12-2001

Examining the Effects of Deer Antler Velvet Supplementation on Muscular Strength, Performance, and Markers of Delayed Onset Muscle Soreness.

Robyn Suzanne Percival
East Tennessee State University

Examining the Effects of Deer Antler Velvet Supplementation On Muscular Strength, Performance, and Markers of Delayed Onset Muscle Soreness

---

A thesis
presented to
the faculty of the Department of Physical
Education, Exercise, & Sport Sciences
East Tennessee State University

In partial fulfillment
of the requirements for the degree
Master of Arts in Physical Education

---

by
Robyn Percival
December 2001

Dr. Craig Broeder, Chair
Dr. Kevin Breuel
Dr. Lynn Panton

Keywords: Deer Antler Velvet, Resistance Training, Eccentric, DOMS

ABSTRACT

Examining the Effects of Deer Antler Velvet On Muscular Strength,
Performance, and Markers of Delayed Onset Muscle Soreness
by
Robyn Percival

Purpose: To examine the effects of deer antler velvet on muscular strength, performance, and markers of delayed onset muscle soreness following a 10-week resistance training period.

Participants: 16 resistance-trained males (18-35) volunteered.

Measures: DEXA, 1-RM, a power test, and a 70% performance trial were measured. Creatine kinase and self-reported soreness levels were measured following an eccentric trial

Results: No pre-experimental significant differences existed between the groups for any of the variables measured. There were no significant differences between the groups regarding body composition, strength, muscular performance, or improvements in creatine kinase and soreness levels from pre to post-intervention. Both groups demonstrated significant ($p<0.05$) increases in creatine kinase and soreness levels immediately post-exercise and 48 hours following the eccentric trial at the 0 and 10-week measurement periods.

Conclusions: Deer antler velvet does not improve muscle size, strength, or performance. Nor does it reduce markers of DOMS following a 10-week supplementation period.

ACKNOWLEDGEMENTS

I would like to thank all of my subjects for participating throughout the duration of the study.

I would especially like to thank Jeremy Quiring for designing the eccentric trial and for helping with the data collection; without you we would not have completed any of the strength testing.

I would like to thank John Quindry for teaching me about all the equipment in the Human Performance Laboratory, assisting with testing, and working on the assays during his busiest time with data collection.

I would like to thank Tracee Murrell for her assistance with data collection.

I would like to thank Dr. Kevin Breuel, committee member, for his guidance on the project.

I would like to thank AgResearch for donating the money and the supplements for the study.

Finally, I would like to thank Dr. Craig Broeder for his guidance throughout the entire study and for the duration of my thesis.

CONTENTS

Page

Chapter Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1
INTRODUCTION

With the introduction of ergogenic aids into athletics, sport at many different levels, ranging from recreational to elite, is quickly becoming a science. Many ergogenic aids are proposed to enhance physical, mental, and mechanical properties within athletics. More specifically, ergogenic aids have gained enormous popularity by promising to increase a person's over-all strength, muscle development, and maintenance of resistance training gains. There are many factors involved in the development, and maintenance of muscle size. McKardle, Katch, and Katch (1) outline six main factors that are vital in impacting the development of muscle mass. These factors include: genetics, nervous system activation, environmental factors, endocrine influences, nutritional status, physical activity, and exercise.

For optimal muscle growth, it is essential to remember that balancing each modifiable factor is important. For example the hormonal influences on muscle growth require a balance between anabolic and catabolic properties of the various hormonal systems (ie., growth-hormone versus cortical-steroid factors). An excess of cortisol will lead to protein breakdown, tissue wasting and ultimately cause negative nitrogen balance (1). Exercise can have both positive and detrimental effects on muscle development. Specifically, animal studies have shown that resistance training can promote both hypertrophy and hyperplasia within the muscle (2, 3). Detrimental effects on muscle development can occur as a result of overtraining. Fry and Kraemer (4) define overtraining as an increase in volume and or intensity of exercise training resulting in long-term performance decrements. Most overtraining research involves endurance based type activities (i.e., marathon training). However, other exercises such as intense weight training produce similar overtraining effects, yet few studies exist in this area (4). A possible solution for combating the effects of overtraining is the use of ergogenic aid based supplementation during training (e.g., protein supplementation, androstenedione, carbohydrate supplementation). It has been proposed that a new supplement, deer antler velvet, may have the potential to enhance recovery time following intense physical activity (5). In addition, the substance has been shown to increase muscle strength and size (6). However, there has been little

scientific research conducted to support this proposal. Therefore, it is necessary to examine the validity of this proposal under well-controlled laboratory conditions.

Statement of the Problem

This study used a double blind administration protocol to determine what the effects of 10 weeks of oral deer antler velvet supplementation had on maximal strength, muscular performance, muscular performance recovery, and markers of delayed onset of muscle soreness (DOMS) in resistance trained men 18 to 35 years old with at least 4 years experience.

Hypotheses and Testing Objectives

Hypothesis 1: It was hypothesized that deer antler velvet would significantly enhance maximal muscle strength after 10 weeks of oral supplementation in resistance trained men compared to a resistance trained placebo group.

Testing Objective For Hypothesis 1: Maximal muscle strength was evaluated by determining the maximal amount of weight that could be lifted one time (1-RM) for the bench press and squat exercise movements before and after 10 weeks with and without the use of oral deer antler velvet supplementation.

Hypothesis 2: It was hypothesized that deer antler velvet would significantly enhance muscular performance after 10 weeks of oral supplementation in resistance trained men compared to a resistance trained placebo group.

Testing Objective For Hypothesis 2: Muscular performance was assessed by comparing each subject's ability to lift 70% of his 1-RM values for the bench press and squat lifting results before and after 10 weeks with and without oral deer antler velvet supplementation. In addition, not only were the number of repetitions determined but the amount of seconds to complete them. Thus, muscular performance was also assessed based on the number reps/sec.

Hypothesis 3: It was hypothesized that 10 weeks of oral deer antler velvet supplementation would significantly enhance muscular performance recovery after completing an eccentric exercise trial to induce DOMS in a resistance trained men.

Testing Objective For Hypothesis 3: Muscular performance recovery was assessed by determining how many times each person lifted 70% of his 1-RM values for the bench and squat

exercises 48-hrs after completing an eccentric exercise trial to induce DOMS with and without oral deer antler velvet supplementation.

Hypothesis 4: It was hypothesized that 10 weeks of oral deer antler velvet supplementation will significantly reduce the markers of DOMS including ratings of muscular pain and creatine kinase.

Testing Objective For Hypothesis 4: The pain markers of DOMS were assessed by using a standardized procedure for rating muscle soreness of primary muscle groups involved in the bench press and squat prior to, immediately following, and 48-hrs after the eccentric exercise trial. In addition, blood samples were taken at the same time periods to determine each person's creatine kinase levels (a marker of muscle damage).

Delimitations

Each subject met the specific requirements in order to be eligible for the study, These requirements were as follows: The participants were males between the ages of 18 and 35. A minimum of 4 years of weight lifting experience was necessary to participate in the study. Each subject avoided additional supplementation such as prohormones or anabolic steroids prior to or during the 10-week study. Each subject maintained regular dietary habits and avoided additional training that was outside the scope of the specific training protocol provided. Height, weight, and body composition were obtained for each subject before and after the 10-week training period. In addition, a pre/post measure of one repetition maximum, anaerobic power, and aerobic capacity were obtained following the 10-week period. A pre-training blood profile was obtained to establish a resting baseline for cholesterol profiles, blood glucose levels, and markers of liver and kidney function. Blood samples were collected pre, post and 48 hours, following an acute training bout specifically designed to investigate muscular power and the effects of DOMS. Similar blood samples were also obtained at the end of the 10-week training program.

Assumptions

1. Each subject avoided any supplements other than deer antler velvet or placebo during the 10-week time frame of the study.
2. Subjects were truthful concerning the guidelines required to be eligible for the study.

3. Subjects were truthful about obeying the specified guidelines provided upon initiation of the study.
4. Subjects were truthful when documenting training exercises throughout the investigation.
5. Subjects did not drastically alter their regular dietary habits throughout the duration of the study.
6. Subjects ingested either the supplement or placebo during the study as described by researchers.
7. Subjects gave a maximal effort during each resistance training period.

Limitations

1. The subjects were not provided with a specific workout regiments or dietary program. However, they were instructed to avoid any drastic changes to either protocols throughout the duration of the study.

2. This investigation used only male subjects, causing the findings to be inapplicable to females.

3. The subjects were males aged 18 to 35, thus the findings cannot be applied to an older population.

4. The results of this study cannot determine the long-term consequences on performance or potential chronic use side-effects from the sue of the deer antler velvet supplement.

Definition of Terms

Delayed onset muscle soreness (DOMS): Muscle soreness that develops a day or two after a heavy bout of exercise (7).

Eccentric Action-Muscle lengthening (7).

Ergogenic Aid: A substance that can improve athletic performance (7).

Myosin: One of the proteins that forms filaments that produce muscle action (7).

Creatine Kinase: A dimeric protein, often found in muscle following intense eccentric exercise (8).

One Repetition Maximum: The greatest amount of weight that can be lifted through the full range of motion only once for a particular lift (7).

Actin: A thin protein filament that acts with myosin filaments to produce muscle action (7).

CHAPTER 2
REVIEW OF LITERATURE

Introduction

Many athletes ranging from a recreational to an elite level strive to improve performance. Ergogenic aids have had both a positive and negative impact with regards to competition. When viewed in a positive light, ergogenic aids are able to contribute by elevating sport to a new level. However, the negative factors associated with ergogenic aids are the abuse of banned substances such as anabolic steroids in an attempt to achieve an unfair competitive edge. Ergogenic aids are often classified in several ways. These include nutritional, mechanical, physiological, chemical, and psychological (9). Examples of these various types of ergogenic aids are presented in Table 1.

Table 1. Ergogenic Aids

Ergogenic Aid Category	Specific Examples of Ergogenic Aids
Chemical	Anabolic steroids, growth hormone
Mechanical	Aero handle bars, specialized clothing
Nutritional	Carbohydrate, protein supplementation
Physiological	Blood doping
Psychological	Visualization

It is apparent that many ergogenic aids are in existence today and that new ones are continually being developed and marketed to athletes. One such example of a new supplement is the introduction of deer antler velvet into the western world. Traditionally, deer antler velvet has been used in eastern medicine as a powerful healing remedy; however, new hypotheses exist concerning the possibility of it being used as a performance enhancement supplement. It is

believed to increase strength and growth of the muscles in addition to acting as an anti-inflammatory agent (10, 11).

Deer Antler Velvet

According to Wang (11) deer antler velvet has been used in Chinese medicine for over 2000 years. Velvet Antler comes from deer and is produced during the regeneration and growth stage that occurs each spring. A medicinal form of deer antler velvet that contains all its active ingredients is a substance called Pantocrine. According to Pavlenko (12), pantocrine is made from the young unossified horns of spotty deer and maral. Velvet Antler is not classified as bone, it begins as protein collagen which eventually matures into cartilage and then bone. This process is influenced by the stag's sex hormones (6). The velvet is removed from the antler and processed during the optimum regeneration period. This occurs health with no harm to the animal.

Velvet is composed primarily of 34% ash, 12% moisture, and 54% organic substances (contributed to by 10% total nitrogen and 3% fat) (6). Pantocrine is the fatty portion that is extracted from the velvet in the antler. Approximately 86% of the fat located in the velvet is extracted to make pantocrine (6). The mineral content that appears in pantocrine is aluminum, calcium, iron, magnesium, potassium, phosphorus, silicon, and sodium. In addition, there are many amino acids found in pantocrine. These include glycine, alanine, and proline. It is believed that these contribute to influencing the processes of growth, metabolism, and biosynthesis in living organisms (6).

Although deer antler velvet is mainly used in Chinese medicine to promote wellness and prevent illness, it is believed to have many health benefits. Suggested benefits of deer antler velvet include: possible growth effects, improved immune function, anti-inflammatory and anti-cancer properties, reductions in anemia, increased athletic performance, decreased recovery time following surgery, memory enhancement, improved blood pressure and cardiovascular function, anti-aging and gonadotrophin effects, and reductions in cholesterol (10, 11, 13-15). Although, velvet antler is believed to benefit all of these ailments, physicians are skeptical about its many curative properties. They find it impossible that one type of medicine can affect so many different diseases that are of no relation to each other (12).

Velvet Antler is believed to have a positive impact on growth and neuromuscular function, which could ultimately affect muscle strength and size. A New Zealand in-house report (1982) outlines several studies with respect to growth. For example, Mineshita, indicates that administering velvet antler to tadpoles may accelerate the growth process. Whereas feeding velvet antler to mice may not benefit growth processes. Bae (10) demonstrated that feeding the substance to chicks increased body weight and feeding efficiency. However, Jiang (6) reported that velvet antler does not stimulate growth in frogs. Thus, these results suggest that there is an additional need for further research in this area.

The report (6) outlined neuromuscular function as follows: Kiselev and Pavlovskaya (6) showed that pantocrine was able to increase the contractions in fatigued frogs by apparently shortening the synaptic delay in the neuromuscular junction. Also simple and complex reflexes were accelerated (27% and 34.5% respectively) in hypoxic frogs following the administration of pantocrine.

Interestingly, the report indicates that the low toxicity level of the velvet antler during preparation testifies the substance being harmless when administrated. Following administration of velvet antler, there were no reported side effects with regards to the internal organs. There were no differences in the comparative weight of the organs such as the spleen, thymus, liver, heart, kidneys, ovaries, and adrenals. Also, no effects on blood proteins were observed.

Although there appears to be a lot of literature on deer antler velvet, New Zealand reports difficulty when trying to compile various sources. Much of the information originates from Russia, Japan, China, and Korea. Some problems encountered were that some of the journals were unattainable, many of the articles did not contain abstracts, often the standards are different when conducting research making it difficult to compare testing, and finally few articles were set in English.

As mentioned previously, a response to DOMS is an inflammatory reaction. It is hypothesized that supplementation of deer antler velvet is shown to have anti-inflammatory effects. In addition, it is believed that pantocrine may contribute to acceleration of the regenerative processes of injured tissue (12). During World War II pantocrine was administered to soldiers who were suffering from various wounds and ulcers. Yudin and Dobryakov have indicated that deer antler velvet or pantocrine (an extract of deer antler velvet) has induced anti-inflammatory activity. AgResearch tested New Zealand velvet antler to examine the anti-

inflammatory effects. They induced inflammation in mice by administering thioglycollate, which causes neutrophils to be released approximately 18-24 hours following injection. Mice were placed into three groups, a deer antler velvet group, a thioglycollate group, and a control group. Then, the mice were killed in order to examine the white blood cell activity. The results indicated that deer antler velvet group suppressed neutrophil production when compared to the other two groups. However, the actual mechanism that causes the suppression of neutrophil production is unknown. It is believed by Wang (11), that the antler produces cytokines, which ultimately aids in reducing the inflammatory response.

As mentioned previously, the mechanisms behind DOMS are similar to inflammatory response. Deer antler velvet could reduce DOMS by possibly suppressing neutrophil production or increasing cytokines (11, 16). Also, the growth properties associated with velvet antler could allow muscle to increase in fiber size and number (10). Thus, making the tissue more resilient to any damage that might occur with overtraining type exercise. If muscle tissue is stronger, then the likelihood that DOMS could occur is dramatically reduced. These properties may contribute to ultimately decreasing recovery time.

