ABSTRACT

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This study was designed to determine if training using a hang board could improve grip strength and climbing performance. The sample included 26 male Ss (18-26 yr.). Subjects voluntarily enrolled in one of two 8 week indoor rock-climbing classes at the University of Wisconsin-La Crosse. The classes were assigned as either the control (n = 11) or treatment group (n = 15). The groups were determined via coin toss. Subjects completed grip strength and climbing performance measurement tests before and after the instructional period. Treatment subjects participated in a total of 12 training sessions over the 8 weeks of instruction. Results of a two-way ANOVA with repeated measures indicated a significant ($p < .05$) pre/post by group interaction. A Tukey's post-hoc test was used to examine within group differences. The treatment group exhibited a significant ($p < .05$) increase of 5% in grip strength whereas the control group experienced a nonsignificant decline of 4%. Results of a two-way ANOVA upon climbing performance data indicated a significant ($p < .05$) main effect for climbing performance gain when both groups' data were combined.

THE EFFECTS OF HANG BOARD EXERCISE ON GRIP STRENGTH AND CLIMBING PERFORMANCE IN COLLEGE AGE MALE INDOOR ROCK CLIMBERS

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CHAPTER I

INTRODUCTION

The sport of indoor rock climbing has become an increasingly popular activity practiced world wide. Since rock climbing's "modernization" in the early 1960's, when kernmantle ropes and chocks became common, it has gradually grown until its recent explosion (Shirer, 1990). Although rock climbing has challenged generations of men and women, it was not until the late 1980's that the sport of indoor climbing started to become popular (Fesko, 1992). For years, the general public did not find the challenges of rock climbing appealing. Only a small community of free spirited individuals knew that climbing was able to transcend mere sport.

An overall image change has accompanied the practical transformation climbing has undergone (Gockley, 1990). What used to be a lifestyle relegated to hippies and "climbing bums", has now become so popular that individuals and families of all socio-economic backgrounds are flocking to over an estimated 1,000 to 1,500 indoor climbing areas open to the public across America (Fesko, 1992).

Today, seasoned rock climbers, novices, and even children are climbing the walls at gyms, health clubs, universities, and elementary schools across the country (Fesko, 1992). People find climbing very gratifying because it is a basic human activity like walking, running, and swimming (Waldron, 1993). Although apparently simplistic, rock climbing is underscored with physical and mental challenges requiring participants to establish heightened self-awareness, concentration, and muscular conditioning. In 1992 Wescott reported that rock climbing may be an effective, efficient, and enjoyable means for improving fitness.

With such evidence, public demand for training devices geared at enhancing climbing performance spawned the development of several products on the market today. The "hang board" (also known as a "finger board") is one such product designed to improve finger, hand, and forearm strength as well as improving hold recognition. Throughout the ranks of new climbers hang board production barely meets the public demand (N. Postma, personal communication, November 1996).

Hang boards, first introduced in late 1986, are rectangular wooden or molded-resin boards that are mounted on a wall up high like a pull-up bar (Long, 1993). These boards feature various shapes on their surface, which resemble a number of possible handholds one might experience on a climb (see Page 67). Training with these devices require a person to hang, supporting their body weight with fully extended arms, much like the positioning at the lowest point of a chin-up repetition. The Differential-Tex™ hang board ("Tex" is short for texture) is a product manufactured and marketed by Nicros Inc. of St. Paul, Minnesota

(Postma, 1997). Nicros Inc. enlisted the design help of rock climber Eric Hörst, who has authored books on rock climbing training, and has worked with some of the worlds most skilled professional climbers during their year round training.

With the advent of climbing competitions, regular training and conditioning has become essential for peak performance (Haas & Meyers, 1995). Nonscientific sources have suggested that the use of a hang board may be of value as a part of a climber's comprehensive training program. Climbers who devote time to an overall conditioning program before a climbing season will find that they can extend themselves to extreme physical limits if necessary (O'Shea, 1976). The desire for improvement in climbing performance is not exclusive to the elite athlete, but includes the thousands of new people each year turned on to training in the indoor environment. Less fit climbers are now joining their elite role models, focused on training and seeking new ways to be more highly skilled climbers. Unfortunately, there is only a small amount of scientific literature available for the climbing population.

Research in the area of training for better climbing performance is in its infancy. None of the available studies have explored the effects of training using hang boards. Sources in books and magazines commonly recommend protocols that are geared towards the higher fitness levels of the elite climber. With no other sources available and with training being a major focus of indoor climbing facilities, more and more novice climbers are motivated to emulate the rigorous training protocols that they observe more accomplished climbers undertaking. A major concern is that these protocols may not be appropriate for novice climbers and may lead to injury. Further concern is fostered because none of the available hang board training protocols have been tested experimentally. Research on this topic will provide information as to whether or not a selected hang board training protocol will have an effect upon grip strength and performance among the new climbing population.

Purpose of the Study

The purpose of this study was to measure the effects of an 8 week hang board exercise program on grip strength and climbing performance in college age male indoor rock climbers.

Hypotheses

This study tested the following null hypotheses:

1. There will be no significant changes in grip strength as a result of participating in an 8 week training protocol on the Differential-Tex™ hang board.
2. There will be no significant changes in climbing performance following an 8 week training protocol on the Differential-Tex™ hang board.

Delimitations

This study had the following delimitations:

1. The subjects were college-aged students enrolled in two beginning rock climbing classes at the University of Wisconsin-La Crosse (UW-L) during the Spring semester, 1997.
2. The subjects were apparently healthy, college-age males, 18 to 26 old.
3. The study was 8 weeks in duration.

Limitations

The possible limitations to this study were:

1. The subjects were enrolled in the Exercise and Sport Science (ESS) 100-116 or ESS 100-216 rock climbing classes and thus were not randomly chosen.
2. Some subjects may have anxiety about being tested on the indoor rock climbing wall which may impact on rock climbing performance measures.
3. Rock climbing performance was only analyzed on the UW-L indoor climbing wall which may be different than other climbing walls.

Assumptions

In the conduct of this study it was assumed that:

1. The teaching plan and instruction were the same for subjects in the experimental and control groups.
2. The subjects adhered to the training protocol and did not engage in additional climbing or training anywhere else during the 8 week training period.
3. The subjects did not have any physical or psychological limitations that would hinder their participation in the testing or the training period.
4. Subjects performed the climbing performance measurement process to the best of their ability.

Definition of Terms

The following terms were used in this study:

ASCF -- abbreviation for the American Sport Climbers Federation (Darml, 1992).

Artificial Aid - grabbing the rope or taking tension on the rope to keep oneself from falling (Darml, 1992).

Belayer - person responsible for securing the climber by use of a rope (Long, 1993).

Climbing Performance - the ability to climb to the highest point possible on routes of successive difficulty, without falling (Darml, 1992).

Climbing Route - a particular way up a given section of a climbing wall often delineated by similarly colored hand holds (Long, 1993).

Differential Texture - varying degree of coarseness on the surface of some hang boards and hand holds (Hörst, 1994).

Fall - when a climber looses upward ascent secondary to letting go of the climbing wall holds or surface (Darml, 1992).

Grip Strength - the maximal amount of grasping force one can generate with the hands (Trombly, 1983).

