

ABSTRACT

KINGSLEY, A. K. The effects of hangboard exercise on climbing performance and grip strength in college age female indoor rock climbers. MS in Adult Fitness/Cardiac Rehabilitation, December 1997, 49pp. (J. Steffen)

A 7-week hangboard training program was conducted on the indoor climbing wall at the University of Wisconsin-La Crosse (UW-L). Two Differential-Tex™ hangboards were utilized for this study. A sample of 21 female Ss (18-26 yr) participated in this study (9 experimental and 12 control Ss). All Ss were students enrolled in an indoor rock climbing class at UW-L. Ss in the experimental group trained on the hangboard twice a week for 7 weeks during class time. Training sessions took approximately 10 minutes. Ss spent the remainder of each class period participating in normal class activities. The hangboard training sessions consisted of 3 cycles of 6 hang repetitions, each one lasting 5 s and progressing to 7 and 10 s over the duration of the study. Each hang utilized a different pair of holds which got progressively smaller. Control Ss participated in normal class activities. Climbing performance and grip strength were measured prior to and upon completion of the training program. The results showed a significant ($p < .05$) interaction between the groups for performance from pre- to posttesting, indicating that the experimental group increased their performance score significantly more than the control group from pre- to posttesting. There was no significant ($p > .05$) interaction found between the groups for grip strength from pre- to posttesting, indicating that the groups responded similarly in grip strength over the duration of the study.

THE EFFECTS OF HANGBOARD EXERCISE ON CLIMBING PERFORMANCE
AND GRIP STRENGTH IN COLLEGE AGE FEMALE
INDOOR ROCK CLIMBERS

A THESIS PRESENTED
TO
THE GRADUATE FACULTY
UNIVERSITY OF WISCONSIN-LA CROSSE

IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
MASTER OF SCIENCE DEGREE

BY
ANGIE M. KINGSLEY
DECEMBER 1997

COLLEGE OF HEALTH, PHYSICAL EDUCATION, AND RECREATION
UNIVERSITY OF WISCONSIN-LA CROSSE
THESIS FINAL ORAL DEFENSE FORM

Candidate: Angie Marie Kingsley

We recommend acceptance of this thesis in partial fulfillment of this candidates' requirements for the degree:

Master of Science in Adult Fitness/Cardiac Rehabilitation

The candidate has successfully completed the thesis final oral defense.

Jeffrey Paul Steffen 6/26/97
Thesis Committee Chairperson Signature Date

J. P. Fu 6/26/97
Thesis Committee Member Signature Date

Elfessi A 6/26/97
Thesis Committee Member Signature Date

This thesis is approved by the College of Health, Physical Education, and Recreation.

David Timerson 7-18-97
Associate Dean, College of Health,
Physical Education, and Recreation Date

Loftis 22 July 1997
Dean of Graduate Studies Date

ACKNOWLEDGEMENTS

I would like to thank the following individuals for their insight and support throughout this process. First, I would like to express my appreciation to Jeff Steffen for chairing the thesis committee and for providing the encouragement I needed to keep my spirits lifted. I would also like to acknowledge my other committee members, John Porcari and Abdulaziz Elfessi. Their insights and advice helped make this thesis possible.

I want to thank Jay Jurrens, my partner and friend, for his unfailing sense of humor throughout this process. He helped me maintain my sanity. Thank you, Jay. It has been a great year!

To Jeff, my source of undying love, support, encouragement, and most of all, patience. Thanks for being there for me. It is finally over.

Lastly, I would like to dedicate this thesis to my parents. Mom and Dad, it is because of your constant support, both financially and emotionally, that I got to be where I am today. You have always been sources of great influence for me and through that I've learned how to work hard while always keeping a smile. I love you both very much.

TABLE OF CONTENTS

	PAGE
ACKNOWLEDGEMENTS.....	iii
LIST OF TABLES	vi
LIST OF APPENDICES	vii
CHAPTER	
I. INTRODUCTION	1
Need for the Study	2
Statement of the Problem	3
Hypotheses.....	3
Assumptions	4
Delimitations	4
Limitations.....	4
Definition of Terms.....	5
II. REVIEW OF RELATED LITERATURE	7
Training for Sport Climbing.....	7
Training for Total Body Fitness Vs. Sport Specific Fitness.....	8
Training for the Beginning Climber	11
Technique Training.....	12
Women in Rock Climbing.....	13
Muscular Strength and Endurance Training	15
Training Devices.....	16
Grip Strength.....	18
Grip Strength Measurement	19

CHAPTER	PAGE
III. METHODOLOGY	21
Introduction	21
Subjects	22
Testing	22
Protocol	23
Statistical Treatment	25
IV. RESULTS AND DISCUSSION.....	26
Introduction	26
Subject Descriptive Statistics.....	26
Grip Strength Measurement Results.....	27
Climbing Performance Results.....	29
Test of Hypotheses.....	31
Discussion.....	32
Limitations to the Study.....	34
V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	36
Summary	36
Conclusions	36
Recommendations	37
REFERENCES.....	38
APPENDICES.....	40

LIST OF TABLES

TABLE		PAGE
1.	Descriptive Statistics of the Groups (N = 21)	27
2.	Grip Strength (Kg) Results for the Control Group (n = 12) and the Experimental Group (n = 9).....	27
3.	T-test Results For Control vs. Experimental Groups' Pretest Grip Strength.....	28
4.	ANOVA with Repeated Measures Summary Table of Grip Strength by Group by Trial for the Control Group (n = 12) and the Experimental Group (n = 9).....	29
5.	Climbing Performance (points) Results for the Control Group (n = 12) and the Experimental Group (n = 9).....	29
6.	T-test Results for Control vs. Experimental Groups' Climbing Performance.....	30
7.	ANOVA with Repeated Measures Summary Table of Climbing Performance Scores by Group by Trial for the Control Group (n = 12) and the Experimental Group (n = 9).....	31

LIST OF APPENDICES

APPENDIX	PAGE
A. Hangboard Description.....	40
B. Climbing Performance Measurement	42
C. Informed Consent.....	44
D. Differential-Tex™ Hangboard Diagram	46
E. Climbing Verbal Contract	48

CHAPTER I

INTRODUCTION

Within the last decade, the sport of rock climbing has seen a dramatic increase in participation. People of all ages and from a variety of demographics are discovering the benefits of a sport which only a few daring individuals in the past have known. Rock climbing is one of the most exhilarating, challenging, and strength and confidence building activities available. Catherine Gockley (1990) describes rock climbing as “an activity that promotes emotional as well as physical growth” and claims that “climbers often attribute heightened self-confidence and independence to the sport” (p.17). Once virtually inaccessible by the average person, rock climbing is now actively promoted and available to anyone interested.

Rock climbing places substantial physical and mental demands on the climber. All of the components of physical fitness and conditioning are involved in the sport of rock climbing. These factors include muscular strength, power, and endurance; cardiovascular power and endurance; flexibility; and balance. Though a combination of fitness factors are required, none are as thoroughly applied as muscular strength and endurance. This common misconception over the years has kept many women from climbing. It was believed that rock climbing required brute upper body strength to pull oneself up the rock wall. Through active participation and investigation, many people have discovered that muscle groups are required to work synergistically in rock climbing (Fox, 1996). Most climbers have found that, as a necessity, the lower body must be relied upon to the same extent as the upper body for climbing success. This is especially apparent in female climbers who, on average, have less upper body strength than males. Proper technique combined with strengthening exercises allows the female climber to more fully utilize her

physiological strengths to adequately compete with her male counterparts. The more a female climber can transfer work from the weaker upper body to the large muscle groups in the lower body, the longer she can delay the onset of localized muscle fatigue. A longer and potentially more successful climb results from utilizing one's physiological strengths and technical expertise. According to Goddard and Neumann (1993) women have a greater percentage of slow twitch muscle fibers which allows for more endurance but less power. They also have greater flexibility than their male counterparts. These two qualities allow them more time on the rock while planning their next move as well as a greater range of possible movements and techniques.

