HIGH INTENSITY STRENGTH TRAINING IN CONJUNCTION WITH VASCULAR OCCLUSION

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HIGH INTENISTY STRENGTH TRAINING IN CONJUNCTION

WITH VASCULAR OCCLUSION

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strong will which will serve you well and lead you to a successful life, both personally and professionally.

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CHAPTER I

INTRODUCTION

Introduction

Strength training is a necessary component to most sport programs and is often seen in many injury rehabilitation settings. There are varying schools of thought and training regimes utilized to increase muscular strength, and many of them are legitimate and effective (22). Empirical evidence supports training at high intensities ~ 80% of one repetition maximum provides optimal strength gains (22). Performing 6-12 reps at ~70-85% of 1 repetition max has been shown to be effective at increasing strength and hypertrophy (23). However, there are many times when training at such high intensities is contraindicated due to potential injury or other compounding factors. Post operative athletes are unable to lift heavy weight in order to protect the integrity of the surgery. Athletes that sustained an acute nonsurgical injury are unable to perform heavy lifting exercises compromising pain, inflammation, and tissue damage. In the past few decades, there has been interest in training at lower intensities while utilizing vascular occlusion (22). This type of training has become widely popular in Japan known as Kaatsu training or low intensity occlusion training (LIO) (9, 12, 19, 22). It has been shown that insufficient blood flow is a necessary condition for adaptation following resistance exercise training (24).

There is very strong evidence that LIO training (~ 20% 1 repetition max) provides similar results in muscle hypertrophy and strength as high intensity training (HI) (~ 80% 1 repetition max) (2-4, 14, 17-22, 24). With this method, only 20% of an individual's one repetition maximum (RM) is being utilized while training and the vascular occlusion provides an additive affect which produces results similar to that of high intensity training. There have been many investigations utilizing varying occlusion techniques, occlusion pressures, training regimes, and anatomical structures. Additional investigations have verified the legitimacy of low intensity occlusion training, or Kaatsu training (1-4, 9, 10, 12, 14, 17-22, 24). Despite the large pool of research, it is still inconclusive as to the greatest contributing factors behind the success of low intensity occlusion training.

Traditional Kaatsu training utilizes a Kaatsu cuff and an individual may undergo a 20 to 25 minute session performing LIO (20-30% of 1RM) exercises. The Kaatsu cuff is similar to a blood pressure cuff and the pressure used is around 110 mmHg for a healthy individual, but a highly trained athlete may use up to 210 mmHg. With this technique, the participant usually completes three to four sets of bilateral exercise of a major muscle group or body part until fatigue. There is usually a 15 to 20 second rest period between sets. After the three to four sets are completed a new body part or major muscle group is trained. The effectiveness of the Kaatsu technique include a proposed increase in motor unit recruitment, increased hormonal responses, local growth factors, increased activity of intracellular signaling pathways, and increased muscle protein synthesis. During low intensity exercise, type I (slow-oxidative) muscle fibers, are primarily utilized to provide force. These fibers are fueled by oxygen and blood, unlike type II muscle fibers (fast-glycolytic). Type II fibers are used in anaerobic exercise when there is a lack of oxygen and these fibers have a greater potential for growth (22). During LIO training, the blood flow is restricted forcing type II fibers to play a larger role in the output of force. Kaatsu training utilizes muscle fibers with a greater potential for increases in hypertrophy and strength as compared to those individuals undergoing the same training protocol without occlusion. Kaatsu training also provides similar improvements in strength and hypertrophy when compared to those undergoing a high intensity resistance training program (24).

Problem Statement

The abundance of research spanning the past few decades supports the legitimacy of LIO training (1-4, 9, 10, 12, 14, 17-22, 24). The research on occlusion training focused on LIO training with limited research placed on high intensity occlusion (HIO) training. There have been few studies investigating the effects of HIO training, resulting in a significant lack of knowledge in this area of research. The purpose of this study is to investigate if occlusion provides an additive effect to high intensity resistance training in regards to muscle strength and hypertrophy. This study can add to the extremely limited amount of research regarding HIO training.

Hypothesis

The experimental group, individuals utilizing the occlusion sleeves, will see greater gains in muscular strength and hypertrophy as compared to the control group, the individuals undergoing the same battery of exercises without the occlusion.

Operational Definitions

HI- high intensity resistance training without occlusion (repetitions performed in between 70-85% of one repetition maximum)

LI- low intensity resistance training without occlusion (repetitions performed in between 20-50% of one repetition maximum)

HIO- high intensity occlusion training (70-85% of one repetition maximum lifted with blood flow restriction)

LIO- low intensity occlusion training (20-50% of one repetition maximum lifted with blood flow restriction)

1RM- one repetition maximum (maximum amount of weight that can be lifted one time with proper form)

Delimitations

This experiment has certain delimitations or boundaries that could affect the collection and interpretation of data.

1. The subjects will be competitive collegiate athletes between the ages of 18 and 23 years of age.
2. Only highly trained males will be included in the study due to the fact that males are the desired group of participants.
3. Subjects will be asymptomatic, for any upper extremity orthopedic injuries, at the time of and throughout the duration of the testing.
4. Various supplements taken by the participant cannot be controlled.

5. The study is delimited to an 8 week training protocol.

Limitations

This experiment has certain inherent limitations that may have an effect on the collection and interpretation of the data. Generalizations made from the results are compromised by the following limitations:

1. The results of this study cannot be applied to those that are not physically active and do not perform resistance exercises at a minimum of three times per week.
2. The results of this study cannot be applied to physically active or inactive females.
3. The results of this study cannot be applied to males or females suffering from an upper extremity orthopedic injury.
4. The results of this study are limited to the training of the upper extremity.
5. The results of this study are limited to competitive baseball players.

Assumptions

The basic assumptions for this study include:

1. Subjects will perform the resistance exercises with maximum effort.
2. Subjects will not complete additional physical activity outside of the specified battery of exercises.
3. Subjects will utilize the occlusion sleeves on the correct exercises for the entirety of the study.
4. Subjects will complete all questionnaires accurately to the best of their knowledge.

Significance of Study

Many competitive athletes and recreational individuals are always looking for an edge to be utilized during strength training and conditioning programs. What may seem like an insignificant edge may be the difference in winning and losing for athletes participating in highly competitive activities. This study may present a new type of training that may allow physically active males to increase their muscular strength and hypertrophy, thus elevating their performance (22). The results may lead to the future research of occlusion training in other populations, in turn possibly offering a safe method for increasing strength and hypertrophy for all interested individuals (12). This study can add to the extremely limited amount of information regarding high intensity occlusion training.

CHAPTER II

REVIEW OF LITERATURE

Introduction

The abundance of research spanning the past few decades supports the legitimacy of low intensity occlusion training (1-4, 9, 10, 12, 14, 17-22, 24). The problem that manifests itself is with the focus on LIO training there has not been much research into high intensity occlusion training. The purpose of this type of training is to provide another tool for highly trained athletes to utilize during their high intensity resistance training programs to elevate their performance in their respective sport or activity.

Physiology

The effects of occlusion on various organs have been studied for the past 130 years (9). Much of the research regarding occlusion training is focused on LIO training. LIO training has yielded great results and for this reason a great deal of time and effort has been placed into learning the physiology behind this training. Although this study is designed to investigate heavier loads the physiology behind LIO training must be understood. Some theories behind the success of LIO training includes a proposed increase in motor unit recruitment, increased hormonal responses, local growth factors, increased activity of intracellular signaling pathways, and increased muscle protein synthesis.

