The Effects of Eccentric Overload Bench Press Training on 1RM Performance and EMG Activity in Powerlifters

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THE EFFECTS OF ECCENTRIC OVERLOAD BENCH PRESS TRAINING ON 1RM PERFORMANCE AND EMG ACTIVITY IN POWERLIFTERS

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THE EFFECTS OF ECCENTRIC OVERLOAD BENCH PRESS TRAINING ON 1RM PERFORMANCE AND EMG ACTIVITY IN POWERLIFTERS

By

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THESIS

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Abstract

For powerlifters, bench press performance is directly related to success in competitions since it is one of the three main lifts performed during a powerlifting competition. For a powerlifter to be competitive, they must train efficiently, building strength as quickly and safely as possible. Research has shown that eccentric training elicits greater strength increases when compared to concentric training. Furthermore, previous research observed that eccentric overload training for the lower limbs resulted in not only significantly improved strength, but it also takes place at a faster rate than traditional training. However, there is a lack of research on whether the same form of training provides the same results for the upper body. The purpose of this research is to investigate 1) effects of incorporating eccentric overload training to the bench press on 1-repetition maximum (1RM) performance and surface electromyography (EMG) activity; 2) determine at which percent of overload is EMG activity the greatest; and 3) determine if a 4-week eccentric overload training intervention is beneficial for strength and rate of force development improvements. Results showed that 1RM performance increased significantly from pre to post test (116.62 ± 27.48 kg to 124.28 ± 26.96 kg, respectively) (p = 0.001). Additionally, electromyography of the pectoralis major significantly decreased to 0.60 ± 0.15 % of Maximum Voluntary Contraction (MVC) at the 125% condition (p = 0.049). Furthermore, bar velocity of baseline 1RM increased significantly from pre to post test (p = 0.02). The data from this study suggests that incorporating eccentric overload bench press training into a resistance training program may improve 1RM performance.
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Chapter 1: Introduction

An Introduction to Eccentric Overload Training

Resistance training plays a crucial role in the success of individual and team sports. Generally, during resistance training, an athlete will train their muscles equally between eccentric and concentric movements. However, there is evidence that eccentric muscle actions play a larger role in both hypertrophy and strength/rate of force development improvements when compared to concentric muscle actions (Norrbrand, Fluckery, Pozzo, & Tesch, 2008; Hortobagyi et al., 1996). Also, adding an additional mechanical load during the eccentric phase, known as eccentric overload, can amplify strength improvements when compared to concentric only muscle actions or coupled eccentric-concentric muscle actions (Norrbrand et al., 2008; Hotobagyi, Devita, Money, & Barrier, 2001; Brandenburg and Docherty, 2002).

During resistance training, the body is placed under a great amount of stress, leading the body to adapt not only physically, but neurologically as well. Strength improvements are the results of hypertrophy of muscle fibers and changes in myosin heavy chain (MHC) composition of those muscle fibers (Friedmann et al., 2004). Improvements to the stretch-shortening cycle (SSC) also result in better performance during lifts, especially during the eccentric phase (Cormie, McGuigan, & Newton, 2010). When considering the SSC for eccentric overload bench press, the eccentric phase would be considered the “pre-stretch” action, with the muscles being overloaded, preparing the body to lift a heavier load than what will actually be lifted.

Eccentric overload training (EOT) is a relatively novel method of training for improvements in hypertrophy and strength. EOT is when the weight being lifted through the eccentric phase is heavier than an individual’s concentric one repetition maximum (1RM). During a training program, an athlete would normally choose a weight for a specific lift
determined by their 1RM performance, but with EOT, the eccentric phase of a lift would be greater than 100% of 1RM, and the concentric phase would be lower than 100% of 1RM. Norrbrand et al. (2008) stated in their study that EOT still follows the traditional eccentric-concentric muscle actions of a lift. The difference being that only that the eccentric phase would experience an overload greater than a subject’s measured 1RM. An individual’s regular training program does not need to be changed if EOT is introduced into their program.

**Methodologies of Eccentric Overload Training**

Previous research has concluded that eccentric training plays a greater role in strength and hypertrophy development (Schoenfield, Ogborn, Vigotsky, Franchi, & Krieger, 2017), and these improvements become even greater when EOT is implemented (Friedmann-Bette et al., 2010). In a typical strength training session, concentric and eccentric loads are equal throughout an entire lift. However, since maximal eccentric strength is generally greater than maximal concentric strength, it can be inferred that a smaller, relative load is applied eccentrically (Friedmann-Bette et al., 2010), meaning that an athlete can lift greater than 100% of their 1RM eccentrically, but typically below 100% concentrically. Knowing this, in order to effectively train both concentric and eccentric strength, two different loads need to be applied during the lift. It is here where EOT training can be implemented, so that both the eccentric and concentric phase of a lift will have a load representative of an athlete’s strength. While this is still a traditional eccentric-concentric action, the load greater than 100% during the eccentric phase is more representative of an athlete’s eccentric strength, where loads below 100% concentric strength is an accurate representation of an athlete’s concentric strength. For the bench press, eccentric hooks, also known as weight releasers, are typically used to apply the greater load during the eccentric phase, and detach, allowing for a lighter concentric phase to be performed.
Figure 1. a.) Beginning of a lift, with eccentric hooks applied to increase the eccentric load, and; b.) Eccentric hooks detaching at the bottom of the eccentric phase, allowing a lighter concentric load to be applied.

Eccentric hooks are platforms that are attached to the barbell, next to the weight already loaded on the bar, made to detach at the bottom of the eccentric phase during a lift. These hooks are adjustable, allowing anyone using them and ensure they are maintaining a full range of motion. At the bottom of the hooks is a platform where additional weight can be placed. This allows for lifts to be performed where the eccentric load is greater than the maximal concentric load, with a reduced load being lifted during the concentric phase (Doan et al., 2002). However, when using eccentric hooks, the additional weight applied needs to be controlled by the individual performing the lift. This is typically done by enforcing a three second eccentric phase, making sure that the subject can control the lifted weight (Doan et al., 2002).

With EOT being a relatively new form of training, there are a limited amount of ways to implement eccentric overload, especially when it comes to upper body training. During EOT, it can be difficult to efficiently and safely change the lifted weight at the bottom of the eccentric phase, before beginning the concentric phase. Because of it, eccentric overload studies focusing on the bench press are limited. To date, only two published studies are available (Ojasto & Hakkinen, 2009; Doan et al., 2002), with both having used eccentric hooks to implement
eccentric overload. If eccentric hooks are not used during upper extremity lifts, the option is an eccentric-only lift, where the concentric phase is avoided entirely.

When these conditions are met, it has been found that there can be an immediate improvement to concentric 1RM strength, as well as the rate of force development during the concentric phase (Doan et al., 2002). Unfortunately, only two published studies have been conducted using both the bench press and eccentric hooks, leading to a lack of conclusive information available.

It is possible to have a spotter help lift the weight through the concentric phase as another way to implement eccentric overload. However, using a spotter to accomplish this makes it hard to quantify with precision how much weight is unloaded during the concentric phase. When compared to other forms of bench press training, eccentric only actions were found to have the greatest effects on the rate of force development and EMG activity when compared to heavy weight training, rest-pause, isokinetic, and several other forms of resistance training techniques (Keogh, Wilson, & Weatherby, 1999). During eccentric only training, there is no concentric phase performed, leading to completion of only half of the lift. Eccentric only lifts typically take 3-5

Figure 2. Adjustable weight-release device to allow additional loading during the eccentric phase that detach at the bottom of the eccentric phase (Doan et al., 2002).
seconds to complete, ensuring that the subject has full control over the weight used (Keogh, Wilson, & Weatherby, 1999).