Hand Hold - artificial rock-like formation that is bolted to the surface of an indoor climbing wall used for grasping with one's hands or feet (Shirer, 1990).

Hang Board - training device used in rock climbing designed to improve finger, hand, and forearm strength (Shirer, 1990).

Novice Climber - a person that has never rock climbed before or has less than one year of climbing experience either indoors or outdoors (Long, 1993).

Sport Climbing - the competitive offshoot from traditional rock climbing where performance between climbers is judged by using a point system (Darml, 1992).

Traditional Rock Climbing - climbing using hands and feet, utilizing a rope and specialized equipment and techniques to protect against a fall in an outdoor setting such as cliffs and mountains (Long, 1993).

UIAA - abbreviation for the Union Internationale Des Association D'Alpinisme, the international governing body for climbing competitions (Darml, 1992).

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The purpose of this chapter is to review related literature pertaining to rock climbing, and the physiologic/cognitive aspects of climbing. Despite the sport's rapid growth in popularity, research specific to climbing has failed to flourish at the same rate. There have been few scientifically based studies, which provide objective data that could be used to govern the development of new research. However, as rock climbing is a sport where performance is dependent upon many factors, review within these areas provides useful insight. This chapter is presented in three sections: a) research related to rock climbing, b) research related to physiologic aspects of rock climbing, and c) research related to the cognitive aspect of rock climbing.

The following topics concerning rock climbing will be discussed: a) climbing trends, b) indoor climbing walls, and c) fitness benefits of rock climbing.

The following topics concerning the physiologic aspects of rock climbing will be discussed: a) anthropometric profiles of rock climbers, b) strength and endurance in rock climbing, c) grip strength measurement, d) aerobic capacity and rock climbing, and e) injuries associated with rock climbing.

The following topic concerning the cognitive aspect of rock climbing will be discussed: a) motor learning and skill acquisition in rock climbing.

Climbing Trends

Today's rock climber is all together different than his or her predecessors. Although the overall goal of reaching the top of a climbing route is the same, the techniques, equipment, and environment have undergone some substantial changes over the last few decades. Dramatic changes in the 1970's were due in large part to the innovative development of rock climbing techniques born in California's Yosemite Valley, which allowed the ascent of the spectacular cliffs there (Long, 1993). Much of these changes occurred as creative American climbers modified and developed new and better equipment. During this time the world's climbing community focused their attention upon the new methods being developed in America.

By 1980, many climbers were traveling the world over to explore different areas, and climbers from many countries now trained exclusively for climbing. The techniques and equipment were common to all, and a new gymnastic approach was applied to the style of ascent, particularly by the French (Long, 1994a). In addition, the 1980's saw an increase participation in sport climbing competitions held outdoors. Sport climbing usually refers to any indoor or outdoor climbing on bolt-protected routes (Hörst, 1994). Sport climbing removes most of the risk inherent in climbing, and allows the climber to focus solely on technical difficulty (Long, 1994b). The world's most skilled climbers attended these competitions, hopeful of winning the substantial cash prizes. Even greater changes came about in 1987 when competition moved indoors onto artificial walls, cash prizes grew larger, and the UIAA (Union Internationale Des Associations D'Alpinisme) laid plans for a World Cup and World Championship (Darmi, 1992). The world's attention was becoming more and more focused on these intriguing new athletes as they performed their powerful and graceful ballet on stages of vertical wall.

Indoor Climbing Walls

Currently, the 1990's have seen an exponential growth in the participation of rock climbing. A major factor fueling the sport is the explosion in numbers of artificial climbing walls and structures (Shirer, 1990). Experienced climber and author John Long (1993) supported this notion by stating, "If there isn't one near you, there probably will be soon" (p. 168). Now, individuals interested in rock climbing can go to any of the thousands of facilities located across the U.S.. These facilities house indoor walls within a controlled indoor environment leaving concerns about the weather, temperature, or hiking to far away locations by the wayside.

Construction of artificial walls varies greatly, ranging from plywood to cement and utilizing holds of wood, rock, and molded epoxy/sand (Shirer, 1990). The technology is still evolving, but at present most walls consist of molded fiberglass or laminate panels which have a grainy texture for friction, and rocklike features which can be used as intermediate holds (Darmi, 1992). These structures range in size and height with no two walls appearing exactly the same. While some are only vertical, others are more sophisticated with inset pockets, sweeping angles, and overhangs (Long, 1994c).

Acknowledging the upsurge in the popularity of indoor climbing walls, health clubs and other training facilities, with less available space, have developed smaller devices used as climbing fitness trainers. These devices stand no more than 12 feet tall, and look much like an oversized treadmill with the belt oriented vertically. They are nonmotorized, with artificial hand and foot holds bolted to the surface of the rotating apparatus. As a climber moves upwards, a rope attached to the climbers harness releases a breaking system allowing for ascent. This enables the exerciser to climb continuously without ever being more than two feet above the floor (Wescott, 1992). The growing number of indoor walls and training devices represents a large presence in the growth of the rock climbing industry. Their emergence hallmarks the enthusiastic interest that thousands of people across the nation are expressing today. Climbing walls continue to show up in a host of locations including universities, schools, health clubs, and even luxury ocean liners.

Fitness Benefits of Rock Climbing

In 1992, Wescott conducted research seeking to assess changes in selected fitness parameters as a result of a rock climbing training program. All climbing was performed on a 12 foot high, revolving fitness trainer called a Treadwall. This study utilized 20 volunteers for a treatment group as well as 11 for a control group (mean age 36 years). Participants in the treatment group performed two climbing sessions per week for a period of 7 weeks. Pre- and posttesting was conducted evaluating physical parameters that included bodyweight, percent fat, fat weight, lean weight, flexibility, leg strength, and arm strength. Each exercise session performed consisted of 15-20 minutes of continuous rock climbing (Wescott, 1992). At the end of the study, results indicated that the treatment group had experienced significant ($p < .05$) positive changes in all measured parameters. Control group data indicated no such improvement except for a curious significant improvement in arm strength. Wescott concluded that the effects of the training protocol utilized in this study were significant in terms of the fitness improvements observed. An additional finding noted in the research was a relatively high heart rate response observed during the climbing sessions. This observation led Wescott to pursue yet another study to investigate the fitness benefits of rock climbing.

Again in 1992, Wescott gathered an additional ten men and women with a mean age of 39 years. The subjects performed the same exercise protocol as his previous study, but for a period of 8 weeks. Subjects' heart rate, blood pressure, and perceived exertion were monitored for this second study. A submaximal cycle test was conducted to assess the subjects' pre- and posttesting predicted maximal oxygen consumption (Max VO_2). Wescott stated that the results of the submaximal cycle tests revealed statistically significant improvements in cardiovascular performance after 8 weeks of rock climbing.

Based on the findings of these two studies, one may conclude that participation in rock climbing may have a significant impact on cardiovascular endurance, body composition, flexibility, and muscular strength (Wescott, 1992).

Anthropometric Profiles of Rock Climbers

Watts, Martin, and Durtschi (1993) combined efforts in order to provide a description of the sport specific anthropometric profiles of elite male and female competitive sport rock climbers. The study utilized 21 male and 18 female elite climbers who were competitors at the International World Cup Sport Climbing Championship in 1989. Subjects were measured immediately prior to competition in the following areas: age, years of climbing experience, height, body mass, height-weight ratio, sum of seven skinfolds, body fat, fat-free mass, hand and arm volumes, average of right and left grip strengths, grip strength to body mass ratio (SMR), and climbing ability defined as the most difficult route climbed on lead. For the purpose of this review, only the information as it applies to the male subjects will be discussed.