One of the more prominent theories suggests that motor unit recruitment has a great deal to do with increasing strength and hypertrophy (22). Type I fibers are utilized by the body to produce the force necessary to lift and move in a slow manner. These fibers are also known as slow-oxidative or slow twitch and are fueled by oxygen, blood, among other physiological processes. Type II fibers are used by the body when a state of hypoxia exists or there is an increased demand. These fibers, also known as fast-glycolytic or fast twitch, function without oxygen and have a limited work output before fatigue sets in. Fast twitch fibers have a greater potential for growth as compared to slow twitch fibers (3). During low to moderate resistance training type I fibers are primarily the main source of power. During occlusion training the blood flow is restricted, reducing oxygen flow, forcing the type II fibers to play a larger role in resistance training (3). Thus, occlusion training utilizes muscle fibers with a greater potential for growth (22). Muscular fatigue can also play an important role in fiber recruitment. Fatigue translates to decreased force production, which in turn leads to fast twitch fibers being called upon to help carry the load (14). In HI training type II fibers are inherently utilized more often than in LI training due to the increased demand (22). Thus, the similarities existing between HI training and LIO training in regards to strength and hypertrophy seem to make sense. It has also been suggested that plasma lactate, which accumulates during occlusion training, inhibits muscle contractions so additional motor units are required to fire to maintain similar production of force (21). These additional motor units are usually comprised of type II muscle fibers.

LIO training has been shown to increase the accumulation of lactate along with ions such as hydrogen and sodium ions (22). Lactate and metabolites have been shown to be an important factor in the release of growth hormone (22).

Accumulation of lactate only occurs at highly intense levels of exercise, this is due to the fact that aerobic training produces cellular adaptations that increase rates of lactate removal (13). Blood lactate has been shown to increase exponentially at about 55% of the healthy, untrained individual's maximum capacity for aerobic metabolism (13). The physiology behind the increased levels of lactate in intense exercise assumes a relative lack of oxygen, or tissue hypoxia. With the lack of adequate oxygen, anaerobic glycolysis partially meets the required amount of energy, and hydrogen release begins to exceed its oxidation down the respiratory (electron transport) chain. At this point, lactate forms as the excess hydrogen produced during glycolysis passes to pyruvate. Lactate formation increases at progressively higher levels of exercise intensity when active muscle cannot meet the additional energy demands aerobically (13). There is an increase in the levels of lactate during relative states of tissue hypoxia, similar to an environment precipitated by vascular occlusion.

Large acute increases in plasma growth hormone have occurred after LIO training, as well as increases in strength and hypertrophy (9, 17, 22). This phenomenon may be possible due to the theory that occlusion training results in lactate accumulation, and in turn the lactate releases growth hormone. There may be a correlation between the increase in growth hormone and a greater hypertrophic response. Takarada (18) 2000 found that the concentration of GH increased dramatically, about 290 times the amount before exercise, in the body part that underwent exercise with occlusion (18). Levels of GH did not rise significantly in the body part that was trained without occlusion. IGF-1 has intrigued researchers in the field about its possibility of playing a role in muscular hypertrophy and strength. Recently, it has been shown that growth hormone stimulates insulin growth factor-1 production in muscles (22). IGF-1 is a systemic growth factor thought to be produced by the liver in response to the presence of GH (22). According to Takarada (18), GH and IGF-1 may play a crucial role in growth, development, and maintenance of skeletal muscle (18). GH has been shown to increase glucose and amino acid uptake, as well as promoting protein synthesis for muscular hypertrophy (4). Increased muscle protein synthesis may also lead to increases in muscular strength and hypertrophy. Protein synthesis was shown to be a result of LI (20% 1RM) occlusion training (7).

Restricted blood circulation stimulates an increase in the acidity of the muscular environment. This acidic environment may lead to a significant increase of muscular hypertrophy, due to the fact that there is an inverse relationship between pH and lactate. The potential for an increase in lactate is stimulated by an acidic pH. As was stated earlier, lactate may be a key factor in releasing GH.

Teramoto (21) stated that accumulation of metabolic by-products, such as hydrogen ions from lactic acid, stimulate group III and IV afferent neurons and activates metaboreceptors within skeletal muscles (21). The activation of metaboreceptors, known as metaboreflex, increases the sympathetic nerve activity to the skeletal muscles. The plasma lactate and hydrogen ions caused by vascular occlusion may increase activation of metaboreceptors and thereby increase sympathetic nerve activity to the skeletal muscles, which may affect motor unit activation (21).

Resting muscle glycogen has been shown to increase after LIO training. Resting adenosine triphosphate has been shown to decrease after LIO training (3, 9)

Reperfusion on pressure release of the cuff or removal of the external compression after the acute muscle hypoxia during exercise may promote muscular hypertrophy. The thought is that the reperfusion may promote cell survival and cellular growth adaptations within the muscle, such as the mammalian target of rapamycin, a signaling pathway relating to muscle hypertrophy (6).

Specific Tension and Stiffness

There have been questions about the differences between HI training and LIO training and their individual effects on tendon properties and tension. Research in this area may play a key role in preventing sports injuries and how to properly progress rehabilitation programs. Kubo concluded that LIO resistance training did not alter specific tension and stiffness of the tendon-aponeurosis complex (10). HI resistance training altered the tension and stiffness significantly. In addition to this information, Kubo also stated that LIO training increased performance during stretch- shortening cycle exercises (10). One negative effect of LIO training is the strength of the tendon would not correlate with the overall strength of the corroborating muscle (10). This effect may lead to a greater increase in tendon injuries.

Step Exercise and Walk Training Programs Utilizing Occlusion

Occlusion training is not only limited to resistance training, it has been utilized during step exercise programs. There have been multiple studies that took the blood flow restriction concepts and incorporated the principles into a step exercise program (1, 16, 21). Teramoto (21) 2006 study showed that after a 5 week step exercise program the occluded leg gained significantly greater strength than the non-occluded leg (21). The subjects participated in 3 training sessions per week, for a total of 15 bouts of exercise. However, the occluded leg did not show a significant difference in mass and endurance when compared to the non-occluded leg (21). Abe (1) 2006 reported similar results, but in addition to the increase in strength there was also a clinically significant gain in size of the occluded leg (1). This study showed significant results after 3 weeks of twice daily Kaatsu walk training in 18 healthy young men (1). Sakamaki (16) reported that blood flow restricted walking only manifested significant differences in muscular hypertrophy in the occluded distal leg muscles (16).

Ischemic Preconditioning Improves Maximal Performance

Ischemic preconditioning, successive bouts of arterial occlusion followed by reperfusion, has been shown to increase oxygen consumption and power output (5). De Groot (5) utilized fifteen healthy and trained subjects to undergo three series of five minute ischemia on both legs with resting periods of five minutes in between (5). Maximal effort cycling tests were done after the ischemic preconditioning by all participants. The ischemic preconditioning improved the subject's maximal oxygen consumption by 3%, and increased power output by 1.3% during an incremental max effort cycling test. It has been shown that ischemic preconditioning is an endogenous protective mechanism that delays cell injury, as well as increases blood flow and improves endothelial function (5).

Hypoxia Chamber and High Intensity Resistance Training

Significant results have been seen with low intensity occlusion training programs (1-4, 9, 10, 12, 14, 17-22, 24). Nishimura (15) hypothesized that by placing the entire body in a hypoxic environment greater gains in muscular hypertrophy would be seen. Fourteen untrained male university students were randomly divided into the normoxia and hypoxia training groups, 7 in each group. The study lasted 8 weeks and all participants completed the same training twice a week. The participants trained at 70% of their 1RM for both standing French presses and arm curls. Four sets of 10 for both the French presses and arm curls were performed. The hypoxic training group rested in the hypoxia chamber for 30 minutes before and after each training session. Faster and greater gains in muscular strength and hypertrophy were seen in the hypoxic group as compared to the normoxic group. The rate of perceived exertion was similar between the two groups. The results seen in this study are thought to have been mediated by the production of reactive oxygen species. The reactive oxygen species are thought to have promoted tissue growth, GH secretion stimulated by the intramuscular accumulation of metabolic byproducts, such as lactate, and possibly further recruitment of fast-glycolytic muscle fibers (15, 18).