In order to gain a better understanding of how deer antler velvet acts as an ergogenic aid and its role in reducing DOMS, the following pertinent areas will be reviewed, muscle physiology, delayed onset muscle soreness, and creatine kinase as a marker of DOMS.

Muscle Physiology

Muscle is composed of fibers that are held together by connective tissue. The connective tissue, which serves to protect muscle fibers, consists of the endomysium, perimysium, fasciculus, and epimysium (1). Each individual muscle fiber consists of myofibrils, which are composed of numerous sarcomeres. There are 12 different proteins located within the myofibril; however, actin and myosin account for approximately 85% of the structure. Actin, along with troponin and tropomyosin, make up the thin filament of the sarcomere, while myosin composes the thick filament. In addition, each sarcomere complex is connected by Z-disks. Between Z-disks, are the I-band, A band, H zone, and M line which are light and dark in nature and contribute to the muscles striated appearance. (1).

Both mechanical and chemical changes must occur in order for a muscle to contract. Wilmore and Costill (7) outline a sequence of events that occurs during muscle contraction.

Initially, the motor unit, which is comprised of a single motor nerve and all the muscle fibers, must be stimulated in order to cause a muscle related action potential. Stimulation occurs via a motor nerve impulse which then induces the release of the neurotransmitter, acetylcholine. When enough acetylcholine crosses the neuromuscular junction, successfully and binds to receptors on the sarcolemma, an electrical charge is generated which is known as an action potential. The action potential travels across the membrane until it reaches the sarcoplasmic reticulum, which causes the stored calcium to be released. The calcium binds to troponin, which as mentioned previously is located on the thin filament. The binding effect causes tropomyosin to lift off the actin filaments in order to allow myosin heads to attach to the actin filament (7). The process in which actin and myosin attach is known as the sliding filament theory, which was first established by H.E. Huxley and A.F. Huxley in 1954 (17). It is believed that the muscle undergoes a cross-bridge cycle, which is fueled by the hydrolization of adenosine triphospate (ATP) to adenosine diphosphate (ADP). The components of the cross-bridge cycle include the initial release of calcium, which stimulates the binding of myosin heads to actin. Myosin heads have stored ATP, which provides the fuel that allows actin and myosin to move past each other. The filaments do not actually shorten, they slide past each other which causes the H zone to become smaller and induces eventual shortening of each sarcomere. Free energy is created as a result of the hydrolysis process and binds to myosin in order to prepare for the next contraction.

As mentioned previously, muscle is made up of many fibers that are held together via connective tissue. There are different classifications of muscle fibers that are recruited in order to perform specialized functions. The two main types are fast twitch muscle fibers, also known as type II and slow twitch muscle fibers, also known as type I. Fast twitch fibers are required for quick explosive type actions that primarily depend on the short-term glycolytic system for energy. These fibers are also 3 to 5 times faster with regards to contracting and shortening when compared to slow twitch muscle fibers (1). In contrast, slow twitch muscle fibers are recruited during prolonged lower intensity exercise. These fibers contain numerous mitochondria and have a very high capillary to fiber density which allow the muscle to sustain extended aerobic exercise. The slow contraction period involving shortening and lengthening of the sarcomere allows this fiber type to be fatigue resistant (1).

The primary muscle fiber type that is used in resistance training is fast-twitch muscle fiber. Repeated contraction occurring in the muscle, specifically fast twitch fibers, can lead to

hypertrophy of the muscle tissue. Hypertrophy has been observed in both animal and human studies employing various resistance training protocols. McCall, Byrnes, Dickinson, Pattany and Fleck (2)examined the effects of a resistance training program on muscle hypertrophy (increase in muscle size) and hyperplasia (increase in fiber number) in 12 college age males. Magnetic resonance imaging and muscle biopsies were obtained in order to determine the effects of the training protocol on muscle tissue. The results indicated that there was a significant increase in strength from week 3 to week 9 at the $p<0.05$ level. There were significant increases ($p< 0.05$) in cross-sectional muscle area in the biceps brachii (12.6%), triceps brachii (25.1%), and total arm (14.6%) as a result of training. Fiber size for both type I (10%) and type II (17.1%) muscle fibers significantly increased at the $p<0.05$ level. However, there was no significant increase in the number of muscle fibers. The estimated number of fibers during the pretraining period was 293.2 $\pm$ 61.5 X 10^3 whereas after the post-training period the estimated number of fibers was 297.5 $\pm$ 69.5 X 10^3. Thus establishing that muscle hypertrophy occurs as a result of resistance training whereas muscle hyperplasia does not. In contrast, Tamaki et al., (3) found that hyperplasia occurred in response to weight lifting in untrained rats. The researchers trained male Wistar rats using resistance exercises designed to use hind limb muscles. In order to measure development of new tissue, 5-bromo-2′-deoxyuridine (BrdU) was injected into the tissue before sampling. BrdU is a marker that is used to measure DNA synthesis and is often used when examining proliferation of the muscle tissue. The results indicated a significant increase in anti-BrdU positive cells 1.5 to 2 days after exercise, which is displayed in Figure 1.

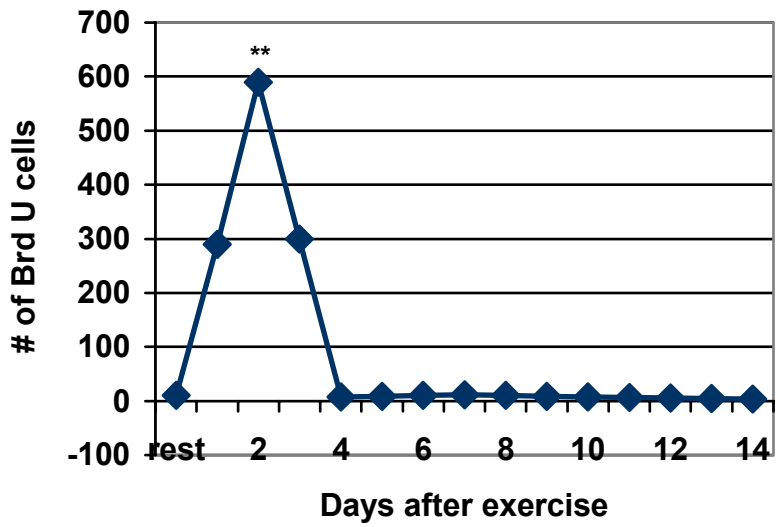


Figure 1. Serial Changes in Number of Anti-BrdU-Positive Cells in Histological Sections From Plantaris Muscle. Note the significant increase in the number of BrdU-positive cells 1-3 days after exercise. Note also that the peak number of anti-BrdU-positive cells is seen 36-48 h after exercise. Values are mean counts ±SE per section. **P<0.01 compared with resting values

In addition to the increase in anti-BrdU cells, there was a presence of satellite cells (119 ± 33/section) which are precursors to muscle regeneration. This study suggests that following resistance training, damage occurs in the muscle tissue, which then activates satellite cells and could contribute to possible regeneration of damaged muscle tissue. Also, there was evidence of new fibers present in the interstitial space of the muscle, which was reported via electron microscopy. These findings indicate that muscle may undergo both hypertrophy and hyperplasia following resistance training exercise. However, some authorities believe that hypertrophy is the main effect in human muscle growth following resistance training (1). Resistance training has been shown to be beneficial for contributing to overall increases in muscle size and strength. However, when resistance training causes decreases in performance the result is overtraining. Overtraining, as defined by Fry and Kraemer (4) is the overall increase in volume or intensity,

which results in long term performance decrements. Fry and Kraemer state that overtraining is best described as a continuum of events, which is outlined in Figure 2.

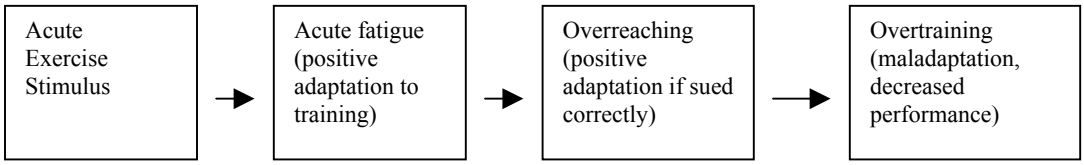


Figure 2. Overtraining Continuum from Fry and Kraemer to Show the Progression of Overtraining.

Overtraining may result in a variety endocrine responses that may affect performance. Fry and Kraemer (4) review that resting testosterone levels have been shown to both increase and decrease following overtraining. Also cortisol levels have been shown to increase and decrease. Suggestions for an increase in resting cortisol could be due to the need to replenish energy stores. The decrease in cortisol could be due to down regulation of production as a result of existing high levels in the blood. No change in growth hormone has been reported due to overtraining. Although Fry and Kraemer (4) have defined overtraining, not all studies adopt the same criteria. This makes it difficult to find definitive results with respect to how overtraining impacts performance. Further research needs to be done and a clear definition needs to be developed in order to understand all of the implications associated with overtraining.

DOMS

An acute form of overtraining that can occur following resistance training is delayed onset muscle soreness. It is the most prevalent in untrained individuals following intense exercise. DOMS is described as a feeling of discomfort or pain within the muscle following unaccustomed muscular exertion. It is common in individuals who initiate an unfamiliar exercise regime. Untrained individuals may experience discomfort, which peaks approximately 24-48 hours after an intense bout of exercise (18). Although, the soreness associated with DOMS is acute in nature and is not debilitating, it can reduce muscular performance. The underlying mechanisms that cause DOMS is unknown; however, it is believed that mechanical injury followed by biochemical forces damage muscle tissue following intense exercise (18). Armstrong (18) proposed that DOMS may follow a distinct sequence of events. Following

exercise, mechanical forces act on the muscle, which causes a disruption of structural proteins in muscle fibers and tissue. This elicits an influx of calcium as a result of the altered permeable state in the cell membrane. High calcium concentrations may inhibit oxidative phosphorylation and also activate a proteolytic enzyme that degrades the Z-discs in the muscle. The eventual degradation of the muscle attracts monocytes that convert to macrophages to remove damaged tissue. Finally, Armstrong proposes that the sensation of DOMS is stimulated by the accumulation of histamine, kinins, and potassium and an increase in edema which affect group IV nerve endings.

Similar to Armstrong's proposed sequence of events is Smith's (19) hypothesis related to the etiology of DOMS. Smith (19) states that initially disruption occurs within connective and/or contractile tissue following exercise. Then the damaged tissue experiences an elevation in neutrophils, which eventually migrate from circulation to the site of tissue injury. This is followed by an increase in monocytes approximately 6 to 12 hours after the initial injury. Macrophages begin to make prostaglandins (PGE_2) which signal the type III and IV pain afferents. Finally, Smith states that the pain is induced by edema which leads to an increase in intra-muscular pressure which in turn may stimulate pain receptors upon palpation of the effected area. In spite of the similarity that exists between the two proposed pathways, both indicate that more research needs to be conducted in order to establish the exact cause of DOMS.

As previously mentioned by Smith (19) neutrophils are involved in the initial processes of DOMS. Pyne (20) also recognize that neutrophils are recruited as the first line of defense in order to combat against injury and inflammation. He indicates that neutrophils are obtained from the bloodstream and attracted to the area of injury, upon arrival they will signal for additional neutrophils, immonugloubulins, and cytokines to promote the repair process. Neutrophils are phagocytotic in nature and function by engulfing foreign invaders and bacteria. Armstrong (18) stated that z-disks might become damaged during exercise as a result of proteolytic enzymes being released. Pyne (20) suggests that neutrophils may function by engulfing the damaged tissue in the myofibrils following intense exercise. Although neutrophils function to remove foreign material, they are not efficient in distinguishing between healthy tissue and damaged tissue. Thus, they may actually contribute to the local inflammatory response by also invading healthy tissue and cytokines that are released to further mediate tissue repair. Pedersen, Ostrwoski, Rhode and Bruunsgaard (21) report that cytokines such as interleukin IL-6, tumor

necrosis factor-α (TNF) and increase in response to inflammation following eccentric exercise. They report that cytokines are released in order to promote the healing process following inflammation of muscle tissue. A review by MacIntyre, Reid and McKenzie (22) also indicated that there is an increase in cytokine activity following exercise. The specific cytokines released are interleukin-1, interleukin-6 and tumor necrosis factor. An investigation by Stauber, Fritz, Vogelbach and Dahlmann (23) examined the effect of muscle lengthening of the soleus in 18 male rats on DOMS and related muscle damage. The results indicated that necrotic tissue was present possibly due to tumor necrosis factor. TNF is a cytokine that is produced by neutrophils, lymphocytes, macrophages, natural killer cells, lymphokine activated killer cells, astrocytes, endothelial cells, and smooth muscle cells. It is released in response to injury in order to destroy and kill injured tissue, ultimately allowing growth and regeneration of new tissue. Also macrophages were present but were not the predominant cell type.

Monocytes and macrophages are also believed to play a role in the inflammatory process associated with DOMS. They engulf the neutrophils that are located in the damaged necrotic tissue and also produce various other cytokines, to promote the healing process (22).

Although, the specific etiology has not yet been determined, the conditions under which DOMS is the most prevalent have been established. Evidence indicates that the syndrome predominantly occurs following eccentric exercise and is the most prevalent in untrained individuals. Stauber et al. (23) observe that at 48 hour post exercise mean perceived soreness increased from a rating of 1 to 8 on a scale of 10 being the highest. The scale was defined as follows: 1 was classified as normal whereas 10 was defined as being very sore. They also observed extracellular matrix damage within the muscle following eccentric exercise. Evans et al. (24) indicate that following a 45-minute bout of eccentric exercise on the cycle ergometer untrained men experienced significantly elevated ($p<0.01$) levels of creatine kinase 3 hours after exercise that continued to increase for 5 days reaching a level 33 times greater than base line level. Interleukin-I was also significantly higher ($p<0.01$) in the untrained men when compared to trained men. The metabolic response incurred suggests that following eccentric exercise delayed onset muscle soreness is more prevalent in untrained individuals.

It has also been suggested that eccentric exercise may contribute to strength decrements as a result of DOMS. A review by McIntyre, Reid and McKenzie (22) indicates that Clarkson and colleagues proposed that strength loss may be attributed to overstretched sarcomeres, which

could affect force production (22). In addition, McIntyre et al. (22) support findings by Faulkner and colleagues who state that some sarcomeres may stay the same while others are stretched causing damage. The overstretching hypothesis could be directly related to eccentric exercise due to the continual lengthening of the muscle during exercise.

As mentioned previously DOMS is not debilitating; however, it may cause decreases in strength. Ironically, a way to prevent the syndrome from occurring is to continue exercise. Clarkson and Tremblay (25) found that following recovery from DOMS, the muscle tissue was able to heal and make adaptations in order to prevent future injury. They investigated the effects of exercise induced muscle damage, repair, and adaptation in women. Eight college-aged women performed eccentric exercises using both the right and left forearm. The exercise protocol was as follows: One arm was required to complete 70 maximal contractions (70-Max), while the other arm only completed 24 maximal contractions (24-Max), followed by an additional 70 maximal contractions (70-Max) 2 weeks later. They measured muscle force, soreness, and creatine kinase activity following the 2-week study. The results indicated that there was a significant initial ($p<0.01$) strength loss and a high rating of perceived soreness following the initial 70max contraction protocol. In addition, there was a significant increase ($p<0.01$) in creatine kinase levels following the initial 70max contraction protocol when compared to the 70max2 contraction protocol. According to these results, it is apparent that the muscle undergoes an adaptive phase in order to prevent future exercise damage. The level of creatine kinase and the amount of muscle soreness significantly diminished during the repeated bout of exercise when compared to the initial bout. The muscle became more resistant to exercise induced damage and was able to repair the damaged tissue at a faster rate.