Results indicated that the elite male climbers were quite small in stature. Watts et al. (1993) described the elite climbers to have a similar build to that of a "long distance runner" (p. 116). Height-weight ratios were high indicating ectomorphy, and were accompanied by markedly low estimated body fat percentages and sums of skinfolds. The sum of left and right hand grip strength was compared to population percentile norms. Results indicated that the athletes scored between the 40th and 50th percentile. The numeric ratio of grip strength was divided by body mass to yield SMR. The results ranked the elite climbers in the 80th percentile suggesting that SMR is more important than absolute grip strength.

In summary, Watts et al. (1993) concluded that elite male rock climbers are extremely lean individuals of small stature who possess average to high grip strength and have a high strength to body mass ratio.

Strength and Endurance in Rock Climbing

Strength and endurance are important facets of rock climbing performance. Muscular strength is defined as the maximum force a muscle group can generate, whereas muscular endurance refers to a single muscle or muscle group's ability to sustain high-intensity, repetitive, or static exercise (Wilmore & Costill, 1994). During a climb, one needs only to experience the burning forearms, weakening fingers, and tightening leg muscles to understand the important roles that strength and endurance play. Using strength and endurance tempered by technique, and balancing precariously between anxiety and determination, a climber can find success through difficult physical challenges (Goddard & Neumann, 1993). Improving strength and endurance can lessen the difficulty of these challenges.

In general, training regimens which aim to improve these two factors must incorporate a number of considerations. Frequency, intensity, duration, and mode of training govern the development of appropriate strength training protocols. When these factors are appropriately integrated, one can expect strength gains to occur. The American College of Sports Medicine's (ACSM's) Guidelines for Exercise Testing and Prescription (1995), establishes general recommendations that are fundamental for the development of any strength training routine. The ACSM reports that muscular strength and endurance are developed by the overload principle, by increasing the resistance to movement or the frequency or duration of activity to levels above those normally experienced. Furthermore, the guidelines state, "the intensity of resistance training can be manipulated by varying the weight, the number of repetitions, the length of the rest interval between exercises, or the number of sets of exercises completed" (p. 173). The ACSM expresses that the maintenance or enhancement of muscular strength and endurance enables an individual to perform tasks with less physiological stress. In rock climbing, such enhancements may result in improvements in climbing performance. As rock climbing is a unique activity, so to are the physiologic stresses it places upon the body. Training must be geared such that adaptations occur within the muscle groups that are utilized most. Specificity of training addresses this need.

Specificity of training requires that at least part of the training should involve movements that closely mimic those needed for the athlete's sport or activity, including movement patterns and speed (Wilmore & Costill, 1993). In rock climbing, the closer an exercise is to the actual climbing positions the better (Hörst, 1996). Training results are highly specific to the type of training program used. Wilmore and Costill (1993) stated, "gaining strength, power, or muscular endurance simply for the sake of being stronger, being more powerful, or possessing greater muscular endurance is of relatively little importance to athletes unless it also results in improvements in their athletic performance" (p. 85). This holds true for rock climbers, thus requiring the adoption of a sport specific training regimen which targets those parameters of climbing that will have a positive effect upon climbing performance. Goddard and Nuemann (1993) identified the aspects of climbing which have an affect upon performance. These include: coordination, flexibility, technical skills, experience, knowledge, fear, concentration, talent, strength, and endurance.

Goddard and Neumann (1993) stated, "Although performance represents the combined result of many different abilities, it is not the simple sum of them. Performance will be diminished down to the level of the weakest of the abilities"

(p. 6). The "weakest link" principal helps target that muscle group, which may improve climbing performance if strength and endurance of that group is increased. In novice climbers, this weakest link is most often found at the level where the hands meet the climbing surface. Thus, finger, grip, and forearm strength is imperative (Shirer, 1990).

Grip Strength Measurement

Special measurement procedures have been developed to assess and quantify grip strength for the purposes of training, injury prevention, and rehabilitation. Grip strength testing is commonly used to evaluate the integrated performances of muscles by determining maximal grip force that can be produced in one muscular contraction (Nwuga, 1975). The force of muscular contraction produced by the hand is measured with a hand held dynamometer. The grasp dynamometer measures the strength of grasp in pounds or kilograms. Popular dynamometers include the Jamar and Lafayette dynamometers.

In 1981, The American Society of Hand Therapists (ASHT) suggested a standardized testing protocol in which a subject is seated with the shoulder adducted and neutrally rotated, the elbow flexed at 90 degrees, and the forearm and wrist in neutral position (Fess & Moran, 1981). A modification of this position allows the subject to rest his or her forearm on a table top if desired, ensuring not to rest the dynamometer on the tables surface (Trombly, 1983). Grip strength is evaluated by taking the mean of three successive attempts (Chwen-Yng, Jau-

Hong, Tsui-Hsien, Kuang-Fang, & Yue-Tung, 1994). Watts et al. (1993) studied elite competitive sport rock climbers and measured their grip strength. Watts et al. (1993) reported that maximum hand grip strength was determined for both hands as the highest of three trials using a Lafayette hand grip dynamometer. The means of right and left maximal scores were used to provide an average hand grip score.

In 1985, Mathiowetz, Kashman, Volland, Weber, Dowe, and Rogers conducted a comprehensive study aimed at establishing clinical norms for adults aged 20 to 75+ years on tests of hand strength. A sample of 310 male and 328 female adults, ages 20 to 94 were tested using standardized positioning and instructions. Mathiowetz et al. (1985) found that the highest grip scores occurred in the 25 to 39 age groups. Mathiowetz reported that subjects 20-24 years, had an average (mean of right and left hand scores) grip strength of 112.7 pounds. Subjects 25-39 years scored a mean of 115.6 pounds when tested. Mathiowetz et al. recommended that to improve reliability and validity of testing, researchers should utilize standardized positioning and ensure that the same test instrument is used for pre- and posttesting.

Aerobic Capacity and Rock Climbing

Aerobic capacity is defined as the maximal capacity for oxygen consumption by the body during maximal exertion (Wilmore & Costill, 1994). This is also known as aerobic power, maximal oxygen uptake (VO_2 max), maximal oxygen consumption, or cardiorespiratory endurance capacity. Aerobic activities incorporate the use of large muscle groups and are repetitive and continuous over 20-60 minutes. This type of activity typically increases heart rate, breathing frequency, and oxygen consumption. The heart and lungs are the organs that meet the bodies' needs during this type of activity.

The cardiovascular and cardiopulmonary systems represent two additional variables, which may affect climbing performance. These added factors accompany concurrent musculoskeletal and cognitive adaptations secondary to the stresses of climbing. Goddard and Neumann (1993) consider aerobic capacity to be a measure of "general endurance" (p. 126). Goddard and Neumann suggest that because climbing does not require cyclic movements, general endurance is not considered to be a performance-limiting factor in climbing. Enhancing general endurance (aerobic capacity) benefits a climber indirectly by aiding in fat loss, athletic recovery, and stress (Hörst, 1996).