Optimal Occlusion Pressure

Many studies have shown significant increases in strength and mass with the use of LIO training (1-4, 9, 10, 12, 14, 17-22, 24). However, the optimal occlusion pressure to provide the most significant results is still unclear. It is clear however that significant adaptations have been seen with an occlusion pressure as little as 50 mmHg, which equates to reducing about half of the blood flow in the occluded area (17). Sumide (17) divided 21 individuals into four different occlusion training groups (17). The participants exercised three times a week, for eight weeks at ~20% of their 1RM. The most significant results were seen in the patients that utilized the 50 mmHg, and 150 mmHg occlusion groups, respectively. The participants complained of discomfort, numbness, and pain with the 250 mmHg pressure. Also, no significant increases in strength and endurance were seen in the 250 mmHg group (17). With the increasing popularity around the world, especially in Japan, there needed to be some emphasis placed on the safety of LIO training. Loenneke (12) concluded that when LIO training is utilized in the proper environment and under trained supervision it provides a safe training alternative for individuals regardless of age and physical shape (12). Wernbom (22) came to the same conclusion that LIO training is safe when in a controlled environment and subjects are under the proper supervision (22).

Rapid Increases in Hypertrophy with LIT-KAATSU

Abe (2) implemented KAATSU training sessions that were completed twice daily, for a total duration of two weeks. Nine young men performed LIO training and seven men performed LI training. 3 sets of squats and leg curls were performed at each individual session. There was a gradual increase in circulating IGF-1 and muscle hypertrophy in the LIO group, but the aforementioned results were not seen in the LI group (2). The muscular hypertrophy seen in the LIO group after two weeks of twice daily training is similar to the hypertrophy seen in individuals performing a HI training regime after 3-4 months (2).

High Intensity Occlusion Training

The amount of research conducted for HIO training is minimal when compared to the research completed for LIO training. There are few research articles investigating this type of training. Laurentino (11) studied a total of 16 physically active men that were divided into a high intensity and moderate intensity group (11). The participants trained twice a week for a total of eight weeks. An occlusion cuff was attached to the proximal end of the right thigh and the left leg served as the control for all participants. The high intensity group trained at 6 reps at around 80% of their 1RM. The moderate intensity group trained at 12 reps at around 60% of their 1RM. The first three weeks all subjects performed three sets, then during the following two weeks they performed four sets. In the last three weeks they performed five sets. The occlusion pressure was released during each 120 second rest period between sets throughout the entirety of the experiment. The HI group's occlusion pressure was 125.6 ± 15.0, and the MI group's occlusion pressure was 131.2 ± 12.8. The occluded leg in both groups did not show significantly greater gains in strength and hypertrophy than the non-occluded leg after the 8 weeks (11). The researchers concluded that vascular occlusion has no effect on high intensity and/or moderate intensity training (11).

Combination Training

Some occlusion training has shown positive results, which has caused intrigued individuals to implement many different variations of an occlusion training regime. Some have even utilized LI occlusion training in conjunction with HI training. Yasuda (25) divided forty young men into four different training groups (25). The groups are as follows; LIO training, HI training, combined LIO and HI training, and non training control. There were a total of 10 participants in each group. The participants exercised three times a week, for a total of 6 weeks. After the results were analyzed, they concluded that the combined training group showed the greatest increases in strength (25). A combination program of LIO and HI training may be a feasible and effective training program for improving strength in practical applications (25).

Conclusion

There is considerable evidence that validates the effectiveness of LIO training (1-4, 9, 10, 12, 14, 17-22, 24). There are many times when HI training is contraindicated and occlusion training is a feasible and effective alternative. It is considered to be a generally safe training technique when supervised by trained personnel and in an appropriate environment. There are many different theories as to the reason behind the physiological success of LIO training, but the most widely accepted thought is an increase in motor unit activation. There are other theories which include increases in GH, IGF-1, metabolites, lactate, protein synthesis, as well as a slew of other reasons. LIO training appears to provide positive results, however the physiological reasons behind the success has yet to be completely validated and accepted by all groups of researchers and professionals in the field. There still needs to be more research not only about the physiological aspect, but also its long term effectiveness and optimal occlusion pressures, cuff widths, and its effectiveness in conjunction with other resistance training regimes. There is a considerable amount of evidence about Kaatsu, or LIO training, but there is still much to learn about other aspects of occlusion training (1-4, 9, 10, 12, 14, 17-22, 24). A major point of research that can be investigated includes the effectiveness and safety of occlusion training when utilized in conjunction with HI resistance training. Also, its effectiveness when utilized during walking or cardiovascular exercise. There are many exciting possibilities in regards to occlusion training, and the research conducted to this point has only scratched the surface of what's possible

CHAPTER III

METHODOLOGY

Purpose

The purpose of this study is to determine the effect of vascular occlusion in conjunction with an eight week HI resistance training protocol on muscular hypertrophy and strength of the bilateral arms.

Setting

The research study will take place in the University Athletic Department's strength and conditioning weight room in Jowers. The majority of the lifting, paperwork, and testing will take place in the university weight room, however some measurements and paperwork will take place in an Athletic Training facility.

Subjects

The subjects (n=15) are healthy trained males between the ages of 18 and 23. The subjects will be recruited from a NCAA division I baseball team (San Marcos, TX). All subjects are considered to be competitive athletes, healthy with previous weightlifting experience. The main incentive for participation in this study is the possibility of enhanced gains in strength and hypertrophy over previous exercise training programs attempted by the subjects. All subjects will perform exercises in accordance to the resistance training program set forth by the team's strength and conditioning coach.

Subjects will be excluded from the study if they have any unresolved upper extremity orthopedic injuries over the previous two years that necessitated a change in the lifting routine, in regards to weight, exercise, or technique. These injuries may include any injury relating to the phalanges, wrists, hands, forearm, arm, shoulder, neck, head, lower back, and upper back. Individuals who are overtly obese (over 25% body fat), have a family history of known cardiac, respiratory or metabolic disease or musculoskeletal disease that would limit exercise participation, or are experiencing a major physical or mental illness will be excluded from participating. All inclusion and exclusion criteria will be done in accordance with American College of Sports Medicine Guidelines. The level of percent body fat will be calculated following the guidelines set forth by Jackson and Pollock (8). Each individual subject will be given a randomly selected number to maintain the confidentiality of the participant's data collection, test results, and demographic information. There will be a control and experimental group. The control and experimental group will perform the same battery of exercises, with the only difference between the groups being the subjects in the experimental group will utilize the occlusion sleeves throughout the entirety of the study. The participants will be randomly divided into either the experimental or control group.

Instrumentation

The training for all subjects will be completed over an eight week period, consisting of two sessions per week. A typical weightlifting session will consist of a ten minute dynamic warm up under the guidance of a Certified Strength and Conditioning Coach (National Strength and Conditioning Association- NSCA, Certified Strength and Conditioning- CSCS). The three lifting sessions per week are usually broken down by upper body and lower body, with an additional day consisting of less intense exercises that targets both the upper and lower body. Abdominal and core exercises will be performed at the end of each session, normally taking between seven to nine minutes. Between the warm up, resistance and core exercises the workout will take around an hour. The lifting program will change exercises and intensities on a fairly regular basis to provide maximal results. There is a conditioning program that will be performed by all subjects twice a week.

The university athletic department strength and conditioning weight room will have all the necessary materials to accommodate the prescribed lifting program. The Adidas Micro Nylon (Portland, OR) sleeve size will be individually determined to provide maximal results in regards to muscular strength and hypertrophy. The individual participants sleeve size will be based upon bilateral biceps brachii circumferences as well as overall fit and comfort. All participants will undergo girth measurements of bilateral arms (14cm above olecranon process) with a standardized tape measure before and after the eight week study. Those individuals with a relaxed bilateral biceps brachii circumference greater or equal to 32.5 cm will utilize the Large/XLarge micro nylon sleeves. Those individuals with a relaxed bilateral biceps brachii circumference of 32.49 cm or less will utilize the Small/Medium micro nylon sleeves. The Large/XLarge compression sleeves when used on a PVC pipe with a circumference of 32.5 cm exerted ~ 50mm Hg. When used on a PVC pipe with a circumference of 33 cm the Large/XLarge compression sleeves exerted ~ 52 mm Hg. The Small/Medium compression sleeves when used on a PVC pipe with a circumference of 32.5 cm exerted ~ 62mm Hg. When used on a PVC pipe with a circumference of 30 cm the Small/Medium compression sleeves exerted ~ 48 mm Hg. The participants in the experimental group will fold the sleeves over itself, so the sleeves will be doubled up. The micro nylon sleeve will extend from the cubital fossa to the deltoid tuberosity. The primary investigators will be present for all data collection and will conduct every data collection session according to the step by step procedures.

