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The effect of training pattern on overuse injuries among rock climbers

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The Effect of Training Pattern on Overuse Injuries Among Rock Climbers

A Thesis

Presented to

The Faculty of the Department of Human Performance

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

Carl A. Timm IV

August 2000

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ABSTRACT

THE EFFECT OF TRAINING PATTERN ON OVERUSE INJURIES AMONG ROCK CLIMBERS

by CARL A TIMM IV

Presently, research dealing with rock climbing injuries has not offered a potential explanation supported by data as to the cause of overuse climbing injuries. Many recent studies have simply described injuries commonly associated with rock climbing, then offered hypothesis as to what may cause the injuries. Studies have not statistically explored the problem.

A clustered sample of recreational rock climbers was chosen for this study. These rock climbers were contacted through rock climbing gyms in the San Francisco Bay Area. A questionnaire containing twenty-one general questions as well as seventeen Likert-scale questions pertaining to injuries and training patterns was then administered. One hundred, fifty-six climbers were surveyed at a climbing gym in northern California.

Collectively, the participants of this study were on average $32.28 \text{ years} \pm 7.94 \text{ years}$. Most of the 156 subjects were male ($n=105$). The average weight reported was $154.54 \text{ pounds} \pm 26.29 \text{ pounds}$. On average the participants of this study had climbed $6.36 \text{ years} \pm 7.11 \text{ years}$ for an average of $2.2 \text{ days/week} \pm 1.08 \text{ days/week}$. During a typical climbing session the participant's averaged $316.06 \text{ feet/session} \pm 173.72 \text{ feet/session}$, and typically climbed on average a 5.10a (ranging between 5.8 and 5.10d).

The main question was: Is there a significant relationship between training frequency, training volume, training intensity, warm-up time, overall training score and injury status (overuse injuries vs. no overuse injuries)? Of the variables (intensity, frequency, volume, warm-up, and Likert-scale score) entered into the step-wise discriminant analysis, intensity was the

only variable that significantly helped to discriminate between those with an overuse injury and those with no overuse injury. Overall, the study added some insights regarding the relationship between training and overuse injuries including the finding that climbing intensity appears to be related to the development of overuse injuries. In addition, two related questions suggest a relationship between the number of overuse injuries and the best onsight and best redpoint (both measurements of intensity). There also seemed to be a difference in climbing volume between those with (336.93 feet/session) and without (290 feet/session) an overuse injury. However, to what extent intensity or volume was responsible was not determined.

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TABLE OF CONTENTS

	<u>Page</u>
Chapter I	
Introduction	1
Statement of the Problem	2
Approach to the Problem	3
Statement of the Hypothesis	3
Assumptions	3
Delimitations	3
Limitations	4
Definitions	4
Chapter II	
Introduction	6
Rock Climbing History	6
Overuse Conditions	11
Overuse Conditions Associated with Rock Climbing	13
Specific Injuries Associated with Rock Climbing	16
General Training	25
Recent Related Studies	33
Summary	39

Chapter III

Introduction	41
Subjects	41
Instrument	42
Instrument Development	42
Pilot Study Procedures	43
Subjects	43
Procedures	44
Pilot Study Results	44
Survey Modifications Based on Pilot Study	46
Main Study	48
Instrument Content	48
Subjects	50
Procedures	51
Analysis of Data	51
Survey Items	51
Main Question	52
Related Question	52

Chapter IV

Introduction	54
Main Study Results	54
Descriptive Statistics	54

Factor Analysis	57
Relevant Findings	58
Main Question	61
Related Questions	62
Chapter V	
Discussion & Conclusion	64
References	71
Appendix A	75
Appendix B	79
Appendix C	80

LIST OF TABLES

Table

1. Pilot Study Factor Matrix	45
2. Means and Standard Deviations of Continuous Variables	55
3. Frequencies of Categorical Variables	56
4. Primary Study Factor Matrix and Reliability Scores (Coefficient Alpha)	58
5. Summary Statistics for Those Whose Most Severe Injury Was Overuse Compared to Those Whose Most Severe Injury Was Not Overuse	60
6. Summary Statistics for Those With an Overuse Injury and Without	60
7. Correlations for Related Questions	63
8. Proposed Factor Structure	65

Chapter I

Introduction

With the increasing popularity of “extreme” sports in the last five years, the traditional public settings (e.g. academic/city sports programs) are not the only environment where an individual can train or engage in sport. The number of participants who snowboard, mountain bike, kayak, in-line skate, and skateboard has been growing on a professional level as well as recreational level. The same is also true for the extreme sport of rock climbing. Rock climbing, as an all-encompassing activity, has witnessed an enormous increase in participants in the recent past. Over 80% of all rock climbing gyms currently operating in America opened within the last five years. The Access Fund, the United States’ largest climbing organization, boasts over 3,900 new members from 1998–1999. Accompanying the growing number of rock climbers is the growing risk for new and specific injuries akin to the peculiarities of the activity.