Vincent and Vincent (26) examined the effect of training status in response to muscle soreness following resistance exercise. Their subjects included 20 college-aged males (mean age untrained = 18.2 ± 1.3, trained = 22.7 ± 2.4) who were placed into either a trained group or an untrained group. The trained group was identified as having a minimum of 3 years of weightlifting experience whereas the untrained group did not participate in weightlifting for at least 3 years. The training protocol was a split-day leg exercise regime, which targeted the knee extensors on day 1 and the knee flexors on day 2. The results indicated that serum creatine kinase was significantly elevated ($p<0.01$) in the untrained group (CK = 3272 IU) when compared to the trained group (CK = 1349 IU). These results demonstrate that there is an

adaptive effect that the muscle undergoes in order to prevent further injury and inflammation. Vincent et al. (26) state that the sarcolemma may strengthen as a result of chronic exercise training thus preventing the leaking out of muscle proteins. In addition, they hypothesized that the permeability of the sarcolemma may have been altered, which could have prevented enzymes such as creatine kinase being lost in the bloodstream. Although it is evident that an adaptation occurs with regards to exercise and DOMS, the amount of time for the adaptation to occur is still unclear. Nosaka, Clarkson, McGuiggin and Byrne (27) observed the changes in muscle adaptation in 2 different groups of college aged females (19.2 ± 0.8 yrs) following eccentric exercise. Group 1 had 6 weeks of recovery time and group 2 had 10 weeks of recovery time before repeating the exercise. Both groups experienced significant decreases ($p<0.01$) in serum creatine kinase activity during the second exercise bout; however, there was no significant difference $p<0.01$) between the groups. This suggests that time needed for muscle adaptation and repair to occur remains unclear.

Acute Performance Following DOMS

A review by McIntyre, Reid, and McKenzie (22) indicates that Clarkson and colleagues attribute strength losses to overstretched sarcomeres, which could affect force production (22). In addition, McIntyre et al.(22) support findings by Faulkner and colleagues who state that some sarcomeres may stay the same while others are stretched, causing damage. As a result, one would expect that performance would decline following an eccentric exercise bout. Several studies support the hypothesis that performance declines immediately following heavy eccentric exercise when there is damage to the muscle. A study by Mair and colleagues (28) examined the effects of eccentric exercise on 22 male volunteers from a physical education class that ranged in age from 20 to 26 years. The volunteers were split into two groups. Group A had exercise sessions separated by 4 days and group B had sessions separated by 13 days. The eccentric exercise bout involved 7 sets of 10 eccentric contractions of the quadriceps femoris muscle group. Performance was tested using the Kistler force platform where the subjects performed one-legged vertical jumps, which measured force production and vertical jump height. This test was completed before, immediately after, 1, 2, 3, and 4 days following the eccentric exercise for both groups. The results indicated that there was a significant ($p=0.0001$) decline in force production following the exercise bout for both groups. The most pronounced decline was

observed immediately following; however, performance remained affected up to 4 days after the eccentric trial. A previously mentioned study by Vincent and Vincent (26) demonstrates reductions in performance following resistance exercise. Force during extension and flexion of the knee was measured using an isovelocity dynamometer before, immediately after, 1, 2, 3, 4, 5, 6, and 10 days following the resistance exercise. During the knee extension phase, the baseline value for the trained group was 365 ± 83 Nm; the baseline value for the untrained group was 316 ± 34 Nm. Both the trained and untrained group demonstrated a significant ($p<0.05$) reduction (30% and 24% respectively) in isometric peak torque capacity immediately following the exercise. During the knee flexion phase, the baseline value for the trained group was 167 ± 11 Nm; the baseline value for the untrained group was 163 ± 13 Nm. Again there was a significant decrease ($p<0.05$) in isometric peak torque capacity for both groups (Trained= 25%, Untrained = 17% following the exercise bout. Both groups recovered by day 10 of the exercise testing. A study by Clarkson and Tremblay (25) also examined the effects of eccentric exercise on force production. Eight college aged women performed 3 eccentric trials using a modified arm curl machine. Subjects performed 70 maximal contractions with the non-dominant arm and 24 followed by 70 maximal contractions with the dominant arm. Force generation was assessed using the arm curl machine, prior to, immediately following and 5 days after the eccentric trials. The results indicated that in all trials strength losses were observed following the eccentric exercise bout. However the 70 maximal contraction period with the non-dominant arm declined significantly ($p<0.01$) compared with the other 2 trials. It was observed that for the 24 maximal contraction and the second 70 maximal contraction force returned to levels that were not significantly different from baseline values and 2 and 4 days respectively. For the non-dominant 70 maximal contraction phase force remained significantly impaired 5 days following the trial. These studies indicate that following eccentric exercise performance will be acutely affected. This decline can be attributed to the damage associated with delayed onset muscle soreness, which is induced from the eccentric exercise.

Creatine Kinase

In a review by Ebbeling and Clarkson (29), creatine kinase is recognized as being the most common indicator of exercise induced muscle damage. They suggest that it is a marker because it is found to be located in the muscle and is released following intense exercise.

Creatine kinase is the most prevalent in eccentric exercise, which has also been shown to have the greatest increase in DOMS. Evans, et al., (24) examined the effects of eccentric exercise in trained versus untrained males. The subjects were 4 trained runners and 5 untrained males, each of whom exercised on a cycle ergometer that was designed to mimic eccentric exercise. Plasma creatine kinase was significantly higher in the untrained group compared to the trained group. The untrained group displayed creatine kinase levels up to 33 times greater than the obtained baseline levels prior to exercise. Whereas the trained group only experienced increases in creatine kinase up to 2.3 times greater than baseline levels. Creatine kinase levels did not return to normal in the untrained group until 9 days following exercise while the trained group's CK levels returned to baseline 2 days after exercise. It was apparent that muscle soreness and decreased mobility was evident in the untrained group following exercise. In addition, creatine kinase was significantly higher in the untrained group than the trained group suggesting that it is a useful measure in identifying D.O.M.S.

Studies show that levels of creatine kinase have been shown to peak 48 hours following eccentric exercise. Mair et al. (28) examined the effects of eccentric exercise on muscle soreness and creatine kinase. They randomly allocated 22 college age males into two groups, which performed two identical bouts of exercise. Group A had two sessions which were separated by 4 days and group B had two sessions separated by 13 days. Creatine kinase levels increased significantly ($p=0.0001$) peaking 2 to 3 days following the first bout of exercise in both groups. During the second session of eccentric exercise, neither group saw any significant increase in creatine kinase suggesting an adaptive effect of the muscle. Glesson et al. (30)also observed significant ($p>0.01$) increases in CK ranging from 120 to 1950%and peaks occurring from 1, 2, 3,4, or 7 days following eccentric exercise.

In addition, Clarkson and Tremblay (25) report an association between elevated creatine kinase levels and soreness following unaccustomed eccentric exercise involving an arm ergometer. Vincent and Vincent (26) show a significant increase ($p<0.01$) in creatine kinase levels in untrained subjects (3272 IU) following exercise when compared to trained individuals (1349 IU). However, they report no association between soreness and CK levels because their trained group had higher levels of soreness compared to the untrained group. Suggesting that there is a possibility of having an increase in soreness without significantly elevated creatine kinase levels.

There is some question as to how reliable creatine kinase is as a measure of overtraining due to inter-subject variability. Harmann and Mester (31) report enormous differences in both men and women athletes with respect to creatine kinase levels. In addition, they indicate that some athletes exhibit low levels of creatine kinase while others demonstrate very high levels (31). As a result of this finding it is apparent that it may be difficult to compare creatine kinase in a cross-sectional study design. However, a way to alleviate this controversy with respect to creatine kinase is to use it in a longitudinal design. In this situation each subject can serve as their own control and establish a baseline level to be compared to as proposed in the current study.

CHAPTER 3
RESEARCH METHODOLOGY

Subjects

This study included 32 male subjects who agreed to participate on a volunteer basis. Subjects ranged in age from 20-35 years. In order to be eligible to participate in the study, each subject was required to meet the minimum entrance requirements outlined in the delimits of this study. Subjects were required to have a minimum of 4 years of weightlifting experience and had to be training at the onset of the study. All subjects were screened for cardiovascular and metabolic related diseases prior to the investigation. Subjects were required to fill out personal, medical, demographic, physical activity questionnaires. (Appendix A) If any symptoms were observed following the screening process, subjects were excluded from the study.

Research Protocol

This investigation was conducted using a double blind procedure. Each subject was assigned an identification number and then randomly assigned to receive either the deer antler velvet supplement or placebo. Subjects were required to consume 1500 mg of the supplement 60 minutes prior to training and 1500 mg following resistance training. Periodic checks were made to count the number of pills in each bottle to ensure that each subject was following the supplement regime. The subjects continued their current resistance protocol, but each was required to document each exercise following every workout. After each subject gave consent to participate they were required to complete a series of pretests. Height, weight, and blood pressure were obtained first. Maximal Oxygen Uptake (VO_2 max) was measured using a graded exercise test. Anaerobic power was measured on the Computrainer cycle system. One repetition maximum was obtained for both the bench and squat. Body Composition was assessed using Dual energy x-ray absorptiometry (DEXA). Finally the eccentric trial was completed with pre, post, and 48 hour blood draws to measure creatine kinase activity.

Instrumentation

Maximal Oxygen Uptake

Each subject had his maximal aerobic capacity measured on the Quinton 65 treadmill in order to assess cardiovascular ability. A graded exercise test was used to determine maximal oxygen uptake and monitor heart function using a 12 lead electrocardiogram (EKG). Upon arrival to the ETSU Human Performance Lab, each subject was given instructions as to how the treadmill test was performed. The guidelines outlined by Maud and Foster (32) were used: The subject was instructed to lie face up on the prep table. All the landmarks for electrode placement using a 12-lead system were located. The landmarks were free of hair and cleaned using alcohol. Electrodes were placed on the landmarks, and the subject was hooked to the EKG machine. Resting blood pressure and heart rate were recorded in the supine, sitting, and standing positions. The subject was instructed to begin walking. In order to measure maximal oxygen uptake (VO2 max), subjects were connected via a mouthpiece to the SensorMedics 2900 cart. The connection allowed the SensorMedics 2900 to measure the amount oxygen consumed and carbon dioxide produced. During the test a rating of perceived exertion was given by the subject and recorded every minute. A 12-lead EKG tracing was taken during the last 10 seconds of each minute and heart rate was recorded. Blood pressure was taken every 3 minutes by an experienced technician using the Colin STBP-780 electronic blood pressure cuff. In order for the test to be determined a true maximal effort, it was required that specific criteria were met during the exercise bout. Maud and Foster (32) outline the criteria as follows; a plateau in VO_2 must occur as the workload increases, respiratory exchange ratio must exceed 1.1, and heart rate must be within 10 beats of the age predicted maximum heart rate. The test was terminated at the request of the subject if the subject became dizzy or confused or if EKG problems were detected.

Anaerobic Power

Anaerobic power was measured on the Computrainer cycle system using a test protocol designed to serve as a baseline for measuring power (i.e., completing a 0.2 mile flat course as quick as possible). Each subject was instructed to avoid any strenuous exercise 12 hours prior to testing. In addition, each subject had to avoid eating any big meals at least 4 hours prior to testing. The test was performed at the ETSU Human Performance Lab, room 113. Prior to

testing, equipment was calibrated at 3.25 lbs of load resistance for each subject's trials. After the calibration procedure, the subjects were instructed on how to perform the test before beginning the protocol, which is outlined as follows: The subject warmed-up at a light intensity for 5 minutes. During the test the subject was instructed to remain seated on the bicycle for the duration of the test. The subject began cycling in the 52,23 gear combination at 60 revolutions per minute (rpm) for 1 minute in order to obtain a steady state heart rate. The subject continued to cycle for another minute while the resistance was increased every 15 seconds. The subject then cycled at a maximal effort for 0.2 miles, in the 52, 13 gear. This bout usually lasted between 25-40 seconds depending on the person. The subject then rested for 3 minutes, which allowed him to recover for the next bout. This trial was repeated for a second and third trial. If the subject experienced dizziness or nausea during the trial the test was terminated. The subject then was instructed to cycle lightly until his heart rate returned to less than 100 bpm. The best performance of the three trials was used to measure three variables. The maximum watts, average watts, and time to peak power was measured in order to determine anaerobic power (33).

Strength Testing

Initial strength was determined using a 1-repetition protocol for both bench and leg press. All the lifts were performed on the Muscle Maxx ® equipment with a spotter present to ensure full safety precautions. The initial weight was estimated based on previous weight lifting experience. A successful attempt involved fully lowering the weight to the chest and then extending fully until the arms were straight without any assistance. This protocol was repeated until the subject could no longer lift the weight without assistance from the spotter. Between lifts subjects were given approximately 2-5 minutes of rest to ensure recovery. One repetition maximum (1-RM) was determined using the last successful attempt prior to failure. For the maximal squat attempt the subject was instructed to squat until the leg reached a 90 degree angle. A spotter stood behind the subject to ensure safety. One repetition maximum was determined using the last successful attempt prior to failure. The weight was recorded in pounds and then converted to kilograms to the nearest tenth. The total amount of weight was determined by adding the 45 lbs bar to the weight of each plate for the bench press and squat.

Body Composition

Each subject's body composition profile was assessed by taking height (m), weight (kg), body mass index, and DEXA measurements. DEXA measurements were performed at The Center for Reproductive Sciences in Johnson City, Tennessee. The subjects were required to remove all jewelry and shoes during the scan. The subjects were instructed to lie straight and still on the table while the scan takes place. The top of the subject's head was positioned 0.05 inches from the edge of the table to ensure that the whole head was included in the scan. The subject's feet and knees were secured with velcro straps to the table. The same technician conducted all the scans to ensure reliability during the investigation. From the DEXA measures, each subject's body fat percentage, fat weight, fat free weight, and trunk-to-limb ratio were determined.