Procedures

All participants will undergo body composition testing using a skin caliper. The level of percent body fat will be calculated following the guidelines set forth by Jackson & Pollock (8). The body composition results will be utilized only for inclusion and exclusion criteria. Bilateral circumferential measurements of the relaxed middle point of the upper arm (14cm above olecranon process) will be taken for each participant using a standardized tape measure. A repetition maximum will be tested for isolated biceps curls and overhead triceps extension and then be converted into a one repetition maximum. The one repetition maximum for both exercises will be used to objectively assign the training intensity (70-75% of 1RM). All participants will train at 70% of their 1RM for the first four weeks, then train at 75% for the last four weeks. All participants will undergo a four week resistance training program prior to the eight week study. Each individual subject will be given a randomly selected number to maintain the confidentiality of the participant's data collection, test results, and demographic information. All subjects will provide written informed consent in accordance with the Institutional Review Board at Texas State University-San Marcos.

The participants in the experimental and control group will perform the same battery of exercises as overseen and prescribed by the team's certified strength and conditioning coach (CSCS, NSCA). The only difference being that the participants in the control group will perform the specified isolated biceps and triceps exercises without the occlusion sleeve. The participants in the experimental group will utilize the occlusion sleeves, twice a week during their isolated biceps and triceps exercises. The participants will be given new sleeves after six weeks, and will train for the remaining two weeks with the new sleeves. These participants will train the opposing muscle groups on different days. The experimental group will perform three sets of eight standing bilateral bicep curls during the first weightlifting session of the week. The experimental group will release the pressure in between sets for a maximum of 120 seconds. Three sets of eight standing overhead triceps extension will be performed during the second weightlifting session of the week. The pressure from the sleeves will be released for a maximum of 120 seconds between sets.

All participants will undergo a Biodex test of the biceps and triceps at 60 and 120 degrees per second before and after the eight week treatment period. Measurements and muscle power included flexion and extension in foot/pounds along with maximal muscle strength in foot/pounds. All participants will undergo a repetition maximum for biceps and triceps before and after the eight week treatment period.

Statistical Analysis

This study will attempt to investigate the effects of vascular occlusion on strength and hypertrophy when utilized during a high intensity lifting program. The bilateral biceps and triceps strength of the patients will be tested through a Biodex protocol and a repetition maximum, at the beginning and end of the research study. Hypertrophy will be measured through bilateral circumferential measurements of the relaxed biceps brachii (14cm above olecranon process) before and after the 8 week training protocol.

Demographic information including age, height, and weight as well as body fat composition will be collected.

CHAPTER IV

MANUSCRIPT

Abstract

The purpose of this study was to determine the effect of vascular occlusion in conjunction with an 8 week high intensity resistance training or occlusion protocol on muscular hypertrophy and strength. There is limited amount of research investigating high intensity occlusion training. The purpose of this type of training was to provide a tool for competitive athletes to utilize during their high intensity resistance training programs to elevate their performance in their respective sport or activity. A total of 15 NCAA Division I baseball players participated in this study. Seven participants utilized occlusion sleeves during a section of their high intensity occlusion training program targeting their biceps and triceps, twice a week for a total of eight weeks. Eight participants underwent the same training program, without the use of the occlusion sleeves. All participants underwent pre and post training strength measurements and girth measurements, 14 cm above olecranon process. Overall, the participants utilizing the occlusion sleeves during parts of their training program realize no significant changes when compared to the control group. In fact, the right bicep isokinetic strength at 60 degrees per second of the experimental group decreased when compared to the control group. In conclusion, a high intensity occlusion training program does not improve muscular strength gains or muscle hypertrophy when compared to a traditional high intensity training program. Based on the results of this investigation, a high intensity

occlusion training program would not be recommended for an athlete looking for an advantage in their training regime.

Introduction

Strength training is a necessary component to most sport programs and often seen incorporated during post-injury rehabilitation. Empirical evidence supports training at high intensities ~ 80% of one repetition maximum provides optimal strength gains (22). Performing 6 to 12 reps at ~70-85% of 1 repetition maximum has been shown to be effective at increasing strength and hypertrophy (11, 13, 22, 23). However, there are many times when training at such high intensities is contraindicated due to potential injury or other compounding factors. Post operative athletes are unable to lift heavy weight in order to protect the integrity of the surgery. Athletes that sustained acute nonsurgical injuries typically are unable to perform heavy lifting exercises compromising pain, inflammation, and tissue damage. In the past few decades, there has been increased interest in training at lower intensities while utilizing vascular occlusion (22). This type of training has become widely popular in Japan known as Kaatsu training or low intensity occlusion (LIO) training (9, 12, 19, 22).

There is very strong evidence that LIO training (~ 20% 1 repetition max) provides similar results in muscle hypertrophy and strength as high intensity training (HI) (~ 80% 1 repetition max) (2-4, 14, 17-22, 24). With this method, only ~20% of an individual's one repetition maximum (RM) is being utilized while training and the vascular occlusion provides an additive affect which produces results similar to that of high intensity training. There have been many investigations utilizing varying occlusion techniques, occlusion pressures, training regimes, and anatomical structures. Additional investigations have verified the legitimacy of LIO training, or Kaatsu training (1-4, 9, 10, 12, 14, 17-22, 24).

The effectiveness of the Kaatsu technique include a proposed increase in motor unit recruitment, increased hormonal responses, local growth factors, increased activity of intracellular signaling pathways, and increased muscle protein synthesis (22). During low intensity exercise, type I (slow-oxidative) muscle fibers, are primarily utilized to provide force. These fibers are fueled by oxygen and blood, unlike type II muscle fibers (fast-glycolytic). Type II fibers are used in anaerobic exercise when there is a lack of oxygen and these fibers have a greater potential for growth (22).

During LIO training, the blood flow is restricted forcing type II fibers to play a larger role in the output of force. Kaatsu training utilizes muscle fibers with a greater potential for increases in hypertrophy and strength as compared to those individuals undergoing the same training protocol without occlusion. Kaatsu training also provides similar improvements in strength and hypertrophy when compared to those undergoing a high intensity resistance training program (24).

The abundance of research spanning the past few decades supports the legitimacy of LIO training (1-4, 9, 10, 12, 14, 17-22, 24). The research on vascular occlusion training focused on LIO training with limited research placed on high intensity occlusion (HIO) training. There have been few studies investigating the effects of HIO training, resulting in a significant lack of knowledge in this area of research. With the overwhelming success seen in LIO training, HIO training should be researched more in depth to discover if it holds a potential for providing advantageous results. The purpose of this study was to investigate if occlusion provides an additive effect to high intensity resistance training in regards to muscle strength and hypertrophy. The inspiration for this research comes from the hope of finding a practical way for competitive athletes to increase their training ceiling.

Methods

Experimental Approach to the Problem

To examine the effects of vascular occlusion (VO) in conjunction with a HI resistance training program on strength and hypertrophy, an experimental and control group were utilized. The subjects were randomly divided into each group.

Subjects

Fifteen healthy trained male subjects (19.8 ± 1.28 years of age, 84.69 ± 7.20 Kg, 182.19 ± 4.88 cm) were recruited from a NCAA division I baseball team (San Marcos, TX). All subjects were considered to be competitive athletes, healthy with previous weightlifting experience. Three subjects dropped out during the training regime due to injuries, which modified the lifting protocol. The individual participant's group assignments were randomly chosen. The main incentive for participation in this study was the possibility of enhanced gains in strength and hypertrophy over previous exercise training programs attempted by the subjects. All subjects performed all exercises in accordance to the resistance training program set forth by the team's strength and conditioning coach. Subjects were excluded from the study if they had any unresolved upper extremity orthopedic injuries over the previous two years that necessitated a change in the lifting routine, in regards to weight, exercise, or technique. These injuries may include any injury relating to the phalanges, wrists, hands, forearm, arm, shoulder, neck, head, lower back, and upper back. Individuals who were overtly obese (over 25%

body fat), had a family history of known cardiac, respiratory or metabolic disease or musculoskeletal disease that would limit exercise participation, or were experiencing a major physical or mental illness were excluded from participating. The level of percent body fat was calculated following the guidelines set forth by Jackson and Pollock (8). Each individual subject was given a randomly selected number to maintain the confidentiality of the participant's data collection, test results, and demographic information.