Fortunately, the medical community is already familiar with most climbing injuries. The majority of injuries associated with rock climbing have been termed overuse injuries (Haas & Meyers, 1995; Maitland, 1992; Rooks, 1997; Rooks, Johnston, Ensor, McIntosh, & James, 1995). While it is true that more traumatic injuries (i.e. fractures, sprains, and paralysis) were once associated with rock climbing, these have been almost eliminated by modern advances in safety equipment (Haas & Meyers, 1995; Maitland, 1992; Rooks et al., 1995). Since a large majority of climbers have turned to a safer type of climbing found in gyms and sport climbing areas, it is possible to focus on the sport and difficulty of a climb rather than the risk factor. Therefore, climbers have

been able to push to new limits. In order to reach these limits, however, a new method of training has developed. This method of training has included climbing many days during a week, month, and year. It seems possible that multiple climbing days separated by relatively little rest has resulted in the development of overuse injuries among climbers (Haas & Meyers, 1995; Maitland, 1992).

The fact is that overuse injuries can stem from a variety of problems. These could include loads too great for the athlete, poor technique, faulty equipment, inappropriate anatomy for the sport, as well as a low work to rest ratio (Sperryn, 1994). In addition, overuse injuries can stem from overusing body parts as a result of improper training methods. It has been reported that climbers are not familiar with proper training schedules or how to avoid injury (Bollen & Gunson, 1990). It has also been widely published that upper limb overuse injuries are common among climbers (Haas & Meyers, 1995; Maitland, 1992; Rooks, 1997; Rooks et al., 1995). Yet the cause of these injuries is still unknown, and so it seems that studies must begin analyzing each plausible option. Therefore, the purpose of this study was to determine the impact of training patterns on the development of overuse injuries among rock climbers.

Statement of the Problem

Presently, research dealing with rock climbing injuries has not offered any potential explanation supported by statistical data. The current problem in the literature dealing with rock climbing injuries is the assumptions associated with the injuries. Many recent studies have simply described injuries commonly associated with rock

climbing, then offered hypothesis as to what may cause the injuries. However, to date, no studies have statistically explored the problem.

Approach to the Problem

A clustered sample of recreational rock climbers was chosen for this study. These rock climbers were contacted through rock climbing gyms in the San Francisco Bay Area. A questionnaire pertaining to injuries and training patterns was then administered.

Statement of the Hypothesis

1. There will be no relationship between the training pattern of rock climbers and acquired overuse injuries.

Assumptions

It was assumed that each participant was able to accurately separate an injury from “pains of training”. It was also assumed that participants accurately and honestly depicted their own training methods. Additional assumptions included that the sample was representative of the larger subgroup of Bay Area rock climbers as well as that the survey was sound. Also, it was assumed that a high from the 17 Likert-scaled items represented better the training habits.

Delimitations

This study was delimited to rock climbers who had been climbing at least six months. This was to avoid including individuals who just began climbing and had not had the chance to develop an overuse injury. This study was also delimited to climbers

who were eighteen years and older. This was done in order to obtain a sample that was as homogeneous as possible with respect to training resources and experience. Also, only those who climbed indoors using primarily ropes were surveyed. This was done in order to survey a group with similar climbing experience.

Limitations

One factor out of control of this study was that climbers may not have consulted proper medical authorities when injured. Therefore, these climbers may not have had accurate information to relay concerning those injuries. An additional limitation was that all climbing routes are rated subjectively, which allows for noticeable difference in ratings. This could have affected data collected that deals with climbing intensity and climbing volume. Finally, all data collected was retrospective.

Definitions

Bouldering: Climbing that is performed without a belay rope at the base of a cliff or on small boulders (Horst, 1997).

Climbing Frequency: The number of days per week a person climbs.