The substantial mental demand required of the climber lies in the area of technique. Technique is an important element of successful climbing as many climbers can partially make up in technique what they lack in finger and forearm strength. Technique is generally the main focus of most beginning rock climbing courses offered in rock gyms throughout the country, with little or no attention being given to muscular strength and endurance gains. In order to facilitate these physiological gains, many serious climbers are using indoor climbing gyms and training devices. Climbing training devices serve to mimic the the physical demands of climbing, namely in upper body muscular strength and endurance (fingers, hands, forearms, and shoulders), with specific regard for technique. Hangboards are an example of these devices that most closely replicate climbing surfaces and holds while being more accessible than a climbing gym or natural rock wall for training purposes.

Need for the Study

Though there have not been any published training studies using hangboards, they have been used extensively by experienced and competitive climbers wanting improve their upper body muscular endurance, or more specifically, their finger and forearm strength and

endurance. Studies focusing on the acquisition of physiological improvements or technical skills in women are lacking as well.

Hangboards utilize the principal of “specificity of training”, in that they most closely resemble climbing movements in order to yield the greatest results in climbing performance. The Differential-Tex™ Hangboard (see Appendix A), made by Nicros, Inc., is designed to simulate actual rock surface and shape with varying grips. This unique design creates more demand on the muscles and tendons in the forearm and hand, the muscles which tend to fatigue first on an actual climbing route. Theoretically, by improving the physical aspects required of climbing, a person could more easily and rapidly learn proper technique and thus have greater success in climbing.

Statement of the Problem

The purposes of this study were to: 1) determine whether a training program on the Differential-Tex™ Hangboard (DTH) would enhance climbing performance in novice female rock climbers as measured by American Sport Climbing Federation (ASCF) rock climbing scoring system (see Appendix B) and 2) to determine the effect of a training program with the DTH on grip strength in novice female rock climbers as measured by a grip strength dynamometer.

Hypotheses

The major null hypotheses of this study were:

1. A 7-week training program on the hangboard will have no significant effect on climbing performance in novice female rock climbers.
2. A 7-week training program on the hangboard will have no significant effect on grip strength in novice female rock climbers.

Assumptions

The following assumptions were relative to this study:

1. All subjects were novice climbers prior to the climbing program, in that they had no more than three prior experiences rock climbing.
2. All subjects had no known illness or limitations to climbing and remained in good health throughout the training and testing periods.
3. All subjects performed to the best of their ability during training and testing.
4. All subjects did not engage in additional resistance training other than normally performed prior to the study.
5. All subjects did not engage in additional rock climbing other than in the class during the study.

Delimitations

This study had the following delimitations:

1. Subjects were college age females enrolled in the ESS 100-115 and 100-216 Beginning Rock Climbing courses at UW-L.
2. Only novice female climbers were used as subjects.
3. The training duration was limited to 7 weeks.

Limitations

This study had the following limitations:

1. Motivational effects of having peers observing could have effected performance.
2. Different instructors for the control and experimental rock climbing classes could have effected performance.
3. Holds on the wall were not changed throughout the study.
4. Prior fitness levels within groups were not accounted for.

Definition of Terms

Belay - The procedure of securing the climber by managing the rope to which the climber is attached and preventing them from falling to the ground.

Campus Board - a training device consisting of horizontal strips of wood mounted on a long plank in a ladder-like configuration.

Climbing Wall - a stable and stationary structure typically made of a wooden frame with wood or cement panels attached in a vertical, slightly sloping, or overhanging fashion. The panels have hand- and foot-holds attached to them or they have the holds built in as in the case of molded cement panels. The climbing wall at UW-L has vertical and overhanging walls with multicolored holds made of a resin-type material.

Grip Strength - The force generated by the muscles of the hand and forearm upon maximal contraction of the fingers and thumb while squeezing the handle of a hand dynamometer.

Hand-hold or Foot-hold - a rock or artificial rock-like formation bolted or glued on to a climbing wall for the purpose of pushing or pulling on to ascend or descend a climbing route. These holds come in a variety of shapes and sizes depending on the desired difficulty of the climbing route.

Hangboard (Fingerboard) - A molded resin board, textured and molded to simulate various rock surfaces, that is mounted on the wall and used for hanging, pull-ups, and isometric exercises. It includes holds of varying size, shape, and difficulty.

Rock Climbing - traditionally a sport in which ropes and protective equipment are used to aid in ones ascent up a route with all protection being placed in the rock and removed by the climber.

Route - a predetermined path to the top of a pitch, usually named and graded for difficulty by members of it's first ascent.

Sport Climbing - climbing on artificial walls or bolted routes either recreationally or competitively.

System Wall - a training device, similar to the campus board, but with diagonal strips of wood of various widths included.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

Training for Sport Climbing

Sport climbing is one of the fastest growing adventure activities in the U.S. (Kascenska, Dewitt, & Roberts, 1992). Sport climbing is an off-shoot of traditional rock climbing with the differences being the type of protection used and type of surface being climbed. Sport climbing is done on either artificial walls or outdoor bolted routes. It is this type of climbing that is giving way to increasing levels of competition. Traditional rock climbing is done using protection which is placed in the rock by the climber. The term “rock climbing” will be used throughout this chapter to refer to all types of climbing.

To reduce the demands placed on our natural resources, most climbing competitions take place in climbing gyms or on artificial walls outside (Roberts, 1988). Accordingly, many climbers train on indoor or artificial walls. Most climbing gyms include climbing routes with textures, holds, cracks, and overhangs similar to those found in the natural environment (Attarian, 1989). Sport climbing competitions are scored by judges using established guidelines for judging climbing performance. These guidelines were adopted by the Union Internationale Des Associations D’Alpinisme (UIAA), the international governing body for climbing competitions and are employed by the American Sport Climbing Federation (ASCF) (Darmi, 1992).

Many enthusiasts are constantly searching for an optimal training strategy specific to climbing. Rock climbing is a very strenuous activity. A unique combination of strength, power, endurance, and flexibility is required for success (Kascenska et al., 1992). Climbers repetitively face high physical demands, however there are other very important and influential factors involved in rock climbing. Mental acuity, confidence, problem solving, and familiarity with various rock surfaces are also crucial to successful climbing. As there are many physical and mental components to rock climbing, so are there many areas of training that take many forms. Training can be divided into five areas: muscular strength, muscular endurance, technique, flexibility, and cardiorespiratory endurance. There are as many training programs as there are elite rock climbers and authors. Each propose to be the most effective training regimen to improve the physical and mental components of rock climbing and each prioritize the various aspects of training to different degrees. The basic areas of training, training and instruction for novice climbers, women and climbing, and the use of training devices will be discussed in this chapter.