Eccentric Trial

As mentioned previously, DOMS is most prevalent with eccentric related exercises. Therefore, in order to induce DOMS it was necessary to concentrate primarily on eccentric type exercises when designing the overtraining protocol. The purpose of the eccentric trial was to determine if deer antler velvet could enhance recovery time and performance at 70% of max lifting to high intensity resistance training. This was accomplished by having each subject complete a series of resistance based exercises as outline in Table 2 and evaluated for markers of DOMS (pain rating scales, creatine kinase) before, immediately after, and 48-hours post the eccentric exercise trials. Subjects had their blood drawn by a licensed phlebotamist at the ETSU Human Performance Lab immediately before beginning the eccentric protocol. The investigators ensured that each subject was ready to participate in the trial after giving blood (ie check for blood clotting and dizziness). The subjects were escorted to the varsity weight room at ETSU to participate in the trial. The trial was explained thoroughly by the investigator to ensure that each subject understood each exercise. Subjects were grouped according to similarities in bench press and leg squat in order to limit the time it takes to load the weight on to the racks. Each subject focused on upper body and then lower body exercises. The upper and lower body exercises are presented in Table 2 below:

Table 2. Eccentric Trial Exercise Protocol

Upper Body Exercises	Weight	Repetitions	Sets
Bench Press	Based on 70% of pre-determined 1-RM	Until Failure, no longer being able to lift the weight	3
Smith Machine Negatives	Based on 10% > than pre-determined 1-RM	Until Failure, no longer being able to keep with the cadence	3
Push-ups	Body Weight	Until failure, no longer able to propel self upward	3
Lower Body Exercises			
Squats	Based on 70% of pre-determined 1-RM	Until failure, no longer being able to lift the weight	3
Medicine Ball Jumps	10 lbs medicine ball	Until Failure, can no longer jump and hold weight over head	3
Box Jumps	Body weight	Until Failure, can no longer jump onto the box	

*see appendix B for a complete trial description

The upper body exercise protocol began with the bench press as shown in appendix B. The weight used for the bench press was calculated at 70% of each person's predetermined 1-RM. Bench press exercises were performed to fatigue. This was defined as the inability to continue to lift the pre-determined weight. A spotter was present in order to ensure safety precautions. Smith machine negatives were performed on a smith machine, which allowed the subjects to safely lift very heavy resistance. The weight that each subject lifted was based on greater than 10% of his predetermined 1-RM for the bench press. Each subject lowered the bar in conjunction with a specific cadence that was counted out by the spotter, which was approximately 3 seconds/repetition. Then the bar was raised up by spotters in order to specifically focus on eccentric loading. Fatigue was defined as that point in which the subject could no longer maintain the 3 seconds/repetition cadence. Push-ups were repeated until fatigue, which was defined as the inability to continue propelling the body up and down. The subjects placed their hands and feet on a mat for comfort.

The lower body exercises involved squats, medicine ball jumps, and box jumps. Squat weight was calculated based on 70% of each person's pre-determined 1-RM for the squat exercise before initiating the protocol. Squats, shown in appendix B, were performed to fatigue with a spotter present for safety. The medicine ball jumps, shown in appendix B, involved beginning in a squat position while holding onto the medicine ball. The subject jumped into the

air while hoisting the ball above his head. Then the subject landed in the squat position, again focusing on eccentric loading. This was repeated until fatigue, which was defined as being unable to lift the ball directly above the subject's head. Also, the inability to jump off the ground ended the trial. Finally, box jumps shown in appendix B, were performed on a 12-inch box. Each subject began on the floor and stepped onto the box, alternating which foot he stepped up with. When the subject reached the top of the box he stepped off the box into a squat position and jumped as high as he could landing on two feet. This was repeated until fatigue, which is defined as no longer being able to successfully step up onto the box.

The protocol was as follows: a) the subject began with upper body exercises; b) the subject completed the sets until failure of each upper body exercise without any rest in between exercises or sets; c) the subject was timed on each exercise and the times and number of repetitions were recorded; d) this circuit was repeated 3 times; e) after completing upper body, the subject completed the 3 lower body exercises; f) the exact same sequence occurred with the lower body protocol. Refer to appendix B.

Following completion of the eccentric trial, the subjects were required to give another blood sample. This blood draw occurred 5 minutes after the trial finished. Subjects were scheduled to return to the Human Performance Lab exactly 48 hours following the last blood draw. Another sample of blood was drawn to measure creatine kinase. Following the blood draw, subjects completed a 70% trial involving bench press and squat to measure performance. Each subject exercised at 70% of his pre-determined 1-RM. The trials were timed, and the number of repetitions was counted with a spotter present to ensure safety. After the eccentric trial subjects were given either supplement or placebo.

Perceived Soreness Scale

A subjective pain scale was used in order to assess perceived levels of soreness following the eccentric trial. A baseline measure was obtained by administering the scale prior to initiating the eccentric trial. Additional measures were obtained immediately post, 24, and 48 hours following the completion of the trial. Each subject was asked to rate soreness from a scale of 0-10 (0=none, 10=excruciating) as shown in appendix C. Soreness was assessed in the following areas: neck, shoulders, upper back, triceps, biceps, chest, abdomen, forearms, lower back, buttocks, hips, groin, hamstring, quadriceps, calf muscle, and shins.

Performance Trial

Subjects returned 48 hours after the completion of the eccentric trial to assess muscular performance after muscle damaging exercise. Muscular performance was assessed by comparing each subject's ability to lift 70% of his 1-RM values for the bench press and squat lifting results before and after 10 weeks with and without oral deer antler velvet supplementation. Muscular performance was also assessed based on the number reps/sec.

Assay Procedure

In order to analyze and compare the levels of serum creatine kinase between the subjects in both the supplement and placebo groups, specific assays were performed. The guidelines necessary for creatine kinase analysis are outlined by Sigma Diagnostics as follows: a). 2 different test tubes were labeled, Test and Blank, and the appropriate solutions were pipetted into each one. In the tube labeled "test" 1.0 ml of Creatine Solution, Catalog No 661-6, 0.3 ml of Serum and 1.0 ml of Water was pipetted. In the Blank tube 1.0 ml TRIZMA ® Buffer Solution, 0.3 ml of Serum and 1.0 ml of water was pipetted. B) Both tubes were then placed into a 37° C for a 5 minutes. c) After the tubes were warmed, 0.10 ml of ATP-Glutathione Solution was added and incubated for 30 minutes. d) After incubation, 1.6 ml of cold Trichloroacetic Acid was added to stop the reaction. e) After 5 minutes the tubes were centrifuged to obtain clear supernatant or filter through the ashless filter paper. f) Then 2 cuvets were labelled "blank" and "test" which received 1.0 ml of clear supernatant from the corresponding tube. g) Each tube received 4.0 ml of water, 1.0 ml of Acid Molybdate Solution and 0.25 mL Fiske and SubbaRow Solution. h) After the mixture was added, each tube was left to stand for 30 minutes at room temperature (18° C-26°C) while the phophocreatine (CPK) hydrolyzed and color developed. I) The solutions were then transferred no later than 10 minutes into cuvets, in order to read and record the absorbance levels using a mass spectrophotometer. j) The μg P for the Test and Blank cuvets was determined. k) Then both numbers were subtracted in order to determine the change in μg P. l) CPK was determined using the values from Sigma Diagnostics.

Statistical Analysis

All data are presented as means ± standard deviations. Repeated measures analysis of variance was used for all analysis. For example, the effects of deer antler velvet on VO_2 max used a 2 x 2 repeated measures ANOVA (1 between variable = supplement versus placebo and 1 within variable = pre versus post measurement). When a significant Group * Measurement period interaction was observed ($p<.05$), a Student-Neuman-Keuls post Hoc procedure was used looking at the individual groups. All statistical procedures were performed using Statview Statistical Software (SAS Institute).

CHAPTER 4
RESULTS

Sixteen subjects from the original 32 were excluded from the final data pool due to the following reasons. There were six subjects who completed the initial testing procedures but did not participate in the eccentric trial. Six subjects were excluded due to lack of compliance regarding experiment protocol. Of those six, three failed to complete the 5-week testing requirements and three did not adhere to the guidelines regarding supplement ingestion. Two subjects dropped out as a result of time constraints with work and school. One subject dropped out due to an unrelated injury. Finally, one subject dropped out because he wanted to drastically alter his workout regime, which fell outside the study guidelines.

The final data pool consisted of 16 participants, who were randomly allocated into either the Deer Antler Group (n=8) or the placebo group (n=8).

Baseline Characteristics

There were no observed significant differences ($p>0.05$) between or within the groups at 0 or 10-week measurements, regarding age, height, weight, or body mass index (BMI) as reported in Table 3. The values for BMI indicate the presence of grade 1 and 2 obesity for both group B and A respectively; however, both groups are considered a special population therefore excluding BMI as a valid predictor of obesity. This fact is supported by the DEXA percent body fat data showing that each group should be classified as borderline obese only (ie. % body fat between 20.0%- 24.9%)

Following the 10-week intervention period, alterations in DEXA % body fat, DEXA fat free weight, and trunk-to-limb fat weight ratios were observed as indicated in Table 3. In the deer antler velvet group, DEXA percent body fat declined from 21.7 ± 6.5 to 20.2 ± 6.2% ($p=0.08$) while DEXA fat free weight increased 76.8 ± 7.8 kg to 77.6 ± 7.6 kg ($p=0.08$). In the placebo group, the decline in DEXA % body fat neared significance (0-weeks = 20.0 ± 5.2% to 10 weeks = 18.7 ± 4.5%; $p=0.06$), while fat free weight significantly increased 0 to 10 weeks following treatment (0-weeks = 74.8 ± 8.6 kg to 10 weeks = 76.3 ± 8.6 kg; $p=0.03$). In addition, a significant reduction in the trunk to limb ratio of 2.75% was observed ($p=0.03$) in the placebo group only.

Table 3. Subject Characteristics

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
Age	26.6± 2.2	•	24.3± 2.8	•
Height (m)	1.78 ± 0.0	•	1.81 ± 0.1	•
Weight (kg)	99.1 ± 15.9	98.2 ± 15.1	93.6 ± 10.0	94.0 ± 10.5
BMI	31.1 ± 4.4	30.8 ± 4.0	28.7 ± 2.7	28.8 ± 2.8
Dexa %BF	21.7 ± 6.5	20.2 ± 6.2 ¥	20.0 ± 5.2	18.7 ± 4.5 ϕ
Dexa FW (kg)	22.3 ± 8.8	20.5 ± 8.1	18.8 ± 5.7	17.7 ± 5.1
Dexa FFW (kg)	76.8 ± 7.8	77.6 ± 7.6 ¥	74.8 ± 8.6	76.3 ± 8.6 π
Trunk to Limb FW Ratio	109.8 ± 31.4	110.3 ± 30.1	102.0 ± 27.3	99.2 ± 25.8 π

¥= significantly different from pre-training values within the supplement group $p = 0.08$; ϕ= significantly different from pre-training values within the placebo group $p=0.06$; π = significantly different from pre-training values within the placebo group $p=0.03$.

Aerobic and Anaerobic Assessments

When examining the aerobic and anaerobic variables shown in Table 4, there were no reported response differences between the treatment and placebo groups following the treatment period. However, there was a significant $p < 0.0040$ increase in relative and absolute VO_2 max (47.0 ± 8.6 to 50.0 ± 9.5 $ml \cdot kg \cdot min^{-1}$, 4.3 ± 0.5 to 4.7 ± 0.6 $l \cdot min^{-1}$) for the placebo group following the 10-week intervention. For the anaerobic power measures (peak power, time-to-peak power, peak power/fat free weight (kg), average power/ fat free weight (kg)) no significant changes occurred in either group following the treatment period. However, it is important to point out that although peak and average power showed small declines in the placebo group, time to peak power declined 13.9 %. These data suggest that the placebo group improved their ability to generate peak force more quickly.

Table 4: Aerobic and Anaerobic Results

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
VO_2 Max $ml \cdot kg \cdot min^{-1}$	43.1 ± 7.4	43.7 ± 8.4	47.0 ± 8.6	50.0 ± 9.5 ¥
VO_2 Max $l \cdot min^{-1}$	4.0 ± 0.5	4.2 ± 0.5	4.3 ± 0.5	4.7 ± 0.6 ¥
Peak Power (watts)	726.4 ± 175.9	715.1 ± 167.7	772.6 ± 139.5	766.8 ± 156.2
Average Power (watts)	571.3 ± 106.9	571.4 ± 122.3	612.9 ± 106.2	603.6 ± 108.0
Time to Peak Power (secs)	6.9 ± 2.24	6.86 ± 1.79	8.06 ± 2.78	6.94 ± 1.50
Peak Power (W)	726.4 ± 175.9	715.1 ± 167.7	772.6 ± 139.5	766.8 ± 156.2
Average Power (W/0.22 kms)	571.3 ± 106.9	571.4 ± 122.3	612.9 ± 106.2	603.6 ± 108.0

¥ =significantly different from pre-training relative and absolute VO_2 max values within the placebo group $p < 0.0040$

1 RM, Lift Performance @ 70% of Max, and Markers of Eccentric Muscle Damage

Following the 10- week intervention, both absolute bench press and squat max weight lifted increased significantly ($p < 0.05$) for both groups as shown in Figures 3 and 4. However, there were no significant differences in treatment responses between the supplement and placebo groups from 0 to 10 weeks.

The best performance for both the bench press and squat were analyzed to determine if deer antler velvet had any effect on muscular lift performance before and 48 hours after the eccentric exercise trials. There were no significant differences regarding weight lifted per second between the groups, 0 to 10 weeks for the bench press. The were no significant differences for the bench press performance observed within the supplement group at 0 to 10 weeks following treatment from baseline to 48 hours following the eccentric trial. At 0-weeks there were no significant differences within the placebo group for the bench press weight lifted per second performance. Post-treatment the placebo group lifted significantly ($p=0.02$) less weight per second (109.9 ± 30.82 to 88.17 ± 20.43) for the bench press from baseline to 48 hours following the eccentric trial.

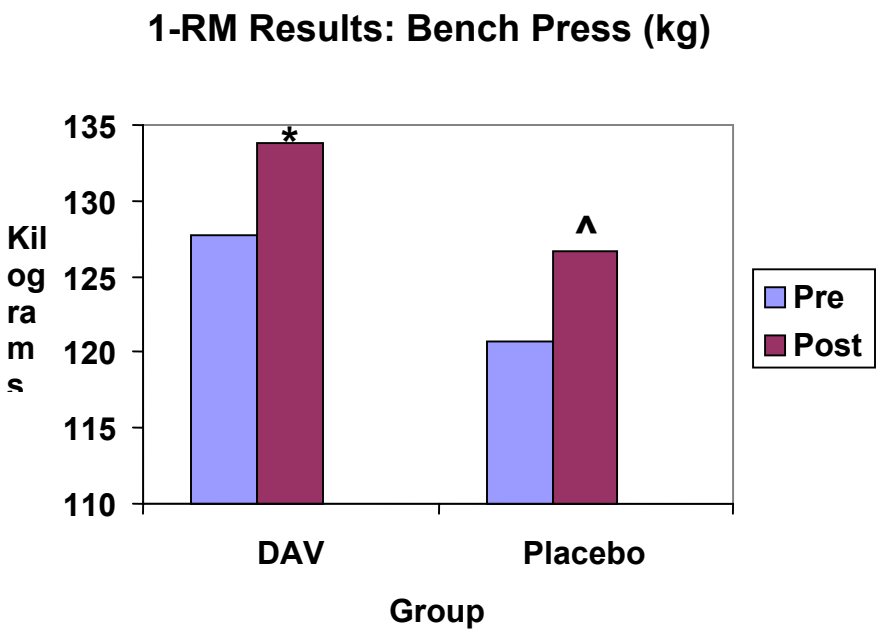


Figure 3: 1-RM Results: Bench Press (kg)
*= significantly different from pre-training values within the supplement group p=0.0040; ^ =significantly different from pre-training values within the placebo group p=0.0020.