Climbing Intensity: The mean level of difficulty a person climbs.

Climbing Volume: The total number of feet a person climbs in a workout session.

On-sight: When a route is climbed the first try without falling and without prior information concerning the route (Horst, 1997).

Overuse Injuries: An injury that developed from repeated micro-traumas over a period time (Arnheim & Prentice, 1997; Starkey & Ryan, 1996).

Redpoint: When a route is climbed entirely without falling on a second or subsequent attempt (Horst, 1997).

Rock Climber: One who uses the rock as a means of gaining altitude (Horst, 1997).

Sport Climbing: Climbing that is performed with a belay rope that uses bolt-protection every five to ten feet in order to anchor the rope.

Top-Roping: Climbing that is performed with a belay rope that uses an anchor at the very top of the route only.

Training: Webster's Dictionary gives the simple definition of becoming "proficient or fit". There are many types of training including strength training, flexibility training, and endurance training, implying a person would become "proficient or fit" for that task. In terms of climbing, training would refer to activities that result in a person becoming a more "proficient or fit" climber.

Training Patterns: This refers to climbing frequency, climbing intensity, climbing volume, warm-up methods, and additional strength training.

Warm-up: A means of increasing general body temperature as well as stretching body parts prior to exercise. Often times a warm-up will also include practicing specific movements associated with the activity that is to follow (Baechele, 1994).

Chapter II

Review of Literature

Introduction

Rock climbing is currently viewed by society as a high-risk or “extreme” activity. This is supported by its inclusion in the ESPN summer X-games. Often times, injuries resulting from high-risk activities include fractures, paralysis, and even death. Although these are possible results, it has been observed that the more common injuries associated with rock climbing are overuse injuries (Bannister & Foster, 1986; Bollen, 1988; Haas & Meyers, 1995; Maitland, 1992; Rooks, 1997; Rooks et al., 1995). Therefore, this chapter offers a possible explanation as to why overuse climbing injuries have become prevalent. First, a brief overview on the history of rock climbing will be presented. Next, the development of overuse conditions will be explained, followed by descriptions of general overuse injury conditions possibly acquired by rock climbers. Then specific overuse injuries expected among rock climbers will be clarified. In addition, information concerning proper training methods and protocols will be relayed. Finally, previous research concerning climbing injuries will be discussed.

Rock Climbing History

The act of climbing has existed as long as humans have. However, rock climbing, which eventually led to the modern version, began as early as 1786. This year is marked by the story of King Charles VII giving his servants orders to assail a certain mountain (Corbett & Boga, 1995). His servants did so by the use of a wooden ladder. This method of using wooden ladders to summit remained the preferred method to summit for

an entire century (Corbett & Boga, 1995). However, the idea that reaching the alpine summit was the only point to climbing remained current in America as late as the 1960's (Long, 1998; Bacher & Boga, 1996; Corbett & Boga, 1995; Watts, 1992). At this point, alpine climbing was the practice of using any means necessary to reach the top.

Eventually, stronger, lighter, and more accessible pitons, bolts, and hooks (gear placed in the rock in order to attach a carabiner and rope) were invented by John Salathe and Yvon Chouinard in the late '50s through early '60s. From the 1930s through the 1950s the improved gear made it easier for Americans to climb. It was also the use of better gear that ushered in the next era of rock climbing.

The 1960s exploded with new climbing accomplishments due to the new gear available. It was in this decade that climbers began to climb every big wall with a summit that had previously been unclimbed (Bacher & Boga, 1996; Watts, 1992). At this time aid climbing found its roots. Aid climbing is the practice of leaning, standing, or pulling on the rope or anchors in order to rest or make progress. While all this had been transpiring in America, many changes were continuing in Europe. The rock climbers in Europe had long since been viewed as "further along" than their American counterparts (Long, 1998; Watts, 1992). After all, Europeans had been using more advanced gear since the early 20th century (Long, 1998). It was also as early as the 1920s that the Germans began a rating system, which was adopted in America by the Sierra Club in 1937 (Bacher & Boga, 1996). However, the Sierra Club adapted the rating system to classes, which remains in effect today. Class one is walking, class two is hiking, class