**Bench Press and Eccentric Overload**

Previous research investigating surface EMG activity during the eccentric overload bench press is limited to only one identified study. In the study conducted by Ojaston and Hakkinen (2009), researchers recorded surface EMG activity for the pectoralis major, medial portion of the triceps brachii, and the medial deltoid anterior. During the bench press, muscle electrical activity was recorded and analyzed. However, the results of the study failed to identify differences in muscle activity between eccentric overload and bench press (Ojaston & Hakkinen, 2009). These findings contradict those from other previous studies where significant improvements in SEMG activity were observed almost immediately during various lower body eccentric overload exercises (Norrbrand et al., 2008; Friedmann et al., 2004).

**EMG During Bench Press**

Previous research investigating EMG activity during eccentric overload bench press is currently limited to only one study. During the study conducted by Ojaston and Hakkinen (2009), EMG activity was recorded for the pectoralis major, medial portion of the triceps brachii, and the medial deltoid anterior. During the bench press, muscle activity was recorded and analyzed. However, the results of the research found no significant changes when comparing eccentric overload EMG activity to a tradition bench press EMG activity (Ojaston & Hakkinen, 2009). However, these findings contradict other previous studies where EMG activity was observed during various lower body eccentric overload exercises, where significant improvements in EMG activity can be observed almost immediately (Norrbrand et al., 2008; Friedmann et al., 2004).
**Bench Press Training Accessibility**

Bench press training can be executed anywhere a flat bench and a barbell are available. Every gym, recreational center, and other fitness facilities commonly have a large selection of benches and barbells on hand. However, consistency may be a cause for concern. Barbells are not all the same. There are differences in terms of its thickness, weight, and ability to bend. Those without access to a gym equipped with a bench and barbell, will not be able to perform EOT using eccentric hooks.

**Knowledge Gap**

The effects of EOT and lower body exercises have been heavily researched. Unfortunately, research looking into the effects of EOT with the bench press is scarce. Current studies have limited to examining the acute effects of implementing overload during the eccentric phase and its results immediately after. To date, we have identified no studies investigating the effects of an eccentric overload training program for the bench press. Therefore, the to date, the potential benefits of EOT upper body training are not fully understood.

**Purpose of Study**

The purpose of this proposed research was to determine the results of a 4-week, EOT bench press mesocycle on 1RM performance, maximal signal amplitude SEMG muscle activity, and rate of force development. Additionally, we compared SEMG muscle activity and percentage of concentric maximal voluntary contraction (MVC) with SEMG muscle activity from several different eccentric loads. The primary goal of the proposed research was to determine if EOT and lower body exercises would produce and effect during upper body exercises, as well as determine the percentage on concentric 1RM that will elicit the greatest SEMG muscle activity, and rate of force development. To accomplish the goals of the proposed
study, results from pre- and post-training were measured to compared to determine if eccentric overload is a viable option for improving bench press training.
Chapter 2: Literature Review

Bench press performance is important in many team and individual sports as it one of the best indicators of upper body strength. Sports such as football, powerlifting, rugby, and other contact sports all require athletes to be as strong as possible, as physical characteristics improved by resistance training were found to be connected with successful performance outcomes (Douglas, Pearson, Ross, & McGuigan, 2018; Ross, Gill, Cronin, & Malcata, 2015). As it stands, 1RM bench press performance is one of the most common upper body tests performed by athletes (Chapman, Whitehead, & Binkert, 1998). Because of this, bench press training is a large part of many athlete’s training programs. To date, research regarding eccentric overload bench press training has been limited, with research currently available concluding that eccentric overload during bench press can lead to immediate improvements in the stretch-shortening cycle due to the increased eccentric load (Doan et al., 2002). On the other hand, eccentric overload training for the lower body has been researched extensively. Several studies have found that when incorporating eccentric overload into lower body training, there are significantly greater gains in strength, rate of force development, and hypertrophy when compared to traditional eccentric-concentric training (Norrbrand et al., 2008; Friedmann et al., 2002; Sabido, Hernandez-Davo, Botella, Navarro, & Tous-Fajardo, 2017).

Eccentric vs Concentric Training

Resistance training can be broken down into static or dynamic muscle actions. Where static muscle actions are actions where the muscle fiber is held at a fixed point, dynamic muscle actions contain both an eccentric and concentric phase (Roig et al., 2008). Through the Specific Adaptations to Imposed Demands principle (SAID), it can be determined that both eccentric and
concentric muscle actions provide different muscle stimulus, therefore resulting in different adaptations to said movement (Floyd & Thompson, 2009).

When comparing both eccentric and concentric muscle actions in isolation, it has been found that there several, distinct physiological differences between the two movements. Previous research has found that when compared to concentric muscle actions, eccentric muscle actions have been shown to have an inversed pattern of motor unit activation, increased cross-education effect, faster neural adaptations to resistance training, as well as a reduced EMG amplitude at similar force levels, but greater EMG signaling prior to movement (Horotobagyi et al., 1997; Carrasco, Delp, & Ray, 1999; Grabiner & Owings, 2002).

1RM Performance

Eccentric training has been shown to be more beneficial when focusing to improve strength and hypertrophy gains. When looking at hypertrophy improvements, Schoenfeld et al., (2017) found that there are significantly greater improvements to hypertrophy (p = 0.076) when comparing eccentric actions (10% increase) vs concentric actions (6.8% increase). Since maximal eccentric strength has been shown to be 20%-50% greater than that of concentric strength (Schoenfield et al., 2017; Bamman et al., 2001), when comparing eccentric only to concentric only training, where total repetitions are similar for both conditions, it can be speculated that eccentric only muscle actions will result in greater hypertrophic effects when compared to concentric only muscle actions. On the other hand, when total worked is matched for both concentric only and eccentric only muscles actions, it was still found that eccentric only muscle actions produce greater hypertrophic improvements; however, not all previous research has found this to be of statistical significance (Schoenfeld et al., 2017; Hawkins et al., 1999; Moore, Young, & Phillips 2012).
In regard to strength gain, it has been found that eccentric only training results in not only greater improvements to eccentric strength, but total strength as well when compared to concentric only training (Roig et al., 2008). In the same meta-analyses, a trend was found where concentric only training improves concentric only strength at a greater rate than eccentric only training, however these findings were not significant (Hortobagyi et al., 1996). In the same meta-analyses, greater total strength gains were seen when eccentric overload was used (Komi & Buskirk, 1972; Raue, Terpstra, Williamson, Gallagher, & Trappe, 2005; Vikne et al., 2006), and eccentric strength and peak torque increased significantly (Komi & Buskirk, 1972; Vikne et al., 2006) From this, it has been concluded that eccentric only training is superior to concentric only training when looking to improve total strength gains (Roig et al., 2008).

Overall, when comparing the differences between eccentric only and concentric only training, research has found that eccentric training performed at higher intensities resulted in greater increases in muscle mass, increased muscle cross-sectional area, as well as a greater increase in muscle strength (Roig et al., 2008). However, strength gains in eccentric training were found to be more specific in terms of mode of contraction as well as velocity. The observed superiority of eccentric training over concentric training is possibly due to the higher loads developed specifically during eccentric muscle actions.

**EMG Activity**

When comparing EMG activity between eccentric and concentric training, previous has research has found that eccentric training was also found to be highly specific to not only the mode of contraction (Morrissey, Harman, & Johnson, 1995), but the velocity of the muscle actions as well (Roig et al., 2008). When looking at improvements in total strength with eccentric training, the extreme specificity of eccentric muscle actions must be considered. When analyzing
EMG activity during eccentric overload bench press, it was found that there was significantly greater muscle activity during an eccentric overload of 110% of concentric 1RM (p < 0.01) (Ojasto & Hakkinen, 2009), but significantly lower muscle activity during an overload of 120% (p < 0.001). Ojasto & Hakkinen, 2009, also observed a slight positive trend in muscle activity for the pectoralis major as eccentric loading increased, however, muscle activity for the deltoid and triceps brachii remained relatively consistent. In the same study, concentric EMG activity was also found to have a slight positive trend for the pectoralis major and triceps brachii, but slightly lower EMG for the deltoid concentrically. Even when eccentric load was set as a percentage of concentric 1RM, meaning that the eccentric muscle actions being performed were not considered a MVC, eccentric only training was still shown to improve total strength at a greater rate than concentric only muscle actions (Crenshaw, Karlsson, Styf, Backlund, & Friden, 1995; Westing, Cresswell, & Thorstensson, 1991).