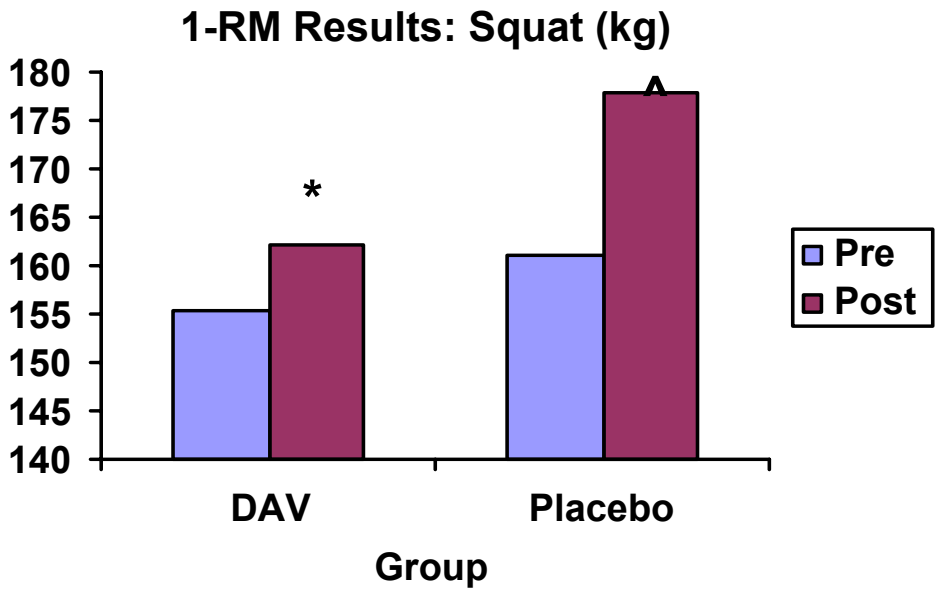


Figure 4: 1-RM Results: Squat (kg)
*= significantly different from pre-training values within the supplement group p=0.0040; ^ = significantly different from pre-training values within the placebo group p=0.0020.

Muscular performance was measured by determining each person's lifting weights equal to 70% of his 1-RM bench and squat value as many times as possible as shown in the following formula.

$$\text{Muscular Performance} = \frac{\text{Total number of repetitions} * 70\% \text{ of } 1\text{-RM (kg)}}{\text{Total Lift Time (sec)}}$$

As reported in tables 5 and 6 there were no significant group differences prior to and following the treatment period. The placebo group did show significant improvement in the amount of weight lifted/second for the squat compared to the pretreatment period. This resulted in a 9.7% improvement.

Table 5: Pre-Eccentric Performance (Best Trial): Bench

	Deer Antler Supplement		Placebo	
Variable	Pretreatment	Posttreatment	Pretreatment	Posttreatment
Bench Press (kg) @ 70% 1-RM	89.8 ± 15.0	93.5 ± 16.8	82.47 ± 17.3	87.01 ± 19.9
Total Weight Lifted (kg)	1330.7 ± 223.2	1224.4 ± 183.7	1242.2 ± 197.0	1209.4 ± 297.8
Wt Lifted / Second (kg/sec)	46.7 ± 19.8	38.4 ± 11.4	44.9 ± 13.9	50.0 ± 14

*no differences for any of the variables

Table 6: Pre-Eccentric Performance (Best Trial): Squat

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
Squat Wt (kg) @ 70% 1-RM	108.2 ± 18.4	113.9 ± 19.5	112.7 ± 34.	124.0 ± 35.0
Total Weight Lifted (kg)	1281.0 ± 395.1	1203.7 ± 341.8	1696.4 ± 560.8	1644.5 ± 616.8
Wt Lifted / Second (kg/sec)	32.18 ± 6.6	33.0 ± 6.2	36.4 ± 13.5	39.9 ± 13.0 §

§: significantly different (p=0.06)from pre value at week 10

For both the bench and squat measurements @ 70% of max, there was a decline in the amount of weight lifted in absolute weight and weight per second 48 hours following the eccentric trial which is shown in Figures 5 and 6 below. The supplement group declined 21.5% whereas the placebo group declined 11.1% for the bench press from 0 to 10 weeks of the eccentric trial for the total amount of weight lifted. The squat indicated positive changes in the deer antler velvet group (10.2 %) whereas the placebo group declined 13.4 %, which was significantly (p=0.05) different between the two groups for the total amount of weight lifted. The total amount of weight lifted per second indicated no significant differences between the groups at 0 and 10 weeks of the eccentric trial.

Table 7: 70% Bench Performance 48 hour Post Eccentric Trial

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
Total Weight Lifted (kg)	1105.4 ± 317.5	896.9 ± 361.8	1110.4 ± 138.2	1068.5 ± 277.5
Wt Lifted / Second (kg/sec)	43.7 ± 9.1	40.2 ± 9.1	39.7 ± 10.3	40.1 ± 9.3

*no differences for any of the variables

Table 8: 70% Squat Performance 48 hour Post Eccentric Trial

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
Total Weight Lifted (kg)	1447.5 ± 502.6	1295.5 ± 522	1401.6 ± 372.3	1490.6 ± 376.8
Wt Lifted / Second (kg/sec)	31.3 ± 6.4	32 ± 4.9	35.1 ± 11	41.0 ± 14.6

*no differences for any of the variables

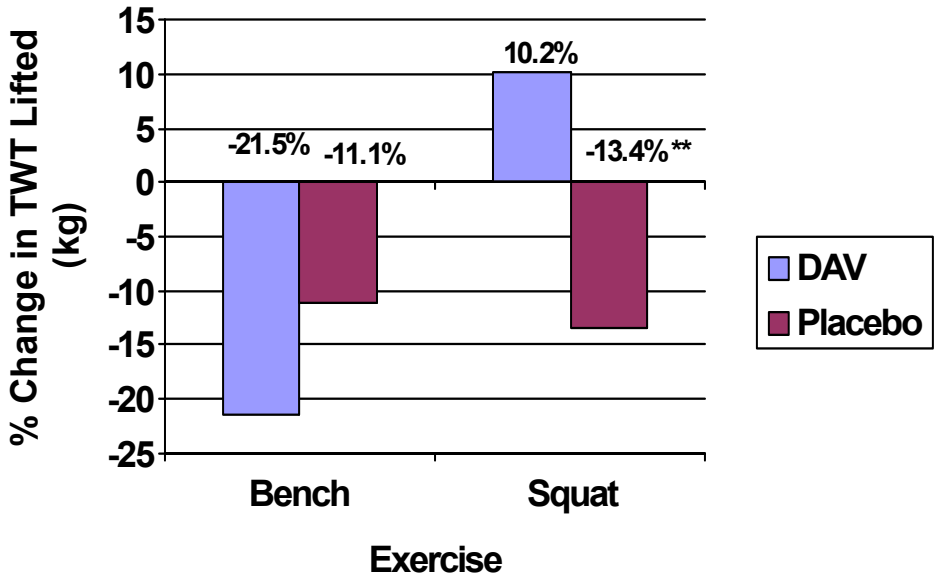


Figure 5: Percent Change in Total Weight Lifted (kg) Pre to Post-Treatment
**= significantly different from pre to post eccentric trial within the groups.

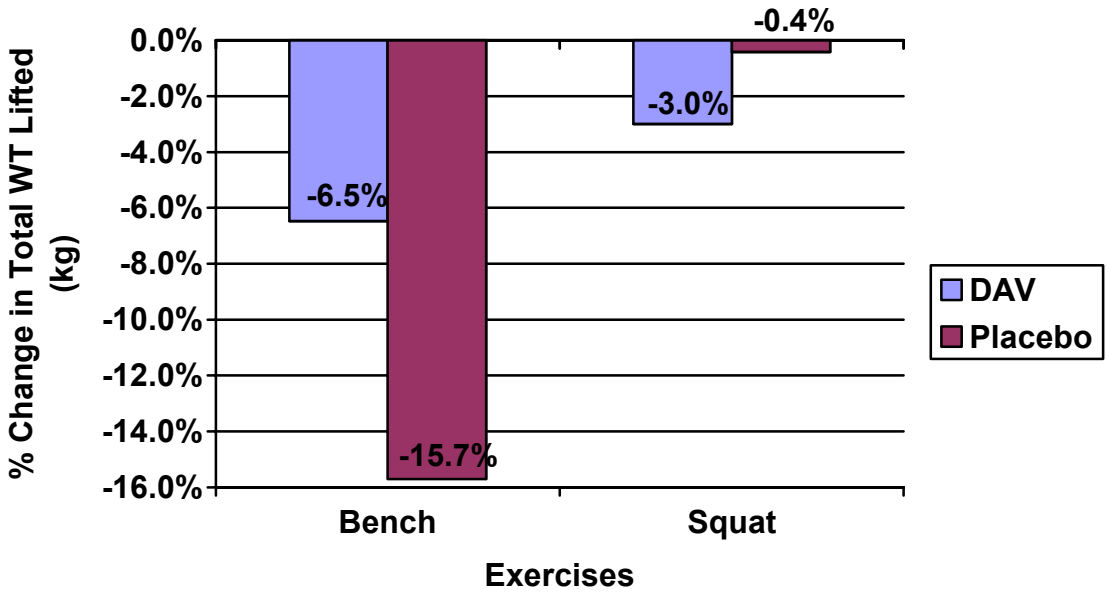


Figure 6: Percent Change in Total Weight Lifted Per Second Pre to Post-Treatment
* no significant differences between the groups

Creatine Kinase Assessment

After completion of the eccentric trial at 0 and 10 weeks, there was an expected significant ($p<0.05$) rise in creatine kinase values for both the supplement and placebo groups, which is indicated in Table 9. There were no significant differences between the groups at 0 and 10 weeks following the intervention. There were no significant differences within the groups at 0 and 10 weeks except at the 48-hour measurement period. The placebo group showed a significant decrease ($p<0.05$) in creatine kinase values (53.6 ± 42.0 to 33.4 ± 40.9 sigma units) when compared to the supplement group at week 10, 48 hours post-eccentric trial.

Table 9: Creatine Kinase Values

	Deer Antler Supplement		Placebo	
Variable	0 weeks	10 weeks	0 weeks	10 weeks
Pre Eccentric Trial	14.6 ± 14.0	12.6 ± 19.0	11.3 ± 11.0	7.7 ± 6.0
Immediately Post	27.0 ± 23.0 ¥	23.3 ± 17.9 ¥	49.4 ± 50.0 ¥	21.3 ± 14.9 ¥
48 hr Post	34.2 ± 33.1 ¥	20.1 ± 13.6 ¥	53.6 ± 42.0 ¥	33.4 ± 40.9 ¥,*

¥ = Significantly different from Pre eccentric trial; * No significant differences between the group responses except at 48 hr post in group B in which CK was significantly less than pretreatment values ($p=0.02$).

Measures of Soreness

Following the eccentric trial levels of soreness were evaluated by each subject pre, immediate post, and 48 hours post at both 0 and 10 weeks. A sum total of each of the variables was calculated from the soreness questionnaires, and the mean was calculated in order to compare the placebo and supplement groups. The variables analyzed were neck, deltoids, triceps, biceps, chest, abdomen, quadriceps, hamstrings, buttocks, calves, and shins. When the two groups were compared, there were no significant differences between the groups at 0 and 10 weeks for any of the measurement periods. However, when each group was analyzed individually, there were significant differences with respect to levels of soreness. At 0 weeks the deer antler velvet group reported a soreness level of 16.14 ± 8.07 prior to the eccentric trial. Immediately after the eccentric, trial soreness levels increased to 33.4 ± 19.8. The soreness levels then significantly increased to 34.9 ± 18.4 ($p= 0.05$) 48 hours following the trial, which is indicated in Table 10 below. Similar results were observed following the 10-week supplementation period. Soreness levels significantly increased immediately following the trial from 8.1 ± 6.7 to 22.9 ± 14.0 ($p=0.05$) and then continued to rise to 39.0 ± 18.7, 48 hours after. The soreness levels reported at 48 hours were significantly higher from pre values and post

values. At 0 weeks, the placebo group reported a soreness level of 11.4 ± 17.8 which then continued to increase to a level of 45.0 ± 34.3, which was significantly (p=0.05) higher. Soreness continued to significantly increase (p=0.05) from pre to 48hrs (48.3 ± 26.6) after completion of the eccentric trial. At 10 weeks there were similar reported significant increases between measurement periods. Soreness levels before the trial began were reported at 14.3 ± 12.6, they continued to increase to 46.9 ± 30.0 immediate post and then continued rising to 59.3 ± 40.5, 48 hours after.

Table 10: Soreness Scale Values

	deer antler velvet Group		Placebo Group	
Measurement Periods	0 Weeks	10 Weeks	0 Weeks	10 Weeks
Pre	16.1 ± 8.1	8.1 ± 6.7	11.4 ± 17.8	14.3 ± 12.6
Immediate Post	33.4 ± 19.8 ¥	22.9 ± 14.0 ß	45.00 ± 34.32 ¢	46.9 ± 30.0 §
48 Hours Post	34.9 ± 18.4 ¥	39.0 ± 18.7 ß £	48.3 ± 26.6 ¢	59.3 ± 40.5 §

¥ = significantly different from pre eccentric trial at 0 weeks p=0.05 ß= significantly different from pre values at 10 weeks p=0.05 £ = significantly different from immediate post at 10 weeks p= 0.05. ¢ = significantly different from pre-eccentric trial at 0 weeks p=0.05. § = significantly different from pre-eccentric trial at 10 weeks p=0.05.

CHAPTER 5
SUMMARY, DISCUSSION AND RECOMMENDATIONS

Summary of Findings

The purpose of this study was to examine the effects of deer antler velvet on maximal strength, muscular performance, muscular performance recovery, and markers of delayed onset of muscle soreness (DOMS) in resistance trained men 18 to 35 years old with at least 4 years experience. Using a double blind administration protocol, subjects were assigned either supplement or placebo and continued a regular workout regiment for a 10-week duration.

The study's results indicate that any improvements in maximal strength, power, performance, or recovery time following a workout were not from oral ingestion of deer antler velvet. These findings were not consistent with those reported by the New Zealand in-house report. The report detected trends toward increases in strength measures that were higher in the supplement group than the placebo group. Thus indicating that velvet antler may have beneficial effects with regards to strength improvements.

Discussion

Body Composition Findings

Fat free weight, fat weight, and percent body fat was assessed using DEXA. There were no significant differences between the groups with regards to body composition. Both groups indicated strong trends towards increases in fat free weight and decreases in percent body fat. The placebo group had significant improvements in fat free weight (pre = 74.8 ± 8.6 kg to post = 76.3 ± 8.6 kg; $p=0.03$) following the 10-week intervention period. These findings demonstrate that supplementing deer antler velvet with weight training provides no evidence of ergogenic benefits. These findings were similar to the values observed by Agresearch from a preliminary pilot study. They also observed strong trends regarding reductions in fat weight and percent body fat as measured using the DEXA technique. However, the New Zealand report was unable to distinguish whether or not the positive effects could be attributed to the deer antler velvet or the training regiment. This study provides additional support that deer antler velvet does not contribute to improvements in body composition because the placebo group showed significant

increases in fat free weight whereas the supplement group only demonstrated a strong trend. Evidence indicates that following resistance training, subjects reduce body fat percentage and increase overall muscle size. An investigation conducted by McCall et al. (2) indicates that fat free mass and cross-sectional muscle hypertrophy improves as a result of continual resistance training without supplementation usage. Thus, these results combined with the Agresearch report show that deer antler velvet does not provide an ergogenic benefit regarding body composition during resistance training.