Each participant was informed about the procedures and potential risks before signing the informed consent form. Each participant completed an informed consent form (Appendix A), medical history questionnaire (Appendix B), and pre-participation physical (Appendix C) and was cleared for participation by a licensed medical physician. Participants did not receive any monetary gains for participating in this study. The Institutional Review Board at Texas State University San Marcos approved the study (Code #2012V8852)

Procedures

Overview

The resistance training regimes for all subjects were completed over an eight week period. Previous research has favored at minimum an eight week protocol for strength training so physical changes can become evident. All participants performed the same resistance training program for a month prior to the study to decrease the learning effect. The participants in the experimental group utilized occlusion sleeves, twice a week during their isolated biceps and triceps exercises. This protocol was considered high intensity resistance training due to the previous research indicating that training above

70% of 1RM would provide significant gains in strength and hypertrophy (22, 23). The participants were given new sleeves after six weeks, and trained for the remaining two weeks with the new sleeves. These participants trained the opposing muscle groups on different days. The experimental group performed three sets of eight standing bilateral bicep curls at 70% of their one repetition maximum during the first weightlifting session of the week. The experimental group released the pressure in between sets for a maximum of 120 seconds. Three sets of eight standing overhead triceps extension at 70% of their one repetition maximum were performed during the second weightlifting session of the week. The pressure from the sleeves was released for a maximum of 120 seconds between sets. A one repetition maximum for both exercises was used to objectively assign the training intensity (70% of 1RM). After four weeks of training, all participants added five pounds to the weight they lifted during their training of the biceps and triceps.

A typical weightlifting session consisted of a ten minute dynamic warm up under the guidance of a Certified Strength and Conditioning Coach (National Strength and Conditioning Association- NSCA, Certified Strength and Conditioning- CSCS). The three lifting sessions per week are usually broken down by upper body and lower body, with an additional day consisting of less intense exercises that targets both the upper and lower body. Abdominal and core exercises were usually performed at the end of each session, normally taking between seven to nine minutes. Between the warm up, resistance and core exercises the workout took around an hour. The lifting program changes exercises and intensities on a fairly regular basis to provide maximal results. There was a conditioning program that was performed by all subjects twice a week.

The Adidas Micro Nylon (Portland, OR) sleeve size was individually determined to provide maximal results in regards to muscular strength and hypertrophy. The individual participants sleeve size was based upon bilateral biceps brachii circumferences as well as overall fit and comfort. All participants underwent girth measurements of bilateral arms (14cm above olecranon process) with a standardized tape measure before and after the eight week study. Those individuals with a relaxed bilateral biceps brachii circumference greater or equal to 32.5 cm utilized the Large/XLarge micro nylon sleeves. Those individuals with a relaxed bilateral biceps brachii circumference of 32.49 cm or less utilized the Small/Medium micro nylon sleeves. The Large/XLarge compression sleeves when used on a PVC pipe with a circumference of 32.5 cm exerted ~ 50mm Hg. When used on a PVC pipe with a circumference of 33 cm the Large/XLarge compression sleeves exerted ~ 52 mm Hg. The Small/Medium compression sleeves when used on a PVC pipe with a circumference of 32.5 cm exerted ~ 62mm Hg. When used on a PVC pipe with a circumference of 30 cm the Small/Medium compression sleeves exerted ~ 48 mm Hg. This information was used as a measurement for determining which sleeve size the participants would utilize. This was also a variable because the pressure placed on each individual, as well as each individual arm was different due to the different girths of the participant's arms and constant size of the sleeves. The desired pressure was 50 mmHg because previous research has shown that this amount of pressure is adequate in inducing physiological responses and occluding about half of the blood flow in the occluded area. The participants in the experimental group folded the sleeves over itself, so the sleeves were doubled up. The micro nylon sleeve extended from the cubital fossa to the deltoid tuberosity. The primary investigators were present for all data collection and conducted every data collection session according to the step by step procedures. The participants in the experimental and control group performed the same battery of exercises as overseen and prescribed by the team's certified strength and conditioning coach (CSCS, NSCA). The only difference being that the participants in the control group performed the specified isolated biceps and triceps exercises without the occlusion sleeve. A repeated measures ANOVA was performed to provide the statistical analysis of the data.

Strength Testing

All participants underwent an Isokinetic strength test of peak torque (Biodex System 4 Isokinetic Dynamometer, Shirley NY) of the biceps and triceps at 60 and 120 degrees per second before and after the eight week study. All participants underwent a repetition maximum for standing isolated bilateral bicep curls and standing overhead triceps extension before and after the 8 week study.

Results

For the 60 degree flexion measurements, the results for the right and left arm differed. For the right arm, the treatment and control groups differed in change from the pre-test to the post-test, $F(1,13) = 6.97$, $p = .020$. For the control group, there was no significant change, $t(7) = 0.58$, $p = .285$, from the pre-test (44.0 ± 7.8) to the post-test (45.1 ± 7.9); however, for the treatment group a significant decrease, $t(7) = 3.11$, $p = .010$, from the pre-test (43.4 ± 6.9) to the post-test (37.7 ± 4.0) was observed. For the left arm, there was no change in 60 degree flexion from the pre-test to the post-test for both groups combined, $F(1,13) = 0.78$, $p = .392$, and there was no difference in change between the treatment and control groups, $F(1,13) = 1.36$, $p = .265$.

Descriptive Statistics

	Mean	Std. Dev.	Std. Error
Girth Pre R	31.133	1.714	.442
Girth Post R	31.317	1.486	.384
Girth Pre L	31.329	1.846	.477
Girth Post L	31.533	1.772	.458
Pre R Ext60	39.207	7.390	1.908
Post R Ext60	42.400	6.508	1.680
Pre L Ext60	37.107	5.319	1.373
Post L Ext60	39.427	6.740	1.740
Pre R Flex60	43.733	7.126	1.840
Post R Flex60	41.627	7.278	1.879
Pre L Flex60	43.833	7.937	2.049
Post L Flex60	42.353	6.712	1.733
Pre R Ext120	35.433	4.778	1.234
Post R Ext120	40.140	7.013	1.811
Pre L Ext120	31.953	6.020	1.554
Post L Ext120	35.267	5.615	1.450
Pre R Flex120	38.680	8.559	2.210
Post R Flex120	34.767	6.182	1.596
Pre L Flex120	40.840	9.710	2.507
Post L Flex120	35.040	5.652	1.459
Bicep 1RM Pre	55.833	10.028	2.589
Bicep 1RM Post	60.587	5.828	1.505
Tricep 1RM Pre	92.953	14.191	3.664
Tricep 1RM Post	94.694	14.272	3.685

For the 60 degree extension measurements, 120 degree flexion measurements, 120 degree extension measurements, girth measurements, and one-repetition maximum measurements there was no difference between the treatment and control groups. The study started with a total of eighteen participants, however three dropped out during the study due to injuries. At the conclusion of the study, there were seven participants in the experimental group and eight participants in the control group. Effect sizes for the group differences were calculated, and with such small effects it would take a much larger sample to find any significant differences in groups.

Discussion

In this present study, we did not find an advantage gained by the experimental group, as compared to a control, in regards to muscle hypertrophy and strength. There was no change between both groups for isokinetic muscle strength and hypertrophy. However, the experimental group saw a decrease in strength of the right bicep at 60 degrees per second when tested on the isokinetic dynamometer, whereas the control group saw no significant change.