Eccentric Overload Training

As previously stated, bench press eccentric overload training related research is limited, with what is currently available contradicting one another. However, there is a wide range of EOT research concerning lower body exercise and the improvements that can be seen.

Lower Body EOT

Lower body related eccentric overload training has been heavily researched in the past. Friedmann-Better et al. (2010) found that eccentric overload training greatly improved squat jump performance compared to traditional training over the course of a 6-week intervention. It was concluded that this improvement was a result of the increased eccentric load, causing a shift towards a faster muscle type, as well as increasing power output and strength, making the muscle better equipped for explosive movements.
The same study also found that incorporating EOT resulted in a significant increase in IIx fiber cross-sectional area, and percentage of type IIa fibers expressing myosin heavy chain (MHC) IIx mRNA. It was concluded that relative improvements as a percentage gain were greater in EOT when compared to traditional concentric/eccentric training (Friedmann-Better et al., 2010), which aligns with previous studies (Norrbrand et al., 2008; Ahtiainen, Pakarinen, Alen, Kraemer, & Hakkinen, 2003). Norrbrand et al. (2008) found that after 5 weeks of eccentric overload training in individuals with little resistance training experience mean hypertrophy gains were approximately 6.2% in the eccentric overload group and only a 3.0% increase in the traditional training group, which aligns with previous research (Tesch, Dudley, Duvoisin, Hather, & Harris 2004). Eccentric overload training more than doubled hypertrophy gains between the two groups in only 5 weeks.

When observing surface EMG changes in lower body EOT, strength improvements over a 10-week EOT program significantly increased in proportion to significantly increased in muscle activation (Hortobagyi et al., 2001). Not only were these improvements significantly greater when compared to traditional training, it also appeared to occur at a quicker rate. Nichols, Hitzelberger, Sherman, & Patterson (1995) found that traditional training results in strength gains anywhere from 0.5% to 5% per session, while EOT was found to have a 2.8% increase per session for the first two weeks, followed by 1.2% increases per session for the remainder of the 14-week intervention in an untrained, elderly group. When looking at younger subjects, there was a 4.8% increase in strength per session, over a 10-week EOT intervention (Godard, Wygand, Carpinelli, Catalano, & Otto 1998), and a 3.8% strength increase per session found in middle-aged woman over a seven-day intervention (Hortobagyi et al., 2001). In the previously mentioned studies, EMG data was found to parallel increases in strength. These findings lead to
the prediction of a constant force to EMG ratio, meaning that as EMG activity and muscle force increases, the neural cost of force production remains constant (Hortobayi et al., 1996).

Munger et al. (2017) investigated the acute effects of eccentric overload training on 1RM front squat performance. This study recruited 21 recreationally trained individuals, tested their 1RM front squat, then randomly assigned subjects to 1 of 3 different groups, where the same test would be performed, but at eccentric loads set at either 105%, 110%, or 120% of subject’s concentric 1RM. While analyzing results, Munger et al. (2017) concluded that peak velocity, peak power, and peak ground reaction force, were significantly greater for all 3 eccentric overload groups when compared to baseline results. On top of these findings, an eccentric load set at 120% of concentric 1RM elicited the greatest results. These results were due to improvements in SSC, increased motor neuron recruitment, as well as an increased firing rate, all of which lines up with research previously conducted (Gorassini, Yang, Siu, & Bennett, 2002; Henneman, 1985).

**Upper Body EOT**

To date, only two studies have been published regarding eccentric overload and bench press. Doan et al. (2002) tested the immediate responses to an increased eccentric load on the bench press. Eight subjects were tested in changes to 1RM performance after eccentric hooks – with an overall eccentric load of 105% that of concentric 1RM – were added to a subject’s 1RM attempt. If the subject was able to successfully lift the weight, they were allowed to increase the concentric load by 5%. It was found that this additional eccentric loading had an immediate increase to subjects’ 1RM (from 97.44 kg to 100.57 kg). Ojasto & Hakkinen (2009) investigated eccentric overload and bench press, and tested acute neuromuscular, maximal force, and power responses to various eccentric loads at 100%, 105%, 110%, and 120% of concentric 1RM.
In the studied conducted by Doan et al. (2002), it was found that all subjects showed an immediate increase to their concentric 1RM after eccentric overload was introduced. Four possible explanations for this instant increase to 1RM are: increases in neural stimulation, recovery of stored elastic energy, contractile machinery alterations, and an increased preload (Doan et al., 2002). In line with previous research, Doan et al. (2002) concluded that the increase in neural stimulation is due to the body being “tricked” into thinking it is about to lift more than it will. However, these same studies have shown only a slight increase in EMG activity during these increased eccentric loads (Bobbert, Huijing, & Van Ingen Schenau, 1987). It is believed that the greatest contributor to the improved 1RM performance is because of the increased preload (Walshe, Wilson, & Ettema, 1998), as well as improvements to the Stretch-Shortening Cycle (SSC) (Cavanga, 1977).

The second bench press related eccentric overload study, conducted in 2009 by Ojasto & Hakkinen found that there were no significant changes to neuromuscular, maximal force, and power responses between any of the experimental groups, as well as the control. In fact, all experimental conditions decreased in concentric 1RM performance. Although previous research has concluded that an increased eccentric load improves concentric 1RM performance (Doan et al., 2002), Ojasto & Hakkinen (2009) current study stated the opposite. It is believed that these contradicting findings could be a result of differences in experimental design, equipment and range of loads used, velocity of lift, and trained status of subjects involved in the study. A study conducted by Doan et al. (2002) suggested that an enhanced training effect could be realized if eccentric overload is implemented as a component of a strength-training program and that a longitudinal training study is required to explore these possible benefits. However, there has yet to be a study conducted that has done this.
Hypothesis

As stated before, only two previous studies were identified that have explored incorporating eccentric overload into the bench press (Doan et al., 2002; Ojasto & Hakkinen, 2009). B only observed the immediate responses to implementing eccentric overload. Results from these studies contradict each other. To date, there have been no studies looking at the possible benefits of including EOT as a component of a strength-training program. Based on reviewed literature, we that after a 4-week EOT program, subjects’ strength levels, as measured by 1RM bench press, would increase significantly. Therefore, we hypothesized that incorporating a 4-week, eccentric overload bench press training intervention to an elite powerlifter’s training program, would begin to fill this gap in the literature. We also believed that rate of force development and velocity of the barbell during the concentric phase will increase when applying an eccentric load of 125% of maximal concentric strength. Furthermore, it is our belief that an EOT regimen will increase 1RM post-testing session muscle activation of the PM, AD, and TB. Hypothesizing that eccentric overload training may be a superior form of strength and power training for elite athletes.
Chapter 3: Methods

Experimental Approach

For this study, male and female powerlifters, between the ages of 18-38 years old were recruited to participate in the study. Subjects were considered for the study if they have been actively competing in powerlifting competitions for at least two years. All subjects went through a series of baseline testing and familiarization of the eccentric hooks. Fortunately, most powerlifters from Goliath Strength and Nutrition (a local powerlifting specialty gym) already have some familiarity using the eccentric hooks, so this time was spent to ensure proper form and safety measures are followed when using the hooks. Once all subjects were familiar and comfortable with using the eccentric hooks, 48-72 hours of rest took place before the experimental sessions begin. All subjects participated in all five training sessions. Based on subject’s baseline 1RM testing, the weight placed on the barbell remained consistent at 90% of each subject’s individual 1RM. The load placed on the eccentric hooks increased for each session, which represented 105%, 110%, 115%, 120%, and 125% of maximal concentric strength during the eccentric phase of the lift. After the initial baseline and familiarization session, the first training session began at an overload of 105%, and each session saw an eccentric load increase of 5%, until a max load of 125% was achieved. Following the completion of baseline testing and familiarization, all subjects begun the four-week bench press EOT, followed by a post-test session. After the subjects who met inclusion criteria are selected, the baseline and familiarization session took place. At this point, each subject determined their 1RM bench press, followed by a period of familiarization with the eccentric hooks. There was a total of five experimental sessions, each followed by at least 48 hours of rest. During the rest periods, the subjects were allowed to maintain their normal training schedule but asked to avoid
upper body lifts that may have affected the outcome of the study. After the completion of all five experimental sessions, another 48-72 hours of rest took place before the post-test session. The post-test consisted of subjects performing the 1-RM bench press test protocol mentioned before.