Anaerobic and Strength Findings

The results of this study did not give any indication that deer antler velvet could increase power. There were no significant differences between or within the groups regarding an increase in power output following the intervention. A New Zealand in-house report found no significant increases in peak or average power output with subjects who had undergone 10 weeks of strength training while ingesting deer antler velvet or placebo. A t-test was used of absolute change in each measured power variable. Based on the number of subjects in the New Zealand based study, a t-test value greater than 2.1 indicated a significant change. Both peak power and average power exhibited a t value of 0.1. Those subjects were ingesting 70 mg per day of deer antler velvet. In the current study subjects were ingesting 1500 mg per day of deer antler velvet. Despite a 21-fold increase in supplement dosage per day, no significant changes in power were observed. These results strongly suggest that deer antler velvet supplementation provides no ergogenic benefits on power related performance. This investigation disproves anecdotal theories that deer antler velvet may have ergogenic benefits with respect to power output. This is especially true when one considers how power was tested in the current study. Unlike the 1-RM testing procedures, power was tested using a special cycle ergometer system designed by Computrainer. Unlike the 1-RM tests (i.e., bench press and squat), subjects only performed the cycle ergometer power testing procedures during orientation session, in the 0-week, and 10 week testing periods. Thus, if deer antler velvet supplementation indeed improves power related performance, it could not be related to a training effect. This is in stark contrast to the 1-RM tests in that each person's training sessions include both exercises, which might explain why each group showed significant improvements in max bench and squat performance as described below.

This study showed that both groups demonstrated increases in strength because 1-RM for bench and squat values significantly improved within both groups. However, these improvements cannot be attributed to supplementation, rather the increases were a direct result of weight training for 10 weeks. Studies show that following a resistance training period, subjects show significant increases in strength measures. An investigation by Staron et al., (34) reported significant increases ($p< 0.05$) in leg extension and squat for both men and women following an 8-week progressive resistance training program. Hickson et al. (35) reported a 22% significant increase in bench press and a 29% significant increase in squat for an 8-week training protocol. Finally, Mazzetti et al. (36) examined the effects of supervised versus non-supervised weight training for 12 weeks on males ages 18-35. They reported that although the supervised group had significantly ($p<0.05$) higher increases in bench and squat for 1-RM, both groups showed significant improvements from pre to post intervention similar to those observed in the current study.

Aerobic Findings

Although the subjects were not specifically training to enhance their aerobic capacity, measurements of VO_2 max were taken in order to monitor aerobic capacity. It is believed that deer antler velvet may have cardiovascular benefits. Kim et al., (6) indicated a significantly higher hemoglobin and erythrocyte count in rabbits treated with deer antler velvet when compared with those treated with placebo. The results of this study disprove the theory that deer antler velvet may enhance aerobic capacity because there was no significant increase regarding VO_2 max, hemoglobin, and hematocrit in the supplement group. There was, however, a significant increase in relative and absolute VO_2 max (47.0 ± 8.6 to 50.0 ± 9.5 $ml \cdot kg \cdot min^{-1}$, 4.3 ± 0.5 to 4.7 ± 0.6 $l \cdot min^{-1}$, $p < 0.0040$) for the placebo group following the 10-week intervention. It has been suggested that resistance training alone may enhance aerobic capacity. However, according to Baechle and Earle (37) these improvements are only observed in untrained individuals. A study by Kraemer (38) indicates that following resistance training no improvements in VO_2 max were observed in trained males. Thirty-five males were recruited from the army to participate in the study. Subjects were randomly allocated into 1 of 4 groups, which included, an endurance training group (E), strength group (ST), a combined strength and

endurance trained group, and an upper body strength and endurance trained group (UC). The results indicated that when resistance training was combined with endurance training VO_2 max improved significantly ($p<0.05$) in both the C and UC groups (58.88 ± 5.95 to 63.41 ± 8.02, 51.43 ± 6.92 to 51.43 ± 6.92 to 56.38 ± 4.69 respectively). However, the subjects who were in the strength group did not indicate any improvement in VO_2 max following the 12-week training period (53.47 ± 4.95 to 53.02 ± 4.34). This study may support the findings of the current investigation, because the only improvements that were observed were in the placebo group. Possible explanations may be that the placebo group could have incorporated more aerobic exercise than the supplement group. However, according to the exercise training logs, this change could not be attributed to an increase in aerobic exercise training. It cannot be discounted that the subjects did not properly report any increases in aerobic training. Another possible explanation could be due to improve mechanical efficiency within the placebo group. They demonstrated a greater increase in lower body strength although not significantly different from the supplement group. As mentioned previously, this effect has only been observed in untrained individuals and has not yet been demonstrated with trained individuals, similar to the subjects in this investigation.

Performance Findings

There were no significant improvements found in any of the 70% performance trials, which analyzed bench press and squat following the eccentric trial. These findings are consistent with those reported in a review by McIntyre, Reid, and McKenzie (22) which indicates that Clarkson and colleagues demonstrate strength losses following eccentric exercise that may be attributed to overstretched sarcomeres which could affect force production (22). In addition, McIntyre et al., (22) support findings by Faulkner and colleagues who state that some sarcomeres may stay the same while others are stretched causing damage. As a result, one would expect the amount of weight a person could lift per unit of time to decline as occurred in the current investigation. Studies have shown that performance following eccentric exercise declines as a result of the damage associated with DOMS. A study by Mair and colleagues (28) examined the effects of eccentric exercise on 22 male volunteers from a physical education class that ranged in age from 20 to 26 years. Performance was tested using the Kistler force platform where the subjects performed one-legged vertical jumps, which measured force production and vertical

jump height. This test was completed before, immediately after, 1, 2, 3,and 4 days following the eccentric exercise for both groups. The results indicated that there was a significant ($p=0.0001$) decline in force production following the exercise bout for both groups. The most pronounced decline was observed immediately following however, performance remained affected up to 4 days after the eccentric trial. A study by Vincent and Vincent (26) demonstrates reductions in performance following resistance exercise. Force during extension and flexion of the knee was measured using an isovelocity dynamometer before, immediately after, 1, 2, 3, 4, 5, 6, and 10 days following the resistance exercise. During the knee extension phase, the baseline value for the trained group was 365 ± 83 Nm, the baseline value for the untrained group was 316 ± 34 Nm. Both the trained and untrained group demonstrated a significant ($p<0.05$) reduction (30% and 24% respectively) in isometric peak torque capacity immediately following the exercise. During the knee flexion phase, the baseline value for the trained group was 167 ± 11 Nm; the baseline value for the untrained group was 163 ± 13 Nm. Again there was a significant decrease ($p<0.05$) in isometric peak torque capacity for both groups (Trained= 25%, Untrained = 17%) following the exercise bout. The findings regarding performance are consistent with those of the current study, which indicated that both groups demonstrated a significant decline in performance 48 hours following the eccentric trial.

Creatine Kinase Findings

Ebbeling and Clarkson's (29) review defines creatine kinase as the most common indicator of muscle damage because it is released after strenuous exercise. As a result creatine kinase was use as a marker of DOMS for this investigation.

After completion of the eccentric trial at 0 and 10 weeks, there was a significant ($p<0.05$) rise in creatine kinase values for both the supplement and placebo groups. There were no significant differences between the groups from 0 to 10 weeks following the intervention. The only significant differences within the groups was observed in the placebo group which reported a significant decline ($p<0.05$) in creatine kinase values (53.6 ± 42.0 to 33.4 ± 40.9 sigma units) from week 0 to week 10, 48 hours post-eccentric trial.

These findings are consistent with evidence shown in similar studies that used eccentric trials as a means to increase creatine kinase and measure overall muscle damage. It has been

proven that following eccentric exercise delayed onset muscle soreness and creatine kinase will increase. Evans et al. (24) indicate that creatine kinase levels peak 24-48 hours and continue to increase up to 5 days after the exercise in trained and untrained subjects. These findings are similar to the current investigation, which indicated significant increases in creatine kinase 48 hours following eccentric exercise. In addition, Mair et al. (28) examined the effects of eccentric exercise on muscle soreness and creatine kinase. They randomly allocated 22 college age males into two groups, which performed two identical bouts of exercise. Group A had two sessions which were separated by 4 days and group B had two sessions separated by 13 days. Creatine kinase levels increased significantly ($p=0.0001$) peaking 2 to 3 days following the first bout of exercise in both groups. They reported significant ($p<0.0001$) increases in creatine kinase activity, which peaked 48-72 hours following the eccentric trial. Again, the findings are consistent with the current study, which also used college-aged males to measure creatine kinase following an eccentric exercise. Glesson et al.(30) also observed significant ($p<0.01$) increases and peaks in creatine kinase ranging from 1, 2, 3,4, or 7 days following eccentric exercise. Clarkson and Tremblay (25) report evidence that following repeated bouts of eccentric exercise, muscles experience an adaptation effect regarding delayed onset muscle soreness and creatine kinase.

Although not significant, during the 10-week measurement period the supplement group actually started a small decline in creatine kinase levels immediately post to 48 hours post (23.3 ± 17.9 to 20.1 ± 13.6). This was the only measurement period that creatine kinase levels showed a slight decrease. All other measurement indicated increases from pre to 48 hours following the eccentric trial. These findings may suggest that deer antler velvet may have some anti-inflammatory properties as indicated by the Agresearch in-house report (6).

Soreness Scale Findings

Both groups reported significant increases in levels of soreness immediately post and 48-hours following the eccentric trial at 0-weeks and 10 weeks. These findings are consistent with those reported by Stauber, Clarkson, Fritz and Evans (23). They indicated that soreness levels increased from 1 to 8 on a scale of 10, 48 hours after exercise. Gleeson et al. (30) used a self-

reported soreness scale and observed complaints of maximal soreness 48 hours following eccentric exercise. Finally a study by Nosaka, Sakamoto, Newton and Sacco (39) also indicates that soreness levels peaked 24-48 hours following unaccustomed eccentric exercise.

It has also been reported that delayed onset muscle soreness will decrease as a result of the muscle experiencing an adaptive effect to unaccustomed exercise. The results of this study did not produce an adaptive effect between the two eccentric trials. Reported soreness levels were the same within groups and between the groups at 0 and 10 weeks of the intervention. These findings are different than those reported by Clarkson and Tremblay (25) that found that following recovery from DOMS, the muscle tissue was able to heal and make adaptations in order to prevent future injury. When eccentric exercise was repeated the level of creatine kinase and the amount of muscle soreness significantly diminished during the repeated bout of exercise when compared to the initial bout.

Recommendations for Future Research

It is recommended that:

1. A similar study be conducted using either a specific training protocol or a monitored training regiment with college aged males with at least 4 years weight lifting experience.
2. A similar study be conducted that monitors dietary intake specifically protein consumption.
3. A similar study be conducted that monitors creatine kinase and soreness 7 days following exercise.

References

1. McCardle WD, Katch FI, Katch VL. Exercise Physiology Energy, Nutrition, and Human Performance. Baltimore: Williams & Williams, 1996.
2. McCall GE, Byrnes WC, Dickinson A, Pattany PM, Fleck SJ. Muscle fiber hypertrophy, hyperplasia and capillary density in college men after resistance training. Journal of Applied Physiology 1996;81:2004-2012.
3. Tamaki T, Akatsuka A, Tokunaga M, Ishige K, Uchiyama S, Shiraishi T. Morphological and biochemical evidence of muscle hyperplasi follwoing weight-lifting exercise in rats. American Journal of Physiology 1997;273:C426-C256.
4. Fry AC, Kraemer WJ. Resistance exercise overtraining and overreaching. Sports Medicine 1997;23:106-129.
5. Suttie JM, Haines SR. The effect of aqueous velvet extracts on the immune system. New Zealand: New Zealand Game Industry Board, 1996.
6. Properties of New Zealand deer velvet: Unpublished in-house report.: AgResearch, 1982:1-47.
7. Wilmore JH, Costill DL. Physiology of Sport and Exercise. Champaign: Human Kinetics, 1994.
8. Devlin T. Textbook of Biochemistry with Clinical Correlations. New York: Wiley-Liss, 1997.
9. Thein LA, Thein JM, Landry GL. Ergogenic Aids. Physical Therapy 1995;75.
10. Bae D. Studies on the effects of velvet on growth of animals. Korean Journal of Animal Science 1976;18:342-348.
11. Wang BX. Advances in the research of the chemistry, pharmacology, and clinical application of pilose antler. Proceedings of the International Symposium on Deer Products. Changchun, Peoples Republic of China, 1996:14-32.
12. Pavlenko SM. Pantocrine and its curative properties. Collection of Scientific Workds of the Scientific Research Laboratory for Breeding Deer with Non-ossified Antlers.: Altai Scientific Research Institute of Agriculture, 1969:3-8.
13. Song SK. Influence of deer horn on erythropoetin activity and radioactive iron uptake in rabbits. Journal of Catholic Medical College 1970;18:51-58.

14. Arapov DA. Data on the use of pantocrine in surgical practice. Collection of Scientific Works of the Scientific Reserach laboratory for Breeding Deer with Non-ossified Antlers.: Atlai Scientific Research Instititute of Agriculture, 1969:92-98.
15. Clifford DH, Lee MO, Kim CY, Lee DC. Can an extract of deer antlers atler cardiovascular dynamics? American Journal of Chinese Medicine 1979;7:345-350.
16. Yudin AM, Dobryakov YI. Reindeer Antlers: A guide to preparation and storage of uncalcified male antlers as medicinal raw material. Vladivostok, 1974.
17. Huxley HE. The mechanism of muscular contraction. Science 1969;164:1356-1366.
18. Armstrong RB. Mechanisms of exercise-induced delayed onset muscular soreness: a brief review. Medicine and Science in Sports and Exercise 1984;16:529-538.
19. Smith LL. Acute inflammation: the underlying mechanism in delayed onset muscle soreness? Medicine and Science in Sports and Exercise 1991;23:542-551.
20. Pyne DB. Regulation of neutrophil function during exercise. Sports Medicine 1994;17:245-258.
21. Pedersen BK, Ostrowski K, Rohde T, Bruunsgaard H. The cytokine response to strenous exercise. Canadian Journal of Physiology and Pharmacology 1998;76:505-511.
22. MacIntyre D, Reid D, McKenzie D. Delayed muscle soreness:The inflammatory response to muscle injury and its clinical implications. Sports Medicine 1995;20:24-40.
23. Stauber W, Clarkson P, Fritz VR, Evans W. Extracellular matrix disruption and pain after eccentric muscle action. Journal of Applied Physiology 1990;69:868-874.
24. Evans WJ, Meredith CN, Cannon JG, et al. Metabolic changes following eccentric exercise in trained and untrained men. Journal of Applied Physiology 1986;61:1864-1868.
25. Clarkson PM, Tremblay I. Exercise-induced muscle damage, repair, and adaptation in human. Journal of Applied Physiology 1988;65:1-6.
26. Vincent HK, Vincent KR. The effect of training status on the serum creatine kinase response, soreness and muscle function following resistance exercise. International Journal of Sports Medicine 1997;18:431-437.
27. Nosaka K, Clarkson P, McGuiggin ME, Byrne JM. Time course of muscle adaption after high force eccentric exercise. European Journal of Applied Physiology 1991;63:70-76.