Training for Total Body Fitness Vs. Sport Specific Fitness

Many training programs written by elite rock climbers have not emphasized total fitness. Though most suggest maintaining a high level of overall fitness, they do not provide a comprehensive approach to achieve it. Instead, their focus is directed to improvement in technique, muscular strength, and various mental aspects. Eric Horst (1996) claimed that climbing ability depends on having the right combination of technique, finger strength, and mental fitness. The fingers and forearms are often the point of failure when climbing (Horst, 1994). He added that forearm specific workouts are the best way to increase contact strength, the ability to hang on to small holds, and that fingerboard hangs are the most effective approach. According to Horst (1996), gains in contact strength yield

improved forearm endurance, although the reverse is not true. Endurance training does not lead to improved contact strength. Since rock climbing involves gripping with a wide variety of hand positions, improving contact strength in various hand positions will benefit a climber much more than building up endurance in one hand position, such as in dumbbell wrist curls. “Some of the best strength training exercises aren’t pull-ups, but are a series of brief, intense hangs on small to mid-sized holds” (Horst, 1996, p. 150). Goddard and Neumann (1993) discussed their theory of the weakest link principle: “A small change in your weakest areas will have great effect on overall performance, while a significant improvement in the strongest areas will have a much smaller effect” (p. 7). Bill Fox, a personal trainer discussed the contribution of the neuromuscular system to improvements in performance (1996). He maintained that working on system wall (see Definition of Terms) improves the neuromuscular system’s ability to coordinate powerful movements. By practicing the same types of hangs and movements on the wall, the nervous system is better able to control the actions of the various muscles involved with the movement. Those muscles can be classified as the muscles producing the movement (agonists), the muscles stabilizing the movement (synergists), and the muscles inhibiting the movement, providing a protective mechanism (antagonists). When working on a particular route, improvement stems not from muscles getting stronger, but by the nervous system teaching the body how to perform the movements more efficiently (Fox, 1996).

In contrast, many physical education instructors and professionals in the field of health and fitness emphasize developing or maintaining high levels of total body fitness to enhance climbing performance. As the instructor of a climbing conditioning course at Montana State University, Curt Shirer (1990) often discusses with his students the importance and relationships of flexibility, cardiovascular endurance, strength, and climbing techniques. Kascenska and colleagues stated that “many students rush into a

rock climbing training program with little or no knowledge of the basic principles of fitness and how to apply those principles toward the enhancement of their climbing” (1992, p. 73). According to Kascenska and colleagues (1992), most rock climbing course instructors typically spend most of the instructional time on the technical aspects of climbing with fitness often receiving the least amount of attention. These physical educators recommend developing and maintaining all five components of fitness and not focusing on a single aspect. They also feel that climbing students should understand the body’s three energy systems and how they apply to the various climbing movements.

The three energy systems of the body are the adenosine triphosphate-creatine phosphate (ATP-CP) system, lactic acid system, and the oxidative system. The first two do not require oxygen (anaerobic) and are involved in fast and powerful movements which last only a short time. The oxidative system requires oxygen (aerobic) and is used during lower intensity, long term movements. “Rock climbing requires the development of all three systems to provide adequate amounts of energy throughout the diverse demands of the climb. Specificity of training dictates that each system be overloaded for beneficial adaptations to occur” (Kascenska et al., 1992, p. 74). Many climbers claim that bouldering (climbing low to the ground in a horizontal fashion without the use of rope) is an optimal way to receive a comprehensive workout. Robyn Erbesfield (1997) stated that “the best ways to gain power are by doing specific exercises on a fingerboard, bouldering, footless climbing, and working a hard route” (p. 114). She believes bouldering to be the most enjoyable way to practice technique and train for power. One can overload the energy systems individually by varying the speed of the traverse and by attempting quick powerful moves in which near maximal voluntary contractions must be performed.

Training for the Beginning Climber

Several training programs have been developed by elite rock climbers. However, most of them were created for climbers with high levels of skill and ability. These advanced climbers possess above average flexibility and upper body strength especially in the forearms and fingers. For the beginning climber to attempt some of the specialized training designs that the elite climbers practice, the potential for injury to tendons in the fingers, wrists, and elbows is great. Prior to utilizing many of the training programs and training devices created by elite climbers, one needs to consider one's present skill level and amount of upper body strength and endurance (Goddard & Neumann, 1993). Few authors or climbers have developed training programs designed specifically for novice climbers. Kascenska and colleagues (1992) provided a training plan which focused on improving overall fitness for both beginning and advanced climbers. The authors stressed that instructional climbing courses should provide "adequate and up-to-date fitness and training guidelines for rock climbing students of different skill levels" (p. 73). For the beginning climber, instructors need to emphasize the importance of each aspect of the activity.

Climbing techniques and fitness components should be developed simultaneously to optimize performance. Should either be neglected, climbing improvements will be slowed. Kascenska and colleagues (1992) suggested climbing students perform a variety of nonclimbing training activities when access to a climbing wall was limited. Included in their recommendations were various weight lifting exercises, emphasizing muscular endurance, and performance of exercises that most closely mirror the movements common in climbing. Some of the exercises suggested were the "seated row", "lat pulldown", "bicep curls", "wrist curls and extensions", "seated leg press", and "heel raises". Also suggested was cardiorespiratory training such as running, flexibility training with an

emphasis on regular dynamic stretching, balancing exercises, and utilization of climbing training devices. It was noted that the beginning climber should use extreme caution when utilizing training devices, as their potential for causing over-use injuries is high. Shirer (1990) included in his climbing conditioning class a session on cardiovascular fitness, suggesting jogging, cycling, and swimming as methods for achieving this component of fitness. Students in this class were also given information on development of a muscular strength and endurance program that duplicated as closely as possible the movements frequently performed in climbing such as pullups, leg press, and hand squeezers of various types.

Technique Training

Many elite climbers have developed training protocols specific to their competitive needs. Some have modified them slightly and published them in climbing magazines, manuals, and books. Though there are differences in suggested combinations of training practices, most authors of climbing books agree that technique has the greatest impact on performance. Goddard and Neumann (1993) stated, "For most climbers, technique training is the most potent springboard to performance" (p. 20). Consistent with this is Eric Horst's statement, "For the ordinary climber, it becomes obvious that practicing to improve skill is more important and productive than training for fitness" (1994, p. 7). Horst also claims that most climbers would benefit more from increasing their time spent on rock technique and mental training than on strength training. He added that strength is important to climbing, but time spent on improving technique and mental control will provide faster and greater benefits. John Long (1993) agrees stating "Of course, the best training for climbing is climbing itself" (p.168).

The levels of difficulty in rock climbing have been gradually increasing since climbing became a competitive sport (Horst, 1994). The Yosemite Decimal System,

created in the 1930s, is the rating system used to identify the difficulty of particular climbing routes. When first developed it ranged from 5.0 to 5.9 with anything above 5.9 being considered impossible. Recently, a new route was established as the first 5.15. Many noncompetitive climbing enthusiasts are routinely climbing routes with 5.9 and 5.10 difficulty ratings after only a few times on the rock. Routes of this difficulty used to be completed by only the elite climbers. Some reasons for the increasing difficulty of climbing routes attainable by the noncompetitive climbers are improved and safer equipment, more bolt protected routes, and advances in technique training (Darmi, 1992). Many people who have been dissuaded from climbing in the past are finding that technique, not abundant strength, is the key to success. With the more recent gymnastic style seen in advanced climbers, agility, flexibility, and strength-to-weight ratio play a much larger role than raw muscular strength (Gockley, 1990). Women tend to make very efficient use of these qualities as they typically exhibit greater performances than their male counterparts at the novice level. At the elite level many top women are coming closer to climbing at equal levels of difficulty as men, despite men generally having greater upper body strength and power than women (Goddard & Neumann, 1993).