### Preparation for Recruitment.

The researcher has obtained IRB approval from the University of Texas at El Paso in order to recruit participants from the university. After IRB approval was attained, the researcher then met with the owner of Goliath Strength and Nutrition to help aid in informing and making athletes aware of the proposed study. Upon agreement with the owner, the researcher then spoke to the potential subjects to distribute consent forms and recruit participants. An informed consent form outlining the purpose and details of the proposed study was provided to those interested in participating.

### Subject Population

Eleven healthy, injury free powerlifters, between the ages of 18 to 38 years old were recruited to participate in the study. Participants were recruited from a local gym, Goliath Strength and Nutrition. To exclude possible confounding factors which could affect the results of the study, inclusion and exclusion criteria was established. No restrictions were placed on sex for
the purposes of this study. To have been considered for participation in the study, subjects must be between the ages of 18-38, with no major injuries (requiring surgery and/or physical therapy) within the last two years and have been actively participating in powerlifting for at least two years prior.

Actively participating in powerlifting is defined as having competed in multiple (2 or more) powerlifting competitions over the last two years, as well as training specifically for a powerlifting competition. Potential subjects had to meet a minimum strength criterion, with women being able to lift a minimum or 1.5x their body weight and men lifting a minimum of 2x their body weight (McLaughlin & Madsen, 1984). Participants were excluded from the study if they were not within the accepted age range, have recently recovered (within the last two years) from an injury, or do not have the required amount of experience (having competed in 2+ competitions over the last two years). All recruited subjects must not be in preparation for competition, as dietary changes, may affect performance.

Each subject’s training history was assessed in the form of a questionnaire. The questionnaire was made to determine level of powerlifting experience for each subject. For any subject, having no previous history of powerlifting was considered an exclusion criterion and was not accepted in the study. The questionnaire is in a checklist format asking the subject to provide a check mark for the number of times a week they engage in weight training, specifically powerlifting training. The subject received the questionnaire and filled out their activity level (preferably 3-5 days a week spent training). Subject were considered if they perform some type powerlifting training, with the intent of competing in powerlifting events.

During the 4-week intervention, subjects were asked to maintain their normal nutritional intake and hydration levels. Subjects were not allowed to introduce new supplements that may
alter their performance during the intervention and were asked not to consume alcohol during the 4-week program. Subjects who would begin cutting weight in preparation for a competition were also excluded from the present study. Before participation of the study began, each subject was given a written consent form, approved by the Institutional Review Board of the University of Texas at El Paso, which they signed to participate.

**Baseline Testing and Familiarization**

The assessment of upper body strength was obtained using a 1 RM bench press. Bench press form and performance was completed in compliance with the United States Powerlifting Association (USPA) standard competition rules. As part of their warm-up, participants lied supine on the bench, grasped the barbell bar with a close grip, and performed 10 repetitions with no weight added. After the 10 repetitions, the participants loaded a comfortable weight to perform 5-10 repetitions. After the warm up sets, the load was increased by 20% of the weight used on the first set and the subjects completed 2 -3 repetitions. After the 2 or 3 repetitions, the participants attempted the first 1 RM by increasing the load in the warm up set by 10% and 1 repetition was performed. If the participant was able to successfully lift the weight, the subject was asked if another repetition can be performed with weight increments of 5-10 lbs. To ensure the safety of the participants, three spotters were monitoring the participants and provided support when necessary during a failed attempt. There was a spotter at each end of the barbell, as well as a spotter directly over the subject to help with the lift-off of the barbell from the rack. The participants had a three to five-minute rest period between sets and 1RM attempts. This protocol has been safely used with trained and untrained individuals (Baechle, Earle, & Wathen, 2008).
Testing Procedures

All subjects that completed the baseline testing and familiarization with no cause for concern were then moved on to the training portion of the study.

Data Collection

Recruited subjects first reported to Goliath Strength and Nutrition to sign consent forms for the study, followed by anthropometric measurements (height and weight), and then their 1RM for bench press. Collected data included weight of the barbell for the given training session plus the weight added on from the eccentric hooks. The weights chosen for both the barbell and the eccentric hooks were based off each subject’s baseline 1RM bench press test. Surface electromyography of the pectoralis major (PM), anterior deltoid (AD), and triceps brachii (TB) were recorded for every set performed by the subject. Data was collected during every training session, as well as during the pre and post-test sessions.

Experimental Sessions

Each subject took part in all five of the experimental sessions. Before experimental sessions began, each subject took part in a general warm-up, followed by a specific warm-up to limit risk of injury. The first experimental session was set at 105% of concentric 1-RM strength during the eccentric phase, and 90% of concentric 1-RM during the concentric phase. Each subject completed 7 sets of one repetition at 105%/90% (eccentric/concentric respectively), with 3-5 minutes of rest between set. After completion of all seven sets, each subject completed a cool-down before finishing the session. The same protocol was used for the next four sessions, set at 110%/90%, 115%/90%, 120%/90%, and 125%/90% of concentric 1-RM strength respectively.
Surface Electromyography

Surface electromyography (EMG) (Noraxon Inc., Scottsdale, AZ, USA) was placed at the PM, AD, and TB using dual EMG electrodes 272s. Electrode placement was the same for both male and female subjects, with female research assistants having placed electrodes on the female subjects. The electrode for the PM was placed at the most superior part of the muscle on the medial sternum lateral to the supra sternal notch, one-third of the distance from the sternal notch and anterior axillary line (Korak, Paquette, Brooks, Fuller, & Coons 2017). Electrodes for the TB and AD were placed at the belly of the muscle, considered the standard site, roughly 50% of between the insert and origin of the muscle, (Kim, Ahn, Park, & Oh, 2019). Sampling rate was set at 1000 Hz and a band-pass filter of 20-450 Hz was used to filter the noise signal. The band-pass filters were set at similar frequencies used for previous studies that observed EMG activity during a bench press (Korak et al., 2017; Kim et al., 2019). A half-wave rectification of the signal was performed in order to avoid negative numbers from the raw data. Amplitude information was obtained using Root Mean Square (RMS) calculated at 250 ms (Korak et al., 2017). Data was then obtained from a standard report generated by the Myomotion Noraxon software.

Eccentric Hooks

Weight releasers, also known as eccentric hooks (Monster Grips Inc., USA), were hung from the barbell beside the weights already on the barbell. The hooks were designed to support extra eccentric loading and detach from the bar at the end of the eccentric phase, which allowed a lighter concentric phase to be performed. Hooks are adjustable, in order to accommodate an individual’s height and arm length, and to ensure full range of motion before the hooks detach themselves. These hooks were used to add the increased eccentric load during the bench press.
The weight placed on the barbell was equal to that of 90% of a subject’s 1-RM, with the remainder of the weight needed to achieve eccentric overload was placed onto the hooks.

**Bar Displacement and Velocity**

Bar displacement and velocity was recorded to determine rate of force development as well as concentric speed during the lift. This was recorded using PUSH Band 2.0 wearable device. The Push band sampling rate is set to 200 Hz, and measured data was recorded using the company’s mobile application on an iPad. The PUSH Band 2.0 accelerometer was placed on the end of the bar to avoid any contact with the subject or the eccentric hooks during the bench press.

