ASSESSING BENCH PRESS STRENGTH AFTER TRAINING WITHOUT THE BENEFIT OF VISION

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TRAINING WITHOUT THE BENEFIT OF VISION

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CHAPTER I

INTRODUCTION

Injuries and age lead to progressive declines in muscular strength and lean muscle mass. Evidence exists that age-related and injury related declines in muscular strength and lean mass (Feigenbaum & Pollock, 1999) can be impeded following mechanical stress on the body resulting in the form of resistance training. Recommendations made by the American College of Sports Medicine (ACSM) regarding the importance of resistance training (Kenney, 1995), has resulted in health professionals more frequently prescribing resistance training for adults as a component of overall wellness and fitness programs. People with injuries are also prescribed resistance training to return them to their pre-injury status (Kenny, 1995).

Resistance training is beneficial for everyone, from children to adults (Petranick & Berg, 1997; Feigenbaum & Pollock, 1999; Yu, Sung, So, Lui, Lau, Lam, & Lau, 2005; Brentano, Cadore, Da Silva, Ambrosini, Coertjens, Petkowicz, Viero, & Kruel, 2008; Dalleck, Borresen, Wallenta, Zahler , & Boyd, 2008; Malavolti, Battistini, Dugoni, Bagni, Bagni, & Pietrobelli, 2008; McGuigan, Tatasciore, Newton, & Pettigrew, 2009; Sgro, McGuigan, Pettigrew, & Newton, 2009). Strength training has been shown to significantly improve health compared to sedentary individuals (Dalleck, Borresen, Wallenta, Zahler, Boyd, 2008). Strength training programs have also been shown effective in helping obese individuals increase lean muscle mass, loose body fat and increase power and strength (McGuigan et al, 2009). Kids are not the only beneficiaries of strength training, older adults who strength train have been shown to increase bone mass and balance which prevents falls (Petranic & Berg, 1997). Moderate resistance training is considered a safe and effective means of enhancing protein synthesis and retards the normal age-related loss of muscle mass and strength (Hunter, McCarthy & Bamman, 2004; Macaluso & De Vito, 2004; McCartney, 1999; Reeves, Narici & Maganaris, 2004). Research has concluded that resistance training leads to decreased fat mass, increased muscle mass, bone density, power, strength and cardio-respiratory fitness (Yu et al, 2005; Brentano et al, 2008; Malavolti et al, 2008; McGuigan et al, 2009; Sgro et al, 2009).

A goal of resistance training is to increase muscular strength, and currently the method most often employed is progressive resistance. Progressive resistance tends to increase isotonic muscular strength over a 6-8 week period and accounts for muscle hypertrophy, neural adaptation and joint overload (Baechle & Earle, 2000). Novice lifters tend to use muscle overload as the only form of increasing strength. Muscle overload is achieved through consistently increasing the load placed on the musculature during strength training. However, this method does not account for increased load on the proprioceptory response, which has shown to increase isotonic strength (Ambrose, Taunton, MacIntyre, McConkey, & Khan, 2003).

Proprioception is defined as the ability of the body to know where the head and limb are located without having to look (Tortora & Derrickson, 2006). Proprioceptors are described as specialized sensory receptors located within joints, muscles, and tendons

(Bachle & Earle, 2000). These sensory receptors are sensitive to pressure and tension, and they rapidly relay information about muscular dynamics and limb movement to the conscious and subconscious ports of the central nervous system. Muscle spindles are a type of proprioceptors that provide sensory information about changes in muscle fiber length and tension of muscle fibers (Bachle & Earle, 2000; McArdle, Katch & Katch, 2001; Tortora & Derrickson, 2006). Another form of proprioceptors is Golgi tendon organs (GTOs), which detect the amount of tension generated by active muscle rather than muscle length (McArdle et al, 2001; Tortora & Derrickson, 2006).

Weight lifters primarily use progressive mechanical overload and achieve this through either, linear or non-linear periodization or non-periodization (Buford, Rossi, Smith & Warren, 2007), whether training 2-3 times a day (Candow & Burke, 2007) using 1 or more sets (Rhea, Alvar, Ball, & Burkett, 2002). Progressive mechanical overload is the theory of progressively increasing the mechanical load on the muscle to increase strength gains. The objective of these sets and repetition manipulations are an attempt to increase neuromuscular activation and eventually increase muscle hypertrophy (Baechle & Earle, 2000).

It is suggested that early increases in strength are attributed to neural adaptations (Mortini & DeVries, 1979; Hakkinen, Kallinen, Linnamo, Pastinen, Newton, & Kraemer, 1996; Baechle & Earle, 2000; Hakkinen, Alen, Kallinen, Newton, & Kraemer, 2000; McArdle et al, 2001; Hakkinen, Alen, Kraemer, Gorostiaga, Izquierdo, Rusko, Mikkola, Hakkinen, Valkeinen, Kaarakainen, Romu, Erola, Ahtainen, & Paavolainen, 2002; Brandenburg & Docherty, 2002; Ahtianen, Pakarinen, Alen, Kraemer, & Hakkinen, 2003; Valkeinen, Hakkinen, Pararinen, Hannonen, Hakkinen, Aiaksinen, Niemitukia, Kraemer, & Alen, 2005), and after motor learning has occurred an increase in cross-section area of the muscle may be the reasons behind increases in strength (Moritan & DeVres, 1979; Lexell, 2000; Hakkinen, 2000; Ahtiainen et al, 2003; Valkeinen et al, 2005; Hurley, Redmond, Pratley, Treuth, Rogers, Goldberg, 2008). These initial increases in strength are attributed to neuromuscular adaptation in the form of kinesthetic learning, inhibition of certain neuroreceptors and changes in other neuroreceptors.

Strength training outcomes are very different between genders. During sexual maturation, boys develop greater muscle mass than girls due to hormones therefore leading to greater increases in strength (Bale, Mayhew, Piper, Ball & Willman, 1992; Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman & Hikida, 1994). Men tend to have greater increases in absolute strength comparative to women (Heyward, Johannes-Ellis, & Romer, 1986; Miller, MacDougall, Tarnopolsky & Sale, 1992; Mayhew, Bemben, Bemben, Piper, Rohrs, Salm, 1994; Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman & Hikida, 1994; Lemmer, Hurlbut, Martel, Tracy, Ivey, Metter, Fozard, Fleg & Hurley , 1999; Delmonico, Kostek, Doldo, Hand, Bailey, Rabon-Stith, Conway, Carignan, Lang, & Hurley, 2005; Walts, Hanson, Delmonico, Yao, Wang & Hurley, 2007), whereas relative strength gains in both sexes are very similar (Heyward et al, 1986; Mayhew et al, 1994; Delmonico et al, 2005; Walts et al, 2007).

Joint injuries result in a decrease in proprioceptory reception in the injured joint (Freiwald, 1993; Van Der Esch, Steultjens, Harlaar, Knol, Lems & Dekker, 2007)). There is a loss of proprioception and nocioceptors which leads to motor coordination problems in injured joints (Freiwald, 1993; Van Der Esch et al, 2007). By training the proprioceptors in those injured joints, there is an increase in coordination of appropriate muscle firing patterns during functional activities without conscious awareness (Ambrose et al, 2003). A greater change in isotonic strength is found with patients who participate in proprioceptive training than strength training (Ambrose et al, 2003). Strength training in an unstable environment lead to increased proprioceptory reception which also resulted in increased isotonic strength (Trans, Aaboe, Henriksen, Christensen, Bliddal, & Lund, 2009).

Vision loss is shown to increase proprioceptory responses in the lower extremities as seen in several balance studies (Ambrose et al, 2003; Elliot, Patla, Flanagan, Spaulding, Rietdyk, Strong & Brown, 1995).This increased proprioception is credited to the body's response to the vision loss in order to help the body stabilize and balance itself during vision loss (Brown, Rosenbaum, & Sainburg, 2003; Lord & Menz, 2000; Lord, Russell, & Webster, 1991). Therefore, with loss of vision, there is an increase in proprioceptory reception in selected tasks, and an increase in proprioceptory reception leads to an increase in isotonic strength.

A predictor of isotonic strength is the one-repetition maximum (1-RM). A one-repetition maximum is defined as the ability of muscle to shorten and lengthen under control with the load that is put upon it (Baechle & Earle, 2000). One-rep max is calculated by progressively increasing resistance on the lifter until the person can no longer complete a repetition (Baechle & Earle, 2000). Determining a1-RM may be difficult and unsafe for untrained individuals. It is unsafe to take an untrained individual to a 1-RM to determine maximal strength because it may lead to injury (Mayhew, Ball, Arnold & Bowen, 1995). Accuracy of 1-RM is also questioned, since performing a 1-RM requires concentration and entails considerable mental preparation by the lifter. It is difficult for novice lifters to master this approach, since they are unaccustomed to the insecurity of handling heavy loads, inadequate spotting assistance, and fear of failure (Mayhew et al., 1995). To avoid these problems of determining 1-RM, numerous 1-RM prediction equations using repetitions to fatigue (RTF) with sub maximal weight have been developed and tested with both males and females (Wood, Maddalozzo & Harter, 2002).

There are many resistance training exercises, and the bench press is a resistance training exercise that applies a load on the upper extremity (Baechle & Earle, 2000). The bench press exercise is performed when the subject is lying supine on a bench in a five-point body contact position and a barbell is then lifted from a rack, lowered to the chest and pushed up until the elbows are fully extended. The five-point body contact position requires that the subject have the back of the head, upper back/shoulders and lower back/buttocks firmly placed on the bench and both feet should be in constant contact with the ground (Baechle & Earle, 2000).

Problem Statement

Current protocols for increasing isotonic strength call for joint overload and do not place much emphasis on neuromuscular adaptations and their effects on loads that can be lifted by an individual. Reducing or eliminating vision increases proprioceptive response in muscles in order to stabilize the joints that have a load placed upon them. Given that eliminating vision may increase proprioceptive response in muscles (Mittelstaedy, 1997; El-Kahky et al, 2000), and an increase in proprioception in muscles may also increase strength (Friewald, 1993; El Kahky et al, 2000; Ambrose et al, 2003), one can deduce that strength training while eliminating vision will increase strength. Therefore, it would seem that there a significant change in 1-RM on the bench press among novice lifters training with eyes closed would increase proprioception and strength compared to those who train with their eyes open.

Purpose of Study

The purpose of this study was to compare the proprioceptive system's contribution to strength gains in novice lifters training with and without the benefit of visual input and to determine if one group gained more strength than the other.

Definition of Terms

1-RM (repetition max)- A one repetition maximum is defined as being able to concentrically lift an object until the muscle is unable to lift the load.

Balance control- The ability of the body to maintain equilibrium in relation to its position

Bench press- Upper-body exercise performed when the subject is lying supine on the bench, and bringing a mass down to their chest and then pushing the mass back up till the arms are straight.

Isotonic strength- the maximal force that a muscle or muscle group can generate at a constant velocity.

Joint overload- Increasing the weight supported by the joints in question.

Kinesthesia- Used interchangeably with proprioception

Load- The weight supported by the body

Muscle-overload- Increase in load placed on the muscle.

Nociceptors- A sensory receptor that responds to pain.

Novice weight lifters- People who currently strength train, but have never competed in strength competitions.

One-repetition maximum- The maximal amount of mass an individual is able to lift once in a controlled manner.

Overload Principle- Principle of overload states that a greater than normal stress or load on the body is required for training adaptation to take place. The body will adapt to this stimulus. Once the body has adapted then a different stimulus is required to continue the change. In order for a muscle, including the heart to increase strength, it must be gradually stressed by working against a load greater than it is used to.

