light resistance group (combined repetitions) were as followed: velocity (M= .582 (m/s) ± .026

; P= .744(m/s) ± .120), power (P=737.80 (w) ± 52.86; M=500.229(w) ± 40.56), and force (P=1774.77(n) ± 125.242; M= 878.279 (n)± 55.30). The performance variable means and standard deviations for the combined repetitions (1-3), for both the heavy and light resistance groups are listed in table 1.

Table 1.

Combined Repetition Averages for Peak and Mean Force, Power, and Velocity, for the Heavy and Light Lifting Intensities.

Resistance	Mean Force (newtons)	Mean Power (watts)	Mean Velocity (m/s)	Peak Force (newtons)	Peak power (watts)	Peak velocity (m/s)
85%1RM	985.94 ±62.90*	482.93 ± 38.78	.49 ±.02	1877.51 ±141.44	782.47 ± 233.58	.69 ± .11
75%1RM	878.27 ±55.30	500.22 ±40.56	.582 ±.02 *	1774.77 ±125.24	737.80 ±52.86	.74 ±.12

Note. * Denotes a significant difference (P=<.05)

ANOVA

The assumption of a normal distribution were met so the repeated measures ANOVA was used to determine within subject variations across the three tests for each dependent variable, light load (15% of 1RM; 75% 1RM total) and heavy load (25% 1RM; 85% 1RM total), for the three measures of force, velocity and power. Significant differences were found by the ANOVA, so a Bonferroni post hoc test was used to find where the significant interactions occurred. A significant effect was found (F (Degrees of freedom) 1,11) = 17.81, p = .001) for mean velocity between the light and heavy loads. There was also a significant effect found (F(1,11) = 86.11, p = .001) for mean force between the light and heavy load. No significant effect was found (F(1,11) = 1.25, p =

.286) for mean power; ($F(1,11) = 2.853$, $p = .119$) for peak velocity; ($F(1,11) = 2.176$, $p = .17$) for peak power; or ($F(11,22) = 4.722$, $p = .052$) for peak force.

Therefore the main effects for the study were found in mean force and mean velocity. The heavy loading condition had significantly higher mean force values compared to the lighter loading intensity ($P=<.05$). The lighter loading conditioning had significantly higher values for mean velocity compared to the heavier loading intensity ($p=<.05$).

Conclusion

After analyzing the research throughout the chapter there were two variables that met significance, mean force and mean velocity. The mean force was significantly higher for the heavy loading condition (85%1RM) and mean velocity was significantly higher for the light load condition (75% 1RM). The remaining variables (peak power, mean power, peak force, and peak velocity) failed to reach significance. Therefore the heavy loading resistance had the greatest effect on the kinetics, while the lighter loading conditions had the greatest influence on kinematics.

Summary

The results of the study of the study and the statistics in terms of the main effects were explained throughout the chapter. The main effects between the group was mean force and mean velocity which was found by the ANOVA analysis and further assessed with a Bonferonni post hoc test.

Chapter 5

Discussion and Conclusion

Introduction

The purpose of the study was to determine the acute effects of elastic resistance loads of 15% and 25% 1RM in terms of force, velocity, and power production. The results of the study will be reviewed and compared to previous research, to see if there is a general consensus about elastic loading intensity and performance variable output. A conclusion along with recommendations for future research will be included, as well as a summary at the end of the chapter.

Findings

Based on previous research elastic loads of 15% and 25% 1RM were chosen for the present study. With free-weight lifting, a load of 75% has been used to explosive strength, while a load of 85% typically is used to develop maximal strength (Verkhoshansky & Verkhoshansky, 2011). Elastic loading intensities are recommended to be between 15%-25% 1RM for maximal potentiating (Baker et al, 2008). These specific loads have not been used or tested in acute elastic resistance studies regarding the bench press and could create significant alteration in the kinetics and kinematics of a repetition