**Statistical Analysis**

Data was collected on the Myomotion software system and Pushband portal, then exported to Microsoft Excel. Data was then exported to SPSS IBM 23 for statistical analysis. A normality test was conducted; a Shapiro-Wilk test, skewness and kurtosis levels were obtained. Paired t-test was used to show changes in 1RM bench press performance from pre to post-test, with data also being sectioned into gender, with percent changes shown. Data were non-normally distributed, hence, the non-parametric Friedman test for repeated measures was used; a post-hoc Dunn test was used to test for pairwise differences. A significance alpha level of 0.05 was used for all analyzes.
Chapter 4: Results

Eleven actively competing powerlifters were initially recruited (agreed to participate) for this study. Out of the initial 11 subjects who agreed to participate, only 8 completed the study. The other three subjects dropped out after the first eccentric EOT session. Because of this, these subjects were entirely excluded from the study. Due to the exclusion of the non-compliant subjects, data was analyzed for the eight powerlifters that completed the study. Descriptive statistics are shown in table 1 for all subjects.

Table 1. Mean ± standard deviation of anthropometric measurements of subjects

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Age (years)</th>
<th>Height (m)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>8</td>
<td>26.25 ± 4.13</td>
<td>1.66 ± 0.06</td>
<td>79.09 ± 6.38</td>
<td>25.58 ± 1.26</td>
</tr>
<tr>
<td>Male</td>
<td>5</td>
<td>25 ± 4.10</td>
<td>1.68 ± 0.05</td>
<td>82.54 ± 4.11</td>
<td>29.26 ± 1.13</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>28.67 ± 3.51</td>
<td>1.63 ± 0.06</td>
<td>73.33 ± 5.38</td>
<td>27.42 ± 0.1</td>
</tr>
</tbody>
</table>

1RM Performance

Paired t-test showed significant changes in 1RM bench press performance from pre to post from 116.62 ± 27.48kg to 124.28 ± 26.96kg with a mean percent change of 7.06 ± 4.15% (p = 0.001). Additionally, data was sectioned by gender; males and females showed significant improvements in performance from 135.20 ± 11.64 kg to 142.56 ± 10.82 kg, with a mean change of 5.49 ± 3.80% for men (p < 0.01), and females showed significant improvements in performance, from 85.5 ± 6.93 kg to 93.83 ± 9.17 kg, with a mean percent change of 9.66 ± 8.33% (p < 0.01).
Table 2. *IRM Pre to Post*

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Pre-1RM (kg)</th>
<th>95% CI (Lower-Upper)</th>
<th>Post-1RM (kg)</th>
<th>95% CI (Lower-Upper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>8</td>
<td>116.62 ± 27.48</td>
<td>93.65 - 139.60</td>
<td>124.28 ± 26.96*</td>
<td>101.74 - 26.96</td>
</tr>
<tr>
<td>Men</td>
<td>5</td>
<td>135.29 ± 11.64</td>
<td>120.84 - 149.75</td>
<td>142.56 ± 10.82*</td>
<td>129.13 - 155.98</td>
</tr>
<tr>
<td>Female</td>
<td>3</td>
<td>85.50 ± 6.93</td>
<td>68.28 - 102.73</td>
<td>93.83 ± 9.17*</td>
<td>71.04 - 116.62</td>
</tr>
</tbody>
</table>

*Denotes significant difference from pre to post (p < 0.05)

Figures 4 and 5 below illustrate 1RM changes from pre to post for the group and separated by males and females.

![Figure 4](image_url)  
*Figure 4. Group pre to post changes in 1RM Bench Press performance.  
*Denotes significant difference from pre to post (p < 0.05).
Electromyography

The non-repeated measures Friedman test was conducted to determine differences between the seven repetitions performed at 105%, 110%, 115%, 120%, and 125%. There was no significant difference between the repetitions at each of the conditions (p > 0.05). Thus, an average of the seven repetitions was used to compare muscular activation between conditions. Values were normalized by using % of the MVC using pre-test 1RM (Table 3). There were no significant differences in AD and TB at any of the overload conditions and Post 1RM (Figures 7 - 8) (p > 0.05). A significant difference between conditions at the PM was found (Figure 6); pairwise comparison indicated that PM activation was significantly decreased to 0.60 ± 0.15 % of MVC at the 125% condition (p = 0.049).
Table 3. Muscular Activation for all conditions using percentage of MVC values from pre-testing.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Pectoralis Major</th>
<th>Anterior Deltoid</th>
<th>Triceps Brachii</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>0.89 ± 0.20</td>
<td>0.89 ± 0.77</td>
<td>0.74 ± 0.17</td>
</tr>
<tr>
<td>110</td>
<td>0.76 ± 0.25</td>
<td>0.90 ± 0.51</td>
<td>0.68 ± 0.29</td>
</tr>
<tr>
<td>115</td>
<td>0.79 ± 0.26</td>
<td>0.88 ± 0.98</td>
<td>0.66 ± 0.16</td>
</tr>
<tr>
<td>120</td>
<td>0.82 ± 0.20</td>
<td>0.81 ± 0.58</td>
<td>0.61 ± 0.26</td>
</tr>
<tr>
<td>125</td>
<td>0.60 ± 0.15*</td>
<td>0.90 ± 0.90</td>
<td>0.62 ± 0.21</td>
</tr>
<tr>
<td>Post 1RM</td>
<td>0.97 ± 0.58</td>
<td>1.58 ± 2.10</td>
<td>0.80 ± 0.34</td>
</tr>
</tbody>
</table>

*Denotes significant difference (p < 0.05)

Figure 6. Muscular activation of the Pectoralis Major at different conditions and post testing using percentage of MVC.
*Denotes significant difference (p < 0.05)
Figure 7. Muscular activation of the Anterior Deltoid at different conditions and post testing using percentage of MVC.

Figure 8. Muscular activation of the triceps Brachii at different conditions and post testing using percentage of MVC.
Table 4. Mean and SD values obtained from PUSH Band 2.0 for each testing condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Force (n)</th>
<th>Power (w)</th>
<th>Velocity (m/s)</th>
<th>Acceleration (m/s²)</th>
<th>Concentric Duration (s)</th>
<th>Eccentric Duration (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre 1RM</td>
<td>2522.64 ± 647.17</td>
<td>511.35 ± 237.46</td>
<td>0.36 ± 0.10</td>
<td>6.42 ± 3.69</td>
<td>1.61 ± 0.93</td>
<td>1.13 ± 0.94</td>
</tr>
<tr>
<td>105</td>
<td>2348.00 ± 548.81</td>
<td>565.67 ± 212.00</td>
<td>0.40 ± 0.08</td>
<td>6.82 ± 3.33</td>
<td>1.44 ± 0.27</td>
<td>0.90 ± 0.42</td>
</tr>
<tr>
<td>110</td>
<td>2757.37 ± 793.61</td>
<td>702.02 ± 268.14</td>
<td>0.43 ± 0.08</td>
<td>8.74 ± 4.29</td>
<td>1.29 ± 0.18</td>
<td>0.84 ± 0.38</td>
</tr>
<tr>
<td>115</td>
<td>2422.46 ± 350.83</td>
<td>568.52 ± 165.68</td>
<td>0.40 ± 0.06</td>
<td>6.93 ± 4.85</td>
<td>1.26 ± 0.18</td>
<td>0.75 ± 0.28</td>
</tr>
<tr>
<td>120</td>
<td>2680.29 ± 583.92</td>
<td>644.16 ± 216.30</td>
<td>0.41 ± 0.06</td>
<td>8.54 ± 3.39</td>
<td>1.32 ± 0.23</td>
<td>0.76 ± 0.22</td>
</tr>
<tr>
<td>125</td>
<td>2457.24 ± 409.11</td>
<td>584.10 ± 178.62</td>
<td>0.40 ± 0.06</td>
<td>6.94 ± 2.77</td>
<td>1.33 ± 0.22</td>
<td>0.64 ± 0.23</td>
</tr>
<tr>
<td>Pre 1RM</td>
<td>2592.20 ± 497.84</td>
<td>639.07 ± 233.93</td>
<td>0.43 ± 0.10*</td>
<td>5.67 ± 2.08</td>
<td>1.22 ± 0.41</td>
<td>0.93 ± 0.61</td>
</tr>
<tr>
<td>Post 1RM</td>
<td>3411.03 ± 1715.67</td>
<td>698.88 ± 317.34</td>
<td>0.38 ± 0.08</td>
<td>9.99 ± 8.75</td>
<td>1.11 ± 0.68</td>
<td>1.06 ± 0.89</td>
</tr>
</tbody>
</table>

*Denotes significant difference (p < 0.05)
**Bar Displacement and Velocity**

The repeated measures Friedman test showed no statistical changes in Force (N), Power (w), Velocity (m/s), Acceleration (m/s²), concentric duration (s), or eccentric duration (s) (p > 0.05). Paired t-test showed a significant difference for baseline 1RM from pre to post-test (p = 0.02). Mean and Standard Deviation values for all variables are reported on table 4 (above) and figures 9-15 (below).