Periodization- Periodization is the process of structuring training into phases or cycles.

Progressive Training- Progressive training is defined as training which is sequenced to require increased levels of performance proficiency.

Proprioception- The unconscious perception of movement and spatial orientation arising from stimuli within the body itself. In humans, these stimuli are detected by nerves within the body itself as well as by the semicircular canals of the inner ear..

RTF- Repetitions to failure, used when lifting sub-maximal weight.

Assumptions

- It was assumed that none of the participants were using performance enhancing drugs or any other form of supplements.

- It was assumed that the only time the subjects spent strength training was with the researcher.
- It was assumed that none of these subjects had any muscular diseases which prevent them from increasing strength.
- It was assumed that the subjects exerted maximum effort while training and testing. Subjects were encouraged by the instructor to exert maximum effort.

Significance of Study

With significant outcome, this study may change the view of strength training blindfolded. If strength training without the benefit of vision can significantly increase strength over training with the benefit of vision, the strength and conditioning coaches will have a new resource to employ and a new door will be opened for further research. This method could also reduce injury risks in novice lifters, as they attempt to overload their joints with mass that they cannot lift safely. Novice lifters tend to ignore neuromuscular adaptations and tend to increase mass to overload joints. If this method of strength training is proven effective, novice lifters may actually use lighter weights in their strength training routine.

Limitations of Study

- This study cannot be generalized to all individuals since participants in this study tend to be individuals who normally participate in physical activity.
- The study used the bench press as a measurement tool. The bench press is a field test and therefore does not detect subtle changes.

- Human motivation is subjective and cannot be measured during testing or administration of the treatment.
- Due to time constraints the treatment was administered for a period of 6 weeks, instead of the 6-8 weeks suggested in the literature.

Delimitations of Study

- The subjects for this study were recruited from a large, Midwestern university.
- The subjects were relatively healthy, college-age men and women.
- The subjects in this study were limited to the students enrolled in the weight training class in the University recreation center.
- The subjects were required to have had one year or less of weight lifting experience. Subjects who had previously lifted regularly, but had not done so in the past six months were also eligible for this study.

Organization of Study

The introduction of this study offers background information on the subject and outlines the context of the problem being investigated. This area being a relatively unexplored field, the review of literature was conducted on studies that focused on parts of the problem at hand. The following sections outline the literature relevant to this study as well as outlining the selection of the population and sample. A detailed procedure of how this study was conducted and data analysis of this study are also presented.

Hypothesis

Training without the benefit of sight may lead to increased proprioceptive responses that may, in turn lead to increased strength gains, as evidenced by some of the studies conducted on injured joints. If some subjects were trained visually impaired and other trained with the use of their vision, the two groups may see differences in strength.

Hypothesis 1- Since there is no literature supporting increases in strength while training visually impaired, it is hypothesized that there will be no differences between the increases in 5-RM between the two groups.

Hypothesis 2- Since there are no differences in relative strength gains between genders, there will be no difference between genders in the 5-RM test between the group training with the benefit of vision and the one training without the benefit of vision.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this review of literature is to introduce studies related to this proposed study. Since the field is relatively un-explored, the literature supports the theories behind this proposed study. The literature will summarize, skeletal muscle and muscle contraction; role of proprioception, vision and vestibular influence on movement; definition and measurements of strength; adaptation to strength training: hypertrophy and neuromuscular adaptation; gender differences; ways to increase strength; recommended time-frame for increasing strength; vision loss and increased proprioception; proprioceptive training and strength; motor learning and motivation.

Skeletal Muscle and Muscle Contraction

The human body has three types of muscle tissue, cardiac, smooth and skeletal. Only the heart contains cardiac muscle tissue, which forms most of the heart wall. Smooth muscle tissue is located in the walls of hollow internal structures such as blood vessels, under skin attached to hair follicles, airways and most organs of the abdominopelvic cavity. Skeletal muscle tissue is the muscle that moves bones in the skeleton (Tortora & Derrickson, 2006, Rogers, A. 1992). Skeletal muscle tissue is striated and is usually contracted in a voluntary manner. Activity in the skeletal muscle is consciously controlled by the neurons (nerve cells) that are part of the somatic (voluntary) division. However, most skeletal muscles are controlled subconsciously, such as the musculature required for stability of one's posture (Rogers, A., 1992; Tortora & Derrickson, 2006).

Skeletal muscle when stimulated can contract up to 30% of its resting length at full contraction (Rogers, A., 1992). Each sarcomere in a muscle fiber contracts synchronously thus causing very rapid contraction and relaxation. Full contraction can cause rapid conversion of energy stores to metabolites in muscle fibers, therefore fatigue sets in and the inability to maintain the expected contraction sets in (Rogers, A., 1992). However, the actual mechanism of muscle fatigue is unknown (Tortora, Derrickson, 2006). It suggested that fatigue may set in due to metabolic acidosis, or lactic acid build up caused by a breakdown in glycogen (Neptune, McGowan & Fiandt, 2009), induced alterations in levels of Central Nervous System (CNS) neurotransmitters that cause a muscle to contract (McArdle et al, 2001), lack of oxygen and increase lactate level in the blood (Neptune et al, 2009; McArdle et al, 2001), or failure in Neuro-Muscular Junction (NMJ) action potential (McArdle et al, 2001).

A single motor neuron stimulates multiple muscle fibers and causes them to contract simultaneously. However, several motor neurons together cause the contraction of several muscle fibers which form a motor unit (Rogers, A., 1992; Tortora & Derrickson, 2006). The motor unit controls a specific movement pattern, such as moving an eye to straightening a leg, with movements that require precise movements having smaller motor units (Rogers, A., 1992).

Force output of a muscle varies over a wide range and is dependent upon the movement in question and the smooth, coordinated pattern of movement necessary to perform that particular movement. Muscular force can be graded in two ways, frequency of activation and recruitment. Frequency of activation is how frequently the motor unit is activated to summate and produce a force, while recruitment is the number of motor units activated to produce a movement (Baechle & Earle, 2000; McArdle et al, 2001).

If a motor unit is activated once, the twitch produced by the activation of that motor unit does not generate great force. However, by increasing the frequency of activation so that the charge summates is able to generate greater force (Bachle & Earle 2000; McArdle et al, 2001; Tortora & Derrickson, 2006). This type of summation of motor unit activation results in force being generated in smaller muscles such as those in the hand and feet. Another activation pattern that is identified in human movement occurs during recruitment of large muscles in movements that would require a sizable number of frequencies when called upon. Instead these large muscles recruit several additional motor units to increase force output. The type of activation and motor unit activated depends on the type of movement that is to be performed (Bachle & Earle 2000; McArdle et al, 2001).

The coordination of movements and postural stability in a smooth and controlled manner is a complicated matter, consisting of coordination of specific firing patterns of small (fine) motor units and large (gross) motor units (Brown et al, 2003). Some of these control movements are generated subconsciously, while others are conscious (somatic) decisions (Rogers, A., 1992; Tortora & Derrickson, 2006). Somatic movement control requires information on the force being generated within the muscle and the degree of muscle shortening, the relative position of the bones and joints involved and the rate of change of position (Rogers, A., 1992). This information comes from three primary sources, the vestibular, proprioceptory and visual systems (Purves, Augustine, Fitzpatrick, Kats, LaMantia, McNamara, 1997).

Vestibular, Proprioception and Visual Systems

The peripheral part of the vestibular system is a part of the inner ear that works as a miniature accelerometer and inertial guidance device. This portion of the vestibular system continually reports information about the motion and positions of the head and the body to the brainstem and cerebellum, which are the integrative centers (Purves, Augustine, Fitzpatrick, Katz, LaMantia & McNamara, 1997). The vestibular system is a key component of the production of motor responses that are critical for function and survival (Haines, 1996). Vestibular system is a key component in eye movements and postural reflexes. If the vestibular system is damaged, balance, control of eye movements when the head is moving, and the sense of orientation in space are affected (Purves, et al, 1997).

Proprioception senses allow one to know where the head and limbs are located and how they are moving without having to look at them (Tortora & Derrickson, 2006). Proprioceptors are specialized sensory receptors located within joints, muscles, and tendons (Bachle & Earle, 2000). These sensory receptors are sensitive to pressure and tension, and rapidly relay information about muscular dynamics and limb movement to the conscious and subconscious ports of the central nervous system. Muscle spindles are a type of proprioceptors that provide sensory information about changes in muscle fiber length and tension of muscle fibers (Bachle & Earle, 2000; McArdle et al, 2001; Tortora & Derrickson, 2006). Another form of proprioceptors are Golgi tendon organs (GTOs), which detect the amount of tension generated by active muscle rather than muscle length (McArdle et al, 2001; Tortora & Derrickson, 2006).

Muscle spindles provide information concerning muscle length and the rate of change in the length. Spindles indicate the degree to which the muscle can be activated in order to overcome a given resistance (Rogers, 1992; Bachle & Earle, 2000). Muscle spindles in postural muscles continuously receive neural input to maintain their readiness to respond to conscious movement. These postural muscles require continual feedback to adjust to the pull of gravity (McArdle et al, 2001). As load increases, the muscles are stretched to a greater extent and engagement of muscles which results in greater activation of muscle (Bachle & Earle, 2000).

Golgi tendon organs are activated when tendon attached to an active muscle is stretched. The discharge of GTOs increases as the tension on the muscle increases (Bachle & Earle, 2000). When stimulated by extensive tension, the GTOs conduct their signals rapidly to the spinal cord to elicit a reflex inhibition for the muscle they supply. Excessive change in muscle tension increases GTO release, which depresses motor neuron activity and reduces force output (McArdle et al, 2001). The Golgi tendon organ acts as a protector of muscles and connective tissue to prevent injury (Bachle & Earle, 2000; McArdle et al, 2001; Tortora & Derrickson, 2006). With training, the GTOs can be inhibited which results in output of greater force (Bachle & Earle, 2000; McArdle et al, 2001).

The visual system provides the body with a map of the movement and the ability to locate and relocate the body in space. It provides information regarding the flow movement of the environment, changes in retinal disparity, image size and position (Elliot et al, 1995). Visual source is usually considered the most dominant source of feedback in a movement and when all sources of information for a movement are available vision is still the most trusted (Davlin, Sands & Shultz, 2002).

Together, the proprioceptive system provides one's body with the local information about stress placed on one's body, which is supplemented by visual data, as one's eyes confirm the position of one's limbs. This information is further supplemented by input from one's vestibular system, or inner ear informing one of the position and acceleration of the head relative to the earth's gravitational field.

Definition and Measurements of Muscle Strength

Muscle strength may be defined as the maximum force or tension generated by a single muscle or related muscle group (Baechle & Earle, 2000; McArdle et al, 2001). Muscle strength may be measured in four commonly used methods, tensiometry, dynamometry, one-repetition maximum and computer-assisted force and power output determinations (McArdle, et al, 2001). However, when determining how much weight a person should use during exercise, a percentage of 1 rep max (RM) is used (Mayhew, Ball, Arnold, & Bowen, 1995).