The primary components of explosive strength are acceleration, velocity, and power development against moderate loads. The primary characteristic of maximal strength is absolute force development, and the secondary characteristics are power and velocity (Verkhoshansky et al., 2011). For the current study, 15% and 25% 1RM of elastic resistance was used in conjunction with 60% 1RM free-weight to represent two different resistance training techniques: maximal strength and explosive strength development (75% and 85% 1RM)(Verkhoshansky et al., 2011). The goal of the research was to determine whether maximal strength development load, 85% 1RM (25% 1RM elastic and 60% 1RM free weight) could be potentiated by the elastic resistance bands to increase the lifting velocity and acceleration to that of an explosive strength movement (lighter intensity). This way a heavier load would have the kinematics of a speed movement, which would create superior adaptive responses when used long term. The lower resistance of 75% (60% 1RM free weight plus 15% elastic resistance) was used to determine if an explosive strength resistance could overcome the lockout load (maximal loading phase of elastic resistance) with greater acceleration and velocity, to create greater power than maximal strength loads 85% 1RM.

In support of the hypotheses of the present study, in terms of kinetic and kinematic measures, it was found that there were two significant interactions between the elastic loading intensities. Mean force and mean velocity were significantly different between the heavy and light load intensities (Table 1). Although there were significant differences between elastic loads, these differences were most likely not due to any mechanical or potentiating effect brought on by the elastic resistance bands. They were due to the variances between the loads, which follow similar force/velocity and length/tension relationships as traditional free weight loads.

Discussion

Similarities between the loading conditions that were seen in this study, are displayed throughout the literature (Lawrence et al., 2009; Stevenson et al., 2010; Wallace et al., 2006). In a studies using leg squat's with both high amounts of elastic resistance (35% elastic resistance on 45% 1RM free weight)(Wallace et al., 2006), and low amounts of elastic resistance (20% elastic resistance on 55% 1RM free weight) (Stevenson et al., 2010), show either no effect or a negative effect on power output. Research in terms of the bench press have not been tested as extensively as the squat and current research regarding power production by Lawrence (2010), were negated due to large standard deviations. Loading conditions in that study were based off of the 85% 1RM and elastic resistance ranged from 20% - 75% of the total load. In the current bench press study, we had elastic resistances of 25% and 15% 1RM on 60% 1RM free weight and had no differences in power production, similar to past research.

One difference between the studies was the movement being performed. In the current study the bench press was used while Wallace et al. (2006) and Stevenson et al. (2010) used a squat. Although the muscle groups and movements are different the actual biomechanics of the exercises are similar. Each movement has four distinct phases: acceleration phase, sticking point, second acceleration phase, and deceleration phase (Elliot et al., 1989; Zink, Perry, Robertson, Roach, & Signorile, 2006), and have shown almost identical responses to elastic and free weight intensities in terms of strength gain/adaptation after a progressive periodized strength program (Anderson et al., 2008).

In addition to the different lifts, the loading intensities were also applied differently between the studies. Wallace et al. (2006) and Lawrence (2010) used the same overall resistance, 85% of 1RM, and varied both the free weight and the elastic resistance. Stevenson et al., (2010) along with the present study used two different loads; Stevenson et al. (2010) used 20% elastic on 55% 1RM. Also, the prior mentioned studies calculated the elastic components based on relative intensities (85% 1RM and 55% 1RM) instead of the absolute 1RM, which was done in the present study. These two factors created a condition that has been shown to be a problem in other research, the 35% of 85% 1RM and 20% of 55% 1RM created an elastic resistance load of 30% 1RM and 11% 1RM, which load outside the recommended ranges of 15%-25% (Simmons, 1999).

Exceeding and not meeting the recommended training ranges has been shown to decrease the potentiating effects brought on by the elastic resistance bands (Lawrence, 2010; Stevens, 2010; Wallace et al., 2006). This increased (>25% 1RM) or reduced loading intensity (<15% 1RM) likely decreases force and/or velocity, which subsequently reduces power output (power=Force x velocity). Training within the recommended ranges been shown to alter the kinematic and kinetic properties of a single movement (Baker et al, 2009; Lawrence, 2010; Wallace et al., 2006).