In 1995, Billat, Palleja, Charlaix, Rizzardo, and Janel conducted a study to estimate the contribution of aerobic metabolism in relation to a climber's maximal aerobic power. The study utilized four students (mean age 22.2 years) each having 3 years of climbing experience and typically practiced climbing 6 hours per week. Baseline measurement of VO_2 max was determined directly by using a treadmill test and a pulling test. The expired gases were collected with Douglas bags and Rudolph three-way valves. Climbing VO_2 was determined by direct measurement on an artificial indoor climbing wall by the same methods. The subjects were allowed to practice on the climbing wall routes in order to minimize the cognitive and emotional aspects which may modify heart rate response. Billat et al. (1995) reported that oxidative metabolism plays a secondary role in rock climbing since oxygen uptakes only represented a small fraction of the climber's VO_2 max. Their study concluded that the capacity to maintain a high percentage of maximal strength or endurance must be more appropriate in order to succeed in competitive rock climbing.

<u>Injuries Associated with Rock Climbing</u>

With the increase in rock climbing's popularity, there has been a concurrent rise in the incidence of associated injuries. This rise is partly due to improvements in safety equipment and gear that has enabled climbers to pursue routes, which just a decade ago were considered impossible or too dangerous. Medical research in this area most often addresses several overuse injuries among climbers. Whether or not these common injuries will have any long-term effect upon degenerative disorders is a question that remains unanswered (Bollen & Gunson, 1990).

Bannister and Foster (1986) reported cases of upper limb injury resultant secondary to training for rock climbing. Four male climbers, age 19-26 years, presented with different ailments. The first case described traumatic injury to both shoulder joint capsules as a result on intensive training on a "Bacher

Ladder". This training required support of the whole body weight by each arm as the subject swung from rung to rung. The second climber was diagnosed with traumatic tendonitis following repetitive wrist dorsiflexion against resistance. Case three involved the avulsion of the terminal insertion of the flexor digitorum profundus, secondary to an attempted one-arm pull up. The last case described the development of pain on finger flexion following a climbing trip taken by the young male. A diagnosis of traumatic tenosynovitis of the flexor tendons was made. The authors of the article suggest that rock climbing injuries seem to be mainly confined to the upper limbs, with recovery being delayed due to unawareness of the type of injury sustained.

In 1990 Cole provided a case report on a common fingertip injury found in rock climbers. A group of rock climbers who had been climbing for several weeks in Australia were examined and interviewed by the author. The injury described consisted of damage to the skin of the fingertips caused by excessive abrasion upon the hands during rock climbing. Cole (1990) stated "the palmer surface of the fingertips, initially the index and middle fingers, and subsequently the ring and little fingers first become red and have a mild serous exudate (p. 14). The skin of the fingertips becomes white and macerated and eventual splitting results if subjected to further injury. It was stated that "an affected climber will have to rest for around two weeks for full recovery" (p. 14).

In an article by Bollen and Gunson (1990) several hand injuries associated with rock climbing were discussed. The authors conducted precompetition examinations on 67 climbers prior to the 1989 British Open Championship. Special attention was given to the history of previous hand injuries among the climbers. Findings upon medical examination and health history indicated several common injuries experienced by this group of competitive climbers. The most common reported site of hand injury involved the proximal phalanx of the ring finger. At this site, A2 pulley injury of the tendon sheath was commonly reported among the examined climbers. Fixed flexion deformity of the proximal interphalangeal (PIP) joints of the hands was another common physical examination finding. This was attributed to the abnormally high loading of the fingers while climbing, and training on finger boards (Bollen & Gunson, 1990). The presence of tendon nodules was also noted, which were thought to imply previous partial tears of the tendons. With these findings, the authors concluded that hand problems were very common among top climbers.

Survey studies have been a useful means by which researchers have been able to gather information regarding rock climbing injuries. Two such studies have provided considerable insight upon the injuries, which are common among climbers.

A comprehensive study conducted by Maitland (1995) explored the clinical presentation of injured rock climbers as well as the possible mechanism of injury.

A survey was conducted of rock climbers registered at the University of Calgary Outdoor Pursuits Center climbing wall. In 1990, climbers were requested to complete surveys, which were directed at the climber's age, previous year's climbing experience, and his or her injury experience for both natural rock and artificial walls. Respondents reported a total of 102 overuse injuries of which hand injury was the most common (Maitland, 1995). From the results of the survey, the author concluded that overuse injuries most commonly occur to the upper extremities. The author suggests that "recognition of the overuse injury patterns in these athletes may lead to methods to prevent injuries or provide for methods of rehabilitation" (p. 72).

Rooks, Johnston, Ensor, McIntosh, and James (1995) conducted a survey, which looked into the injury patterns in recreational rock climbers. The study utilized 39 recreational climbers in an attempt to elucidate the common injuries in this quickly growing segment of the climbing community. Mean age of the participants was 25 years with an average of 5 years of climbing experience. Results of the survey indicated that half of the climbers had a history of a significant injury secondary to a fall while climbing. Upon physical examination, 20 climbers had an upper extremity inflammatory condition that was related to climbing (Rooks et al., 1995). Of these injuries, the most common site was in the hands and wrists. A new finding that resulted from this study was the incidence of carpal tunnel symptoms in this young study sample. The researchers attributed such early onset of overuse disorders to the regular attempts of this recreational population to climb at very difficult levels.

Haas and Meyers (1995) published an article on behalf of the Department of Health and Human Development, Montana State University, Bozeman, Montana, USA. Following a brief historical review citing the early accounts of climbing injuries, the authors proceeded to discuss injuries associated to rock climbing that impact the hand, wrist, elbow, and shoulder. The content within these areas reflected a comprehensive review of available research findings in the area of climbing injuries. Haas and Meyers concluded, "the prevalence of rock climbing injuries will no doubt continue to rise with the increase in participation" (p. 204). Recommendation was made for further study on the patterns of overuse injury in order to help reduce injury and enhance rehabilitation.

Motor Learning and Skill Acquisition in Rock Climbing

Performance in rock climbing may be largely dependent upon one's familiarity with the optimal usage of strength, posture, balance, technique, and coordination. However, one must consider that these physiologic factors are developed and governed by cognitive influences early in a person's climbing experience. Motor learning represents the cognitive aspect of climbing, which drives the acquisition of skills necessary for the performance and improvement in one's ability.

Motor learning involves the acquisition of an understanding of both the stimulus and the response in the performance of a motor task (Drowatzky, 1981). With such understanding, a person may develop skill, which implies that such a task is performed well within any situational context (Singer, 1982). There are three distinct stages or phases of motor learning (Schmidt, 1988). These include the cognitive, associative, and autonomous phases. A learner first identifies the task to be performed, determines the most effective way of doing the task, and over time, performs the task automatically without great thought (Schmidt, 1988). This process is often facilitated through the practice of specific skills needed for the performance of a given activity.

Practice is considered to be at the heart of improvement (Singer, 1982). Practice allows old responses (to an activity) to be tried out and new patterns to emerge (Drowatzky, 1981). Some of the skills necessary in rock climbing include: how to grip holds with the hands, hold recognition, use of the feet, precision of movement, force control and use of body tension and positioning (Goddard & Neumann, 1993). The practice of developing such skills for rock climbing may be done in several ways, but there is no substitute for actual climbing (Hörst, 1994). There is little dispute that actual climbing will aid one's performance. Whether a person practices outdoors, indoors, or with the aid of training devices, such activity results in motor learning and thus the acquisition of skills. Practice does not always make for perfection. A person can practice without good technique thus reinforcing bad habits. Practice has a positive influence on future performance if transfer of learning takes place (Schmidt, 1988).