28. Mair J, Mayr M, Muller E, et al. Rapid adaptation to eccentric exercise-induced muscle damage. International Journal of Sports Medicine 1995;16:352-356.
29. Ebbeling CB, Clarkson PM. Exercise-induced muscle damage and adaptation. Sports Medicine 1989;7:207-234.
30. Gleeson M, Almey J, Brooks S, Cave R, Lewis A, Griffiths H. Haemoatological and acute-phase responses asssociated with delayed-onset muscle soreness in humans. European Journal of Applied Physiology 1995;71:137-142.
31. Hartmann U, Mester J. Training and overtraining markers in selected sport events. Medicine and Science in Sports and Exercise 2000;32:209-215.
32. Maud PJ, Foster C. Physiological Assessment of Human Fitness. Champaign: Human Kinetics, 1995.
33. Friel J. Computrainer Workout Manual. Fort Collins: RacerMate, Inc, 1998.
34. R. S. Staron, D.L. Karpondo, Kraemer W. J., et al. Skeletal muscle adaptations during early phase of heavy-resistance training in men and women. Journal of Applied Physiology 1994;76:1247-1255.
35. Hickson RC, Hidaka K, Foster C, Falduto MT, Chatterton RT. Successive time courses of strength development and steroid hormone responses to heavy resistance training. Journal of Applied Physiology 1994;76:663-670.
36. Mazzetti SA, Kraemer WJ, Volek JS, et al. The influence of direct supervision of resistance training on strength performance. Medicine and Science in Sports and Exercise 2000;32:1175-1184.
37. Thomas RB, Roger WE. Essentials of Strength Training and Conditioning. Champaign, Il: Human Kinetics, 2000.
38. Kraemer WJ, Patton JF, Gordon SE, et al. Compatibility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. Journal of Applied Physiology 1995;78:976-989.
39. Nosaka K, Sakamoto K, Newton M, Sacco P. How long does the protective effect on eccentric exercise-induced muscle damage last? Medicine and Science in Sports and Exercise 2001;33:1490-1495.

APPENDICES

Appendix A: Informed Consent, Medical Questionnaire, ASU Lifestyle Questionnaire, ACSM Health Status Questionnaire

Informed Consent

TITLE: THE EFFECTS OF DEER ANTLER VELVET ON INDICES OF MUSCULAR STRENGTH, AEROBIC CAPACITY, ANAEROBIC POWER, AND BODY COMPOSITION

PRINCIPAL INVESTIGATOR:
Craig E. Broeder, Ph.D., Professor- The Dept. of Phys. Ed., Exercise, and Sport Sciences

You have been invited to participate in a research experiment entitled: **The Effects of Deer Antler Velvet on Indices of Muscular Strength, Aerobic Capacity, Anaerobic Power and Body Composition.** The purpose of this study is to determine the physiological and psychological effects of 10-weeks of 3,000 mg/day (2-pills/day) supplementation (1-pill prior to and 1-pill immediately following a person's workout) using a supplement known as Deer Antler Velvet for male subjects between the ages of 20 and 35 with at least 4 years of weight lifting experience. Deer antler velvet is a nutritional supplement, which may help my body improve muscular strength and physical work performance.

The nature of this study is as follows. Forty male volunteers between the ages of 20 and 35 years, currently training and with a minimum of 4 years of weight lifting experience will be participating in this study. You have been invited to participate in this study because you are interested in resistance training and improving exercise performance.

Physiological Testing

As a participant in this study, you will complete the following procedures:

Figure 1. A comprehensive pre- and posttreatment physical fitness exams including the measurements of:

- height, weight, and body composition measured by dual-photon absorption and total body water by bioelectrical impedance
- a determination of my aerobic and anaerobic capacity with a resting/exercising electrocardiogram (EKG)
- a determination of my total body strength using a ramp protocol (weight resistance is gradually increased until my maximal lifting capacity is determined) for achieving a 1-repetition upper strength limit on the bench press and leg press

- a comprehensive blood profile including total cholesterol with subtractions (HDL-good cholesterol, LDL-bad cholesterol, triglycerides-form of fat stored in blood), apolipoproteins which counts the number of HDL and LDL molecules, liver enzymes, and a blood count.
- a psychological assessment for mood and sexual function

Figure 1. A ten week intervention period consuming either a 2 pills/day placebo or deer antler velvet supplement (See Figure 1)

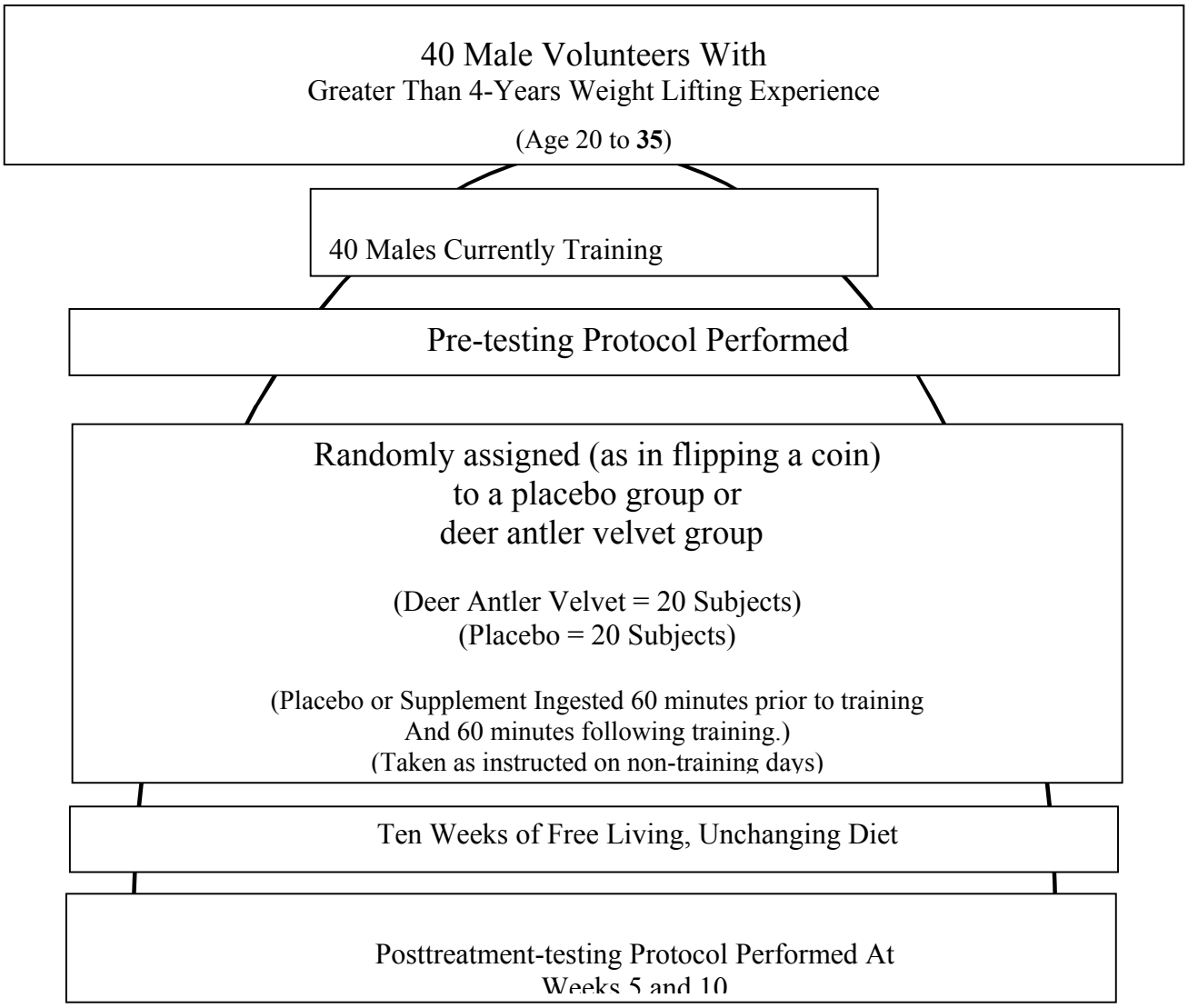


Figure 1. Flow Chart for Program Acceptance and Treatment Assignment

Explanation of Procedures

Your bone density will be measured by dual-photon absorption (a x-ray type device) as well as your total body water will be measured by determining how well a small electrical current is transmitted through my body (Bioelectrical Impedance). Together, the results of your body weight on land, bone density measure, and total body water will be used to determine the amount of bone, muscle, soft-tissue, and fat on your body before and after the study's treatment period.

A graded treadmill test will be used to determine your aerobic capacity before and after the 10 week study period. This test will begin with a three-minute warm-up period with the speed and grade set at 1.7 mph and 0%, respectively. After the warm-up period, either speed or percent grade will be increased gradually until you can no longer continue. During this test procedure, your heart rate will be monitored using a heart monitor device (EKG) and the amount of oxygen you consume will be measured using a computer based measurement system.

You will also be tested for your anaerobic capacity by running on a treadmill or pedaling a cycle at a workload greater than your maximal aerobic capacity test until fatigue before and after the 10 week study period.

Your total body strength will be measured using a gradually increasing resistance protocol for determining the amount of weight you can lift on the bench press (a measure of upper body strength) and leg press (a measure of leg strength) one time (1-RM). You will also be asked to perform both of these tests at 70% of the measured maximum weight to determine how many repetitions are possible. These strength-testing procedures will be performed prior to, at week 5, and following the 10 week study period.

You will be required to have 6-8 tablespoons of blood drawn so that a comprehensive blood profile can be performed prior to and following the 10-week study period. Your blood will be analyzed to determine how your blood lipids, liver, and kidney function were effected by taking the deer antler velvet supplement. In addition, another 2-3 tablespoons of blood will be drawn at the same time to determine my oxygen carrying capacity and red blood cell levels. Finally, blood samples will be taken (2-3 tablespoons each sample) before and after a normal 60 to 90 minute weight lifting session to assess if deer antler velvet supplementation can prevent muscle soreness markers at weeks 0, 5, and 10.

You will also complete a questionnaire prior to and after the 10-week study period that will be used to evaluate your mood and perception, sexual function and overall feeling of wellness or well being. You understand that the information taken in this questionnaire will only be used to determine what perceived effects the treatment had on your mood and sexual function.

In order to account for any change in dietary intakes you will complete a three-day dietary diary prior to, at the end of week 5 and following the 10-week study period.

You realize that after completing all pretreatment requirements outlined above you will continue to participate in your own training program that will be monitored and established for maximum strength gains, all the while maintaining your current dietary habits.

You will not be allowed to take any performance enhancing supplements during this trial period such as creatine, HMB, androstenedione/diol, 19-norandrostenedione/diol or anabolic steroids. You further understand that you will have not taken the aforementioned for substances at least 8-weeks (2 months) prior to the beginning of this trial.

The initial comprehensive and post study physical exam will be associated with the following potential risks:

- This is the first well-controlled clinical trial outside of the Government of New Zealand. The effects of this substance are scientifically unknown.
- The risks associated with taking your blood include a slight possibility of discomfort, bruising, fainting, and in very rare cases a chance of infection at the area in which blood is drawn.
- For bioelectrical impedance there are no obvious risks associated. However because of unfamiliarity with these procedures, you may experience anxiety before and during the procedures.
- For the measurement of bone density (dual-photon absorption), you will be exposed to a small amount of radiation that is equal to watching three hours of television which equals 0.02 rem of x-ray exposure.
- During the measurement of my aerobic, anaerobic capacity and cardiac function testing, you may experience discomfort at the higher levels of exercise, shortness of breath, muscular fatigue, muscle strain, and a rapid heart rate. There is also a risk of death from heart attack during this type of high intensity exercise testing. To minimize this risk, the Guidelines for American College of Sports Medicine will be followed.
- During the strength testing procedures, there is a very slight risk of muscle strain.
- There are no obvious risks associated with the psychological mood and sexual function assessment and dietary recall assessments. However because of unfamiliarity with these procedures, you may experience anxiety before and during the procedures and some questions asked on the surveys may be offensive to some individuals.

The benefits for participating in this study include two comprehensive medical exams completely free of charge ranging in value between $1,500 to $2,000.

Participation in this research experiment is voluntary. You may refuse to participate. You can quit at any time. You may quit by contacting Craig E. Broeder, Ph.D. whose phone number is (423) 439-5380 or (423) 439-4265. You will be told immediately if any of the results of the study should reasonably be expected to make me change my mind about staying in the study. Your doctor may take me out of the study, if s/he decides it is not in my best interest to continue (i.e., not following study related directions, adverse event). You may be taken off the study if it ends early.

You realize if you have any questions, problems or research-related medical problems at any time, you may call Craig E. Broeder, Ph.D. at (423) 429-5380 or (423) 926-9173; or Mary Kathryn Deaton at (423) 439-4265. You may call the chairman of the Institutional Review

Board at (423) 439-6134 for any questions you may have about your rights as a research subject.

East Tennessee State University (ETSU) will pay the cost of emergency first aid for any injury, which may happen as a result of my being in this study. They will not pay for any other medical treatment. Claims against ETSU or any of its agents or employees may be submitted to the Tennessee Claims commission. These claims will be settled to the extent allowable as provided under TCA Section 9-8-307. For information about claims call the chairman of the Institutional Review Board of ETSU at (423) 439-6134.

Every attempt will be made to see that my study results are kept confidential. A copy of the records from this study will be stored in The Human Performance Lab (E-113-Memorial Center) for at least 10 years after the end of this research. The results of this study may be published and/or presented at meetings without naming me as a subject. The ETSU IRB, FDA, Department of Health and Human Services and the principle investigators on this study have access to the study records. My medical records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above.

By signing below, I certify that I have read or had this document read to me. I will be given a signed copy. I have been given the chance to ask questions and to discuss my participation with the investigators. I freely and voluntarily choose to be in this research project.

SIGNATURE OF PATIENT	DATE
SIGNATURE OF INVESTIGATOR	DATE
SIGNATURE OF WITNESS	DATE

Dr. Craig Broeder would like to keep some blood samples that are not needed for your care. If you agree, it may be used in future research to learn more about how "deer antler velvet" supplementation affected your hormonal and general blood profiles.

If you agree, your samples will be stored in a special specimen bank to hold until they are needed for research. Information about your participation will be stored only at The Human Performance Lab. This information will not be put in your medical records. You will get no direct benefit if you allow your specimens to be stored and used for research. But it might help you in some indirect way later on or help other people with medical problems or use deer antler supplementation.

The choice to let Dr. Craig Broeder keep you blood for doing research is up to you. No matter what you decide to do, it will not affect your care. You may decide that we may keep your samples for research but later change your mind. If that happens, just tell your doctor and the specimen bank will then destroy any samples that they still have. Otherwise, the samples may be kept until they are used up, or until Dr. Broeder decides to destroy them.

Your specimens will be used only for research and will not be sold. Some new products might be made because of the results of the research that uses your samples. These products might be sold sometime in the future, but you will not get paid. There will be no cost to you for any samples collected and stored in the specimen storage bank.

Your blood will be stored for further analysis and possible further research. The sample(s) blood, tissue or fluids that you are giving might be used in studies that lead to new products for research, diagnosis and treatment. These products may have some commercial value. By signing this consent section, you authorize the use of your bodily fluids, substances or tissues for research purposes. You give up all rights to any commercial application related to information or samples that you have given during your participation in this research project.

Please answer the following questions and check the answer that is right for you.

I have been told that my samples will be coded and my identity will not be disclosed to anyone without my permission, except as required by law.	___Yes	___No
I agree that remaining blood may be kept for use in future research to learn about, prevent, treat or cure medical problems or cancer.	___Yes	___No
I agree that my doctor (or someone s/he chooses) may contact me in the future to ask me to take part in more research.	___Yes	___No

_____ _____

Subject DATE

_____ _____

Witness DATE

Medical Questionnaire

Please list any current medical complaints:

List any prescription or non-prescription medications that you take:

Do you smoke at the present time?
If YES, How many packs a day? How many years?