Women in Rock Climbing

“As the sport develops into an activity necessitating balance and flexibility rather than upper body strength, more women are being drawn into recreational climbing” (Gockley, 1990, p. 16). “As in other sports, a leveling of abilities has accompanied the leveling of sexual proportions. Already female climbers have emerged whose performances place them among the top climbers in the world” (Goddard & Neumann, 1993, p.162). Big differences exist between the sexes in regard to climbing style, climbing training, and physical advantages to the various demands of climbing.

These different physical qualities possessed by the different sexes dictate the contrast in technique used to climb the same routes.

Typically, women have a greater percentage of slow twitch muscle fibers than men, providing them with more endurance and less power. Those slow twitch fibers allow women to take their time on a route as they search for their next hold or move. Men have more fast twitch muscle fibers that allow them more quick and powerful moves but at the cost of quick fatigue (Goddard & Neumann, 1993). Therefore, women tend to excel at 'face' and 'slab' climbs where the holds are smaller and more dispersed, thus requiring more thought and planning between moves. Women tend to fall behind men on routes with large holds and steep overhangs which require more strength and power.

Flexibility is crucial to rock climbing. Climbers with greater lower body flexibility are better able to climb routes with limited and widely spaced bolts. This is because they are limber enough to be able to spread their feet further apart to reach more foot holds. Women are, on average, more flexible than men, which allows them a broader range of movements and a wide array of technique options while on the rock (Goddard & Neumann, 1993). The greater flexibility in women also makes them less predisposed to injuries due to muscle or tendon strain.

Women, in general, are smaller and weigh less than men. Though this puts less stress on their finger tips and tendons, it does not necessarily mean they have proportionately less weight to pull. On average, women have a higher percent body fat and less strength-to-weight ratios than men. This means that most female climbers have to sustain a greater load on their working muscles relative to their weight as compared to men. For this reason, women must rely more on proper foot placement and rotation of their lower body to achieve success in climbing (Goddard & Neumann, 1993).

Muscular Strength and Endurance Training

Muscular strength is the ability to exert force while muscular endurance is the ability to sustain a workload of low to moderate strength (Goddard and Neumann, 1993).

Climbing routes vary in difficulty partially according to which of these qualities they most demand. Obviously a steep route with several overhangs and roofs to pull oneself over requires greater strength while a longer strictly vertical or slightly sloping route with several pitches requires greater muscular endurance. Goddard and Neumann divide muscular strength and endurance into three categories: power, power-endurance, and local-endurance. Power refers to the rate of which strength is expended. A power demanding route is one in which a maximum muscular effort is required for just a few moves. A route in which there are 8 to 20 strenuous moves but still within one's limit would be classified as a power-endurance route. If no individual move on a route is hard but the combination of all the moves leaves one feeling very fatigued the route is considered a local endurance route. Many routes will incorporate all three classes of muscular strength and endurance so it is important to develop a training regimen that includes each of them (Goddard & Neumann). "To develop muscle strength in the proportions that climbing demands, one's training must simulate as closely as possible the movements made in climbing. The body's physical adaptations are specific to the speeds, positions, and angles of force involved in training. Climbing, therefore, is the best intermuscular training for climbers" (Goddard & Neumann, p. 108).

Eric Horst warns against training for muscle hypertrophy stating, "...ignore any advice to use heavy weights, lower reps, and more sets. That sort of regimen is for body builders in search of mass, not for climbers" (Horst, 1994, p. 24). Goddard and Neumann (1993) made similar suggestions for strength training; "...the relationship between muscle size and climbing ability is inconsistent...people with the biggest muscles are often not as

strong on the rock as those with smaller frames and smaller muscles” (p. 97). In contrast, Kascenska and colleagues (1992) recommended doing resistance training at near maximum weight, completing five to six sets of one to six repetitions, to increase power. There is increasing evidence that elite climbers and physical educators do not share the same views on the most effective training regimen to improve climbing performance in novice climbers. John Long, avid climber and author, dismisses the fear many climbers have about adding too much bulk to their “whippet-thin physiques” by stating that adding 5 pounds of muscle might increase a climbers strength by 10%. He added that it is too much food, rather than iron, that increases body size. Goddard and Neumann stated that as a person builds strength in combination with technique, they increase the range of possible movements they can make.

Training Devices

Although traditional climbing has existed for over 100 years, sport climbing just started gaining popularity in the 1980s (Watts, Martin, & Durtschi, 1993). This type of climbing requires less gear and less time. This is because the routes have closed hooks permanently bolted in the rock, requiring the climber to simply place a carabiner in the hook and then pass the rope through the carabiner. Sport climbing competitions, in which climbers are competing against a clock or another climber, are now common all over the world (Darmi, 1992). The emphasis on competition climbing has prompted an increasing interest in sport climbing-specific training regimens. Within the last 10 years, many climbing enthusiasts of various skill levels have begun making greater use of weight rooms, pull-up bars, and climbing gyms hoping to improve their performance (Kascenska et al., 1992). This trend has stimulated the development and supply of training equipment specifically created for climbing (Long, 1993). Some of these devices include campus boards, rope ladders, peg boards, hangboards (also known as fingerboards), and various

hand squeezers. These devices are meant for increasing strength and endurance in the tendons of the fingers and the forearms, the site of greatest muscular demand in nearly all types of climbing. Eric Horst (1996) claims the hangboard mimics rock climbing, is an effective training tool, and keeps a person interested. He adds that the hangboard is the only device that will give measurable gains in finger strength.

The forearms are small in size relative to other muscle groups in the upper arm, trunk, and lower body. Due to this and to the fact that so much demand is placed on them with use of the training devices, forearms are frequently overtrained by climbers utilizing such devices. When providing hangboard training advice, most climbers and instructors suggest that beginners stand in bungee cords, attached to the Hangboard, to reduce the stress on the fingers and forearms. As the fingers and forearms are frequently the point of muscular failure when climbing, many competitive climbers have injured themselves by being overzealous in training these areas; however, there are safe, low-risk methods of training the fingers and forearms. The hangboard can be an integral part of a safe training program provided it is preceded by a warm up and followed by stretching and massage of the fingers. Horst (1994) added that although it may not seem like much of a workout, increasing evidence has suggested that apparent strength gains from this type of exercise result from improvements in the nervous system, reduced inhibitions, and better technique. Thus, a large recruitment of muscle fibers with training is not always a requirement for improved performance. In discussing hangboards, John Long (1993) states, "there is no doubt that they can increase finger, hand, and forearm strength, and that the carry over value to climbing is high" (p. 172). When training for climbing, methods that use climbing and climbing-like exercises to target the aspects of strength demanded of climbing will often provide the best results (Goddard & Neumann, 1993).

Grip Strength

Sport rock climbers often emphasize the importance of hand to rock contact strength during climbing positions and moves (Watts, Newbury, & Sulentic, 1996). Accordingly, grip strength, grip endurance, and finger contact force have been measured in studies involving physiological effects of rock climbing and rock climbing performance. Horst (1994) stated that one of the requirements for successful rock climbing is arm strength and endurance, especially in the grip. Grip strength (GS) is the force generated by the muscles of the hand and forearm upon maximal contraction of the fingers and thumb against a resistance (Watts et al., 1993). Grip strength is highly specific to the shape of the grip, the positions of the wrist and elbow, and the level of the muscles above the heart (Horst, 1994). Grip endurance (GE) is defined as the time that handgrip force can be sustained above 70% of GS (Watts et al., 1996). Finger contact force (FCF) is the force exerted on a handhold through the pads on the finger tips (Mathis, 1989). Finger contact force is also referred to as contact strength.