Determining the 1-RM may be difficult and unsafe for untrained individuals. It is unsafe to take an untrained adult to a 1-RM to determine maximal strength because it may lead to injury (Mayhew et al, 1995). Accuracy of 1-RM is questioned, since performing a 1-RM requires concentration and entails considerable mental preparation by the lifter. It is difficult for novice lifters to master this approach, since they are unaccustomed to the insecurity of handling heavy loads, inadequate spotting assistance, and fear of failure (Mayhew et al., 1995)

To avoid these problems of determining 1-RM, numerous 1-RM prediction equations using repetitions to fatigue (RTF) with sub maximal weight have been developed and tested with both males and females (Wood, Maddalozzo & Harter, 2002). Researchers have tested these equations almost exclusively on free-weights particularly on the bench press and squat (Wood et al., 2002). Therefore, to determine which formula to use in order to begin this research, one must evaluate the equations that have been developed and determine which equation is best for predicting 1-RM. Several research studies have been performed to determine the accuracy of the different 1-RM equations (Wood et al., 2002). Therefore, any of the formulae may be used to determine a 1-RM.

The studies for 1-RM equations were similar and there were no statistical differences between the seven 1-RM equations selected in the studies (LeSuer et al., 1997). All seven of the equations showed similar means and were fairly similar in their correlations. Therefore, any of the equations may be used to determine the 1-RM of subjects in a study. The equation 1-RM= ((number of repetions/30) + 1) x weight was one of the equations used by LeSuer and associates.

Adaptation to Strength Training: Hypertrophy and Neuromuscular Adaptation

It is suggested that in early stages of strength training, neural adaptations account for primarily most of the strength gains (Mortini & DeVries, 1979; Hakkinen et al, 1996;

Baechle & Earle, 2000; Hakkinen et al, 2000; McArdle et al, 2001, Hakkinen et al, 2002; Brandenburg & Docherty, 2002; Ahtianen et al 2005), and after motor learning has occurred an increase in cross-section area of the muscle may account for the increase in strength (Moritan & DeVres, 1979; Lexell, 2000; Hakkinen, 2000; Ahtiainen et al, 2003; Valkeinen et al, 2005; Hurley et al, 2008). The initial increases in strength are attributed to neuromuscular adaptation in the form of kinesthetic learning, inhibition of certain neuroreceptors and changes in neuroreceptors. After the initial neuro-muscular adaptation, changes in cross-sectional area of the muscle are witnessed, and are attributed to an increase in hormonal response (Ahtainen et al, 2003; Valkeinen et al, 2005).

It is suggested that in the first 3-5 weeks of strength training neural adaptations occur after which muscle hypertrophy takes place (Moritani & DeVries, 1979). Strength training in untrained individuals leads functional and structural adaptations in the neuromuscular system (Ahtainen et al, 2003). It is suggested that this neural adaptation occurs due to voluntary neural activation of proprioceptors and reduced co-activation of antagonists (Hakkinen et al, 1996; Hakkinen et al, 2000), and optimized activation of synergists and agonists (Hakkinen et al, 1996; Brandenburg & Docherty, 2002). Even in trained individuals progressive increase in loading intensity and periodization leads to increased neuromuscular adaptation (Hakkinen et al, 2003). After a few weeks of training increases in muscle cross-sectional area are suggested to be a contributing factor to the increase in strength (Lexell, 2000).

Gender Differences

Prior to sexual maturation, females and males are similar in athleticism and strength (Malina, Bouchard, & Bar-Or, 2004). However, after sexual maturation, women tend to gain more fat mass comparative to muscle mass and men tend to gain more muscle mass. During maturation girls tend to increase their body-fat due to breast development and boys increase more lean body mass (Bale et al, 1992) . This difference can be explained by the increase in estrogen to testosterone level in women and the increase in testosterone levels in men (Bale et al, 1992; Bachle & Earle, 2000; Malina et al, 2004). Post-pubescent females also tend to have smaller bi-acromial to bi-cristal ration comparative to men, and men also have greater absolute bi-acromial and bi-cristal size (Malina et al, 2004). These differences in hormonal and skeletal structures are attributed to a woman's need to reproduce as dictated by evolution.

These genetic differences in men and women lead to men having greater absolute strength than women (Heyward et al, 1986; Miller et al, 1992; Mayhew et al, 1994; Staron et al, 1994; Lemmer et al, 1999; Delmonico et al, 2005; Walts et al, 2007), however, when it comes to relative strength women and men are very similar in their gains (Heyward et al, 1986; Mayhew et al, 1994; Delmonico et al, 2005; Walts et al, 2007). These differences in absolute versus relative strength gain is suggested to be attributed to men's increased testosterone levels (Staron et al, 1994), cultural division between gender (Mayhew et al, 1994), greater muscular hypertrophy (Delmonico et al, 2005) and differences in neural adaptation (Lemmer, et al, 1999). It is also suggested that women are less likely to apply themselves thus resulting in less absolute strength comparative to men (Mayhew et al, 1994).

Weight Training Programs

For strength gains to be maximized throughout a training period, it is important to optimize physiological strain. This may be achieved through a periodic alteration in training load, which may lead to optimized physiological strain, thereby producing greater increments in muscle strength than a program with constant load training (Montier, Aoki, Evangalista, Alveno, Montiero, Picarro, & Ugrinowitsch, 2009). Periodic alterations, or periodization is used by weight lifters everywhere to optimize strength gains. There are two popular models of periodization, linear and non-linear.

Linear periodization breaks down training into macro and micro cycles and is the progressive reduction of training volume and the increase of intensity. Non-linear periodization is defined as the reduction of intensity and the increase of training volume (Prestes,De Lima, Frolling, Donatto, & Conte, 2009). Several studies have been conducted on the effectiveness of both linear and non-linear periodization training and whether non-periodizaton works best for increasing strength gains.

Prestes and associates (2009) concluded that linear periodization worked best for increasing strength gains compared to non-linear periodization, whereas Buford and associates (2007) concluded that there was no difference in periodization models. When trained subjects were measured, non-linear periodization worked best to increase strength (Monteiro et al, 2009). However with untrained individuals there was no difference in the type of periodization training that was conducted (Willoughby, 1993; Baker, Wilson, & Carlyon, 1994; Monteiro et al, 2009). Periodization was found to be a better way of increasing strength than non-periodized models (Fleck, 1999). Another train of thought when it comes to increasing strength is that the total repetition and volume affect strength increases much more than manipulation of sets, however the same study claims that over-training and injuries can be avoided using a periodized model (Herrick & Stone, 1996). Using periodization models, significant strength increases were recorded in as little as 6 weeks (Rhea, et al 2002).

Using a periodized model, Candow and Burke (2007), conducted a study to see whether 2 or 3 times a week of training was more suitable for increasing strength. Their study concluded that there was no difference in strength over a 6 week period whether one trained 2 or 3 days per week. Although there was no significant difference in strength training in the number of days per week, a significant difference was recorded between training using 3 sets versus 1 set. While training using 3 sets a 30% increase in strength was recorded, whereas training using 1 set lead to only a 13% increase in strength (Rhea, Alvar, Ball, & Burkett, 2002). This variation in increases in strength may be attributed to either motor learning or greater volume of training when using 3 sets (Rhea, Alvar et al, 2002).

. The National Strength and Conditioning Association (NSCA) recommends that individuals who are trying to increase strength must perform 3 sets of 6-8 repetitions of the exercise that is being targeted for an increase in strength, with progressive increases in weight. Recommendations also include resistance training for 6-8 weeks for maximal physiological adaptations to this training. It is also recommended to strengthen all muscles in the upper extremities, including the agonists, antagonists and synergists to experience maximal strength gains in upper-extremity exercises, such as the bench press (Baechle & Earle, 2000).

Vision Loss and Increased Proprioception

Vision plays an important role in stabilization of posture by providing the nervous system with continually updated information regarding the position and movements of body segments in relation to each other and the environment (Barela, Barela, Rinaldi & de Toledo, 2009; Lord & Menz, 2000). When subjects close their eyes, body sway increases by between 20 and 70% (Lord & Menz, 2000). When subjects were under challenging conditions, visual impairment was strongly associated with sway (Lord & Menz, 2000). However, proprioception also plays a role in stabilization. Proprioceptive and visual cues are both linked to stabilization during postural stability (Brown, et al, 2003; Golomer & Dupui, 2000).

Balance control is maximally affected by the closure of the eyes and the vibration of the Achilles' tendons, a proprioceptory response to vision loss (El-Kahky et al, 2000). Closure of the eyes has significantly more impact on balance control than a sway referenced visual surround (El-Kahky et al, 2000). Vibration of the Achilles' tendons appeared to be the most effective method disturbing the somatosensory-proprioceptive contributions to balance controls (El-Kahky et al, 2000). Based on these results, one could speculate about the relative contributions of the visual, proprioceptive and vestibular systems on balance control. To support these speculations, one would have to assume that no modalities, other than vision, vestibular and proprioception contribute to balance (El-Kahky et al, 2000). However, this assumption is highly disputed, since the existence of gravito-receptors in the human body has been postulated (Mittelstaedy, 1997).

According to a study conducted by Mittelstaedy in 1997, manipulation of the visual system seems to affect balance control to a greater extent than the proprioceptive system. Eyes closed combined with a sway referenced platform are effective in isolating the vestibular system to some extent (Mittelstaedy, 1997). The combination of eyes closed with a sway referenced platform and vibration leads to a maximum decrease of balance control of about 56% (Mittelstaedy, 1997). This supports the claim that the labyrinthine input can only be estimated to be at the most 44%, with the proprioceptive response contributing at least 26% and vision to a maximum 37% of balance. Sensory information and acquired balance control strategies of the sensory output may vary within these margins (Mittelstaedy, 1997).

Proprioceptors, visual and vestibular input serve to perceive the spatial orientation of the body to induce appropriate motor action. Proprioceptors also serves in the feedback loops of all motor-control systems and play an important role on the effector side of the balance contribution. Data reveal that sensitivity for various perturbations varies widely between subjects (El-Kahky et al, 2000). This might be due to differences in motor learning strategies acquired in relation to daily requirement (El-Kahky et al, 2000). As vision is decreased, proprioceptory responses may increase to stabilize the body.

Motor Learning

Practice improves several elements of a movement, in particular movement planning, and the movement becomes faster and more accurate (Pratt & Abrams, 1996, Cordo, Carlton, Bevan, Carlton, and Kerr, 1994, Pipereit, Bock, and Vercher, 2006).

With a more accurate movement program and less movement, error needs to be corrected by the following slower feedback control. Performers tend to amend movement programs between trials by using error feedback from previous trials (Beaubaton & Hay, 1986, Krakauer, Ghilardi, and Ghez, 1999; Hwang, Smith, and Shadmehr, 2006; Overduin, Richardson, Bizzi, and Press, 2007). In the offline-processes such as learning or control strategies contribute to better accuracy (Hirata & Yoshita, 2000).

In reaching movements, the modalities of sensory feedback used to amend the movement program are vision (Beaubaton & Hay, 1986) and proprioception (Sainburg, Ghilardi, Poizner & Ghez, 1995). The feedforward mechanisms are based on an internal model of limb dynamics and the accuracy of the model relies on proprioceptive signals. Visual dominance over other sensory modalities occurs in various types of motor tasks. Therefore, visual feedbacks can distort other sensory inputs (Hirata & Yoshida, 2000). However, evidence of visual dominance is rather inconsistent. Findings seem to indicate that the proprioceptive information may have greater weight than is suggested by classical research when the localization process is concerned with the body parts involved (Hirata & Yoshida, 2000). Hirata and Yoshida (2000) concluded that visuo-motor learning of transformed spatial mapping is accomplished in reaching tasks. Learning processes take place and as the number of trials is extended, there is a boosting in the weighting on proprioceptive feedback (Krakauer, Ghilardi, & Ghez 1999; Hwang, et al, 2006; Cordo, et al, 1994, Overduin, et al, 2007).