Our results are contradictory to previous studies investigating LIO training (1-4, 9, 10, 12, 14, 17-22, 24). Many investigations found significant increases in strength and mass with the use of LIO training (1-4, 9, 10, 12, 14, 17-22, 24). Takarada found a significant increase in strength and hypertrophy when participants utilized occlusion while training elbow flexors at 50% of 1RM, when compared to a group performing the same protocol without occlusion (19). The participants training their elbow flexors at 50% of 1RM with occlusion saw no differences in strength and hypertrophy when compared to a group that trained elbow flexors at 80% of their 1RM without occlusion. Occlusion training was incorporated into walk training, and Abe showed that the occluded leg showed significant gains in strength and mass when compared to the non-occluded leg (1).

This investigation results are comparable to other studies investigating moderate and HIO training. Laurentino concluded that high intensity strength training in conjunction with vascular occlusion did not provide an additive effect when compared to high intensity strength training alone (11). Laurentino utilized moderate and HIO groups where the high intensity group performed unilateral knee extensions with a load of 6 RM, equating to 80% of 1RM. The moderate intensity group performed unilateral knee extensions with a load of 12 RM, equating to 60% of 1RM. All participants trained both legs twice a week, for a total of 8 weeks. The right leg performed all exercise sessions with occlusion, and the left leg performed all exercise sessions without occlusion and served as the control.

Empirical research has shown positive results from LIO training enhancing muscular strength and hypertrophy. This investigation supports the empirical research that HIO training does not provide significant results when compared to a control (11, 23). A possible explanation for the aforementioned data is the effect of intramuscular occlusion of blood flow naturally created when lifting heavier loads. According to Wernbom, when resistance is greater than ~50-60% of an individual's 1 RM, the intramuscular tension may be so great that it occludes blood flow naturally (22). When training at greater intensity, any additional occlusive device over an anatomical structure may not have any effect on the intramuscular occlusion. In addition, Wernbom found that restriction of the flow of blood had no impact on endurance when performing a dynamic knee extension exercise at 50% of 1RM (23). However, the occlusive device had a profoundly negative effect on muscular endurance while performing a dynamic knee extension exercise at 20% of 1RM.

Our findings should be taken with caution because of the relatively small number of participants and short duration of training. In addition, our participants were highly trained athletes who participated in baseball activities throughout the entirety of the training period. Participants stated that towards the end of the study they felt overall bodily fatigue from repetitive strenuous baseball activities. This common notion of fatigue may have influenced the post study strength testing. Many low to moderate strength training programs that utilize occlusion are associated with some type of pain or uncomfortable sensation in the trained body part. However, none of the patients in the experimental group complained of any type of pain, neurological sensations, or uncomfortable feelings during their training. This study did not have the participants report measures for pain, but the overall consensus among the participants was that this training was not uncomfortable or painful.

Practical Applications

The results of this investigation found no significant advantage utilizing the vascular occlusion sleeves in a high intensity resistance training regime when compared to a control group. In fact, the right bicep strength at 60 degrees per second showed that the experimental group decreased and the control group did not. A HIO training program does not appear to provide any greater gains in muscle strength or hypertrophy when compared to a traditional HI training program. This type of training would not be recommended for a competitive athlete looking to gain an advantage in their resistance training regime.

Positive results, such as increased muscular strength and hypertrophy, have been seen with LIO training. This type of training has been utilized in many different aspects of exercise and among various populations, and seen great success. Even with all the gains seen when implementing vascular occlusion to LI training, the same results are not apparent when implementing vascular occlusion to HI training.

The long term effects of both HI and LI occlusion training needs to be addressed in detail. In particular, focus should be placed on any potential long term damage to the nerves and blood vessels (23). In addition, long term occlusion training and the possibility of any negative effects on the muscular system need to be addressed.

Based on the results of this investigation, competitive athletes should not implement vascular occlusion in their HI resistance training program and expect to have advantageous results.

CHAPTER V

CONCLUSIONS & RECOMMENDATIONS FOR FUTURE RESEARCH

Conclusions

The results of this investigation found no significant advantage utilizing the vascular occlusion sleeves in a high intensity resistance training regime when compared to a control group. In fact, the right isokinetic bicep strength at 60 degrees per second showed that the experimental group decreased and the control group did not. A HIO training program does not appear to provide any greater gains in muscle strength or hypertrophy when compared to a traditional HI training program. This type of training would not be recommended for a competitive athlete looking to gain an advantage in their resistance training regime.

Recommendations for Future Research

The current study has shown that there may be more efficient and effective ways to implement a better approach to research and possibly provide results with greater reliability and validity. Future research studies should utilize more participants in each group to increase the power of the study. Checking lactate levels in each individual before and after each workout, at the beginning and end of the study, and at various times throughout the study would provide some insight on an important physiological process occurring in all participants. There is a correlation between increased lactate levels, high levels of growth hormone and insulin like growth factor, and increased protein synthesis which may have an effect on muscular strength and girth. A lactate device is relatively inexpensive and is rather easy to use and implement.

Hypertrophy was assessed to verify differences between the experimental and control group. We utilized a standard tape measure to check hypertrophy in all participants before and after the study. However, an MRI of the appropriate anatomical part would provide a much more reliable test to check for an increased cross sectional area. This is an expensive and time consuming approach, but the results would be much more reliable. Having participants and investigators "blinded" to which group each individual was in throughout the entirety of the study would ensure no bias present in the results. Due to time constraints for this study the possibility of groups switching protocols after a washout out period was eliminated. This would ultimately provide more reliable and valid results.

A possible extraneous variable in the results could have been the fact that all participants were NCAA Division I baseball players. An interesting finding in this study was the fact that a considerable amount of participants had a smaller girth measurement on their throwing arm when compared to their non-throwing arm. This was seen in both pre and post girth measurements taken 14cm superior to the olecranon. There is a large amount of stress being placed on these baseball players throwing arms because for multiple days a week they are participating in baseball related activities. Their unique baseball activities may have had an impact on the results. All participants were position players on an NCAA Division I baseball team, however they all played different positions which places different bodily stresses on each individual. Utilizing a healthy and competitive group of individuals who only participated in the training regime of the respective study might provide a more reliable and valid study.

APPENDIX A

Consent Form

I hereby give my consent for my participation in the research project entitled: High intensity Strength Training in Conjunction with Vascular Occlusion. I understand that the person responsible for this research project is Christopher Raymond, ATC, LAT, of the Department of Health and Human Performance, Texas State University (518) 944-3948. Chris can be reached by email at cfr23@txstate.edu

Purpose

The purpose of this study is to investigate if occlusion provides an additive effect to high intensity resistance training in regards to muscle strength and hypertrophy. The literature has shown extremely positive results from low intensity occlusion training, but there has been very little exposure to high intensity occlusion training and it effects. There is an unexplored aspect of occlusion training that may provide experienced individuals and top notch athletes an edge to accelerate their performance to the next level. It can be an asset to any physically active male looking to increase strength and hypertrophy in a safe manner while utilizing traditional resistance training programs. This study can add to the extremely limited amount of information regarding high intensity occlusion training. The possible benefits for the subjects include greater gains in strength and hypertrophy than their peers undergoing the same training regime. The risks are limited and there is a significantly low probability that they will occur. This study may provide all physically active males a safe and easily accessible tool to elevate their training.

The study population will consist of at least 15 healthy males (18-23 years of age) that are position players on the Texas State University Division I baseball team. Any individuals experiencing an upper extremity orthopedic injury that will cause a change in the prescribed training regime will be excluded from participating. In addition, all subjects must have previous weight lifting experience and pass the pre-participation physical performed by the student health center and athletic training staff. Subjects must be in a good state of mental health and not have any predisposing factors that may lead to thromboses.

Before I undergo any resistance training with occlusion, I certify to the program that I am in good health and to my knowledge I am able to perform the resistance training regime without any accommodation. It is my understanding that I will be interviewed by trained health care professionals prior to my undergoing the test who will in the course of interviewing me determine if there are any reasons which would make it undesirable or unsafe for me to complete the training program. Consequently, I understand that it is important that I provide complete and accurate responses to the interviewer and recognize that my failure to do so could lead to possible unnecessary injury to myself during the training program. You may refuse to answer any questions.