Wendy Russum (1989) conducted a study which determined the physiological characteristics of rock climbing ability. She found that elite rock climbers had significantly greater GS values than intermediate and novice climbers and intermediate climbers had higher GS values than novice climbers. Watts and colleagues (1993) found that elite female climbers exhibited GS values which placed them in the 90th percentile of the population norms. These researchers suggested that the relatively high GS in elite female climbers may help to compensate for a more limited ability to reduce body fat as compared to their male counterparts.

Grip Strength Measurement

“The strength of grip as measured by a variety of dynamometers has been used more than any other single measure to access muscular strength” (Clasey, 1987, p. 1). In discussing grip strength measurement, Clasey suggested that to attain peak force of the finger flexors in hand dynamometry, the dynamometer handle should be set to a subjective comfort setting for each subject. Mathiowetz et al. (1985) conducted a study in which part of the purpose was to establish norms for hand strength evaluations in men and women, aged 20 to 75+ years. They found that in the 20-24 age group, the mean GS scores for women for right and left hands were 32 kg and 27.3 kg, respectively. It was suggested in the article that when evaluating hand strength it is important to use standardized positioning and instruction. Subjects in their study had their shoulder adducted and neutrally rotated, with elbow flexed at 90 degrees, forearm in neutral position and wrist flexed between 0 and 30 degrees dorsiflexion and between 0 and 15 degrees ulnar deviation. Three successive trials were recorded and averaged for each hand (Mathiowetz et al. 1985). Watts and colleagues (1993) included GS as one of their measurements in their investigation of anthropometric profiles of elite rock climbers. After collecting GS measurements for each hand, those values were averaged to provide an average hand grip score.

Summary

Sport climbing, an off-shoot of traditional rock climbing, has seen a drastic increase in popularity within the female population over the past decade. Women are finding that skill and technique make a successful climber, not brute strength. Currently, many top women climbers are climbing at equivalent levels as their male counterparts. With competitions becoming larger and more lucrative, many climbers are turning to training devices to help improve their performance. Top climbers have published books and articles, offering training advice utilizing such devices, for those seeking to reach higher

levels of climbing. This advice, though potentially helpful, does not stem from scientific research studies. There is no evidence, except for personal testimony, that the training suggestions really work. There have been no training studies published utilizing rock climbing training devices. Also, rock climbing related research in the female population is lacking.

CHAPTER III

METHODOLOGY

Introduction

There is a lack of scientific research specific to rock climbing. Several elite climbers have developed training programs based on extensive personal experience but without scientific data to back up their claims. Often these programs are not meant for the beginning climber. In fact, should a beginning climber attempt some of those training programs, they could risk injury from overtraining. Physical training, in general, has been thoroughly tested using scientific investigations. The American College of Sports Medicine defines it as a strategic combination of proper intensity, duration, frequency, and mode. Studies indicate that the frequency of resistance training should be 2-4 days per week (ACSM, 1995). Hangboard training is an exception to this rule. Because a large amount of tension is placed on the tendon pulleys of the relatively smaller forearms during hangboard training, high frequency can promote damage to these muscles and eventual scar tissue build-up (Goddard & Neumann, 1993). Hangboard training done at a frequency of greater than two days a week will put a person at risk for overuse injury (Horst, 1994).

Training intensity should follow the progressive overload principal which states that to “promote strength and endurance gains a muscle must be exercised at greater than normal work loads” (Heyward, 1991). The intensity while utilizing a hangboard was dependent on the respective upper body strength and weight of each subject. Also influential on intensity was whether or not the subjects used their feet on a foot board to help support some of their weight during the timed hangs. Two foot boards were placed directly below the hangboards for the purpose of slightly decreasing the load placed on the fingers and forearms. Also, including foot work during hangboard exercise is thought to make the

activity more climbing specific. Horst (1994) suggested that the feet should be moved around on small holds placed below the hangboard as a person in hanging. He added that when training for climbing, positions in which the feet are not being used should almost always be avoided. The foot boards were made with 1.22 x 1.22 m sheets of plywood with thin strips of wood nailed to them horizontally and placed approximately 15-20 cm apart. This provided 1 cm edges for the subjects to put their feet on to take a small portion of the load off their upper body.

Subjects

Twenty-one females (N = 21) between the ages of 18 and 26 participated in this study (9 experimental and 12 control subjects). The subjects were University of Wisconsin-La Crosse (UW-L) students enrolled in the ESS 100-section 115 and 100-section 216 Beginning Rock Climbing classes, Spring Term 1997. None of the subjects were experienced climbers prior to the class, and thus classified as novice for the purpose of the study. The students completed and signed an informed consent form (see Appendix C), stating that they were apparently healthy with no known physical limitations to participation. Prior to beginning the research, it was determined that section 216 would be the experimental group while section 115 would be the control group. Experimental subjects were informed of all risks associated with the study. Subjects were required to sign a consent form for the UW-L Intramural Office. In addition, the subjects were provided an overview of the study, the procedures involved, as well as proper safety and rope handling instruction.

Testing

All subjects were tested for rock climbing performance and grip strength before and after the 7-week hangboard training program. An established American Sport Climbing Federation (ASCF) accepted measuring tool for sport climbing was used in this study to

grade each subjects performance (see Appendix B). Performance scoring was completed by the researchers as the subject climbed. The researchers belayed each subject undergoing performance testing. Each subject was asked to remember which hand-hold was last used before they lost purchase of the holds terminating their ascent up the route. Based on which hold was last used, the subjects were given a score for the particular route. As long as they reached the top of the previous route, they moved on to routes of greater difficulty. The researcher did not offer advice to aid in the subjects' ascents.

LaFayette Instrument Company grip strength dynamometers (model #78010) were used to measure grip strength before and after the 7-week hangboard training program. Subjects performed three 2-s trials with both hands in the standard grip strength measurement position (shoulder in neutral position, elbow flexed to 90 degrees, palm rotated medially 90 degrees). Dynamometers were set to a comfortable setting for each subject and the setting was noted and repeated during posttesting. Subjects alternated between hands to allow about a 20-s rest between trials on the same hand. The average of the three trials for each hand was determined and recorded. For statistical purposes, the values for the right and left hands were averaged to give one numerical value for grip strength.

Protocol

The subjects in the control group attended climbing class 2 days per week and engaged in the normal class activities. The experimental group attended climbing class 2 days per week and engaged in normal class activity except for 10 minutes during which they completed a training workout on the hangboard. The duration of the rock climbing class was 8 weeks. The duration of the hangboard training was 7 weeks.

The experimental group went through an orientation prior to beginning the hangboard training program. They were instructed on how to use the hangboard and were

given a demonstration of proper technique. The subjects were directly supervised by the researcher as they performed their hangboard workouts to ensure that they trained correctly and safely. During the Hangboard workout sessions subjects followed a detailed list of hanging exercises previously described by the researchers. Climbing sessions took place in Mitchell Hall at UW-L under the direction of Jeff Steffen, Ph. D.