Singer (1982) stated "almost all of learning is based on the concept of transfer" (p. 468). Singer wrote that transfer training implies practice not only for present use, but also for future application. Transfer is usually defined as the gain in the capability for responding in one task as a result of practice or experience on some other task (Schmidt, 1988). In rock climbing, all training that is done should keep the concept of transfer in mind. Every sport requires specific patterns of movement in specific situations, and the refinement of skill requires highly specialized training (Singer, 1982). For a climber, this means that as skill improves, practice should simulate ultimate potential climbing conditions whenever possible. By ensuring that motor learning is conducted under these conditions, there may be an acquisition of skills, which can have a positive influence upon climbing performance.

Summary

The available literature has suggested that rock climbing is a multifaceted sport, which has seen many changes over recent years. As the popularity of rock climbing continues to explode both indoors and outdoors, more and more of those who participate in this exciting sport will seek to attain the highest level of skill possible. To meet this desire, artificial climbing walls have been erected in thousands of communities across the nation. People of all ages are climbing on these structures on a regular basis and have integrated this activity into their daily lives. Despite reports of a high incidence of upper extremity injuries, rock climbing has been shown to have a beneficial affect upon physical health and promises to be a focus of future research.

CHAPTER III

METHODS AND PROCEDURES

Introduction

This study examined the effects of hang board exercise on grip strength and climbing performance in college age male indoor rock climbers. The methods will be discussed in the following categories: subject selection, instrumentation, grip strength measurement, climbing performance testing, exercise protocol, and statistical analysis.

Subject Selection

Forty apparently healthy, college-age men enrolled in the Exercise and Sport Science (ESS) 100-116 and ESS 100-216 rock climbing classes at the University of Wisconsin-La Crosse (UW-L) were used in this study. Subjects were between the ages of 18 to 26 years. Subjects enrolled in the ESS 100-116 class were assigned as the control group while those having enrolled in ESS 100-216 were utilized as the experimental group for this study. Each subject's individual data were recorded under an assigned number and was then grouped to ensure participant confidentiality. Each group was instructed using an established teaching plan, which was assumed to be similar for each class.

Prior to testing, the subjects signed an informed consent form (see Appendix A) and were required to complete a personal health and information questionnaire. This allowed for screening of potential health or physical limitations that would have precluded a subject's participation in the study (see Appendix B).

In order to minimize potential risks, orientation classes were conducted to ensure proper use of the hand dynamometer, Differential-Tex™ hang board (DTH), and to familiarize subjects with the climbing performance measurement process.

Instrumentation

The following instrument was used in the collection of data:

Hand Dynamometer - a Lafeyette Instrument Co., Model 78010, spring scale dynamometer was used to measure bilateral hand grip strength to the nearest kilogram.

Grip Strength Measurement

Pretesting grip strength measurement was conducted prior to the subjects having had any opportunity to climb on the indoor wall or to participate in the training protocol. Posttesting was conducted during the last class of the control and experimental group's 8 week instruction. Subject's grip strength was measured bilaterally. Since grip strength measurements can vary depending on familiarity with the measuring device and the number of readings taken, subjects were asked to perform a series of three measurement trials. The trials were conducted having the subject's elbow flexed at 90° and forearm supinated at 45°.

Subjects maximally gripped the hand dynamometer and a score, to the nearest kilogram of force, was recorded on the Hand Dynamometry Data Recording Sheet (see Appendix C). Once the three measurements were completed bilaterally, mean scores were calculated for each of the subject's hands. The average of these two scores was then computed and utilized as the overall representation of the subject's total grip strength.

Climbing Performance Measurement

Climbing performance pretesting was conducted during the second week of class instruction. Posttesting was conducted during the eighth week of instruction for each group. The measurement process used in this study was developed using rules set forth by the American Sport Climbing Federation's (ASCF) guidelines for judging sport climbing competitions. These rules and regulations clearly defined a set number of parameters, which enabled the valid and consistent determination of a climber's performance. The same testers scored pre- and posttesting performance measurements. Two judges determined scoring with results being recorded on the Climbing Performance Test Data Recording Sheet (see Appendix D). Subjects were instructed not to eat an hour prior to testing and to wear clothing that provided room to climb freely. They were encouraged to wear rock climbing shoes, but were allowed to wear any other type of footwear that they felt most comfortable in.

There are 12 climbing routes that may be ascended on the indoor climbing wall in Mitchell Hall on the UW-L campus. Each of these routes pose varying difficulty levels. For identification, the routes are numbered 1 to 12 and consist of individually color coded hand holds which are bolted to the climbing wall surface.

The researcher began the testing process by checking the subject's personal climbing equipment (i.e., seat harness, shoes, and clothing) and ensured that proper rope tie-in practice had been followed. Next the belayer was inspected, including his/her personal climbing equipment, belay device, and for proper rope handling technique. Once the safety check was complete, the subject was instructed to establish position at the base of route number one. The researcher then said to the subject, "Once you and your belayer have established the verbal contract, you may begin climbing" (see Appendix E for verbal contract). As the subject ascended the first route, points were earned for each handhold that was successfully reached. Successful completion of a route was obtained when the subject reached the upper most handhold. At that time the climber was lowered to the ground and allowed 5 minutes to rest before continuing on to successive routes of greater difficulty. Testing ended when the subject could no longer continue ascent due to fatigue, or losing grip from the handholds. Testing was also stopped if the climber used the assistance of handholds that were not part of the color-coded route or when the rope was used by the climber for balance or support during the ascent. The subject was then lowered to the ground and given a numerical score. The score was calculated by summing the total number of handholds reached during the entire measurement process. This earned score represented the subject's measured climbing performance by which postintervention data were statistically compared.

Exercise Protocol

During the first week of instruction prior to starting the 8 week hang board exercise protocol, subjects enrolled in the ESS 100-216 experimental group took part in an orientation session. The orientation covered the DTH description (see Appendix F), hang board safety issues, an explanation of appropriate grip techniques, and a demonstration of proper hang board use. Each subject was required to utilize the training device under supervision of the researcher to ensure safety practices and proper technique was utilized.

Subjects were required to perform a series of timed hangs on the DTH, two sessions per week. No other DTH training sessions were allowed to take place on other days. In order to ensure an appropriate warm-up, subjects were not allowed to begin training until after extensive stretching for the upper extremities, torso, and back were performed.

Training Sequence

The subjects in the experimental group followed a structured training protocol (see Appendix G). For the purposes of this study the protocol was repeated six times during each class session. The duration of the protocol was increased over the 8 week training period and was posted near the hang boards.