three is scrambling up rocks, class four is climbing risky enough for a fatal fall, class five is technical rock climbing called “free climbing”, and class six is aid climbing (Long, 1998). As a result of the early European achievements, those in America were often trying to “catch up” (Watts, 1992); however, in 1957 Americans began to step out from the shadow of European climbers. At this time Royal Robbins and Don Wilson further separated class five into ten subcategories (5.0 to 5.9) (Bacher & Boga, 1996). This system began in California and found its way to Yosemite by 1956 (Bacher & Boga, 1996). Later becoming known as the Yosemite Decimal System (Y.D.S.), it has been a climbing standard used nation wide ever since. However, this brought Americans to the realization that every summit could be reached given enough gear and time (Bacher & Boga, 1996). Therefore, Americans began focusing on style rather than the summit pursuit (Bacher & Boga, 1996), which began the era of the “clean climbing revolution” (Reid, 1998).

The clean climbing revolution began in Yosemite in the 1970s (Reid, 1998). From the 1930s to the 1960s it was not uncommon to leave pitons and bolts in the rock in efforts to reach the summit (Reid, 1998). It was in the 1970s when this was no longer acceptable. Although the practice of aid climbing was still often used, the new art of traditional (“trad”) climbing was introduced. Trad climbing involves attaching a rope and carabiner to pieces of protection placed in the rock. This is done to catch a climber in case of a fall. The pieces of protection can then be removed as the climb is finished rather than leaving bolts or pitons behind. Because climbers need cracks to place protection for a climb, the style of climbing often used at this time was crack climbing.

Crack climbing involves “jamming” fingers, hands, feet, and the body into cracks in order to progress. It was this type of climbing in its early phase that led to traumatic injuries infrequently seen today. It is also this “style-focused” climbing that relied on free climbing rather than aid climbing to gain altitude. Free climbing is climbing using only the holds on the rock itself rather than leaning, standing, or pulling on the rope or anchors (aid climbing). With free climbing, the rope and equipment are used solely as backup in case the climber falls. Another equipment advancement at this time involved a new, safe kernmantle rope, which replaced the old hemp ropes. All of these factors combined to help climbers complete climbs of increasing difficulty during the 1970s.

It was also the above mentioned factors that combined to lead the climbing community to its next phase. The 1980s have been associated with the “sport climbing revolution” (Green, 1998; Watts, 1992). Sport climbing involves hard, demanding climbing moves separated by pre-placed bolts in the rock that serve as protection points (places to attach a carabiner and a rope) (Watts, 1992). This style of climbing was not easily accepted at first. Those who climbed in the 1970s during the “clean climbing revolution” believed this was an offensive means of assaulting the rock (Long, 1998). In one sense it was a return to the older methods of leaving pitons and bolts in the rock, which was also offensive. However, it was a safe and viable means to climb rock faces that did not offer natural places for protection, such as cracks and crevices (Watts, 1992). Eventually, sport climbing offered climbers the opportunity to establish many routes on cliffs that were previously believed unclimbable due to lack of protection. Also, many of these new cliffs were found in locations that were easy to reach. This led to many people

climbing often with relative ease. At this point in time, weather was the only obstacle that prevented daily climbing. This led to the emergence of the modern rock climbing gyms in the mid-1980s. In 1985 Pacific Edge in Santa Cruz, CA was the first climbing gym to open in America.

One more significant advancement in 1982 was the invention of “sticky rubber” soles for rock climbing shoes. The combination of numerous easily accessible cliffs and indoor gyms has led climbers to train continuously in efforts to push the limits. This fact, along with the development of sticky climbing shoes, has made the Y.D.S. an open-ended system, which had been pushed from its original 5.9 to the 5.14s by the end of the 1980s (5.10 to 5.14 is further subdivided into a, b, c, d).

Finally, all the previously mentioned facts conjoin to bring climbing to the 1990s. Aid, traditional, and sport climbing are still enjoyed by many and advances continue to be made with equipment, shoes, and gyms. Whereas indoor climbing was once a way to train for outdoor climbing, now many enjoy indoor climbing as an activity itself. In fact, John Long (1997) stated that “indoor climbing is the fastest growing segment of the climbing world, with urban locations, easy access, controlled environment, and relative safety” (p. 5). However, yet another form of climbing moved into the limelight in the 1990s. Bouldering is the practice of climbing performed without a rope at the base of a cliff or on large pieces of rock that lie separately on the ground (Horst, 1997). Although this definition describes the roots of bouldering, currently it is considered by many to be an end in itself. With short routes (five to ten moves in a problem) that mimic hard sections of sport climbs and its own rating system