Lack of vision can lead to increased proprioceptory responses, and as proprioceptory responses are relied upon and the number of trials increases, the movement becomes more accurate (Pratt & Adams, 1996). Increased proprioception also affects the muscle spindle system (Pratt & Adams, 1996). The muscle spindle system is not only affected by central influences and central nervous system control, but also by local factors within the muscle tissue, joint cavity and all structures involved in the composition of the joint (Pratt & Adams, 1996). The system is not only considered a receptor within the musculotendinous system, but also as an effector organ in a system, which integrative processes the information of the various receptors of the muscles, the skin and the joint (Pratt & Adams, 1996).

Proprioceptive Training and strength

Prioceptory training is identified as training where responses from the proprioceptory system are elicited (El-Kahky, 2000; Trans, Aaboe, Henriksen, Christensen, Bliddal & Lund, 2009). Training protocols that included vibrations and balance training are two ways that proprioceptory responses are elicited during training (El-Kahky, 2000; Trans et al, 2009). A study was conducted on patients with ACL-injuries and strength training for rehabilitation of the patients (Freiwald, 1993). The study concluded that strains that would not be harmful in normal conditions can now lead to excitation of the nociceptors. In addition, with proprioceptive training, nociceptors were activated. Due to the close functional connection of nociceptors with mechano-sensitive organelles, the mechano-sensitive coordination of the entire trained extremity changes (Freiwald, 1993).

Over the long term, changes take place, manifested primarily by a change in primary status, which is described as a change in muscle tone, muscular stiffness and modified receptor threshold. There is also a change in the adaptive properties of the tissue especially of the muscle tissues (Freiwald, 1993).

Another study conducted by Ambrose et al in 2003, on ACL injuries as well, used proprioceptive and strength training on neuromuscular function of the reconstructed ACL. This study concluded that an emphasis must be placed upon practice of basic motor tasks at slow speeds. This may be important in regaining normal neuromuscular control after injury. To achieve coordination of appropriate muscle firing patterns during functional activities without the conscious awareness of the individual, adequate practice is essential. Inadequate practice results in errors in performance due to the lack of inhibition of muscles in motor patterns (Ambrose et al., 2003).

Several studies were conducted on decreases in proprioception and their affects on strength. Proprioception tends to be the most important aspect in stability (Lord, et al, 1991), and when weaknesses in muscular strength were detected during stability exercises, decreased proprioception was also noticed (van der Esch, et al, 2007; Fatoye, Palmer, Macmillan, Rowe, and van der Linden, 2008). People with lower-limb muscular weakness tend to rely more on their vision and vestibular system to stabilize themselves than people who do not have lower-limb muscular weakness (Butler, Lord, Rogers and Fitzpatrick, 2008). However, decreases in proprioception does not always lead to decreases in strength (Nocero, Rubley, Holcomb, and Guadagnoli, 2006), rather decreased strength has shown to decrease proprioception (Van der Esch et al, 2007; Fatoye, et al, 2008).

There was a greater change in strength demonstrated in the group that conducted proprioceptive training than strength training (Nelson Chambers, McGown & Penrose, 1986; Salaj, Milanovic & Jukic, 2007; Trans et al, 2009). These changes are proposed to be due to improved coordination and neural activation secondary to the prescribed intervention (Ambrose et al, 2003). Isotonic testing seems to rely primarily on the coordination of the limb. Therefore, the greater gains for the proprioceptive groups may be a result of better performance of the desired motor pattern compared to the strength training group. Proprioceptive training also contributes significantly to neural activation involved in the early stages of strength gain. Neural mechanism plays an important role in strength increase in muscles (Ambrose et al, 2003).

It has also been proven that as fatigue increases, neural mechanisms do not perform at the peak, causing a loss in muscle strength (Gauchard, Gangloff, Vouriot, Mallie, and Perrin, 2002), thus concluding that neural mechanisms play an important role in muscular strength.

Motivation

Goal orientation seems to be one of the most commonly used techniques used by weight lifters to try to improve performance. Goal orientation may be sub-divided into five categories: task-orientation, self-enhancing ego-orientation, social-approval orientation, and work-avoidance orientation (Gilson, Chow & Ewing, 2008). Goal motivation is used by many coaches to increase intrinsic motivation to help improve performance (Fry & Fry 1999; Moore, Decker, Baarts, DuPont, Epema, Reuther, Houser & Mayhew, 2007; Silbernagel, Short, Ross-Stewart, 2007; Gilson et al, 2008).

Motivation has been used in several studies to measure its effects on performance (Fry & Fry, 1999; Tod, Thatcher, McGuigan & Thatcher, 2009), however, until Tod and associates conducted their study in 2009, motivation, had not been measured on performance in multi-jointed exercises. Through the conduct of their research, Tod and associates noted a significant increase in muscular power when extrinsic motivation was provided. Motivation and technique self-talk techniques tended to work best in increasing performance in multi-jointed exercises.

A study conducted by Moore et al in 2007, measured the effects of intrinsic and extrinsic motivation on sprint performance. With experienced athletes, Moore and associates noticed a difference in performance when extrinsic motivation was provided. However, there was no change in performance of recreationally trained athletes, through the use of extrinsic of intrinsic motivation.

Summary

Literature has shown that any of the seven equations used to measure 1-RM may be used to measure strength (LeSeur et al., 1997). It is important to use a RTF equation in order to determine the 1-RM, because several factors play into actual 1-RM testing. Therefore, to conduct 1-RM tests in a safe environment it is best to conduct RTF tests (Wood et al., 2002).

Several studies noted that when the eyes are closed, the body relies on increased proprioceptory responses to balance itself (Beaubaton & Hay, 1986; ElKahky et al, 2000; Hirata & Yoshida, 2000; Lord & Menz, 2000). However, most of the research has been conducted on lower extremities. The research conducted on upper-extremities supported that as vision is taken away, the upper extremity relies more on proprioceptive responses to move the extremity (Beaubaton & Hay, 1986). One can conclude from this that vision impairment would increase proprioceptory response in the upper extremities if an object needed to be stabilized by the upper extremities.

The impairment of vision may lead to increased proprioceptory response, but there is little evidence to suggest that there is an increase in proprioceptory response in a healthy joint. The research has been conducted on injured joints, (Ambrose et al, 2003; Freiwald, 1993) which could skew the results, since injured joints have decreased proprioceptory response, and the initial proprioceptory training may result in tremendous strength gains. However, it can be concluded that in some instances training proprioceptory responses can increase strength gains.

CHAPTER III

METHODOLOGY

This section defines the sample and how the subjects were selected. The methods used to collect and interpret data are also discussed in this section along with the instrumentation needed for this study. An Institutional Review Board (IRB) application and consent was filed with the University IRB and approved.

Research Design

This was a quantitative study with pre-test and post-test data for one dependent variable. The data collected for each participant was the absolute 5-RM bench press prior to the treatment and the absolute 5-RM bench press after the treatment had been administered. The pre-test and post-test 5-RM bench press was used as a dependent variable in the analysis.

Subjects

All subjects selected in this study were volunteers from a large, Midwestern university in the United States. The volunteers were selected from individuals who were enrolled and attended weight lifting classes at the recreation center at the university. All subjects had some experience with resistance training. Subjects with one year or less of weight training experience were allowed to participate in this study. The university from which the subjects were recruited is a public university located in Oklahoma and the students there were primarily from Oklahoma. Males and females from the weight training classes held at the university were recruited for this study. Nine females (19.67 yrs ± 1.12) and 26 males (20.58yrs ± 1.70) with one year or less of weight lifting experience or more, participated in this study. Prior to data collection, participants had participated in six weeks of continuous resistance training in their class.

Exclusionary Criterion

The following exclusionary criteria were used to exclude subjects. A health history questionnaire was administered and is attached in the Appendix.

- Participants with upper-extremity surgeries in the past six months
- Participants who have had more than one year of weight training experience
- Subjects who had taken performance enhancing supplements in the past six months
- Subjects who were currently taking ergogenic aids, creatine, Human Growth Hormone (HGH) or anabolic steroids

Research Instruments

A health history questionnaire was administered to all subjects prior to participation to determine whether subjects were healthy enough to participate and if they were currently consuming any performance enhancing substances. A survey was administered to the participants to determine their exposure to weight training. The bench press exercise was used to measure upper-extremity strength. The bench press measures the upper extremity strength in the linear plane. An Olympic sized 20.45 kg (45 lbs) bar was used on a flat Cybex bench press device. Weight increments of 2.27kg (5 lbs) were utilized when increasing the weight lifted during the measurement of 5-RM. A 5-RM determined the exact weight that could be lifted by each subject, and a 1-RM was estimated.

Procedure

No pilot study was conducted prior to this study. A 1-RM was estimated for the subjects prior to the administration of the treatment. A 5-RM was collected and a 1-RM was calculated using the formula 1-RM= [(number of repetions/30) + 1] x weight. The subjects were re-tested two days after the initial test for a 1-RM. After estimating the 1-RM, the subjects were randomly assigned to 2 groups. During testing each subject was given an approximately 2 minute break between maximal lifts to failure. If a subject was able to perform the required 5 repetitions, the weight lifted was increased by a 5 pounds (2.27kg) increment, and only when 5 repetitions could not be completed with the weight at hand was the testing stopped.

The experimental group contained 17 subjects while the control group consisted of 18 subjects. The control group, was administered a strength training protocol that is considered conventional. The intervention group was given the experimental treatment, where the subjects were administered the same strength training protocol as the control group, however they were blind-folded when performing the bench press. Each subject, in both groups had a spotter when performing the bench press.

For the 6 weeks prior to beginning this training regimen the participants participated in a weight training class where they were taught proper techniques and were part of a training regimen. The subjects were instructed that the repetition range was determined in such a way that if they could perform the number of repetitions stated on the higher end of the rep-range then they were to increase the amount of weight lifted and if they could not perform the lower end of the rep-range then they were to decrease the weight that they lifted. This recommendation was based on the American College of Sports Medicine. They were also instructed to rest approximately 1-2 minutes between sets. Subjects were instructed not to conduct upper-extremity strength training outside of this training protocol.

The exercises and sets for the protocol performed by each group were the following:

Weeks 1-2, 2 days/week

Bench press- 3sets X 10-12 repetitions

Lat-pulldown- 3sets X 10-12 repetitions

Dumbbell shoulder press- 3 sets X 10-12 repetitions

Tricep extensions- 3 sets X 10-12 repetitions

Bicep curls- 3 sets X 10-12 repetitions

Weeks 3-4, 2 days/week

Bench press- 3sets X 8-10 repetitions

Lat-pulldown- 3sets X 8-10 repetitions

Dumbbell shoulder press- 3 sets X 8-10 repetitions

Tricep extensions- 3 sets X 8-10 repetitions

Bicep curls- 3 sets X 8-10 repetitions

<u>Weeks 5-6, 2 days/week</u>

Bench press- 3sets X 6-8 repetitions

Lat-pulldown- 3sets X 6-8 repetitions

Dumbbell shoulder press- 3 sets X 6-8 repetitions

Tricep extensions- 3 sets X 6-8 repetitions

Bicep curls- 3 sets X 6-8 repetitions

After the 6-week resistance training regimen, the subjects were re-tested for their 5-RM on the bench press and a 1-RM bench press was estimated. During testing, all subjects increased the mass lifted during the bench press until they could no longer complete five repetitions.