![Graph showing mean and standard deviation of force output for different conditions.](image)

**Figure 9.** Mean and Standard Deviation of force output (n) for each condition.
Figure 10. Mean and Standard Deviation of peak power (w) for each condition.

Figure 11. Changes in peak velocity (m/s) for baseline 1RM between pre and post-test.
*Denotes significant difference (p < 0.05)
Figure 12. Mean and Standard Deviation of Velocity (m/s) for each condition.

Figure 13. Mean and Standard Deviation of acceleration (m/s²) for each condition.
Figure 14. Mean and Standard Deviation of eccentric duration (s) for each condition.

Figure 15. Mean and Standard Deviation of concentric duration (s) for each condition.
**Chapter 5: Discussion**

**Summary of Literature, Purpose, and Hypothesis**

For powerlifters, bench press performance is directly related to success as it is one of the 3 main lifts performed during a powerlifting competition. For a powerlifter to be competitive, they must train efficiently, building strength as quickly as safely as possible. As it stands, 1RM bench press performance is one of the most common upper body tests performed by athletes (Chapman, Whitehead, & Binkert, 1998). In order to improve one’s 1RM, muscles should be trained equally between eccentric and concentric actions. However, previous research has found that eccentric strength is anywhere between 20-50% greater than that of concentric strength (Schoenfield et al., 2017; Bamman et al., 2001).

While performing bench press training, the load placed on the barbell is often set as a percentage of maximal concentric strength, or 1RM. When considering that eccentric strength can be 120-150% of concentric strength, it is apparent that eccentric stress placed on the muscles is not proportionally equal to concentric stress. Adding an additional mechanical load during the eccentric phase, known as eccentric overload, can amplify strength improvements when compared to concentric only muscle actions or coupled eccentric-concentric muscle actions (Norrbrand et al., 2008; Hotobagyi, Devita, Money, & Barrier, 2001; Brandenburg and Docherty, 2002).

Research related to lower-body EOT interventions has been thoroughly studied. Nichols, Hitzelberger, Sherman, & Patterson (1995), determined that traditional training resulted in strength gains anywhere from 0.5% to 5% per session, while EOT was observed to have a 2.8% increase per session for the first two weeks, followed by 1.2% increases per session for the remainder of the 14-week intervention in an untrained, elderly group. When observing younger
subjects, there was a 4.8% increase in strength per session, over a 10-week EOT intervention (Godard, Wygand, Carpinelli, Catalano, & Otto 1998). However, when researching upper-body EOT, the two published studies available have contradicting results. Doan et al. (2002), observed an immediate, significant increase (p = 0.008) in 1RM performance from 97.44 to 100.57 kg when an eccentric overload of 105% was added to 1RM testing. Ojasto & Hakkinen (2009), found that 1RM performance significantly decreased (p < 0.01) in all overload conditions (105%, 110%, and 120% of concentric 1RM). Because of these contradicting studies, as well as the lack of research observing the outcomes of an EOT bench press intervention, the current study is aimed to fill in these gaps in the literature.

The purpose of this proposed research was to investigate the results of a 4 week, EOT bench press mesocycle, on 1RM performance, maximal signal amplitude SEMG muscle activity, and rate of force development, as well as compared SEMG muscle activity and percentage of concentric maximal voluntary contraction (MVC) between several different eccentric loads (105%, 110%, 115%, 120%, and 125%). The primary goal of the proposed research was to determine if the findings of EOT and lower body exercises would be seen in upper body exercises, as well as determine if there is a percentage on concentric 1RM that will elicit the greatest SEMG activity and rate of force development. Pre- and post-testing results were measured to determine if eccentric overload is a viable option for bench press training. It was hypothesized that an EOT bench press intervention would significantly increase subject’s 1RM. The studied aimed to determine if the rate of force development and speed of the concentric phase of the lift would be greatest at an eccentric load of 125%, as well as determine if EOT will result in higher muscle activation during the re-test of subject’s baseline 1RM during post-testing. To our knowledge, the present study will be the first to implement a training
intervention involving EOT and observe the resulting changes. This was suggested based off previous research pertaining to EOT with lower-body exercises.

**Summary of Results**

Findings of this study only partially accept the working hypothesis. Subjects saw a significant increase of 7.06 ± 4.15% to their 1RM performance (p = 0.001), with males observing a significant increase to 1RM performance of 5.49 ± 3.80% (P < 0.01), and females observing a significant increase to 1RM of 9.66 ± 8.33% (p < 0.01). There were no significant differences in AD and TB during any of the overload conditions and Post 1RM. However, a significant difference between conditions at the PM, pairwise comparison indicated that PM activation was significantly decreased to 0.60 ± 0.15 % MVC at the 125% condition (p = 0.049). Additionally, baseline 1RM velocity significant increased from 0.36 ± 10 m/s to 0.43 ± 0.10 m/s (p = 0.02), however, rate of force development and speed of the concentric phase did not differ significantly from pre to post-testing (p > 0.05).

**1RM Performance**

Doan et al. (2002) observed immediate, significant increases to concentric 1RM performance (p = 0.008) when an eccentric overload of 105% of 1RM is incorporated to the bench press testing. An increase from 97.44 kg to 100.57 kg was observed when an increased eccentric load was introduced. It was believed that this increase was due to increases in neural stimulation, recovery of stored elastic energy, contractile machinery alterations, and an increased preload, with these results also being found in previous studies (Doan et al., 2002; Bobbert, Huijing, & van Ingen Schenau, 1987; Cavanga, 1977; Walshe, Wilson, & Ettema, 1998).

On the contrary, Ojasto & Hakkinen (2009) concluded that incorporating eccentric loads greater than 100% of concentric 1RM results in significantly lower 1RM performance.
Furthermore, the greatest significant decrease was found in the 120% eccentric load condition (p < 0.01). These findings directly contradict the conclusions of the previous bench press EOT study conducted by Doan et al. (2002), as well as previous lower-body EOT studies that found immediate increases to 1RM squat performance (Friedmann et al., 2004; Friedmann-Bette et al., 2010). However, it was noted that these conflicting findings may be a result of the study design and possible increased fatigue as a result from the protocol.

The current study observed that after five sessions of bench press EOT, with eccentric loads set at 105, 110, 115, 120, and 125% of concentric 1RM respectively, post-test 1RM performance increased significantly (p < 0.05) from 116.62 to 124.28 kg, with a mean percent change of 7.06%. When sectioned into gender, post-test 1RM increased significantly for both male and female groups (P < 0.05), with males increasing from 135.29 to 142.56 kg and women increasing from 85.50 to 93.83 kg respectively. These conclusions coincide with previous bench press EOT research conducted by Doan et al. (2002), as well as previous research pertaining to back squats and EOT (Douglas, Pearson, Ross, & McGuigan, 2018). While significant improvements to strength were observed, it is still unclear if this is a possible result of hypertrophy improvements or changes to the SSC.