Did you Smoke in the past?
If YES, Quit Date? Packs/day? How many years?

Has anyone in your family had heart disease, high blood pressure, or high cholesterol before age 60?

Have you ever had a treadmill stress test? (place an 'x' in the column to the left of one item)

1) Never had a stress test.
2) Yes- Result was Normal
3) Yes-Result was Abnormal
4) Yes- Don't Know the Result

Do you have excessive mental stress or insomnia?

Do you have diabetes?

Do you exercise regularly (at least 20-30 min. 3 days/week)?

CARDIO-RESPIRATORY HISTORY

Have you ever had any of the following? (place an "X" in the column to the left of any that apply)

1. Heart Attack
2. Stroke
3. Any other heart disease
4. Rheumatic Fever
5. Emphysema, Bronchitis, or Asthma
6. Poor circulation
7. Elevated cholesterol levels
8. Chest pain or tightness
9. Skipped heart beats
10. Irregular heart rhythm
11. Shortness of breath
12. Dizziness

13. High blood pressure
14. High or low blood sugar

List the following values if you know them:

1. Total Cholesterol
2. HDL:
3. LDL:
4. Blood Pressure:

MUSCULOSKELETAL HISTORY

Have you ever experienced swollen stiff, or painful joints?

If yes-where? (place an X to the left of all that apply)

1. Wrist
2. Hip
3. Shoulder
4. Ankle
5. Back
6. Elbow
7. Knee
8. Neck
9. Other

Please give a brief description

Please list any other muscular or bone illness or injury:

Are you aware of any personal limitations (medical or other) not covered by this questionnaire which would restrict you participation in a planned program of diet and/or vigorous physical activity?

If YES, please describe the nature of the limitation(s):

ASU Lifestyle Questionnaire

A long, high-quality life is not a gift but rather the reward of wise lifestyle choices. This self-test will help you understand just how closely you adhere to a wide variety of recommended health practices. Please answer to the best of you ability.

Cigarette Smoking

[ ] Never smoked or quit more than 15 years ago
[ ] Ex-smoker, quit 5 to 15 years ago
[ ] Ex-smoker quit within 5 years
[ ] Current smoker, fewer than 20 cigarettes per day
[ ] Current smoker, 20-40 cigarettes per day
[ ] Current smoker, more than 40 cigarettes per day

How many alcoholic drinks do you consume?

[ ] Never use alcohol
[ ] Less than once per week
[ ] One to six times per week
[ ] Once per day
[ ] Two to three per day
[ ] More than three per day

How many cups (6 fluid oz. – do not include decaf) of coffee do you drink?

[ ] Never use coffee
[ ] Less than once per week
[ ] One to six cups per week
[ ] Once per day
[ ] Two to four cups per day
[ ] More than four per day

How many glasses (8 fluid oz.) of water do you drink per day?

[ ] More than six glasses per day
[ ] Four to six glasses per day
[ ] Fewer than four glasses per day

For the following, carefully note the portion sizes as you answer the questions. Also, remember to include amounts used in cooking. Fruits and vegetables (1/2 to 1 cup):

[ ] 5 or more servings each day
[ ] 2-4 servings each day
[ ] 1 or fewer servings each day

Grain products (breads, cereals, pasta, rice), one slice/one half cup:

[ ] Six or more servings each day
[ ] Three to five servings each day
[ ] Two or fewer servings each day

Red Meats (beef, pork, lamb, veal; not fish or poultry), 3 oz serving size.
[ ] Seldom or never use
[ ] Less than once per week
[ ] One to four per week
[ ] Five to six per week
[ ] Daily

Cheeses (do not include cottage or low-fat cheese), one ounce

[ ] Seldom or never use
[ ] Less than once per day
[ ] More than once per day

Whole mild (not skim or 1%) one cup:

[ ] Seldom or never use
[ ] Less than once per day
[ ] More than once per day

Eggs(including yolk), one whole:

[ ] Seldom or never use
[ ] One to two per week
[ ] Three to four per week
[ ] More than four per week

Outside of your normal work or daily responsibilities, how often do you engage in exercise that makes you sweat for 20 continuous minutes:

[ ] 5 or more times per week
[ ] 4-3 times per week
[ ] 1-2 times per week
[ ] Less than once per week
[ ] Seldom or never

How would you rate your body weight?

[ ] Very close to ideal
[ ] About 10% to high
[ ] About 11-25% to high
[ ] About 26-40% too high

[ ] More than 40% too high

Mental/social/spiritual well-being. In general, how satisfied are you with your life?

[ ] Mostly satisfied
[ ] Partly satisfied
[ ] Mostly disappointed

How often do you get insufficient rest so that you are unable to function efficiently?

[ ] Less than weekly
[ ] Usually one night per week
[ ] Two or three nights per week
[ ] Four or more nights per week

How would you describe the emotional stress you experience at you job (which includes being a student)?

[ ] Experience average or low levels of stress
[ ] Much stress but am able to cope with it
[ ] Much stress and often feel unable to cope

Have you suffered a serious personal loss or misfortune in the past year? (Divorce/separation, jail term death of a close person, job loss, disability).

[ ] No
[ ] Yes, one serious loss
[ ] Yes, two or more serious losses

How many friends and relatives (including your spouse) do you feel close to? (People that you feel at ease with, can talk to about private matters, and can call on for help).

[ ] 10 or more
[ ] 5 to 9
[ ] 1 to 4
[ ] none

How would you describe your spiritual health? (Ability to develop one's spiritual nature to its fullest potential. This includes our ability to discover, articulate, and act on our own purpose in life?

[ ] Good to excellent
[ ] Fair to poor
[ ] Very poor

Among your close relatives (parents, grandparents, aunts, uncles) how many deaths from heart disease or cancer have occurred before age 60?

[ ] None
[ ] One
[ ] Two or more

What percentage of the time do you use seatbelts while driving or riding?

[ ] 100%
[ ] 50-99%
[ ] 25-49%
[ ] Less than 25% of the time

How often do you see your physician for a physical checkup?

[ ] At least once per year
[ ] Only once every three years
[ ] Only once every five years

Your blood pressure is (if you do not know this value we highly suggest you have it taken. To estimate, select 'Low or Normal' if your weight and salt intake are low. Otherwise, select 'Moderately High')

[ ] Low or normal (less than 120/80)
[ ] Borderline high (120/80 –139/89)
[ ] Moderately high (140/90 – 159/94)
[ ] Very high (160/95 and higher)

Your serum cholesterol is

[ ] low (less than 180 mg/dl)
[ ] borderline high (180-199 md/dl)
[ ] moderately high (200-239 mg/dl)
[ ] very high (240 mg/dl and higher)

ACSM Health Status Questionnaire

On this questionnaire, a number of questions regarding your physical health are to be answered. Please answer every question as accurately as possible so that a correct assessment can be made. Please place a check mark in the space to the left of the question to answer "YES". Lieave blank if you answer is "No". Please ask if you have any wuations. Your responses will be treated ina confidential manner.

Today's Date: ___/___/___ Your Name _____

__ Do you have any personal history of coronary or atherosclerotic disease?

__Any personal history of metabolic disease (thyroid, renal, liver)?

__ Have you had diabetes for less than 15 years?

__ Have you experienced pain or discomfort in your chest apparently due to blood flow deficiency?

__Any unaccustomed shortness of breath?

__Have you had any problems with dizziness of fainting?

__ Do you have difficulty breathing while standing or sudden breathing problems at night?

__ Do you suffer from ankle edema?

__ Have you experienced rapid throbbing or fluttering of the heart?

__ Have you experienced severe pain in leg muscles during walking?

__ Do you have a known heart murmur?

__ Do you have any family history of cardiac or pulmonary disease prior to age 55?

__ Have you been assessed as hypertensive on at least 2 occasions?

__ Has your serum cholesterol been measured at greater than 240 mg/dl?

__ Are you a cigarette smoker?

Appendix B: Perceived Soreness Scale

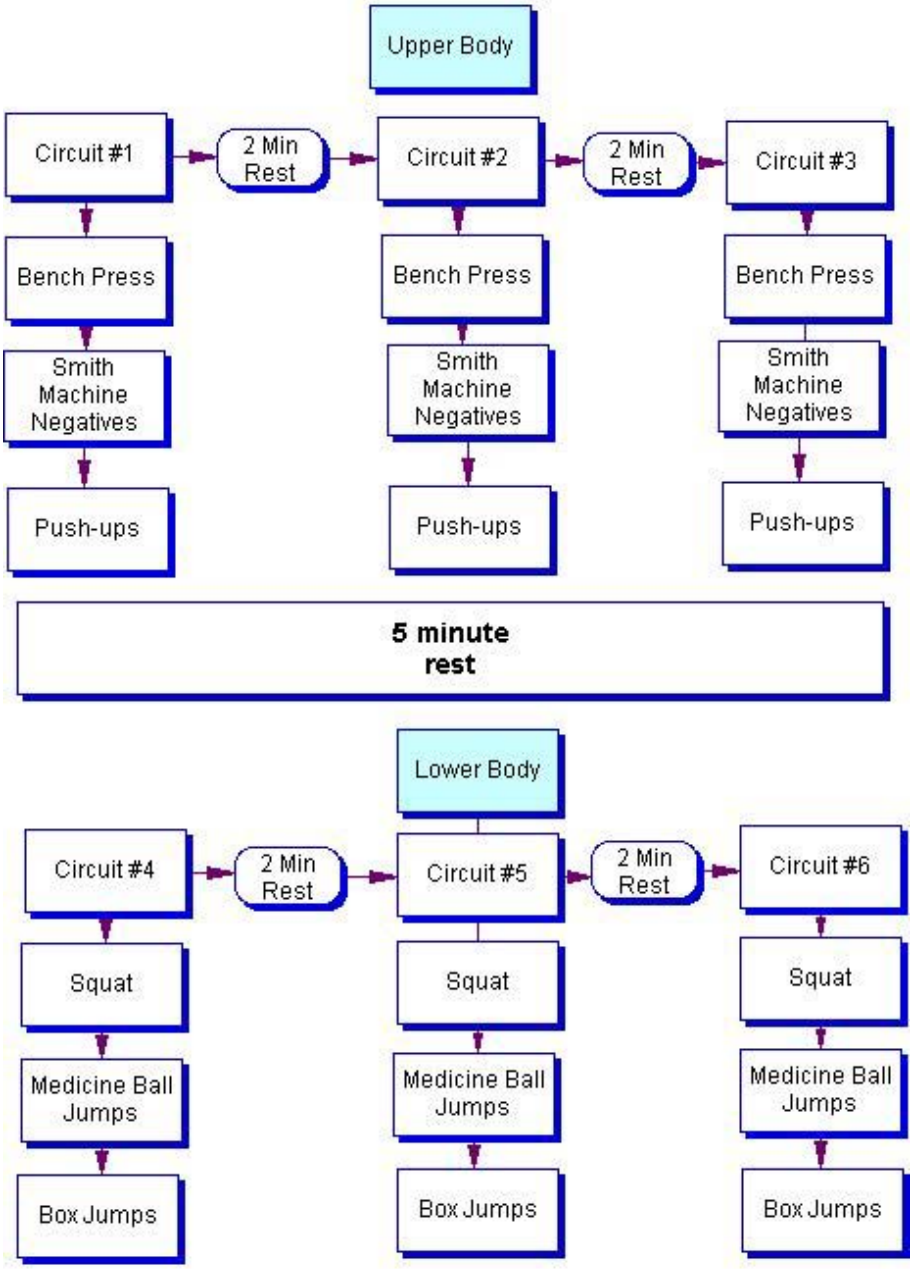
Date of Last Training Session _____

The following is a questionnaire designed to evaluate that amount of muscle soreness (not joints) you are experiencing as a result of your strength training program. Please carefully consider each question before recording the number that best indicates how these muscles feel.

Key: 0 1 2 3 4 5 6 7 8 9 10
None Very Mild Mild Moderate Very Sore Excruciating

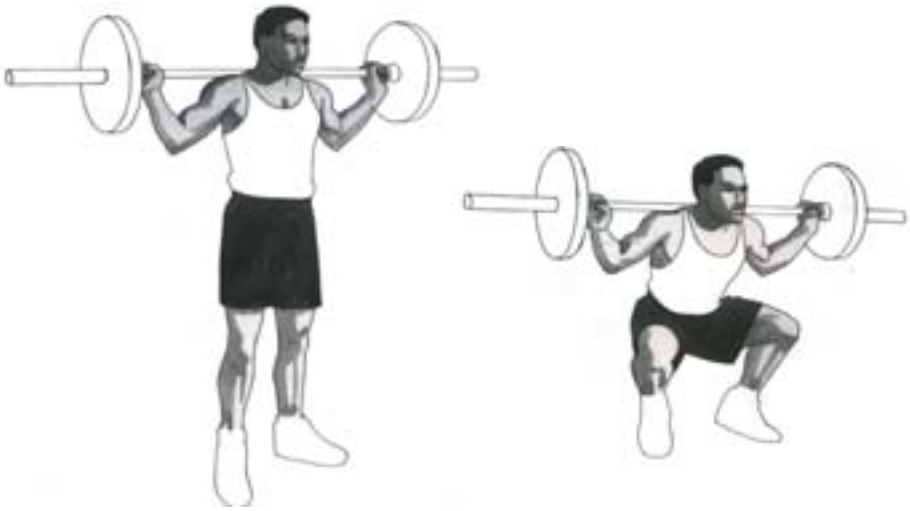
Neck	_____	Buttocks	_____
Shoulders	_____	Hips	_____
Upper Back	_____	Groin	_____
Triceps	_____	Hamstring	_____
Biceps	_____	Quadriceps	_____
Chest	_____	Calf Muscle	_____
Abdomen	_____	Shins	_____
Forearms	_____	Other	_____
Lower Back	_____		

Appendix C: Eccentric Trial



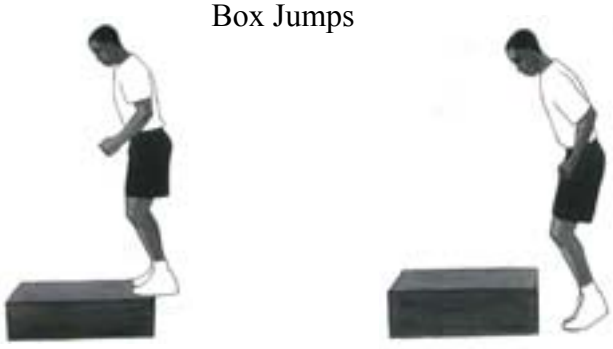
Note: Subjects time and repetitions for each exercise will be recorded

Squat Exercises



Medicine Ball Jumps

Box Jumps



VITA

ROBYN S. PERCIVAL

Personal Data:	Date of Birth: November 5, 1975
	Place of Birth: Lindsay, Ontario, Canada
	Marital Status: Single
Education:	Lindsay Collegiate Vocational Institute
	Brock University, St. Catharines, Ontario;
	Health Studies, B.A., 1999
	East Tennessee State University, Johnson City, Tennessee
	Physical Education, M.A. 2001
Professional Experience:	Graduate Assistant, East Tennessee State University, Department of Physical Education 1999-2001
	Laboratory Assistant, East Tennessee State University, Human Performance Laboratory 2000-2001