There were two hangboards mounted on the wall near the climbing wall in Mitchell Hall. Subjects rotated through the training station, two at a time, throughout the duration of the class. A warm-up and stretching routine, performed as a class, preceded all climbing and hangboard training. Two subjects trained simultaneously while the researcher observed. The hangboard had a total of 13 possible paired grip positions. Of these 13 pairs, the 7 smallest holds were not used with this population as there was potential risk for tendon strain. The grip positions utilized were numbered one through six for identification purposes (see Appendix D). Subjects first performed a cycle of 5-s hang repetitions on each pair of holds. Subjects were given the choice to either hang their full body weight or put their feet on one of the strips of wood on the foot board placed underneath the hangboards. The wooden strips were approximately 1 cm wide and were spaced about 20 cm apart. This allowed the subjects to decrease the load on their fingers and forearms, although they were encouraged to hang the greatest amount of weight that they were capable of. Each repetition was timed by the subject counting 1-1000, 2-1000 ...5-1000. A 5-s rest period was given between hangs. The whole cycle lasted approximately 1 minute in duration followed by another full minute of rest before beginning the next cycle of hangs. Each subject took 10 minutes to complete the hanging exercise. Subjects completed three cycles of hangs during each training session.

During the 7-week training program there were two progressions in the training protocol. After 2 weeks of training at the initial protocol, the 5-s repetitions were increased to 7-s repetitions for 2 weeks, and then increased to 10-s repetitions for the remaining 3 weeks.

Statistical Treatment

Standard descriptive statistics were applied to all collected data. An independent t-test was run on the pretreatment performance and grip strength data to test for between group differences at baseline. A two-way analysis of variance (ANOVA) with repeated measures was used to determine if any significant changes occurred between the control and experimental groups as a result of the training program. A Tukey's post hoc test was used to determine significant changes within the groups from pre- to posttesting. The .05 level of confidence was used for all tests of statistical significance.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This study measured the effects of a 7-week hangboard training program on indoor rock climbing performance. Grip strength was also measured prior to and following the training program. Twenty-one college age females participated in this study, (9 experimental and 12 control subjects). Presented in this chapter are descriptive statistics, results of the training study, a discussion of the results as related to previous literature, and discussion of the limitations of this study.

Subject Descriptive Statistics

Descriptive statistics for the control and experimental groups are presented in Table 1. Twenty-one apparently healthy females participated in this study (9 experimental and 12 control subjects). All subjects were students enrolled in either of two indoor rock climbing courses (ESS 100-section 115, ESS 100-section 216) held at UW-L during Spring semester 1997. Control subjects (section 115) met during the first 8 weeks of the semester, while the experimental subjects (section 216) met during the second half of the semester.

The subjects in the control group had a mean age of 20.17, a mean height of 66.5 inches, and a mean weight of 132.5 pounds. The subjects in the experimental group had a mean age of 21.33, a mean height of 66.61 inches, and a mean weight of 129.44 pounds.

Table 1. Descriptive Statistics of the Groups ($N = 21$)

Variable	Control (n = 12)	Experimental (n = 9)
Age	20.17 (Mean) 1.40 (S.D.)	21.33 2.55
Height (in)	66.58 1.66	66.61 2.12
Weight (lbs)	132.5 9.25	129.44 10.33

Grip Strength Measurement Results

Pretest, posttest, and gain score grip strength results are presented in Table 2. To determine the amount of a subject's improvement, pretest scores were subtracted from posttest scores to yield gain scores.

Table 2. Grip Strength (Kg) Results for the Control Group (n = 12) and the Treatment Group (n = 9)

Group	Pretest Mean (S.D.)	Posttest Mean (S.D.)	Gain Mean (S.D.)
Control	28.83 (2.76)	30.12 (2.56)	1.28 (2.69)
Experimental	30.75 (4.87)	33.29 (4.43)	2.54 (2.53)

T-tests were used to determine significant differences between control and experimental groups prior to the intervention. T-test results for initial differences in grip strength between groups are presented in Table 3. No significant ($p > .05$) difference was found between groups for pretesting grip strength.

Mean pretest grip strength score for the control group was 28.33 Kg. Mean pretest grip strength score for the experimental group was 30.75 Kg. Mean posttest grip strength score for the control group was 30.11 Kg. Mean posttest grip strength score for the experimental group was 33.29 Kg. Mean gain score for the control group was 1.27 Kg. Mean gain score for the experimental group was 2.53 Kg.

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	-1.14	19	0.266	-5.421, 1.587

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

Results of a two-way ANOVA with repeated measures for grip strength are presented in Table 4. The results of the analysis showed a significant main effect for grip strength when data for both groups were combined ($p < .05$). A Tukey's post hoc test found a significant increase in grip strength of 2.54 kg from pre- to posttesting in the experimental group. However, the control group had a nonsignificant increase in grip strength of 1.28 kg. Thus, the interaction observed between the groups was nonsignificant.

Table 4. ANOVA with Repeated Measures Summary Table of Grip Strength by Group by Trial for the Control Group (n = 12) and the Experimental Group (n = 9)

Source of Variation	Sums of Squares	df	Mean Squares	F	P-Value
Between Subjects Effects					
Within+Residual Group	437.43 66.81	19 1	23.02 66.81	2.90	0.105
Within Subjects Effects					
Within+Residual Trial	65.66 37.40	19 1	3.46 37.40	10.82	0.004
Group by Trial	4.11	1	4.11	1.19	0.289

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

Climbing Performance Results

Pretest, posttest, and gain score results for climbing performance of subjects in the control and experimental groups are presented in Table 5. To determine the extent of a subjects performance improvement, pretest scores were subtracted from posttest scores, which produced a gain score.

Table 5. Climbing Performance (points) Results for the Control Group (n = 12) and the Experimental Group (n = 9)

Group	Pretest Mean (S.D.)	Posttest Mean (S.D.)	Gain Mean (S.D.)
Control	70.16 (27.63)	88.83 (22.33)	18.66 (15.53)
Experimental	65.56 (34.92)	119.78 (57.48)	54.22 (32.96)

T-tests were used to determine significant differences between the control and experimental groups prior to the intervention. T-tests for initial differences in climbing performance are presented in Table 6.

Table 6. T-test Results for Control vs. Experimental Groups' Climbing Performance

Group	t-value	df	p-value	95% C.I.
Control vs Experimental	0.34	19	0.739	-23.921, -33.143

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

No significant difference was found between the control and experimental groups for pretesting climbing performance. Mean pretest score for the control group was 70.16 points. Mean pretest performance score for the experimental group was 65.56 points. Mean posttest performance score for the control group was 88.83 points. Mean posttest performance score for the experimental group was 119.78 points. Mean gain score for the control group was 18.66 points. Mean gain score for the experimental group was 54.22 points.

The results of a two-way ANOVA with repeated measures for climbing performance by group by trial are presented in Table 7. The results of the two-way ANOVA with repeated measures showed a significant ($p < .05$) interaction between the groups for climbing performance. A Tukeys's post hoc test indicated that the experimental group showed a significant increase in climbing performance from pre- to posttesting while the control group did not.

Table 7. ANOVA with Repeated Measures Summary Table of Climbing Performance Scores by Group by Trial for the Control Group (n = 12) and the Experimental Group (n = 9)

Source of Variation	Sums of Squares	df	Mean Squares	F	P-Value
Between Subject Effects					
Within + Residual Group	44404.00 1783.14	19 1	2337.05 1783.14	0.76	0.393
Within Subjects Effects					
Within + Residual Trial	5673.11 13661.46	19 1	298.58 13661.46	45.75	0.000*
Group by Trial	3250.79	1	3250.79	10.89	0.004*

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

Test of Hypotheses

Based on the results of this study, the following null hypotheses were accepted or rejected:

1. There was a significant effect of the 7-week hangboard training program on climbing performance in novice female rock climbers, thus the null hypothesis for this variable was rejected.
2. There was no significant benefit of the 7-week hangboard training program on grip strength in novice female rock climbers, thus the null hypothesis for this variable was accepted.