**Electromyography**

To date, only one previous study sought to observe the acute effects of adding an increased eccentric load during a 1RM bench press (Ojasto & Hakkinen, 2009) on muscular activation of the PM, AD, and TB. The authors concluded that there were no significant differences in EMG activity of either the PM, AD, or the TB during the various phases of eccentric overload (105%, 110%, and 120%). These conclusions were also suggested by Korak et al. (2017) where EMG activity of the PM was found to have no significant differences when
comparing traditional and rest-pause bench press training. EMG signaling was set at a bandwidth of 10-10,000 Hz (Ojasto & Hakkinen, 2009), compared to previous research that used a band-pass filter of 20-450 Hz (Korak et al., 2017; Kim et al., 2019).

The current study conducted chose to set sampling rate at 1000 Hz and a band-pass filter of 20-450 Hz was used to filter the noise signal, it was concluded that there was no significant difference between the repetitions at each of the conditions (105%, 110%, 115%, 120%, 125%) (p > 0.05), thus, an average of the seven repetitions was used to compare muscular activation between conditions. There were no significant differences in AD and TB at any of the overload conditions and Post 1RM (p > 0.05). These conclusions line up with the accepted outcomes of previous published research regarding EMG activity and bench press EOT (Ojasto & Hakkinen, 2009). However, a significant difference between conditions at the PM (p = 0.046) was found, and pairwise comparison indicated that PM activation was significantly decreased to 0.60 ± 0.15 % of concentric MVC at the 125% condition (p = 0.049).

**Bar Velocity and Displacement**

To date, there is only one published study observing bar velocity and displacement following eccentric overload bench press. When researching acute changes to bar velocity when eccentric overload is introduced, Ojasto & Hakkinen (2009) observed no significant differences in either velocity, eccentric duration, or concentric duration, measured in seconds. This lines up with the results of the current study, where velocity, eccentric duration, and concentric duration did not show any statistical changes from pre to post-test (p > 0.05). It was also concluded that no statistical changes in force production, peak power, acceleration among any of the conditions (p > 0.05).
In summary, this study revealed that bench press EOT can improve 1RM performance and could possibly be used as a supplemental training method to be incorporated into a powerlifter’s training regimen. To date, this was the first study to observe the short-term training effects of adding EOT to the bench press. Previous research has only observed the acute effects, with conflicting results. Furthermore, this was the first study to track and observe changes to muscular activation of the PM, AD, and TB, as a percentage of baseline 1RM EMG activity, as well as compare the changes to baseline 1RM performance after implementation of a EOT bench press intervention.

Limitations

There are a few limitations relevant to the current research. Currently, sample size was small due to lack of available subjects. At least four more subjects should have been recruited in order to obtain stronger statistical power. Power analysis was calculated beforehand, and it was determined that at least 11 subjects are required. Another limitation was not collecting data on changes to body composition, specifically observing changes to fat-free mass. Although improvements to 1RM performance were observed, we are unable to determine if this is a result of improvements to muscle hypertrophy, improvements to the SSC, or possible changes to body kinematics during the bench press. Previous research has identified four possible categories explaining this increase in 1RM performance: increased neural stimulation, recovery of stored elastic energy, contractile machinery alterations, and an increased preload (Doan et al., 2002; Walshe, Wilson, & Ettema, 1998).

Subject fatigue and soreness are other limitations to consider. Although subjects were given 48-72 hours to recover, subjects were not used to the frequency of training heavy bench press two times a week, resulting in longer muscle soreness. Not only were subjects not used to
this increased frequency of heavy weight bench press, they were also not accustomed to the stress placed on the body at higher eccentric loads, which was made apparent at eccentric loads of 120%. Given that this is the first study to observe the effects of EOT bench press training, there was no previous research available defining proper training frequency for EOT or a previously tested range of eccentric loads that could ensure safe and effective training, with as little risk to injury as possible.

Finally, the exclusion of a control group is also a limitation to consider. Without the inclusion of a control group, we were unable to observe the possible changes that may be seen when compared to a group maintaining a traditional bench press training style.

Future Research

This study suggests that eccentric overload bench press training, through the use of eccentric hooks, could be used as a supplemental training method to further improve 1RM performance. However, we can only speculate that 1RM performance was improved from EOT possibly as a result from hypertrophy of the muscles observed (PM, AD, TB). Given that hypertrophy could be a possible factor contributing to improved 1RM performance, this can be used as the basis for future research. Additionally, due to the inherent high intensity of EOT, future research could limit training to one day a week, as well as extend the training intervention to 8-12 weeks, allowing for multiple sessions to take place at various percentages of overload. Another possible factor to consider, is to limit overload to 115% of maximal concentric strength, as subjects complained of the high stress placed on the shoulders at eccentric loads above 120% of 1RM. Future research should also incorporate a control group to be compared against, where they partake in the same intervention, however without the implementation of eccentric overload. Lastly, a larger sample size must be used provide more statistical power, possibly recruiting from
recreationally trained individuals, since access to a large number of powerlifters can be difficult to accomplish.

**Conclusions**

Results from the analysis of data for this study suggests that EOT bench press training may serve as an additional training modality to further improve 1RM bench press performance. Without knowledge of possible hypertrophy improvements, a limitation of this study, and while no statistically significant changes were found, subjects who completed the study saw an average of a 6.5% increase to their bench press 1RM. In addition, future research should include replication of this study with a longer training period, and with measurements of fat mass and lean mass changes.

**Practical Applications**

While eccentric training has been shown to be effective at strength development, eccentric overload bench press training can be implemented as an additional training method to further improve bench press performance.
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Appendix

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Instructions for consent form:

University of Texas at El Paso (UTEP) Institutional Review Board
Informed Consent Form for Research Involving Human Subjects

Protocol Title: The Effects of Eccentric Overload Bench Press Training on 1RM Performance and EMG Activity in Powerlifters

Principal Investigator: Gruber, Lance, B.S; Samuel Montalvo, M.S.; Dorgo, Sandor, Ph.D.

UTEP College of Health Science

1. Introduction

You are being asked to take part voluntarily in the research project described below. Please take your time making a decision and feel free to discuss it with your friends and family. Before agreeing to take part in this research study, it is important that you read the consent form that describes the study. Please ask the study researcher or the study staff to explain any words or information that you do not clearly understand.

2. Why is this study being done?

You have been asked to take part in a research study to determine the effects of eccentric overload bench press training on 1RM performance and muscle activity. Approximately, 14 subjects will be enrolling in this study as Goliath Strength & Nutrition. You are being asked to be in this study because you are an experienced powerlifter, who is healthy, with no signs of injury, and over the age of 18. If you decide to enroll in this study, your involvement will last seven hour-long sessions over the course of 4 weeks.

3. What is involved in the study?
If you agree to take part in this study, the research team will: require you to fill out a consent form, a general physical fitness questionnaire, and attend to a baseline/familiarization session (where 1RM will be determined), 5 training sessions, and a post-test session, for a total of 7 sessions. Your 1RM from baseline testing results will be used as the basis for determining the load to be placed on the bar and eccentric hooks. In each session you will be required to do a 5-minute general warm-up of light jogging followed by 10 minutes of specific warm-ups. Following the warm-up period, you will be tested in eccentric overload bench press using eccentric hooks. Thereafter and for every training session, the loads will be progressively increased for each training session (5% increase). Starting with an eccentric load of 105% of your 1RM, and a concentric load of 90% of your 1RM, each training session will see a 5% increase until an eccentric load of 125% is reached. Each session will see an eccentric load increase of 5%, while the concentric load will remain at 90%. During each session, electrodes will be placed on the chest (pectoralis major), shoulder (anterior deltoid), and triceps (triceps brachii) to record muscular activity during each lift. Video will be recorded of the lifts performed (i.e. arms/trunk) to identify movement during the exercise, however your face will not be included in the recording. This research will be held at Goliath Strength & Nutrition located at 6455 Hillet Suite 9, the research will start January 21 and will last for 4-weeks after that. The testing and training sessions will be held between 8:00am to 12:00pm and 2:00pm to 6:00pm.