Statistical Analysis

This study was a quantitative study with pre-test and post-test data collected for 1 variable. For each participant a 1-RM was calculated for both pre-test and post test data. The pre-test and post-test 5-RM and estimated pre-test and post-test 1-RM were compared using a Repeated Measures Analysis of Variance (ANOVA). The level of significance was set at $p < 0.05$. Statistical Package for the Social Sciences (SPSS) version 16.0 was used to statistically analyze the data.

This is a mixed factor design, with the two tests being the within factor, and the groups being the between factors (Table 1).

Table 1- Variables and Factors in study

VARIABLE	# LEVELS	FACTOR
Time	2	within
Group	2	between
Gender	2	between
Subjects/group	unequal	
Subjects/gender/group	unequal	

Dependent Variable

5-RM

CHAPTER IV

RESULTS

There were 17 subjects in the experimental group and 18 subjects in the control group with an average age of 20.34 (±1.068) years. Of the 17 subjects in the experiment group, four were female and 13 were male, and of the 18 subjects in the control group, five were female and 13 were males.

Hypothesis 1:

It was hypothesized that there will be no differences between the increases in 5-RM between the two groups. Analysis of the pre-test and post test data yielded in no significant results ($p<0.05$) between control and experimental groups (Table 2 and 3). There were two different analyses conducted, one group and time (Table 2 and 3) and another sex, group and time (Tables 2, 4, 5), for both 5-RM and 1-RM, neither showing in a significant result ($p<0.05$).

Table 2- Pre- to Post-test results for Total Group, Males and Females

Subjects	MS	F	P
Total	132.0	2.21	0.15
Males	123.0	1.76	0.19
Females	8.4	0.30	0.59

Table 2 Legend

MS= Mean Square

F= F variability

P= P-value statistical significane

Table 3- Means and Standard Error Data by Group

5 Reps by Group

.

Group	Reps	Mean (lbs)	Std. Err	-95.00%	+95.00%	N
Experimental	Pre 5r	139.71	12.03	115.22	164.19	17
Experimental	Post 5r	158.53	12.06	133.98	183.07	17
Control	Pre 5r	139.17	11.69	115.37	162.96	18
Control	Post 5r	152.50	11.72	128.65	176.35	18

Table 4- Means and Standard Error Data by Group by Sex

5 Reps by Group (Sex=male)

Groups	Reps	Mean (lbs)	Std. Err.	-95.00%	+95.00%	N
Experimental	Pre 5r	159.23	10.24	138.09	180.37	13
Experimental	Post 5r	179.62	9.36	160.29	198.94	13
Control	Pre 5r	162.69	10.24	141.56	183.83	13
Control	Post 5r	176.92	9.36	157.60	196.25	13

Table 5- Means and Standard Error Data by Group by Sex

5 Reps by Group (Sex=female)

Groups	Reps	Mean (lbs)	Std. Err.	-95.00%	+95.00%	N
Experimental	Pre 5r	76.25	7.44	58.66	93.84	4
Experimental	Post 5r	90.00	8.06	70.94	109.06	4
Control	Pre 5r	78.00	6.65	62.27	93.73	5
Control	Post 5r	89.00	7.21	71.95	106.05	5

However, numerical there is a greater improvement in 5-RM and calculated 1-RM for subjects training blindfolded compared to those who trained without blindfolds (Table 6). Individuals who trained without blindfolds increased their 5-RM on the bench press by an average of 6.06 kg (13.33 lbs ± 10.43 lbs), whereas people who trained blindfolded increased their 5-RM bench press by an average of 8.556 kg (18.8235 lbs ± 11.39 lbs). The calculated 1-RM increased by 7.07 kg (15.56 lbs) for the control group and 9.98 kg (21.96 lbs) for the experimental group.

Table 6- Means and Standard Deviations of 5-RM by group

	N	Minimum (lbs)	Maximum (lbs)	Mean	Std. Deviation
Difference in 5-RM experimental	17	10	50	18.82	11.39
Difference in 5-RM control	18	-10	30	13.33	10.43

Hypothesis 2:

There were no difference between genders in the 5-RM test between the group training with the benefit of vision and the one training without the benefit of vision. Difference between sexes was not statistically significant, however mathematically males increased their absolute 5-RM more than females, but women gained more relative strength (Table 7). Males who trained without the use of vision increased their 5-RM by more than 2.80 kg (6.15 lbs) (Table 7) compared to those who trained with the aid of vision. Women who trained without vision increased their 5-RM by 1.25 kg (2.75 lbs) (Table 7) more than those who trained without being visually impaired. When comparing percentile increases, males in the experimental group increased their 5-RM by 11.3%, whereas males in the control group increased their 5-RM by 8%. Women on the other had had a greater percentile increase in their 1-RM, 15% for females in the experimental group and 12.3% in the control group.

Table 7- Mean and Standard Deviation of 5-RM by Group by Sex

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
difference in pre/post by sex by group (male) experimental	13	10	50	20.38	12.49
difference in pre/post by sex by group (male) control	13	-10	30	14.23	11.15
difference in pre/post by sex by group (female) experimental	4	10	20	13.75	4.79
difference in pre/post by sex by group (female) control	5	0	20	11.00	8.94

Discussion

Several studies have noted that when vision is eliminated, the body relies on increased proprioceptory responses for balance (Beaubaton & Hay, 1986; ElKahky et al, 2000; Hirata & Yoshida, 2000; Lord & Menz, 2000). However, most of the research has been conducted on lower extremities. The limited research conducted on upper-extremities suggests that without the benefit of vision, the upper extremity relies more on proprioceptive responses to move the extremity (Beaubaton & Hay, 1986). However, these studies were conducted on injured joints, (Ambrose et al, 2003; Freiwald, 1993). Because injured joints have decreased proprioceptory response compared to healthy joints, the initial proprioceptory training may result in significant strength gains. However, it may be concluded that in some instances training proprioceptory responses can increase strength gains. Studies conducted on proprioceptive training with ACL injuries showed a statistically significant increase in strength in the quadriceps femoris (Ambrose et al, 2003; Freiwald, 1993).

In the present study, the group that trained blind-folded experienced an average increase of 8.556 kg (18.8235 lbs ± 11.39 lbs) on their 5-RM on the bench press, whereas individuals who trained without blindfolds increased their 5-RM by an average of 6.06 kg (13.33 lbs ± 10.43 lbs). While the results failed to reach statistical significance between the control and treatment group (p=0.14), in the practical world of athletic competition smaller margins can determine first place from last. The experimental group experienced a 11.3% increase in their 5-RM, compared to the control group that only saw a 8% increase in their 5-RM. A 3.3% increase in performance in the practical world of athletic competition may mean the difference between a world record and last place. An example of that is the 100m backstroke finals in the 2008 Olympics, where a 3.3% increase in performance by the 2nd place winner would have resulted in a new world record and a gold medal (The Beijing Organizing Committee for the Games of the XXIX Olympiad).

When the experimental and control group were separated and analyzed by sex there was still no statistical significance between control and experimental group for males (p=0.198) or females (p=0.599). Mathematically there were greater changes in pre/post-test data between males (2.80 kg (6.15)lbs) between groups compared to females between groups (1.25 kg (2.75)lbs). However, when comparing percentile increases, males in the experimental group increased their 5-RM by 11.3%, whereas males in the control group increased their 5-RM by 8%. Women on the other had had a greater percentile increase in their 1-RM, 15% for females in the experimental group and 12.3% in the control group.

These may be explained by the lower number of female participants in the study. Previous studies have noted that men have experienced greater absolute strength gains, and both sexes tend to have similar relative strength gains (Heyward et al, 1986; Mayhew et al, 1994; Delmonico et al, 2005; Walts et al, 2007). Another possible explanation might be that the female participants were more novice as lifters than their male counterparts and had never trained on the bench press. According to the survey conducted prior to the study many female lifters had 6 months or less of strength training experience. The changes in the amount of mass they lifted may partly be attributed to neurological changes in the acquisition of technique of the bench press movement as increased proprioception lead to mechanical adaptation (Pipereit, et al, 2006; Cordo, et al, 1994).

Motor learning has been shown to still affectively take place during visual impairment (Vidoni & Boyd, 2008), and after practise of certain movements errors are reduced (Vidoni & Boyd, 2008; Krakauer, et al, 1999; Hwang, et al, 2006; Overduin, et al, 2007). It may be assumed that movement errors were stored and then corrected through each lifting session, making the movement more efficient over the course of time, similar to the studies by Krakauer, et al (1999) and Cordo, et al (1994). Another theory may be that after seeing how a movement is done, it is easier for a subject to mimic the movement during moments of visual inhibition (Ghez, Gordon, and Ghilardi, 1995).

Numericaly it is visible that the treatment group in the current study outgained the control group. Failure to reach significance may be due to inherent field-test qualify of assessment itself. For example, partial repetitions were not counted, but only full bench press repetitions of chest touch and full elbow extension were counted. It is possible that such assessment lacked the sensistivity to include more subtle changes in strength gains. For instance, incorporating computerized testing would provide data inclusive of all changes. Furthermore, it is plausible that the novice nature of the subjects contributed to similar changes since much of the initial movement in the bench press may have been neurological. The acquisition of technique and initial development of lifting efficiency may have contributed more in novice lifters than in experienced lifters.

Another limitation that may explain the failure to reach statistical significance may be the duration of the treatment. Most literature prescribes 6-8 weeks of administration of strength training treatments, however due to time constraints on this study, a period of 6 weeks was used. It is plausible that with an extra 2 weeks of strength training there may have been statistically significant results. Furthermore, a possibility that the subjects were novice lifters and may not have been applying themselves as much as they should have may have affected the results as well. Measures were taken to prevent such an occurrence during both testing and administartion of the treatment, however human motivation cannot be subjectively measured during testing and administartion of treatment.

Although results were not statistically significant, numerical differences prompt us to further investigate whether strength blind-folded can increase strength. A possible derivation of this study would be to conduct a similar study except using a stronger testing mechanism such as a 1-RM or a computerized method of recording strength which would record partial movement as well. Another possible direction would be to increase the number of weeks the subjects trained from 6 weeks to possibly 12 weeks or more to account for hypertrophic increases in strength. In this study the subjects only trained blindfolded while they were performing the bench press exercise. However, if subjects were to train without the use of vision during their entire workout, there might be increased proprioceptory reception throughout the workout, leading to increased strength. Another possible derivation of this study would be to conduct the exercises that train the muscles used as agonists in the bench press to be trained blindfolded, and the antagonists to be trained with the benefit of vision.

CHAPTER V

CONCLUSION

Summary

This study measured the changes in bench press strength over the course of six weeks. Nine females (19.67 yrs ± 1.12) and 26 males (20.58yrs ± 1.70) with one year or less of weight training experience or more, participated in this study. Prior to their participation in the study, the subjects participated in a six week long weight training class. The subjects were recruited from weight lifting classes that were held at a public university in Oklahoma. Subjects for this study were excluded if they had any upper-extremity surgeries in the past six months, had over a year of weight training experience, used performance enhancing supplements in the last six months or were currently taking ergogenic aids, creatine, HGH or anabolic steroids.