The DTH has a total of 13 possible paired grip positions. Of these 13 pairs, the 7 smallest were not used. The remaining pairs were numbered one to six for identification purposes (see Appendix H for diagram). During the protocol, subjects performed assisted hang repetitions on each of the paired holds. Subjects were instructed on proper body positioning while training. Openhanded grasps were used upon the handholds of the DTH with the arms fully extended above the level of the head. The lower body was used to assist in maintaining hold of the DTH. A 4' X 4' sheet of ¾ inch plywood was positioned upright at the base of the wall, in front of the DTH training area. This plywood sheet provided horizontal strips of wood, 6 inches apart, measuring 1 inch by 3/8 inches. The subjects utilized these small edges to support a portion of their body weight. Subjects were instructed to place their feet such that the inner edge of their shoe, near the ball of the foot, resulted in 90° of knee flexion with the hips externally rotated toward each side of the body. This positioning looked much like how a ballet dancer performs a plie'. Each hang repetition was then timed by the subject counting "one-one thousand, two-one thousand" etc.

In-class training sessions were performed under the direct supervision of the researcher. These sessions were conducted in the Mitchell Field House on the UW-L campus under the direction of Jeff Steffen Ph.D.

Statistical Analysis

Standard descriptive statistics were applied to all data. An independent t-test was used to test for between group differences in pretesting data. A two-way analysis of variance (ANOVA) with repeated measures was used to determine if significant changes occurred between the control and experimental groups as a result of the training protocol. When a significant F ratio was found, a Tukey's post-hoc test was used to test for within group differences. Alpha was set at .05 to achieve statistical significance for all analyses.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This study examined grip strength and climbing improvement as a result of hang board exercise in male University of Wisconsin-La Crosse (UW-L) students. This chapter presents the results and discussion of the following data: a) characteristics of subject groups, b) grip strength measurement results for the control and treatment groups, c) t-test results for the initial measurements of pretesting grip strength, d) ANOVA results for gain score grip strength by group by trial, e) climbing performance results for the control and treatment groups, f) t-test results for the initial measurement of pretesting climbing performance, and g) ANOVA results for gain score climbing performance by group by trial. The .05 level of significance was used for all statistical calculations.

Characteristics of Subject Groups

Group characteristics of this study are presented in Table 1. Twenty-nine subjects between the ages of 18 and 26 years participated as either control or treatment group subjects. Subjects in the control group had a mean age of 21.45 years, while subjects of the treatment group had a mean age of 21.22 years.

Table 1. Characteristics of Subject Groups ($\underline{N}$ = 26)

Variable	Control (n = 11)	Treatment (n = 15)
Age	21.45+ 2.02++	21.22 2.13
Height (in)	70.73 2.15	69.22 1.70
Weight (lbs)	176.54 29.80	167.44 13.42

+ = Mean ++ = Standard Deviation

Both control and treatment subjects were students enrolled in either of two indoor rock climbing courses (ESS 100-116, ESS 100-216) held at UW-L during the Spring semester 1997. Control subjects (ESS 100-116) met during the first 8 weeks of the spring semester, while the treatment subjects (ESS 100-216) met during the last 8 weeks of the spring semester.

All 11 subjects in the control group completed the analysis. The mean height of the group was 70.27 in. with a mean weight of 176.54 lbs.

The treatment group originally consisted of 18 subjects. Two subjects were unable to attend all the training sessions and one subject experienced an ankle injury outside of class, which precluded further participation. Therefore, 15 subjects were used in the treatment group's final analysis. The mean height of subjects in this group was 69.22 in. with a mean weight of 167.44 lbs.

Grip Strength Measurement Results

Pretest, posttest, and gain score grip strength results of subjects who completed the study are presented by group in Table 2. Both control and treatment subjects were given a pre- and posttests to determine mean grip strength. To determine the amount of a subject's improvement, pretest scores were subtracted from posttest scores to yield the gain score.

Table 2. Grip Strength (Kg) Results for the Control Group (n = 11) and the Treatment Group (n = 15)

Group	Pretest	Posttest	Gain
Control	54.00+ 7.86++	52.36 8.84	-1.64
Treatment	52.17 8.59	54.50 8.61	2.33

+ = Mean ++ = Standard Deviation

Grip Strength Pretest

T-test results for initial differences of pretesting grip strength between control and treatment groups are presented in Table 3. No significant ($p > .05$) difference was found between groups for pretesting grip strength.

Mean pretest score for the control group was 54.00 Kg. Mean pretest score for the treatment group was 52.17 Kg. Mean posttest score for the control

Table 3. T-Test Results for Control vs. Treatment Groups' Pretest Grip Strength

Group	t-value	df	p-value	95% C.I.
Control vs. Treatment	.56	24	.583	- 4.965, 8.631

* Indicates a significant difference between groups ($p < .05$)

group was 52.36 Kg. Mean posttest score for the treatment group was 54.50 Kg. Mean gain score for the control group was –1.64 Kg. Mean gain score for the treatment group was 2.33 Kg.

Gain Score Grip Strength by Group by Trial

Two-way ANOVA results for gain score grip strength by group by trial are presented in Table 4. A two-way ANOVA with repeated measures was used to indicate the interaction among the variables of group and testing trials. The results of the two-way ANOVA indicated a significant ($p < .05$) interaction for gain score grip strength among the variables of group and trial. A Tukey's post-hoc test was used to test for within group differences. The treatment group exhibited a significant ($p < .05$) increase in grip strength, whereas the control group had a nonsignificant ($p > .05$) decrease in grip strength.

Table 4. ANOVA Summary Table of Gain Score Grip Strength by Group by Trial for the Control Group (n = 11) and the Treatment Group (n = 15)

Source of Variation	Sums of Squares	df	Mean Squares	F	P-Value
Between Subject Effects					
Within+Residual	3318.69	24	138.28		
Group	.29	1	.29	.00	.964
Within Subject Effects					
Within+Residual	154.69	24	6.45		
Trial	1.54	1	1.54	.24	.629
Group by Trial	50.00	1	50.00	7.76	.010*

* Indicates a significant difference between groups (p < .05)

Climbing Performance Results

Pretest, posttest, and gain score climbing performance results of subjects in the control and treatment groups are presented in Table 5. Both of the groups were given a pre- and posttest to determine climbing performance. To determine the extent of a subject's improvement, pretest scores were subtracted from posttest scores, which resulted in a gain score.

Table 5. Climbing Performance (Points) Results for the Control Group (n = 11) and the Treatment Group (n = 15)

Group	Pretest	Posttest	Gain
Control	78.27+ 35.06++	111.00 49.37	32.73
Treatment	83.47 31.95	133.80 45.04	50.33

+ = Mean ++ = Standard Deviation

Climbing Performance Pretest

T-test results for initial differences of pretesting climbing performance are presented in Table 6. T-tests were used to determine significant differences between the control and treatment groups.

Table 6. T-Test Results for Control vs. Treatment Groups' Pretest Climbing Performance

Group	t-value	df	p-value	95% C.I.
Control vs. Treatment	- .39	24	.698	- 32.461, 22.073

* = Indicates a significant difference between groups ($p < .05$)

No significant ($p > .05$) difference was found between the control and treatment group for pretesting climbing performance. Mean pretest score for the control group was 78.27 points. Mean pretest score for the treatment group was 83.47 points. Mean posttest score for the control group was 111.00 points. Mean posttest score for the treatment group was 133.80 points. Mean gain score for the control group was 32.73 points. Mean gain score for the treatment group was 50.33 points.

<u>Gain Score Climbing Performance by Group by Trial</u>

Two-way ANOVA results for gain score climbing performance by group by trial are presented in Table 7. A two-way ANOVA with repeated measures was used to indicate the interaction among the variables of group and trial.