Studies comparing two different elastic intensities, have similar relationships in terms of variable output response. The current study along with Stevenson, et al. (2010) used two different overall loading intensities that varied by 10% 1RM and 11% 1RM. The velocity and force measures for both studies followed traditional force velocity relationships of free weight loads. Lighter loading intensities created greater movement velocities and decreased force outputs. The heavy loading conditions produced greater force measurements and lower velocity outputs (Stevenson et al., 2010). Power did not change between any of the conditions in the two studies due to the small variance between the force and velocity outputs between the two different intensities. This is different from Wallace et al. (2006), where mean and peak power were significantly different between the elastic loading conditions, even though the total weight was identical (85% 1RM). This could have been due to the high elastic loading condition, which was 30% 1RM. Velocity and acceleration were not measured, but results could of shown a significantly larger variance between velocity/acceleration compared to that of force between the heavy and light elastic loads. The larger the variance between the two acute conditions, the more likely a difference in power production.

There were a few conditions that differed between the Wallace et al (2006) study and the current study, which could explain the difference between power outputs. In the current study the maximal amount of resistance fell within the upper limit of the recommended elastic loading ranges (25% 1RM), which was 10% less elastic resistance that the Wallace et al. (2006). The current study would have to lift 10% less elastic resistance through the second half of the lift. The excessive band tension in the Wallace et al, (2006) study, possibly created significant amounts of deceleration due to the overload at the lockout, that could have reduced lifting velocities and subsequently power output (Lawrence, 2010; Stevenson et al., 2010; Wallace et al., 2006). For this reason, Wallace et al., (2010) state that there is an upper limit of elastic resistance that can be used, before a reduction in potentiating is seen. The current study did not load outside the recommended training ranges therefore the difference in power and velocity would have significantly less variance, reducing any potential for differences in power ouput.

Conclusion

Elastic resistance bands follow similar loading patterns in terms of force and velocity as traditional free weight loads. Heavier elastic loads of 25% 1RM, due to the increased mass or load, increased force to a greater extent than the lighter loading conditions. Lighter elastic loads of 15% 1RM had higher movement velocities throughout the entire range of motion compared to the heavy loading condition, due to decreased elastic loading intensities.

There was no significant difference between the two loads for power output. This suggests that the additional 10% 1RM intensity for the heavy loading group could not compensate for the increased movement velocities seen in the lighter loading group. At the same time, the lighter resistance group could not compensate for the 10% 1RM reduction in elastic resistance and force production of the heavy loading group; therefore significance was not met at any condition for power production.

Recommendations for Future Research

In order to see exactly where the potentiating effect occurs between different elastic resistance loads, more research needs to be conducted. Future research should look at band increments of 5% 1RM, starting at 15% 1RM and going as high as 30% 1RM. Measuring smaller increments will allow for a more accurate gauge as to where potentiation starts and ends. Free weight only loads should also be conducted at the same overall intensities to see if there are any interaction differences between elastic loads.

Acute studies should also look at the difference between recreational and experienced elastic resistance users. No studies have looked at the difference between the two in acute settings during the bench press. Potentially, training ranges and potentiating loads could differ between the two groups. Further research is warranted.

Summary

This chapter reviewed both the purpose and methodology behind the current study. Results of this study were also compared and discussed to current literature regarding elastic resistance bands. Finally, conclusions regarding the results as well as recommendations for future research were presented.

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Appendix A

Participant Information Questionnaire

The questions below pertain to the inclusion and demographic data involved with the study " Comparing the Acute Effects of Elastic Resistance Bands on the Kinetics and Kinematics During the Bench Press Movement." The purpose of this document is to screen potential participants for study inclusion. A secondary purpose the to gain demographical data that could potentially influence relationships associated with the study variable outputs.

Participants who meet and pass the screening process will have data collected and used with the intention to publish in an accredited research journal.

<u>Exclusion Criteria</u>

- Have you ever experienced an upper body injury? Yes___ No___
- If so what was it?
- How long ago did your experience this injury?
- Did the injury require you to be seen by a physician? Yes___ No___
- Does the injury currently influence or restrict any type of movement in terms of range of motion or force production? Yes___ No___

<u>Participant Demographics</u>

- Sex: Male/ Female (circle)
- How long have you been resistance training and how frequently do you train (per week)?
- Have you ever used Elastic Resistance bands before? If so, for how long and how frequently did or are you using them?

VITA

Author: Blake Baxter

Place of Birth: Bellingham, Washington

Undergraduate Schools Attended: Central Washington University

Degrees Awarded: Bachelor of Science, 2009, Central Washington University

Honors and Awards: Omicron Delta Kappa, Central Washington University