4. What are the risks and discomforts of the study?

There are no known risks associated with this research. However, minor discomfort, including soreness, fatigue, muscle cramps or minor strains, may be resulted from the bench press training. There may also be some slight discomfort at the sites where electrodes are placed, however it will not interfere with the quality of exercise. The researches will strive to protect the subjects’ safety by providing supervision from qualified personnel. There are no known nonphysical risks associated with this study.

5. What will happen if I am injured in this study?

The University of Texas at El Paso and its affiliates do not offer to pay for or cover the cost of medical treatment for research related illness or injury. No funds have been set aside to pay or
reimburse you in the event of such injury or illness. You will not give up any of your legal rights by signing this consent form. You should report any such injury to Lance Gruber at (915) 329-1446 or ldgruber@miners.utep.edu and to the UTEP Institutional Review Board (IRB) at (915-747-7693) or irb.orsp@utep.edu.

6. Are there benefits to taking part in this study?

There will be no direct benefits to you for taking part in this study. This research may help us to understand how different stretching protocols affect the jumping ability of the gymnasts.

7. What other options are there?

You have the option not to take part in this study. There will be no penalties involved if you choose not to take part in this study.

8. Who is paying for this study?

This study is not funded.

9. What are my costs?

There are no direct costs. You will be responsible for travel to and from the research site and any other incidental expenses.

10. Will I be paid to participate in this study?

You will not be compensated for taking part in this research study.
11. What if I want to withdraw, or am asked to withdraw from this study?

Taking part in this study is voluntary. You have the right to choose not to take part in this study. If you do not take part in the study, there will be no penalty or loss of benefit.

If you choose to take part, you have the right to skip any questions or stop at any time. However, we encourage you to talk to a member of the research group so that they know why you are leaving the study. If there are any new findings during the study that may affect whether you want to continue to take part, you will be told about them.

The researcher may decide to stop your participation without your permission, if he or she thinks that being in the study may cause you harm.

12. Who do I call if I have questions or problems?

You may ask any questions you have now. If you have questions later, you may call Lance Gruber (principal investigator), at 915-329-1446 or by email at ldgruber@miners.utep.edu. If you have questions or concerns about your participation as a research subject, please contact the UTEP Institutional Review Board (IRB) at (915-747-7693) or irb.orsp@utep.edu.

13. What about confidentiality?

1 Your part in this study is confidential. Your individual information obtained from this testing session will only be known by the researcher(s). None of the information will identify you by name. All records will be kept on the UTEP campus in the researcher’s office in a locked cabinet and destroyed three years after completion of the research study. There will be no harmful use of the data collected in this study.

2. Every effort will be made to keep your information confidential. Your personal information may be disclosed if required by law. Organizations that may inspect and/or copy your research records for quality assurance and data analysis include, but are not necessarily limited to:
Because of the need to release information to these parties, absolute confidentiality cannot be guaranteed. The results of this research study may be presented at meetings or in publications; however, your identity will not be disclosed in those presentations.

14. Mandatory reporting

Not applicable.

15. Authorization Statement

I have read each page of this paper about the study (or it was read to me). I know that being in this study is voluntary and I choose to be in this study. I know I can stop being in this study without penalty. I will get a copy of this consent form now and can get information on results of the study later if I wish.

Participant Name: ___________________________ Date: ___________________________

Participant Signature: ___________________________ Time: ___________________________

Consent form explained/witnessed by ___________________________

Signature

Printed name: ___________________________

Date: ___________________________ Time: ___________________________
Health Status and Exercise Background Questionnaire

Please complete the following questions as accurately as possible.

Date of Birth: _____/_____/______  Age: _____ yr.

Weight: __________________  Height: _______________

Medical History

Is there any possibility that you are pregnant?  Yes  ☐  No  ☐

Please mark and date all surgeries you have had:

☐ Back  _____/______  ☐ Lung  _____/______
☐ Foot  _____/______  ☐ Shoulder  _____/______
☐ Joint  _____/______  ☐ Neck  _____/______
☐ Knee  _____/______  ☐ Heart  _____/______
☐ Ankle  _____/______  ☐ abdominal  _____/______
☐ Other  __________________  _____/______

Please mark all of the following for which you have been diagnosed or treated by a physician or health professional:

☐ Alcoholism  ☐ Emphysema  ☐ Kidney problems
☐ Anemia, sickle cell  ☐ Epilepsy  ☐ Liver disease
☐ Anemia, other  ☐ Eye problems  ☐ Lung disease
☐ Asthma  ☐ Gout  ☐ Mental illness
☐ AIDS  ☐ Hearing loss  ☐ Neck strain
☐ Back Strain  ☐ Heart problem  ☐ Obesity
☐ Bleeding trait  ☐ Heart murmur  ☐ Phlebitis
☐ Bronchitis, chronic  ☐ Hepatitis  ☐ Rheumatoid arthritis
☐ Cancer  ☐ High blood pressure  ☐ Stroke
☐ Cirrhosis, liver  ☐ Hypoglycemia  ☐ Thyroid problem
☐ Concussion # _____  ☐ High Cholesterol  ☐ Ulcer
☐ Congenital defect  ☐ Infectious mononucleosis  ☐ Other _____
☐ Diabetes  ☐ Joint problems  ☐ Neuromuscular disorders (multiple sclerosis, vertigo, cong. myasthenia, etc.)
Please mark all medications/supplements taken during the past 6 months:

- Blood thinner
- Diabetic
- Diuretic
- Insulin
- Epilepsy medication
- Heart medication
- High blood pressure medication
- Hormones
- Other

Please mark any of the following symptoms you have had recently:

- Abdominal pain
- Arm or shoulder pain
- Breathless with slight exertion
- Blurred vision
- Blood in urine
- Burning sensations
- Chest pain
- Cough up blood
- Difficulty walking
- Dizziness
- Feel faint
- Frequent urination
- Leg pain/numbness
- Low blood sugar
- Low-back pain
- Palpitation or fast heart beat
- Shortness of breath
- Significant emotional problem
- Swollen joints
- Unusual fatigue with normal activity
- Weakness in arms

Have you had any of the following injuries in the past 1 year?

- Pelvic
- Elbow
- Knee
- Lower back
- Neck
- Shoulder
- Leg
- Ankle
- Upper back
Exercise Behavioral Questionnaire

Have you been exercising regularly in the past 6 months?  □ Yes    □ No

Do you or have you ever been exposed to eccentric overload training?  □ Yes    □ No

What form of exercise do you engage in regularly?

- Resistance training (bench press, back squat, deadlift, etc.)  □
- Aerobic training (jogging, swimming, biking, etc.)  □
- Fitness classes (step aerobics, cross fit, kick-boxing, etc.)  □
- Recreational sport activities (basketball, soccer, tennis, baseball etc.)  □
- Other type of activities, please specify: _________________________

Do you engage in any competitive powerlifting events?  □ Yes    □ No

And if so please specify when your last competition was: _______________________

How many times a week do you perform power related resistance training?

□ 0 □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7

How long is your average exercise session? ________________

What is the average rest time in between your sets? ________________

Have you ever been ranked nationally/globally or held any records at the national/global level?  □ Yes    □ No

If yes to the previous question, please elaborate. _________________________________
Vita

Lance Dakota Gruber was born in El Paso, Texas. The last of four children of Rick and Tracy Gruber, he graduated from America’s High School, El Paso, Texas, in the spring of 2010 and enrolled at New Mexico Highland University in the fall of 2010 on an athletic and academic scholarship. Here, he played baseball as a pitcher and position player for two years, before an injury ended his athletic career. In the spring of 2012, he then transferred to the University of Texas at El Paso and pursued his bachelor’s degree in kinesiology, graduating in the spring of 2014. After earning his bachelor’s degree, he entered the University of Texas at El Paso’s Kinesiology graduate program in the fall of 2016 and was employed as a teaching assistant. During his graduate studies, he was awarded the Dodson Research Grant which help fund a follow-up study to a previous thesis project. In the near future, he plans to pursue a doctoral degree that focuses on strength and conditioning.

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