A health history questionnaire and survey regarding supplementation was administered to all subjects prior to participation to determine suitability for participation. Subjects were screened and excluded and the remaining subjects were then tested for their 5-RM on the bench press. After the 5-RM was collected the subjects were then grouped into controlled and experimental groups. The experimental group consisted of 17 subjects and the control group consisted of 18 subjects. Each group was then assigned a six week weight training protocol, and the experimental group was instructed to perform the bench press exercise in their six week training protocol blind-folded. Each subject was instructed to try to aim for the high end of the rep-range in their training protocol and if they could perform the higher end of the rep-range then they were to increase the weight lifted. However, if they could not lift the low end of the rep-range then they were to decrease the amount of weight lifted. The participants rested for 1-2 minutes after each set on each exercise in their training protocol. After the six week training protocol, the subjects were retested on their 5-RM.

Findings

The first hypothesis stated that there would be no statistical significance ($p<0.05$) in the 5-RM between the experimental and control group. After data collection and using a repeated measures ANOVA, it was determined that there was no statistical significance between groups ($p=0.15$).

The second hypothesis stated that there would be no statistical significance ($p<0.05$) between sexes between groups. After data collection and using a repeated measures ANOVA, it was determined that there was no statistical significance between males ($p=0.19$) or females ($p=0.59$) between groups.

Conclusions

Although results were not statistically significant, mathematically differences between groups were noted. Individuals who trained without blindfolds increased their 5-RM on the bench press by an average of 6.06 kg (13.33 lbs ± 10.43 lbs), whereas people who trained blindfolded increased their 5-RM bench press by an average of 8.556 kg

(18.8235 lbs ± 11.39 lbs).). Males who trained without the use of vision increased their 5-RM by more than 2.80 kg (6.15 lbs) compared to those who trained with the aid of vision. Women who trained without vision increased their 5-RM by 1.25 kg (2.75 lbs) more than those who trained the benefit of vision. When comparing percentile increases, males in the experimental group increased their 5-RM by 11.3%, whereas males in the control group increased their 5-RM by 8%. Women on the other had had a greater percentile increase in their 1-RM, 15% for females in the experimental group and 12.3% in the control group.

Recommendations

Without statistical significance it is difficult to validate a study however the mathematical differences between groups and sexes can lead us to further investigate whether strength training blindfolded is beneficial. It is recommended that this matter is further investigated through the use of a more sensitive testing method such as a 1-RM or a computerized method of measuring strength. Another recommendation is to increase the duration of the study from six weeks to eight to possibly twelve weeks to see if the increased time may lead to statistically significant results. It is also the researchers recommendation for the participants in the experimental group to conduct all exercises without the benefit of vision to see if that may lead to increased proprioceptory responses and increase in strength. Another possible derivation is to have the participants train the agonists used in the bench press blindfolded and the antagonists to be trained with the benefit of vision to see if there are increases in strength because of the increases in proprioceptory reception in the prime movers.

REFERENCES

Ahtiainen, J., Pakarinen, A., Alen, M., Kraemer, W., Hakkinen, K. (2003). Muscle hypertrophy, hormonal adaptations and strength development during strength training in strength-trained and untrained men. *European Journal of Applied Physiology*. 89: 555-563.

Ambrose, T.L., Taunton, J.E., MacIntyre, D., McConkey, P., & Khan, M.N (2003). The effects of proprioceptive or strength training on the neuromuscular function of the ACL reconstructed knee: a randomized clinical trial. *Scandinavian Journal of Medicine & Science in Sports*, 13, 115-123.

Baechle, T.R., & Earle, R.W (Ed.) (2000). *Essentials of Strength Training and Conditioning (*2nd Ed.). Champaign: Human Kinetics.

Baker, D., Wilson, G., & Carlyon, R., (1994). Periodization: The Effect on Strength of Manipulating Volume and Intensity. *Journal of Strength and Conditioning Research.* 8: 235-242.

Bale, P., Mayhew, J., Piper, F., Ball, T., Willman, M. (1992). Biological and Performance variable in relation to age in male and female adolescent athletes. *Journal of Sports Medicine and Physical Fitness.* 32: 142-148.

Barela, A.M., Barela, J.A., Rinaldi, N.M., & de Toledo, D.R. (2009). Influence of Imposed Optic Flow Characteristics and Intention on Postural Responses. *Motor Control.* 13, 119-129.

Beaubaton, D., & Hay, L (1986). Contribution of visual information to feedforward and feedback process in rapid pointing movements. *Human Movement Science,* 5, 19-34.

Brooks, S. (2003). Current Topics for teaching Muscle Physiology. *Advances in Physiology Education.* 27:171-182.

Brandenburg, J., & Docherty, D. (2002). The Effects of Accentuated Eccentric Loading on Strength, Muscle Hypertrophy, and Neural Adaptations in Trained Individuals. *Journal of Strength and Conditioning Research.* 16:25-32.

Brentano, M., Cadore, E., Da Silva, E., Ambrosni, A., Coertjens, M., Petkowicz, R., Viero, I, & Kruel, L. (2008). Physiological Adaptations to Strength and Circuit Training in Postmenopausal Women With Bone Loss. *Journal of Strength and Conditioning Research.* 22: 1816-1825.

Brown, L.E., Rosenbaum, D.A., & Sainburg, R.L. (2003). Limb Position Drift: Implications for Control of Posture and Movement. *Journal of Neurophysiology*, 90, 3105-3118.

Buford, T., Rossi, S., Smith, D., & Warren, A., (2007). A comparison of periodization models during nine weeks with equated volume and intensity. *Journal of Strength and Conditioning Research.* 21:1245-1250.

Butler, A.A., Lord, S.R., Rogers, M.W., & Fitzpatrick, R.C. (2008). Muscle weakness impairs the proprioceptive control of human standing. *Brain Research.* 1242, 244-251.

Candow, D., & Burke, D. (2007). Effect of short-term equal volume resistance training with different workout frequency on muscle mass and strength in untrained men and women. *Journal of Strength and Conditioning Research.* 21:204-207.

Cordo, P., Carlton L., Bevan, L., Carlton, M., & Kerr, G.K. (1994). Proprioceptive Coordination of Movement Sequences: Role of Velocity and Position Information. *Journal of Neurophysiology*. 71:5, 1848-1861.

Dalleck, L., Borresen, E., Wallenta, J., Zahler, K., & Boyd, E. (2008). A Moderate-Intesity Exercise Program Fulfilling the American College of Sports Medicine Net Energy Expenditure Recommendation Improves Health Outcomes in Premenopausal Women. *Journal of Strength and Conditioning Research.* 22:256-262.

Davlin, C., Sands, W., & Shultz, B. (2002). Influence of Vision on Kinesthetic Awareness While Somersaulting. *International Sports Journal.* 3: 172-177.

Delmonico, M., Kostek, M., Doldo, N., Hand, B., Bailey, J., Rabon-Stith, K., Conway, J., Carignan, C., Lang, J., & Hurley, B. (2005). Effects of moderate-velocity strength training on peak muscle power and movement velocity: do women respond differently than men? *Journal of Applied Physiology.* 99: 1712-1718.

El-Kahky, A.M., Kingma, H. Dolmans, M. & De Jong, I (2000). Balance Control Newar the Limit of Stability in Various Sensory Conditions in Healthy Subjects and Patients Suffering from Vertigo or Balance Disorders: Impact of Sensory Input on Balance Control. *Acta Otolaryngo.* 120: 508-516.

Elliot, D.B., Patla, A.E., Flanagan, J.G., Spaulding, S., Rietdyk, S., Strong, G., & Brown, S. (1995) The Waterloo Vision and Mobility Study: postural control strategies in subjects with ARM. *Ophthalmic & physiological optics.* 15:6, 553-559.

Fatoye, F., Palmer, S., Macmillan, F., Rowe, P., & van der Linden, M. (2008). Proprioception and muscle torque deficits in children with hypermobility syndrome. *Rheumatology.* 48:152-157.

Feigenbaum, M.S., & Pollack, M.L (1999). Prescription of resistance training for health and disease, *Medicine and Science in Sports and Exercise*,31, 38-45.

Fleck, S. (1999). Periodization Strength Training: A Critical Review. *Journal of Strength and Conditioning Research.* 13: 82-89.

Freiwald, J (1993). Muscle strengthening in Rehabilitation. *Rehabilitatives krafttraining.* Deutsche Zeitschrift Fur Sportmedizin. 44, 368-378.

Fry, M. & Fry, A. (1999). Goal Perspective and Motivational Responses of Elite Junior Weightlifters. *Journal of Strength and Conditioning Research.* 13: 311-317.

Gauchard, G.C., Gangloff, P., Vouriot, A., Mallie, J.P., & Perrin, P.P (2002). Effects of Exercise-inducted fatigue with and without hydration on static postural control in adult human subjects. *International Journal of Neuroscience.* 112, 1191-1206.

Ghez, C., Gordon, J., & Ghilardi, M.F. (1995). Impairments of Reaching Movements in Patients Without Proprioception. II. Effectsof Visual Information on Accuracy. *Journal of Neurophysiology.* 73:1, 361-372.

Gilson, T., Chow, G., & Ewing, M. (2008). Using Goal Orientation to Understand Motivation in Strength Training. *Journal of Strength and Conditioning Research.* 22:1169-1175.

Golomer, E., & Dupui, P. (2000). Spectral Analysis of Adult Dancers' sways: Sex and Interaction Vision-Proprioception. *International Journal of Neuroscience.* 105:15-26.

Haines, D. (ed) (1996). *Fundamental Neuroscience*. New York: Churchill Livingstone.

Hakkinen, K., Alen, M., Kraemer, W., Gorostiaga, E., Izquierdo, M., Rusko, H., Mikkola, J., Hakkinen, A., Valkeinen, H., Kaarakainen, E., Romu, S., Erola, V., Ahtainen, J., Paavolainen, L., (2002). Neuromuscular adaptations during concurrentl strength and endurance training versus strength training. *European Journal of Applied Physiology*. 8:42-52.

Hakkine, K., Alen, M., Kallinen, M., Newton, R., Kraemer, W. (2000). Neuromuscular adaptation during prolonged strength training, detraining and re-strength-training in middle-aged and elderly people. *European Journal of Applied Physiology*. 83:51-62.

Hakkinen, K., Kallinen, M., Linnamo, V., Pastinen, U., Newton, R., & Kraemer, W. (1996). Neuromuscular adaptation during bilateral versus unilateral strength training in middle-aged and elderly men and women. *Acta Physiol Scand.* 158:77-88.

Herrick, A., & Stone, W. (1996). The Effects of Periodiation Versus Progressive Resistance Exercise on Upper and Lower Body Strength in Women. *Journal of Strength and Conditioning Research.* 10: 72-76.

Heyward, V., Johannes-Ellis, S., & Romer, J., (1986). Gender Differences in Strength. *Research Quarterly For Exercise and Sport.* 57: 154-159.

Hirata, C., & Yoshida S (2000). Visual Dominance in Amending the Directional Parameter of Feedforward Control, *Journal of Motor Behavior* 32 (1), 17-25.

Hunter, G. R., McCarthy, J. P., & Bamman, M. M. (2004). Effects of resistance training on older adults. *Journal of Sports Medicine,* 34, 329-48.

Hurley, B., Redmond, R., Pratley, R., Treuth, M., Rogers, M., & Goldberg, A. (1995). Effects of Strength Training on Muscle Hypertrophy and Muscle Cell Disruption in Older Men. *The International Journal of Sports Medicine.* 16:378-384.

Hwang, E.J., Smith, M.A., & Shadmehr, R. (2006). Disscociable effects of the implicit and explicit memory systems on learning control of reaching. *Experimental Brain Research* 173:3, 425-437.