(the open-ended V scale), bouldering certainly seems to have taken on a life of its own. Bouldering began as early as climbing itself, but became more prominent at the same time as sport climbing in areas such as Smith Rocks (Watts, 1992). Also, climbers established hundreds of new boulder problems at Hueco Tanks, one of the premier bouldering spots in America, in the 1980s. With the advent of the bouldering pad (a safety crash mat) in 1990 (Sherman, 1997) as well as the attraction of a strong, gymnastic type of climbing, bouldering blossomed in the 1990s. This type of climbing, because of its short nature, tends to involve very small holds on overhanging rock. Since it is a powerful type of face climbing without protection, it is possible for both traumatic and overuse injuries to abound.

Climbing has witnessed an incredible transformation from alpine, summit climbing to its current state. Climbers today may enjoy aid, traditional, sport, bouldering, indoor climbing, or possibly a combination of all of the above. However, it seems that the majority of climbers engage in indoor climbing, sport climbing, and bouldering because of their convenience and abundance of locations (Long, 1998). Also, because of this convenience, modern climbers usually face climb many days a week, which can lead to overuse injuries.

Overuse Conditions

To begin this section, a definition of the term overuse is in order. As suggested in an article concerning medial epicondylitis written by Glazebrook, Curwin, Islam, Kozey, and Stanish (1994), "Mechanically induced injuries can be categorized into two

categories: acute trauma as a result of immediate tissue overload and chronic damage as a result of low-level but repetitive or prolonged loading.” (p. 674). What Glazebrook et. al, (1994) refer to as “chronic damage” is the same as “overuse” in this paper. A few causes of overuse injuries among athletes are loads too great for the athlete, poor technique, faulty equipment, inappropriate anatomy for the sport, or a low work to rest ratio (Sperryn, 1994). Excessive loads may include an athlete returning from a two-week injury to rejoin a team practicing at regular season pace. Poor technique may include poor squatting technique while weight lifting, which could produce low back pain or knee pain. Faulty equipment, such as a loose football helmet contributing to a concussion, could be at fault. Inappropriate anatomy for the sport can be seen in a cross-country runner who develops medial tibial stress syndrome as a result of pes planus (flat feet). Although the best advice for an individual with an overuse syndrome is to rest, that is seldom a realistic option. Therefore, activity modification is often the key to a healthy return (Bogard, Fanton, Figgie, Jupiter, & Larson, 1992).

As a variety of factors can cause overuse injuries, it is also possible for an overuse injury to reveal a variety of signs and symptoms. Overuse injury to bone could involve stress fractures or metabolic over-activity. Joints can develop soreness, tenderness, restricted movement, or effusions. Ligaments reveal tenderness, muscles reveal stiffness or strains, and tendons reveal overstrain or tenosynovitis (Sperryn, 1994). It is also possible to exhibit signs of overuse on nerves, which includes neuropraxia or nerve entrapment. Although rock climbers may not show signs of overuse associated with bones or ligaments, they may show signs of overuse associated with joints, muscles,

tendons, and nerves. Therefore, the conditions expected among rock climbers will be discussed in detail below.

Overuse Conditions Associated with Rock Climbing

Overuse injuries including strains, tendinitis, tenosynovitis, tendon lesions, joint contractures, and nerve entrapments will be explained in detail here. Overuse injuries to bone will not be discussed here since those types of injuries generally require a repetitive jarring action not found in climbing. The following injury types were chosen to describe in general terms the types of injuries seen in climbing.

Since many muscles in the upper extremities are required for climbing, it is not uncommon to develop injuries in these structures. A strain involves a tear or rip of muscle or tendon fibers, generally, but not always, associated with the eccentric loading of a muscle. This is usually the result of too much stretch or tension on these structures (Starkey & Ryan, 1996). Although Arnheim and Prentice (1997) attribute strains to many factors, Starkey and Ryan (1996) simplify the injury by stating that it “occurs when the muscle generates more force than its fibers can withstand” (p. 24). This seems to indicate that a strain is an acute injury. However, it is also true that when a muscle is overused its individual fibers are weakened and more susceptible to tear when the entire muscle unit generates more force than the fibers can withstand. After a strain has taken place it is assigned a grade depending on its severity. Grade I is characterized by minor stretching, or tearing of the fibers (Starkey & Ryan, 1996) with local pain and minor loss of strength