Table 7. ANOVA Summary Table of Gain Score Climbing Performance by Group by Trial for the Control Group (n = 11) and the Treatment Group (n = 15)

Source of Variation	Sum of Squares	df	Mean Squares	F	P-Value
Between Subject Effects					
Within+Residual	68463.56	24	2852.65		
Group	2486.62	1	2486.62	.87	.360
Within Subjects Effects					
Within+Residual	10892.76	24	453.86		
Trial	21891.26	1	21891.26	48.23	.000*
Group by Trial	983.57	1	983.57	2.17	.154

* = Indicates a significant difference between groups ($p < .05$)

The results of the two-way ANOVA indicated a significant ($p < .05$) main effect for gain score climbing performance when both groups' data were combined. No significant ($p > .05$) interaction for gain score climbing performance among the variables of group and trial was found.

Discussion

Following the statistical analysis for this study upon grip strength, the control and treatment groups were not statistically different after pretest data collection. There was a significant. ($p < .05$) interaction by group by trial for grip strength indicating that the control and experimental groups responded differently during the study. The control group's grip strength results indicated a nonsignificant ($p > .05$) decline of 4% over the study period, while the treatment group exhibited a significant ($p < .05$) 5% increase in grip strength at the end of the training period.

Therefore, the first null hypothesis that hang board exercise would have no significant effect upon grip strength between the control and treatment groups was rejected. This finding leads to the conclusion that under the conditions of this study, using the sample of male subjects from the UW-L, hang board exercise was instrumental in the improvement of grip strength.

These results are in keeping with the statement that hang board training will improve finger, hand, and forearm strength (Goddard & Neumann, 1993; Hörst, 1994; Long, 1993). Hörst (1996) further supported this notion by suggesting that finger board hangs may be the single best regimen as it builds contact strength in a variety of grips.

Upon statistical analysis for this study on performance, the control and treatment groups were not statistically different for pretesting climbing performance. There was a significant ($p < .05$) main effect for climbing performance gain when both groups' data were combined. Treatment group gain score climbing performance was greater than the control group. A Tukey's post-hoc test was used to test for within group differences. It was found that both groups' climbing performance improved significantly ($p < .05$) regardless of whether or not training was performed on the Differential-Tex™ hang board. There was no significant ($p > .05$) interaction by group by trial for climbing performance. Therefore the second null hypothesis that hang board exercise would not have a significant effect upon climbing performance failed to be rejected.

These results are in accordance with Goddard and Neumann (1993) stating that climbing performance represents the combined result of many different abilities, it is not the simple sum of them. Despite the improvement in the treatment group's gain score grip strength, both groups experienced improvement in their climbing performance from pre- to posttesting. It must then be considered that grip strength alone is not the deciding variable to this sample's climbing performance. Hörst (1996) acknowledges this consideration by writing that gains in performance come more quickly from practice of climbing skills than strength training.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to measure grip strength and climbing performance improvement as a result of hang board exercise in college age male University of Wisconsin-La Crosse (UW-L) students. Twenty-six subjects between the ages of 18 and 26 years completed the study. The control group, consisting of 11 subjects, took part in 8 weeks of an introductory indoor rock climbing class. The treatment group, consisting of 15 subjects, took part in 8 weeks of the same instructional curriculum and performed hang board exercise.

Each subject completed pre- and posttesting measurements of grip strength and climbing performance. Maximal grip strength scores were determined with the use of a hand dynamometer. The mean of left and right hand grip strength was used to represent each subject's total score. Climbing performance scores represented the subject's ability to climb routes on the indoor wall.

Pre- and posttest data from the control and treatment groups were gathered and statistically analyzed to determine is significant grip strength and climbing performance improvement occurred in response to hang board exercise. Results of a two-way ANOVA indicated a significant ($p < .05$) interaction for gain score grip strength among the variables of group and trial. The treatment group's gain score grip strength increased by 5% whereas the control group's gain score grip strength declined by 4% over the study period. Results of a two-way ANOVA indicated a significant ($p < .05$) main effect for gain score climbing performance when both the control and treatment groups' data were combined.

Conclusions

Based on the results of this study, the following null hypotheses failed to be rejected or were rejected:

1. There will be no significant increase in grip strength as a result of participating in an 8 week training protocol on the Differential-Tex™ hang board. The null hypothesis was rejected.
2. There will be no significant changes in climbing performance following an 8 week training protocol on the Differential-Tex™ hang board. The null hypothesis failed to be rejected.

Recommendations

Based on the results of this study, the following recommendations are presented:

1. It is recommended that future studies be done with an increased number of subjects.
2. It is recommended that future studies be done with experienced rock climbers.

3. It is recommended that future studies be done for a period longer than 8 weeks.

4. It is recommended that future studies be done with pre-, mid-, and posttests.

5. It is recommended that future studies be done with more than one criteria of measuring grip strength.

6. It is recommended that future studies be done with more than one criterion for judging climbing performance, such as the speed or time it takes a climber to complete a route.

7. It is recommended that future studies be done with the class curriculum being presented by the same instructor.

8. It is recommended that future studies be done using a different teaching curriculum.

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APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

Project Title: The effects of hang board exercise on grip strength and performance in college age male indoor rock climbers.

Principal Investigator: Jay D. Jurrens under the supervision of Jeff Steffen, Ph.D., Mitchell Hall, office 215, ph.785-6535.

I ______________________, willingly volunteer to participate in a research study to investigate the effects of exercise with the Differential-Tex™ hang board on grip strength and climbing performance. I understand that my participation in this study may include training using the Differential-Tex™ hang board. I understand that I will be tested on the indoor climbing wall to determine what level of performance I can climb at. I am aware that grip strength will also be measured by use of a hand dynamometer. I acknowledge that I will complete each test in a randomly assigned order.

I understand that my participation in this research study will require a minimum of one practice session, two performance tests, and two hand dynamometry tests. All practice/testing sessions will be scheduled during class time and conducted by Jay Jurrens on the indoor climbing wall in Mitchell Hall on the campus of the University of Wisconsin-La Crosse under the direction of Jeff Steffen, Ph.D.

As with any climbing or exercise testing, there exists the possibility of risks (i.e., falling, abrasions, difficulty breathing, dizziness, etc.) during testing. In addition, I may feel tired at the end of testing and may experience muscle soreness as a result of testing/exercise. If any abnormal observations are noted, the test will be immediately terminated.

To my knowledge, I consider myself to be in good health and have no limiting physical conditions or disabilities, especially with regard to my heart, that would preclude my participation in the exercise tests as described above. I consent to publication of study results so long as the information is anonymous and disguised so that no identification can be made. I further understand that although a record will be kept of my having participated in the experiment, all experimental data collected from my participation will be identified by number only. Any questions which may have occurred to me have been answered to my complete satisfaction. I therefore, voluntarily consent to be tested. Furthermore, I know I may withdraw from these tests at any time without penalty.

I hereby acknowledge that no representations, warranties, guarantees, or assurances of any kind pertaining to the procedures have been made to me by the University of Wisconsin-La Crosse, the officers, administration, employees, or anyone acting on behalf of them.

Questions?: Jay D. Jurrens, 1901 Miller Street Apt. 4, La Crosse, WI 54601 (608) 782-1372.