Kenney, W.L (Ed) (1995). *ACSM's guidelines for exercise testing and prescription* (5^{th} ed.). Baltimore: Williams and Wilkins.

Krakauer, J.W., Ghilardi, M.F., & Ghez, C. (1999). Independent learning of internal models for kinematic and dynamic control of reaching. *Nature Neuroscience.* 2, 1026-1031.

Lemmer, J., Hurlbut, D., Martel, G., Tracey, B., Ivey, F., Metter, E., Fozard, J., Fleg, J., & Hurley, B. (2000). Age and gender responses to strength training and detraining. *Medicine and Science in Sports and Exercise.* 32: 1505-1512.

Lexell, J. (2000). Strength Training and Muscle Hypertrophy in Older Men and Women. *Top Geriatr Rehabil.* 15:41-46.

LeSuer, D.A., McCormick, J.H., Mayhew, J.L., Wasserstein, R.L.& Arnold, M.D (1997). The Accuracy of Prediction Equations for Estimating 1-RM Performance in the bench press, Squat, and Deadlift. *Journal of Strength and Conditioning Research.*11 (4), 211-213.

Lord, S.R. & Menz, H.B (2000). Visual Contribution to Postural Stability in Older Adult. *Gerontolog.* 46: 306-310.

Lord, S.R. Russell, D.C., & Webster, I.W. (1991). Postural Stability and Associated Physiological Factors in a Population of Aged Persons. *Journal of Gerantology.* 46:3, M69-76. 22: 503-508.

Macaluso, A. & De Vito, G. (2004). Muscle strength, power and adaptations to resistance training in older people. *European Journal of Applied Physiology*, 91:450-72.

Malavolti, M., Battistini, N., Dugoni, M., Bagni, B., Bagni, I., & Pietrobelli, A. (2008). Effects of Intense Military Training on Body Composition. *Journal of Strength and Conditioning Research.* 22: 503-508.

Malina, R., Bouchard, C., & Bar-Or, O., (2004). *Growth, Maturation and Physical Activity.* (2nd ed). Champaign: Human Kinetics.

Mayhew, J., Bemben, D., Bemben, M., Piper, F., Bohrs, D., & Salm, P. (1994). Gender Differences in Strength and Anaerobic Power Tests. *Journal of Human Movement Studies.* 26: 227-243.

Mayhew, J.L., Ball, T.E., Arnold, M.D., & Bowen, J.C (1995) Muscular endurance repetitions to predict bench strength in men of different training levels. *Journal of Sports Medicine and Physical Fitness.* 35, 108-111.

McCartney, N. (1999). Acute responses to resistance training and safety. *Medicine and Science in Sports and Exercise,* 31: 31-7.

McGuigan, M., Tatasciore, M., Newton, R., & Pettigrew, S., (2009). Eight Weeks of Resistance Training Can Significantly Alter Body Composition in Children Who Are Overweight or Obese. *Journal of Strength and Conditioning Research.* 23: 80-85.

McArdle, W., Katch, F., Katch, V. (2001). *Exercise Physiology: Energy, Nutrition, and Human Performance.* (5th ed.) Philadelphia: Lippincott, Williams & Wilkins.

Miller, A., MacDougall, J., Tarnopolsky, M., & Sale, D. (1993). Gender Differences in Strength and Muscle Fiber Characteristics. *European Journal of Applied Physiology*. 66: 254-262.

Mittelstaedy, H (1997). Interaction of eye-, head-, and trunk-bound information in spatial perception and control. *Journal of Vestibular Research.* 7, 283-302.

Monteiro, A., Aoki, M., Evangelista, A., Alveno, D., Monteiro, G., Picarro, I., & Ugrinowitsch. (2009). Nonlinear periodization maximizes strength gains in split resistance training routines. *Journal of Strength and Conditioning Research.* 23: 1321-1326.

Moore, A., Decker, A., Baarts, J., DuPont, A., Epema, J., Reuther, M., Houser, J., & Mayhew, J. (2007). Effect of Competitiveness on Forty-Yard Dash Performance in College Men and Women. *Journal of Strength and Conditioning Research.* 21:385-388.

Moritani, T., & DeVries, H. (1979). Neural Factors versus hypertrophy in the time course of muscle strength gain. *American Journal of Physical Medicine.* 58:115-130.

Nelson, A., Chambers, R., McGown, C., Penrose, K. (1986). Proprioceptive Neuromuscular Facilitation Versus Weight Training for Enhancement of Muscular Strength and Athletic Performance. *The Journal of Chiropractic and Sports Physical Therapy.* 7:251-253.

Neptune, R., McGowan, C., & Fiandt, J. (2009). The Influence of Muscle Physiology and Advanced Technology on Sport. *Ann. Rev. Biomed. Eng.*11:81-107.

Nocera, J., Rubley, M., Holcomb, W., & Guadagnoli, M. (2006). Effects of Repetitive Throwing on Shoulder Proprioception and Internal and External Rotation Strength *Journal of Sport Rehabilitation.* 15 351-362.

Overduin, S.A., Richardson, A.G., Bizzi, E., & Press, D.Z. (2007) Simultaneous sensorimotor adaptation and sequence learning. *Experimental Brain Research.* 184:3, 451-456.

Petranick, K, & Berg, K. (1997). The Effects of Weight Training on Bone Density of Premenopausal, Postmenopausal and Elderly Women: A Review. *Journal of Strength and Conditioning Research.* 11: 200-208.

Pipereit, K., Bock, O., & Vercher, J.L. (2006). The contribution of proprioceptive feedback to sensoirmotor adaptation. *Experimental Brain Research.* 174:1, 45-52.

Pratt, J., & Abrams, R.A (1996). Practice and component sub-movements: the roles of programming and feedback in rapid aimed limb movements. *Journal of Motor Behavior.* 28, 149-156.

Prestes, J., De Lima, C., Frollini, A., Donatto, F., & Conte, M. (2009) Comparison of Linear and Reverse Linear Periodization Effects on Maximal Strength and Body Composition. *Journal of Strength and Conditioning Research.* 23: 266-274.

Purves, D., Augustine, G., Fitzpatrick, D., Katz, L., LaMantia, A., McNamara, J. (Eds.). (1997). *Neuroscience.* Sunderland: Sinauer Associates, Inc.

Reeves, N. D., Narici, M. V., & Maganaris, C. N. (2004). Effect of resistance training on skeletal muscle-specific force in elderly humans. *Journal of Applied Physiology*, 96: 885-92.

Rhea, M., Alvar, B., Ball, S., & Burkett, L. (2002). Three Sets of Weight Training Superior to 1 Set With Equal Intensity for Eliciting Strength. *Journal of Strength and Conditioning Research.* 16: 525-529.

Rhea, M., Ball, S., Phillips, W., & Burnett, L. (2002) A comparison of linear and daily undulating periodized programs with equated volume and intensity of strength. *Journal of Strength and Conditioning Research.* 16:250-255.

Rogers, A. (1992). *Textbook of Anatomy.* Edinburg: Churchill Livingstone.

Salaj, S., Milanovic, D., & Jukic, I. (2007). The Effects of Proprioceptive Training on Jumping and Agility Performance. *Kinesiology*. 2:131-141.

Sainburg, R.L., Ghilardi, M.F., Poizner, H., & Ghez, C (1995). Control of limb dynamics in normal subjects and patients without proprioception. *Journal of Neurophysiology*,74, 457-463.

Silbernagel, M., Short, S., & Ross-Stewart, L. (2007) Athletes' use of exercise imagery during weight training. *Journal of Strength and Conditioning Research.* 21:1077-1081.

Sgro, M., McGuigan, M., Pettigrew, S., & Newton, R. (2009). The Effect of Duration of Resistance Training Interventions in Children Who are Overweight or Obese. *Journal of Strength and Conditioning Research.* 23: 1263-1270.

Staron, R., Karapondo, D., Kraemer, W., Fry, A., Gordon, S., Falkel, J., Hagerman, F., & Hikida, R. (1994). Skeletal muscle adaptations during early phase of heavy-resistance training in men and women. *Journal of Applied Physiology.* 76: 1247-1255.

The Beijing Organizing Committee for the Games of the XXIX Olympiad. (2008). 2008 Men's 100-m Backstroke Finals Results. Retrieved May 8, 2009. http://results.beijing2008.cn/WRM/ENG/INF/SW/C73A1/SWM041201.shtml#SWM041201 .

Tod, D., Thatcher, R., McGuigan, M., & Thatcher, J. (2009). Effects of Instructional and Motivational Self-Talk on the Vertical Jump. *Journal of Strength and Conditioning Research.* 23: 196-202.

Tortora, G. & Derrickson, B. (2006). *Principles of Anatomy and Physiology*. (11th ed.). Hoboken: John Wiley & Sons, Inc.

Trans, T., Aaboe, J., Henriksen, M., Chirstensen, R., Bliddal, H., & Lund, H. (2008). Effect of whole body vibration exercise on muscle strength and proprioception in females with knee osteoarthritis. *The Knee* 16, 256-261.

Valkenien, H., Hakkinen, K., Pakarinen, A., Hannonen, P., Hakkinen, A., Airaksinen, O., Niemitukia, L., Kraemer, W., Alen, M. (2005). Muscle hypertrophy, strength development, and serum hormones during strength training in elderly women with fibromyalgia. *Scandanavian Journal of Rheumatology.* 34:309-314.

Van der Esch, M., Steultjens, M., Harlaar, J., Knol D., Lems, W., & Dekker, J. (2007). Joint Proprioception, Muscle Strength, and Functional Ability in patients With Osteoarthritis of the Knee. *Arthritis & Rheumatism.* 57:5, 787-793.

Vidoni, E.D., & Boyd, L.A. (2008). Motor sequence learning occurs despite disrupted visual proprioceptive feedback. *Behavioral and Brain Functions.* 4:32-36.

Walts, C., Hanson, E., Delmonico, M., Yao, L., Wang, M., & Hurley, B. (2008). Do Sex or Race Differences Influence Strength Training Effects on Muscle or Fat? *Medicine and sciences in sports and exercise.* 40: 669-670.

Willoughby, D. (1993). The Effects of Mesocycle-Length Weight Training Programs Involving Periodization and Partially Equated Volumes on Upper and Lower Body Strength. *Journal of Strength and Conditioning Research.* 7: 2-8.

Wood, T.M., Maddalozzo & G.F., Harter, R.A (2002). Accuracy of Seven Equations for Predicting 1-RM Performance of Apparently Healthy, Sedentary Older Adults. *Measurements in Physical Education and Exercise Science,* 6 (2), 67-94.

Yu, C., Sung, R., So, R., Lui, K., Lau, W., Lam, P., & Lau, E. (2005). Effects of Strength and Conditioning and Bone Mineral Content in Children who are Obese. *Journal of Strength and Conditioning Research.* 19: 667-672.

APPENDICES

Appendix A- Health History Questionnaire and Survey

	Yes/No
General Health	
Have you undergone a physical examination in the last 15 years?	
Are you on a special diet? What type?	
Have you gained or lost more than 10lbs in the last 6 months?	
Have you had an illness in the last 2 weeks? Specify	
Do you have allergies? Specify	
Has a physician ever told you that:	
Your cholesterol was too high?	
Your triglycerides were too high?	
Your uric acid was too high?	
Have you ever had a history of:	
Anemia?	
Urinary tract infection, kidney stones?	
Jaundice/gall bladder problems?	
Scarlet Fever?	
Infectious Mononucleosis?	
Epilepsy?	
Dizziness or lightheadedness?	
Other? Specify	
Have you ever been hospitalized for:	
Hepatitis?	
Tuberculosis?	
Loss of consciousness?	
Stomach disorder?	
Frequent vomiting, diarrhea or constipation?	
Blood in bowel movements?	
Cancer?	
Diabetes?	