I hereby consent to voluntarily engage in an 8 week long training program utilizing vascular occlusion. I also consent to the taking of my body fat by a skin caliper and undergo circumferential measurements of both arms. I consent to the wearing of compression sleeves throughout times in the training for the entirety of the 8 weeks. It is my understanding and it is my right that I have been clearly advised that it is my right and obligation to request that a stop be put to the wearing of the compression sleeves at any point throughout the training regime if unusual discomfort or pain arises. I have been advised that I should immediately upon experiencing any such symptoms, or if I so choose, inform the operator that I wish to stop participation in the study. My wishes in this regard shall be absolutely carried out. I have also been advised that I may withdraw from participation in this study at any time. I also understand I may not answer any question for any reason. I also understand that full participation for the length of this study will last approximately 8 weeks.

A summary of findings will be provided to me upon completion of the study if I so request

Risks

I understand and have been informed that there exists the possibility of adverse changes during the training regime. I have been informed that these changes could include subcutaneous hemorrhage, temporary numbness, venous thrombosis, deterioration of ischemic heart disease, cerebral infarction, rhabdomyolysis, pulmonary embolism, and delayed onset of muscle soreness. I have been told that every effort will be made to minimize these occurrences by precautions and observations taken during the test. I have also been informed that trained CPR personnel will be available on site during all exercise bouts. I understand that there is a risk of injury, or even death as a result of my performance of this training, but knowing those risks, it is my desire to proceed to take the test as this form describes it. Furthermore, I understand that if this research project causes me any physical injury, treatment is not necessarily available at Texas

State University or the Student Health Center, nor is there necessarily any insurance carried by the University or its personnel applicable to cover any such injury. In the event that I require medical attention as a result of my participation in this research, I understand that I am personally responsible for any expenses incurred.

The study administrator is a nationally certified athletic trainer, state licensed athletic trainer, CPR/AED and First Aid certified. He has been trained to identify emergency situations and how to properly offer emergency treatment if such occurrences should arise. He will be present during each training session.

Benefits to be expected

The results of this test may or may not benefit me. Potential benefits relate mainly to greater muscular strength and hypertrophy gains as compared to fellow athletes undergoing the same training regime without utilizing the compression sleeves. Benefits of vascular occlusion with high intensity resistance training may include: increase strength, increase muscular hypertrophy, increase muscular performance, and increase on-field performance.

Compensation

I understand that there will be no compensation provided for participation and/or completion of the study. Should I not complete the entirety of the study I will incur no penalty.

Confidentiality and use of information

I have been informed that all information obtained from these testing procedures will be treated as privileged and confidential and will consequently not be released or revealed to any person without my express written consent. A file containing the consent form, results from the health history questionnaire and all collected data will be kept in a locked cabinet for five years, after which, it will be destroyed. I do, however, agree to the use of any data recorded for research or statistical purposes so long as it does not provide facts that could lead to my identification. Any other information obtained, however, will be used only by the program staff to evaluate my exercise status or needs.

Operational Definitions

High intensity- resistance training at 70-85% of an individual's one repetition maximum

Vascular occlusion- compression that is equivalent to ~50 mm Hg

Inquires and freedom of consent

I fully understand that my participation in this research project is voluntary and that refusal to participate involves no penalty, and that I may discontinue participation at any time without penalty

I further understand that there are also other remote risks that may be associated with this procedure. Despite the fact that a complete accounting of all these remote risks has not been provided to me, I still desire to proceed with the test.

I understand if I have any questions about the research, research participants' rights, and/or research-related injuries to participants I can direct them to the IRB chair, Dr. Jon Lasser (512-245-3413 – lasser@txstate.edu), or to Ms. Becky Northcut, Compliance Specialist (512-245-2102).

I acknowledge that I have read this document in its entirety or that it has been read to me if I have been unable to read same.

I consent to the rendition of all services and procedures as explained herein by all program personnel.

________________________ Date ___________

Participant's Signature

________________________ Date ___________

Project Supervisor's Signature

APPENDIX B

Demographic Information

Last Name ____________________

First Name ____________________

Middle Initial ____________________

Date of Birth ____________________

Sex ____________________

Home Phone ____________________

Address ____________________

City ____________________

State ____________________

Zip Code ____________________

Work Phone ____________________

Family Physician ____________________

Code #:______2012V8852_______

B-Health History Questionnaire

Section A

1. When was the last time you had a physical examination?

2. If you are allergic to any medications, foods, or other substances, please name them.

3 If you have been told that you have any chronic or serious illnesses, please list them.

4. Give the following information pertaining to the last three times you have been hospitalized.

	Hospitalization 1	Hospitalization 2	Hospitalization 3
Reason for hospitalization			
Month and year of hospitalization			
Hospital			
City and State			

Section B

During the past 12 months...

1. Has a physician prescribed any form of medication for you? Yes__No__

2. Has your weight fluctuated more than a few pounds? Yes__No__

3. If yes, did you attempt to bring about this weight change through diet or exercise?

Yes__No__

4. Have you experienced any faintness, light-headedness, or blackouts? Yes__No__

5. Have you occasionally had trouble sleeping? Yes__No__

6. Have you experienced any blurred vision? Yes__No__

7. Have you had any severe headaches? Yes__No__

8. Have you felt unusually nervous or anxious for no apparent reason? Yes__No__

9. Have you experienced unusual heartbeats such as skipped beats or palpitations? Yes__No__

10. Have you experienced periods in which your heart felt as though it were racing for no apparent reason? Yes__No__

At present...

1. Do you experience shortness or loss of breath while running/lifting weights? Yes__No__

2. Do you experience sudden tingling, numbness, or loss of feeling in your arms, hands, legs, feet, or face? Yes__No__

3. Do you get pains or cramps in your arms? Yes__No__

4. Do you experience any pain or discomfort in your upper body? Yes__No__

5. Do you experience any pressure or heaviness in your chest or upper body? Yes__No__

6. Have you ever been told that your blood pressure was abnormal? Yes__No__

7. Do you have diabetes? Yes__No__

If yes, how is it controlled? (Check One)

_Dietary means _Insulin injection _Oral medication _Uncontrolled

8. How often would you characterize your stress level as being high? (Check One)

_Occasionally _Frequently _Constantly

9. Have you ever been told that you have any of the following illnesses? Yes__No__

_Myocardial infarction _Arteriosclerosis _Heart disease

_Coronary thrombosis _Rheumatic heart _Heart Attack

_Coronary occlusion _Heart failure _Heart murmur

_Heart block _Aneurysm _Angina

_Heart arrhythmia _Venous Thrombosis _Rhabdomyolysis

_Subcutaneous Hemorrhage _Ischemic Heart Disease

_Cerebral Infarction _Pulmonary Embolism _Raynaud's Syndrome

_Blood Clot _Neuropathy _High Blood Pressure

10. Have you been told that you are prone to, or have a family history of blood clots, venous thrombosis, and/or pulmonary embolism?
Yes__No__

If yes,
explain____
____

11. Have you recently experienced extreme muscle pain unrelated to an acute injury in the upper body Yes__No__

12. Have you recently experienced any numbness, burning, tingling, coldness, loss of feeling, or any abnormal sensations in your arms, forearms, back, and/or neck? Yes__No__

Section C

1. Participants must be physically active and trained healthy males between 18 and 23 years of age. Do you meet these study inclusion criteria?

Yes__No__

2. If not, which criteria in #1, above, does not apply to you:

____

____

3. Individuals who currently have an unresolved upper extremity orthopedic injury, are overtly obese, have a history of known cardiac, respiratory or metabolic disease or musculoskeletal disease that would limit exercise participation, are currently experiencing a major physical or mental illness will be excluded from participating.

Do any of the criteria in the list apply to you?

Yes__No__

4. If yes, please specify which criteria in #3, above:

____

____

UPPER EXTREMITY FUNCTIONAL INDEX

We are interested in knowing whether you are having any difficulty at all with the activities listed below. Please provide an answer for **each** activity.