Experimental Participant: ______________________________ Date: ________

Experimenter: ____ Date: ________

APPENDIX B

PERSONAL HEALTH AND INFORMATION QUESTIONNAIRE

Personal Health and Information Questionnaire

Name: (last)____________________ (first)____________________

(middle)__________ Address: ______________________________

(city) ____________________ (state)________ (zip code)__________

Telephone: (home)________________ (work)____________________

Date of Birth: ________________ Age: _____ Gender: __________

Activity Readiness Questionnaire

This form is designed to determine your initial health and activity level. The test identifies those individuals who may be at risk if they engage in this study. Answer the following questions to the best of your ability. Check "Yes" or "No" to answer the questions as they pertain to you.

YES	NO	
_____	_____	1. Has your doctor ever said you have heart trouble?
_____	_____	2. Do you often feel faint or have spells of dizziness?
_____	_____	3. Has your doctor ever told you that you have a bone, joint or tendon problem that has been aggravated by exercise, or might be made worse by exercise?
_____	_____	4. Is there a good reason not mentioned here why you should not follow an activity program even if you wanted to?

APPENDIX C

HAND DYNAMOMETERY DATA RECORDING SHEET

HAND DYNAMOMETRY
DATA RECORDING SHEET

SUBJECT NAME______________________ ID # ____________________

☐ CONTROL DATE__________/__________
(Pretest) (Posttest)

☐ EXPERIMENTAL TIME__________/__________
(Pretest) (Posttest)

HAND DYNAMOMETER ID ____________________

SCORER NAME

____

DOMINANT HAND ☐ LEFT ☐ RIGHT

MEASUREMENT DATA

LEFT

TRIAL	PRE	POST
1		
2		
3		
AVG.		

RIGHT

TRIAL	PRE	POST
1		
2		
3		
AVG.		

APPENDIX D

CLIMBING PERFORMANCE TEST DATA RECORDING SHEET

CLIMBING PERFORMANCE TEST
DATA RECORDING SHEET

SUBJECT NAME____________________ ID # ________________

☐ CONTROL

DATE________/________
(Pretest) (Posttest)

☐ EXPERIMENTAL

TIME________/________
(Pretest) (Posttest)

SCORER NAME

____

PRETEST

ROUTE #	✓ OFF HOLDS REACHED

POSTTEST

ROUTE #	✓ OFF HOLDS REACHED

PERFORMANCE TOTAL = ______ **PERFORMANCE TOTAL = ______**

APPENDIX E

ROCK CLIMBING VERBAL CONTRACT

ROCK CLIMBING VERBAL CONTRACT

A standardized protocol of communication removes any doubt as to what the subject (climber) or the belayer are doing, are expected to do, are asked to do, or are warned to do. The following explains the communication process as it will occur prior to, during, and following the climbing performance measurement process.

PRIOR TO CLIMBING

"ON BELAY?" The question the subject asks the belayer before he begins climbing.

"BELAY ON" The response the belayer tells the climber when he/she is ready.

"CLIMBING" What the climber says to the belayer indicating the climber is starting to climb.

"CLIMB" The belayer's response that he/she is ready to belay the rope, proceeding to do so as the climber advances.

DURING CLIMBING

"UP ROPE" A command to the belayer to take in the rope, pull up the slack.

"WATCH ME!" Commands the belayer to pay close attention, expect or be prepared for a fall.

"FALLING!" The subject is loosing purchase from the hand holds, a statement of fact.

"TENSION" or "TAKE" A command to the belayer to hold the climber on tension by holding the belay fast. Use of this command will be used once the upper most hand hold of a route is reached, or when the subject voluntarily chooses to end their attempt at climbing higher.

"LOWER" A command to the belayer that the subject is ready to be lowered to the ground.

FOLLOWING THE CLIMB

"OFF BELAY" Climber's signal to the belayer that he is safely on the ground.

"BELAY OFF" The belayer's response to the climber that the belay has ended.

APPENDIX F

DIFFERENTIAL-TEX™ HANG BOARD DESCRIPTION

DIFFERENTIAL-TEX™ HANG BOARD DESCRIPTION

Hang boards, first introduced in late 1986, are wooden or molded-resin boards that are mounted up high like a pull-up bar. The "board" features various holds resembling those on a climb, from large hand-size prominences to rounded shallow pockets just large enough to accommodate one finger.

The Differential-Tex™ ("Tex" is short for texture) hang board is a product manufactured and marketed by Nicros Inc. of St. Paul, Minnesota. Nicros Inc. enlisted the help of Eric Hörst, author of several books on training for climbers, who was the creative mind behind the design of the Differential-Tex™ hang board. The device was first fashioned out of open-cell foam, which was used to produce the mold for production. Other retailer's products on the market use this same technique resulting in a resin-molded hang board whose surface is uniformly smooth. Nicros Inc. took the design one step further by applying sand-like "sprinkles" of varying coarseness to the individual holds on the hang board surface. Holds which are larger in size provide a high contact force area, thus requiring a smaller sized texture or zero texture to ensure a climber's purchase of the hand-hold is maintained. As the size of the holds decrease, thus resulting in a smaller contact area, the coarseness of the texture is increased so fingers will not slip. The end product has a natural feel much like a rocky surface.

The Differential-Tex™ hang board is approximately 21 inches long, 8 inches high, and 3 inches deep. The board is mounted to 3/4" plywood and secured to a wall or chin-up bar.

APPENDIX G

HANG BOARD TRAINING PROTOCOL

Hang Board Training Protocol

Perform six CIRCUITS separated by one minute rest periods.

(Have your partner count "One-one thousand, Two-one thousand etc...)

	Training circuit for Mar 27- Apr 3	Progression Of Training: April 8 - April 17	Progression Of Training: April 22 - April 29
Hold # 1	Five seconds on (Five seconds off)	Seven seconds on (Five seconds off)	Ten seconds on (Five seconds off)
Hold # 2	Five seconds on (Five seconds off)	Seven seconds on (Five seconds off)	Ten seconds on (Five seconds off)
Hold # 3	Five seconds on (Five seconds off)	Seven seconds on (Five seconds off)	Ten seconds on (Five seconds off)
Hold # 4	Five seconds on (Five seconds off)	Seven seconds on (Five seconds off)	Ten seconds on (Five seconds off)
Hold # 5	Five seconds on (Five seconds oft)	Seven seconds on (Five seconds oft)	Ten seconds on (Five seconds off)
Hold # 6	Five seconds on --Finished--	Seven seconds on --Finished--	Ten seconds on --Finished--

Don't forget to properly warm-up prior to starting the training protocol!

APPENDIX H

DIFFERENTIAL-TEX™ HANG BOARD DIAGRAM

DIFFERENTIAL-TEX™ HANG BOARD DIAGRAM

HOLD KEY

A- shallow 2-f pocket
B- deep 1-f pocket
C- deep 2-f pocket (HOLD # 1)
D- shallow 1-f pocket
E- deep 3-f pocket (HOLD #2)
F- .75 inch edge (HOLD #3)
G- small sloper
H- .375 inch edge
I - narrow pinch
J - wide pinch (HOLD #4)
K - "pull-up bar" hold (HOLD #6)
L - medium sloper (HOLD #5)
M- .5 inch edge