Discussion

The increased performance scores seen in the experimental subjects is consistent with Horst's feeling that fingerboards are the most effective approach to increasing contact strength and the ability to hang on the small holds. As the routes on the UW-L climbing wall increase in difficulty, their holds get smaller. Therefore, the experimental subjects had a greater ability to use the smaller holds in their ascents than did the control subjects. These findings also support the premise of Horst's suggestion to train on a hangboard. He claimed that hangboard training results in improvements in the nervous system, reduced inhibition, and better technique.

The experimental group showed a significant increase in grip strength from pre- to posttesting. However, because the control group also increased their grip strength from pre- to posttesting, it cannot be concluded that the hangboard training alone promoted the significant gains in grip strength observed in the experimental group. These findings support Horst (1994, 1996), Long (1993), and Goddard and Neumann (1993) in their accounts of the benefits derived from climbing and climbing-like activities. Each of these authors maintain that to optimally strengthen the muscles involved in climbing, activities specific to climbing need to be performed. The main effect for grip strength observed in this study would suggest that climbing and hangboard training both provided stimulus to increase grip strength in all subjects.

Increase in grip strength cannot be suggested as the main reason for the improved performance observed in the experimental group as both groups increased their grip strength. The experimental groups' improved performance, therefore, may be consistent with Fox's (1996) theory regarding the neuromuscular system's contribution to performance enhancement by more efficient coordination and recruitment of muscles involved in the movement.

When employing the principle of overload theory, it would be expected that following proper training progression on the hangboard, the muscles utilized would be capable of withstanding greater weight for longer periods of time. Successful climbing relies on the climbers ability to repeatedly pull his or her weight up rock walls. When considering Goddard and Neumann's (1993) theory of the weakest link principle, it would seem that improved muscular strength and endurance specific to the fingers and forearms would greatly improve climbing performance in those with knowledge of proper climbing technique.

A limiting factor of this study was time constraints; the training duration could not exceed 7 weeks. Because this duration of hangboard training is not optimal for significant increases in strength in most people, strength gains became a secondary concern while performance enhancement due to sport specific training became the main focus. What the subjects should have gained, whether or not they gained muscular strength, is a familiarity of the rock surface, a better awareness of types of holds, an enhanced feeling of comfort on the rock, and increased confidence in their ability to use the smaller, more difficult holds. What keeps many beginning climbers from reaching their full potential when climbing is their inability to trust their hand-hold and use it to move upwards. They stall while they assess the hold, try to grip it, decide whether or not they can use it, and look around for alternate holds. This takes a considerable amount of time while the muscles being used to stay on the wall are rapidly approaching fatigue. Training on the hangboard offered the subjects practice at hanging their partial or entire body weight while gripping various sized holds. They should have also gained knowledge as to how to most efficiently hang from some of the smaller holds. Considering the above statements, the experimental groups' improved performance may be more supportive of Fox's (1996) theory that the neuromuscular system offers large contributions to performance.

In recalling Horst's (1994) statement regarding the specificity of grip strength, it would seem that measuring the effects of hangboard training on strength utilizing a hand dynamometer would not be a valid measure. The relatively more open position of the hand when hanging on the hangboard is different from the more closed position while squeezing the dynamometer. Perhaps measuring contact strength instead of grip strength would more accurately determine the effects of hangboard training.

Limitations to the Study

Many factors could have played a role in the increased performance scores attained at the end of the intervention period. Due to limitations of this study, these variables were not controlled. Limitations will be discussed and followed by conclusions and suggestions for future research.

The control and experimental groups were enrolled in two different beginning rock climbing classes taught by different instructors. An effort was made by the researcher to include the same activities and instruction in the experimental class as were included in the control class. However, the slightly advanced skill level of the experimental class instructor may have affected the learning curve within the experimental group. This could be due to differing suggestions and advice on technique, more demonstration, or additional technique instruction given to the experimental class which were not offered to the control group.

Due to time constraints, the routes on the UW-L climbing wall were not changed during the study. Therefore the routes which were used for pre- and posttesting remained the same throughout the 8-week class. This is true for both the experimental and control groups. As a result, the subjects had 7 weeks to learn the most effective way to reach the top of any particular route. This still does not explain why the experimental group 'learned' better than the control group. Perhaps the experimental subjects tried harder to

learn the routes due to their knowledge of how the study was being conducted and a possible desire to attain a higher score as a result of the intervention.

Another potential contributing factor to the greater performance improvements seen in the experimental group could have been higher levels of subject motivation. The rock climbing courses offered at UW-L are open to all registered students. Therefore, it was not possible to screen the subjects based on motivational behaviors. It is quite possible that the subjects in the experimental group were, on average, more motivated for physical activity.

Rock climbing is a physically demanding sport. Individuals who are fit, especially in the areas of muscular strength and endurance, are at a much greater advantage than their less fit counterparts. Prior fitness level within the experimental group may have been higher than that of the control subjects. The fact that the experimental and control groups scored similarly prior to the intervention could be due to the lack of familiarity with rock climbing across all subjects. Once the demands of climbing were recognized, the potentially more fit experimental subjects improved to a greater degree than the potentially less fit control subjects.

All training and testing for this study took place during class time. Therefore, the subjects were never climbing in an isolated environment. Observing students were instructed by the researcher to refrain from giving advice to climbers during their ascent, however, verbal encouragement was not controlled. It is possible that the subjects in the experimental group received greater verbal encouragement from their peers as they climbed, both during the training period and during testing. This could have promoted greater levels of motivation and determination in the experimental subjects, which in turn, may have produced greater improvements in performance.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The primary purpose of this study was to determine the effects of a 7-week hangboard training program on indoor rock climbing performance and grip strength in college age females. Twenty-one apparently healthy females (9 experimental and 12 control subjects) enrolled in two different beginning rock climbing classes at the University of Wisconsin-La Crosse successfully completed the study. Climbing performance and grip strength were measured prior to and upon completion of the 7-week hangboard training program.

Performance remained statistically similar from pre- to posttesting in the control group. Performance improved significantly from pre- to posttesting in the experimental group. No significant ($p > .05$) interaction between the groups was found for grip strength from pre- to posttesting.

Conclusions

According to the statistical analysis of the data of this study, the following conclusions were reached:

1. The 7-week hangboard training program resulted in improved indoor rock climbing performance in college age female rock climbers.
2. The 7-week hangboard training program did not provide a significantly greater benefit to grip strength than 7 weeks of indoor rock climbing class. This is shown by the control and experimental groups responding similarly in grip strength over the duration of the study.

Recommendations

Additional research is recommended by the researcher to provide more concrete information on the effects of hangboard training. There are several suggestions the researcher would make to anyone desiring to conduct further research in this area.

1. The training period should be longer than 7 weeks for significant physiological changes to occur in novice climbers. The researcher suggests a training duration of at least 12 weeks for future studies of this kind. Hangboard training or any other training of that nature can be harmful if done too frequently or too intensely, especially in novice climbers. It is this type of overtraining that the researcher tried to avoid during the intervention period. However, because duration could not be increased beyond 7 weeks, total training volume was considered to be insufficient to produce strength or endurance gains in the experimental subjects.
2. To produce a greater training effect, the researcher suggested using only advanced climbers and increasing training intensity with longer hang times, added weight, the addition of pull-ups, or a combination of these. Caution should be used to ensure that the subjects are using the correct technique and that they remain injury or pain free.
3. To prevent the subjects from learning the routes that they test on, the holds on the wall should be rearranged after pretesting. They should then remain the same through the duration of the study and then be moved back to their original position for posttesting. This would more accurately measure any physiological changes that occurred as a result of hangboard training as it would not allow the subjects to learn the easiest way to the top of a given route. They would be more reliant on their ability to grip the holds as they planned their next move.
4. A larger sample size is recommended for additional research of this nature.