Cardiovascular/Circulatory History	**Yes/No**
Have you ever been told you have any of the following	
Heart murmur? ____Childhood ___Recent	
Rheumatic Fever? ____Childhood __Recent	
Restring Electrocardiogram? ____Normal ____Abnormal ____Don't Know	
Exercise Electrocardiogram ____Normal ____Abnormal ____Don't Know	
Varicose Veins? How long ago?	
Phlebitis? How long ago?	
Stroke? How long ago?	
High Blood Pressure ____Current ____Past	
Have you ever had a heart attack? How long ago?	
Have you ever experienced any of the following:	
Pain or tightness in the chest?	
Palpitations or rapid beating of your heart?	
Extra or skipped heartbeats?	
Badly swollen feet or ankles?	
Cold hands or feet even in warm weather?	
Cramping pain in legs or feet?	
Others? Please specify	
Family History of Heart Disease	**Yes/No**
Has anyone in your immediate family (blood relatives) had any of the following:	
Family history of high blood pressure?	
Family history of diabetes?	
Documented heart disease? (please circle) a. Under 50 years of age? b. Between 51 and 65 years of age? c. Over 65 years of age? Was the relative your: father, mother, brother, sister, grandfather, grandmother, aunt, uncle (please circle)	
Sudden death from heart attack? (please circle) a. Under 50 years of age? b. Between 51 and 65 years of age? c. Over 65 years of age? Was the relative your: father, mother, brother, sister, grandfather, grandmother, aunt, uncle (please circle)	

Smoking History	**Yes/No**
Have you always been a non-smoker? (If yes go to the next section)	
Do you presently smoke? The number of years you have been smoking _______. Cigarettes __________________ per day Cigars______________________ per day	
Are you an ex-smoker? If so, when did you stop?	
When you were smoking what was the number of: Cigarettes _______ per day for ______ years Cigars _______ per day for ______ years Pipe bowls _______ per day for ______ years	
Pulmonary Respiration	**Yes/No**
Have you ever experienced any of the following:	
Asthma? When	
Bronchitis? When	
Pneumonia? When	
Emphysema? When	
Lung disease? When Specify:	
Difficulty breathing? When	
Wheezing in chest at rest?	
Shortness of breath during exercise?	
Shortness of breath at rest?	
Chronic cough?	
Cough up blood?	
Other?	
Specify:	
Medication	
Are your currently taking ANY medication(s)?	
What medication(s) is/are being taken?	
For what condition?	
Do you take tranquilizers? How frequently?	
Vitamins?	
Other: Specify	
Do you frequently use non-prescribed drugs?	
Alcohol and Caffeine	**Yes/No**
How much of the following beverages do you consume?	

____cups of coffee per day ____cups of tea per day ____glasses of soda per day ____glasses of beer per day ____glasses of whiskey, gin, scotch and similar liquors per day	
Women's Health	**Yes/No**
Are you presently using any oral contraceptives?	
Are you pregnant at this time? If you are pregnant when was the date of your last menstrual cycle? ___________________________________	
Musculoskeletal/Orthopedic	**Yes/No**
Have you ever had any of the following:	
Hernia or rupture? Number of years ago? _________________	
Present or recurrent lower back injury or stiffness?	
Arthritis/Bursitis? Current?	
Spinal Disc Problem?	
Joint Dislocation?	
Ligament Strain?	
Cartilage tear?	
Tendon tear?	
Intermittent Leg Cramps?	
Swollen Painful Joints?	
Polio?	
Surgery? Please specify:	
Tingling or paralysis in your hands or feet?	
Other? Please specify:	
Exercise Patterns	**Yes/No**
Do you regularly perform strenuous exercise? If yes, please list the information below: Activity: ____ Time spent in activity: _______________________________ Number of times per week: ___________________________	

Have you ever taken any performance enhancing supplements such as creatine, anabolic steroids, etc? ______________________

How old are you? ________________________

How long have you been weight training? ____________________________

Please discuss any other significant medical problems that you consider are important for us to know:

.

Appendix B- Description of Exercises

Bench Press

An Olympic sized 20.45 kg (45 lbs) bar was used on a flat Cybex bench press device.

Beginning position for subject:

Assume a supine position on a bench press in a five-point body contact position.

Head, back, and butt should be on the bench, and both feet should touch the ground.

Place the body on the bench so that the eyes are below the edge of the supports.

Grasp the bar with a closed, pronated grip.

Grip should be slightly wider than shoulder-width.

Signal the spotter for assistance in moving the bar off the supports.

Place the bar over the chest with the elbows fully extended.

All subsequent repetitions begin from this position.

Beginning position for spotter:

Stand erect and very close to the head of the bench (but not so close as to distract the person performing the exercise)

Place the feet shoulder-width apart with the knees slightly flexed.

Grasp the bar with a closed, alternated grip inside the subject's hands.

At the subject's signal, assist with moving bar off the supports.

Guide the par to a position over the subject's chest.

Release the bar smoothly.

Downward Movement Phase Subject:

Lower the bar to touch the chest at approximately nipple level.

Keep the wrists rigid and directly above elbows.

Maintain the five-point body contact position.

Downward Movement Phase Spotter:

Keep the hands in the alternated grip position close to-but not touching- the bar as it descents.

Slightly flex the knees, hips, and torso and keep the back flat when following the bar.

Upward Movement Phase Subject:

Push the bar upward until the elbows are fully extended.

Keep the wrists rigid and directly above the elbows.

Maintain the five-point body contact position.

Do not arch the back or raise the chest to meet the bar.

After the set is completed, signal the spotter for assistance in racking the bar.

Keep a grip on the bar until it is racked.

Upward Movement Spotter:

Keep the hands in the alternated grip position close to-but not touching- the bar as it ascends.

Slightly extend the knees, hips, and torso and keep the back flat when following the bar.

At the subject's signal after the set is completed, grasp the bar with an alternated grip inside the subject's hands.

Guide the bar back onto the supports.

Keep a grip on the bar until it is racked.

Lat Pulldown

A lat pulldown machine is used

Beginning Position:

Grasp the lat pulldown bar with a closed, pronated grip.

Grip should be wider than shoulder-width.

Sit down on the seat facing the machine.

Position the things under the pads with the feet flat on the floor. If necessary, adjust the seat and thigh pad.

Lean the torso slightly backward.

All subsequent repetitions begin from this position.

Downward Movement Phase:

Pull the bar down and toward the upper chest.

Maintain the slight torso backward lean; do not jerk the torso for assistance.

Touch the bar to the chest.

Upward Movement Phase:

All the elbows to slowly extend back to the beginning position.

Keep the torso in the same position.

After the set is complete, stand up and return the bar to its resting position.

Dumbbell shoulder press

Beginning position:

Stand with dumbbells to your side at shoulder level

Grasp the dumbbells with a closed pronated grip.

Dumbbells should be held shoulder width apart.

Press the dumbbells over the head until the elbows are fully extended.

All subsequent repetitions begin from this position.

Downward Position:

All the elbows to slowly flex to lower the dumbbells towards the head.

Keep the wrists rigid and directly above the elbows.

Upward Movement Phase:

Push the dumbbells upwards until the elbows are fully extended.

Keep the wrists rigid and directly above the elbows

Do not arch the back.

After the set is completed put the weights down.

Tricep Extension

Beginning Position:

Stand holding a dumbbell overhead with one hand.

Grasp the dumbbell using a closed grip.

Downward Movement:

Allow the elbows to slowly flex to lower the dumbbell to where the elbow is fully flexed.

Keep the wrists rigid and the elbows pointing outside.

Keep the upper arm parallel to the body and perpendicular to the floor.

Upward Movement:

Push the dumbbell upwards until the elbows are fully extended.

Keep the wrists rigid and the elbows pointing away from the face.

Keep the arm parallel to the body and perpendicular to the floor. Do not arch the back.

After the set is completed slowly put the dumbbell down.

Standing Bicep Curl

Beginning position:

Grasp the dumbbells with a closed supinated grip.

Hands should be shoulder-width apart with the little finger touching the outer thigh

Position upper arms against the sides of the torso and perpendicular to the floor.

Upward movement:

Flex the elbows until the dumbbell is within 4 to 6 in. (10-15cm) off the anterior deltoids.

Keep the torso erect and the upper arms stationary.

Do not jerk the body or swing the dumbbell upwards

Downwards movement phase:

Allow the elbows to slowly extend back to the beginning position.

Keep the torso and knees in the same position.

Bring the dumbbells back to original position.

VITA

Ali Boolani, MA, MEd, CSCS

Candidate for the Degree of

Doctor of Philosophy

Dissertation: ASSESSING BENCH PRESS STRENGTH AFTER TRAINING WITHOUT THE BENEFIT OF VISION.

Major Field: Health and Human Performance

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Health and Human Performance at Oklahoma State University, Stillwater, Oklahoma in July, 2009.

MEd. Exercise Physiology
University of New Orleans, New Orleans, Louisiana, 2005

M.A. International Relations
Tulane University- New Orleans, Louisiana, 2003

B.A. International Relations
Tulane University- New Orleans, Louisiana, 2002

Experience:

Research Assistant- Health and Human Performance Department, Oklahoma State University, 2007- present

Graduate Associate, Health and Human Performance Department, Oklahoma State University, 2006-2008

Professional Memberships:

Member of NSCA, ACSM, ISSA and NSCS

Name: Ali Boolani Date of Degree: December, 2009

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: ASSESSING BENCH PRESS STRENGTH AFTER TRAINING WITHOUT THE BENEFIT OF VISION.

Pages in Study: 72 Candidate for the Degree of Doctor of Philosophy

Major Field: Health and Human Performance

Scope and Method of Study: The purpose of this study was to examine whether upper-extremity strength training visually impaired can increase strength on the bench press. Participants in the study were 35 students, 9 females (19.67 yrs +- 1.118) and 26 males (20.58 yrs +-1.70), taking a strength training class at a rural Oklahoma University. All students were administered a health history questionnaire and a survey to determine their eligibility for the study. Each participant was administered a 5-RM bench press and then split into two groups, an experimental and a control group. Both group were administered the same treatment, with the one exception, that the experimental group trained on the bench press using blind-folds.

Findings and Conclusions: The increases in 5-RM on the bench press were not statistically significant. However, numerically there were greater increases in 5-RM in the experimental group compared to the control group. The experimental group experienced a greater percentage of change both between group and between group and sex. The results may be attributed to the strength of the test and a more stringent test such as a computerized test or a 1-RM may have resulted in significant results. However, numeric increases can lead us to further explore this area.

ADVISER'S APPROVAL: Dr. Bert Jacobson

Oklahoma State University Institutional Review Board

Date: Monday, September 29, 2008

IRB Application No ED08131

Proposal Title: Can Strength Training Blindfolded Lead to Icreases in Upper-Extremity Strength?

Reviewed and Processed as: Expedited

Status Recommended by Reviewer(s): Approved Protocol Expires: 9/28/2009

Principal Investigator(s):

Ali Boolani
1772 Olde School Point
Edmond, OK 73012

Bert Jacobson
204 Willard
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☑ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Shelia Kennison, Chair
Institutional Review Board

ADVISER'S APPROVAL: Dr. Bert Jacobson