Today, do you or would you have any difficulty at all with: (Circle one number on each line) **ACTIVITIES**	Extreme Difficulty	Quite a bit of Difficulty	Moderate Difficulty	A Little bit of Difficulty	No Difficulty
a. Any of your usual work, housework or school activities	0	1	2	3	4
b. Your usual hobbies, recreational or sporting activities	0	1	2	3	4
c. Lifting a bag of groceries to waist level	0	1	2	3	4

d. Placing an object onto, or removing it from an overhead shelf	0	1	2	3	4
e. Washing your hair or scalp	0	1	2	3	4
f. Pushing up on your hands (e.g., from bathtub or chair)	0	1	2	3	4
g. Preparing food (e.g., peeling, cutting)	0	1	2	3	4
h. Driving	0	1	2	3	4
I. Vacuuming, sweeping, or raking	0	1	2	3	4
j. Dressing	0	1	2	3	4
k. Doing up buttons	0	1	2	3	4
l. Using tools or appliances	0	1	2	3	4
m. Opening doors	0	1	2	3	4
n. Cleaning	0	1	2	3	4
o. Tying or lacing shoes	0	1	2	3	4
p. Sleeping	0	1	2	3	4
q. Laundering clothes. (e.g., washing, ironing, folding)	0	1	2	3	4
r. Opening a jar	0	1	2	3	4
s. Throwing a ball	0	1	2	3	4
t. Carrying a small suitcase with your affected limb	0	1	2	3	4
Column Totals:					

http://myturningpoint.org/files/UEFI_2010.pdf

 Score ___________ / **8**

APPENDIX C

TEXAS STATE UNIVERSITY - ATHLETICS

PREPARTICIPATION PHYSICAL EVALUATION -- MEDICAL HISTORY
REVISED 01/05/06

This MEDICAL HISTORY FORM must be completed annually by student-athlete (or parent/guardian if under 18 years of age) in order for the student to participate in athletic activities.

Student's Name:_____________________________________ Sex _________
Age____________ DOB ____________

Permanent Address
____

Phone _____________________

Personal Physician____

Phone ____________________________

Explain "Yes" answers below. Circle questions you don't know the answers to. Any Yes answer to questions 1, 2, 7, 11, or 17 requires a physical exam using the Pre-participation Physical Evaluation Form on the reverse side.

Yes or No

.. .. 1. Have you had a medical illness or injury since your last check up or sports physical?

.. .. 2. Have you been hospitalized overnight in the past year? . Have you ever had any surgery?

.. .. 3. Are you currently taking any prescription or non-prescription (over-the-counter) medication or using an inhaler?

.. .. 4. Do you have any allergies (for example, to pollen, medicine, food, or stinging insects)

.. .. 5. Have you ever passed out during or after exercise?

.. .. Have you ever been dizzy during or after exercise?

.. .. Have you ever had chest pain during or after exercise?

.. .. Do you get tired more quickly than your friends do during exercise?

.. .. Have you ever had racing of your heart or skipped heartbeats?

.. .. Have you had high blood pressure or high cholesterol?

.. .. Have you ever been told you have a heart murmur?

.. .. Has any family member or relative died of heart problems or of sudden unexpected death before age 50?

.. .. Has any family member been diagnosed with (enlarged heart, hypertrophic cardiomyopathy, long QT syndrome, Marfan's

syndrome, or abnormal heart rhythm)?

.. .. Have you had a severe viral infection (for example, myocarditis or mononucleosis) within the last month?

.. .. Has a physician ever denied or restricted your participation in sports for any heart problems?

.. .. 6. Do you have any current skin problems (for example, itching, rashes, acne, warts, fungus, or blisters)?

.. .. 7. Have you ever had a head injury or concussion?

.. .. Have you ever been knocked out, become unconscious, or lost your memory?

.. .. If yes, how many times?__________ When was the last concussion? ____________

.. .. How severe was each one? (Explain below)

.. .. Have you ever had a seizure?

.. .. Do you have frequent or severe headaches?

.. .. Have you ever had numbness or tingling in your arms, hands, legs, or feet?

.. .. Have you ever had a stinger, burner, or pinched nerve?

.. .. 8. Have you ever become ill from exercising in the heat?

.. .. 9. Have you ever gotten unexpectedly short of breath with exercise?

.. .. Do you cough, wheeze, or have trouble breathing during or after activity?

.. .. Do you have asthma?

.. .. Do you have seasonal allergies that require medical treatment?

.. .. 10. Have you had any problems with your eyes or vision?

.. .. 11. Are you missing any paired organs?

.. .. 12. Do you use any special protective or corrective equipment or devices that aren't usually used for your sport or position?

(for example, knee brace, special neck roll, foot orthotics, retainer on your teeth, hearing aid)?

.. .. 13. Have you ever had a sprain, strain, or swelling after injury?

.. .. Have you broken or fractured any bones or dislocated any joints?

.. .. Have you had any other problems with pain or swelling in muscles, tendons, bones, or joints? (If yes, check box & explain below.)

..Head ..Elbow ..Hip ..Neck ..Forearm ..Thigh ..Back ..Wrist ..Knee ..Upper Arm ..Foot

..Chest ..Hand ..Shin/Calf ..Shoulder ..Finger ..Ankle

.. .. 14. Do you want to weigh more or less than you do now?

.. .. Do you lose weight regularly to meet weight requirements for your sport?

.. .. 15. Do you feel stressed out?

.. .. 16. Record the dates of your most recent immunizations (shots) for:

Tetanus _______________ Measles/Mumps/Rubella _______________

Hepatitis B ______________ Chickenpox ___________

Polio _________________ Meningococcal _________________________

.. .. 17. Are you under a doctor’s care?

Females Only

18. When was your first menstrual period? _________________ When was your most recent menstrual period? ____________________

How much time do you usually have from the start of one period to the start of another?___________________

How many periods have you had in the last year? _________What was the longest time between periods in the last year? _____________

Explain "Yes" answers here:

____
____
____
____
____

Sport: ..Baseball ..Football ..Softball ..Tennis ..Basketball ..Golf ..Track & Field/Cross Country ..Soccer ..Volleyball

I hereby state that, to the best of my knowledge, my answers to the above questions are complete and correct.

Student-Athlete Signature: ____
Parent/Guardian Signature: ________________________________

Date: _______________ (If student-athlete under 18)

TEXAS STATE UNIVERSITY ATHLETICS -- PRE-PARTICIPATION PHYSICAL EVALUATION

Name_____________________________________ Sex- (Circle One) Male Female

Age__________________________ Date of Birth_______________________________

Height____________________ Weight______________________
Pulse______________

Blood Pressure________________________

Vision:

R 20/____ L 20/____

Vision Corrected:

Y N

Pupils:

Equal _______ Unequal ________

As a minimum requirement, this Physical Examination Form must be completed prior to NCAA Participation.

NORMAL/ABNORMAL FINDINGS

MEDICAL

Appearance

Eyes

Ears

Nose

Throat

Lymph Nodes

Heart-Auscultation of the heart in supine position

Heart-Auscultation in standing position

Heart-lower extremity pulse

Pulses

Lungs

Abdomen

Genitalia (males only)

Skin

MUSCULOSKELETAL

Neck

Back

Shoulder/Arm

Elbow/Forearm

Wrist/Hand

Hip/thigh

Knee

Leg/Ankle

Foot

CLEARANCE

o Cleared

o Cleared after completing evaluation/rehabilitation for: ____

o Not cleared for: __________________________

Reason: ____

Recommendations:____ ____ ____ __________________

The following information must be filled in and signed by either a Physician, a Physician Assistant or a Nurse

Practicioner, licensed by a State Board of Physician Assistant Examiners. Examination forms signed by any other health care practitioner, will not be accepted.

Name (print/type)____________________________________

Date of Examination:_______________________

Address:____ _____________________

Phone Number:____

Signature:____ ______

Must be completed before a student participates in any practice and/or competition for Texas State University- San Marcos

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VITA

Christopher Raymond was born in Bethlehem, Pennsylvania on May 2nd, 1989, the son of Mark and Kathy Raymond. After receiving his high school diploma from Round Rock High School, Round Rock, Texas in 2007, he entered SUNY Cortland in Cortland, New York. He received the degree of Bachelor of Science in Athletic Training from SUNY Cortland in May 2011. In August 2011, he entered the Graduate College of Texas State University-San Marcos.

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This thesis was typed by Christopher Raymond.