REFERENCES

- American College of Sport Medicine. (1995). Guidelines for exercise testing and prescription. (5th ed.). Philadelphia, PA: Williams & Wilkins.
- Attarian, A. (1989). Artificial rock climbing walls - innovative adventure environments. Journal of Physical Education, Recreation, and Dance, 59 (9), 28-32.
- Clasey, J. L. (1987). The relationship between finger flexion force production and selected hand, forearm, and body physique. Unpublished master's thesis, University of Illinois at Urbana-Champaign, Urbana-Champaign.
- Darmi, P. (1992). The sport climbing competition handbook (Rev. ed.). Evergreen, CO: Chockstone.
- Erbesfield, R. (1997). Going for the gold. Climbing Magazine, 166, 112-117.
- Fox, B. (1996). Power tools. Rock & Ice, 72, 106-107.
- Gockley, C. (1990). Because it's there. American Fitness, May/June, 10-19.
- Goddard, D., & Neumann, U. (1993). Performance rock climbing. Mechanicsburg, PA: Stackpole.
- Heyward, V. H. (1991). Advanced fitness assessment and exercise prescription (2nd ed.). Champaign, IL: Human Kinetics.
- Horst, E. (1996). No excuses: Fingerboard workouts that don't cramp your style. Climbing, 159, 150-152.
- Horst, E. (1994). Flash training. Evergreen CO: Chockstone.
- Kascenska, J. R., Dewitt, J., & Roberts, T. (1992). Fitness guidelines for rock climbing students. Journal of Physical Education, Recreation, and Dance, 63 (3), 73-79.
- Long, J. (1993). How to rock climb (2nd ed.). Evergreen, CO: Chockstone.
- Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., & Rogers, S. (1985). Grip and pinch strength: Normative data for adults. Archives of Physical Medicine and Rehabilitation, 66, 69-72.
- Mathis, S.C. (1989). Finger contact force-time curves in a simulated rock climbing situation. Unpublished master's thesis, University of Maryland, Baltimore.
- Roberts, D. (1988). Showdown at the wall. Outside, Sept, 38-43.
- Russum, W. (1989). Physiological determinants of rock climbing ability. Unpublished master's thesis, San Jose State University, San Jose, CA.

Shirer, C. (1990). The whys and hows of a climbing conditioning class. Journal of Physical Education, Recreation, and Dance, 60 (9), 33-37.

Watts, P. B., Martin, D. T., & Durtschi, S. (1993). Anthropometric profiles of elite male and female competitive sport rock climbers. Journal of Sport Sciences, 11, 113-117.

Watts, P. B., Newbury, V. S., & Sulentic, J. E. (1996). Acute changes in handgrip strength, endurance, and blood lactate with sustained sport rock climbing. Journal of Sports Medicine and Physical Fitness, 36 (4), 255-260.

APPENDIX A
HANGBOARD DESCRIPTION

DIFFERENTIAL-TEX™ HANGBOARD DESCRIPTION

Hangboards, 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-Text™ (“Tex” is short for texture) hangboard is a product manufactured and marketed by Nicros Inc. of St. Paul, Minnesota. Nicros Inc. enlisted the help of Eric Horst, author of several books on training for climbers, who was the creative mind behind the design of the Differential-Text™ hangboard. 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 hangboard 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 hangboard 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 decreases, 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-Text™ hangboard is approximately 30 inches wide and eight inches high. The one and a half inch thick board is mounted to 3/4” plywood and secured to a wall or chin-up bar.

APPENDIX B
CLIMBING PERFORMANCE MEASUREMENT

CLIMBING PERFORMANCE MEASUREMENT

The American Sport Climbing Federation (ASCF) has established guidelines for the judging of sport climbing competitions. These rules and regulations clearly define a set number of parameters which enable the valid and consistent determination of a climber's performance. With little modification, these guidelines function well in gauging performance between competing climbers or, for the purpose of this study, between pre- and postexperimental intervention.

There are 12 climbing routes that may be ascended on the indoor climbing wall in Mitchell Hall on the University of Wisconsin-La Crosse campus. Each of these routes pose varying difficulty levels. For easy 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 begins the testing process by performing the established safety protocol, required per the UW-L Intramural Office, prior to any ascent, including the verbal contract (see Appendix E). As the subject ascends the first route, she earns a point for each hand hold that is successfully reached. Successful completion of a route is obtained when the subject reaches the upper most hand hold. At this time the climber is lowered to the ground and is allowed 5 minutes to rest before continuing on to successive routes of greater difficulty. Testing ends when the subject can no longer continue ascent due to fatigue, or losing purchase from the hand holds. Testing will also be stopped if the climber uses the assistance of hand holds that are not part of the color coded route or when the rope is used by climber for balance or support during the ascent. The subject will be lowered to the ground and given a numerical score. The score will be calculated by summing the total number of hand holds reached during the entire measurement process.

APPENDIX C
INFORMED CONSENT

The Effects of Hangboard Exercise on Climbing Performance and Grip Strength in College Age Female Indoor Rock Climbers

INFORMED CONSENT

Principal Investigator: Angie Kingsley 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™ hangboard on grip strength and climbing performance. I understand that my participation in this study may include training using the Differential-Tex hangboard. 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 Angie Kingsley 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?: Angie Kingsley, 1016 Jackson #3, La Crosse, WI 54601 (608)785-2690.

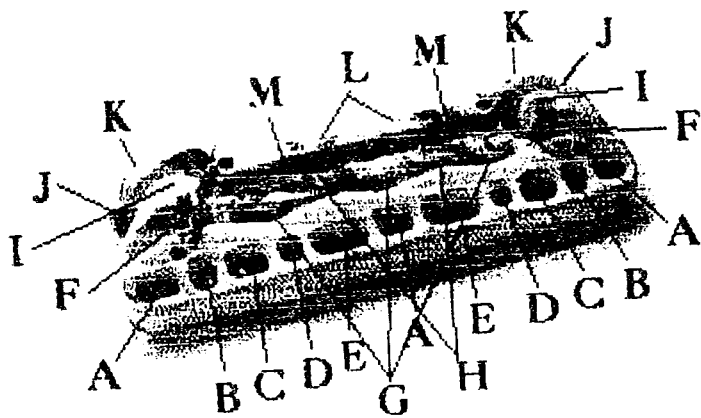
Signed: _____ Date: _____

Witness: _____ Date: _____

APPENDIX D
DIFFERENTIAL TEXT™ HANGBOARD DIAGRAM

DIFFERENTIAL-TEXT™ HANGBOARD DIAGRAM

Holds #1-6 correspond to letters
K, L, E, C, F, and I respectively.



HOLD KEY

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

APPENDIX E
CLIMBING VERBAL CONTRACT

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 measurement process.

PRIOR TO CLIMBING

“ON BELAY?” The question the climber asks before she begins climbing.

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

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

“CLIMB ON” The belayer’s response, indicating 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 slack in the rope.

“WATCH ME” Commands the belayer to pay close attention, expect or be prepared for the climber to fall.

“FALLING” The climber is losing 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 in a locked off position. 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 subject that she is safely on the ground.

“BELAY OFF” The belayer’s response to the climber that the belay has ended.