(Arnheim & Prentice, 1997). Grade II is much the same as Grade I, but more severe with ecchymosis (Starkey & Ryan, 1996) and impaired muscle function (Arnheim & Prentice, 1997). Finally, Grade III involves a complete tear of the muscle with loss of function, a palpable defect, pain, swelling, and ecchymosis (Arnheim & Prentice, 1997; Starkey & Ryan, 1996). Arnheim and Prentice (1997) include a list of the most common strains seen in athletics. Of that list, the muscles most likely affected in climbing include the gastrocnemius, spinalis group of the back, deltoid, and rotator cuff group of the shoulder.

Tendinitis is the term used to describe inflammation of a tendon (Starkey & Ryan, 1996; Curwin & Stanish, 1984). Curwin and Stanish (1984) explain that tendons are supplied with a less rich blood supply compared with other body structures. Therefore, after a tendon injury has taken place, it will take longer for the tendon to repair itself compared with other body structures (Glazebrook et. al, 1994). Since the definition of overuse is repetitive microtraumas, or prolonged loading, this can present a problem for the slow-healing tendon. Once the tendon is stretched to a ten percent strain a considerable microtrauma has taken place (Curwin & Stanish, 1984). Healing time for this may be significant. However, if ignored and subjected to further strain, eventually a pattern will develop ending in pain, inflammation, and tendinitis (Curwin & Stanish, 1984). Starkey and Ryan (1996) state that “although tendinitis may result from a single traumatic force, it most commonly arises from smaller repetitive forces” (p. 25). It is also noted that tendinitis may result from “the alteration of otherwise normal motion (which) redistributes the forces around a joint, resulting in new tensile loads” (Starkey & Ryan, 1996; p. 25). Tendinitis may also arise from “an increased magnitude or increased

duration of activity” (Glazebrook et. al, 1994; p. 677). Grades are assigned to tendinitis as well. Grade I is marked by pain and dysfunction during activity, grade II is associated with pain and dysfunction after activity, and grade III is characterized by constant pain that prohibits activity (Starkey & Ryan, 1996). Some common types of tendinitis (Curwin & Stanish, 1984) among athletes, including climbers, are tendinitis of the rotator cuff group of the shoulder, medial epicondylitis, and lateral epicondylitis.

Tenosynovitis is the inflammation of the synovial sheath surrounding a tendon (Arnheim & Prentice, 1997). The causes of tenosynovitis are very similar to the causes of tendinitis. Arnheim and Prentice (1997) explain that the signs and symptoms of acute tenosynovitis are pain, articular crepitus, and diffuse swelling. However, chronically, the tendon may become locally thickened as well. Starkey and Ryan (1996) state that the signs are similar to tendinitis, but the pain is more localized and the crepitus is more pronounced. These are the initial signs of tendinitis and tenosynovitis, but the long-term effects can be more severe. In general, prolonged tendinitis as well as prolonged tenosynovitis in anyone with an aggravated shoulder injury can result in partial-thickness tears of the tendon sheath, and eventually full-thickness tears of the tendon (Starkey & Ryan, 1996).

A contracture is a pathological shortening of muscle fibers which limits the length of a muscle (Starkey & Ryan, 1996). Arnheim and Prentice (1997) add to the definition that there is a great deal of resistance to passive stretch. This condition inevitably affects joint movement. Contracture commonly finds its origin in muscle injury, which produces unyielding and resisting scar tissue (Arnheim & Prentice, 1997).

A nerve entrapment is a nerve compressed between bone or soft tissue (Arnheim & Prentice, 1997). Often in the ankle, wrist, elbow, and cervical spine a nerve is required to pass through a small space, which increases the nerves' chance of entrapment (Arnheim & Prentice, 1997; Starkey & Ryan, 1996). This can cause sharp, burning pain, paresthesia (Arnheim & Prentice, 1997), and muscular weakness (Starkey & Ryan, 1996). The two most common sites for nerve entrapment among all people include the median nerve in the carpal tunnel and the ulnar nerve in the Guyon tunnel (Arnheim & Prentice, 1997).

Specific Injuries Associated with Rock Climbing

The previous information dealt with six conditions likely to be seen among rock climbers. These included strains, tendinitis, tenosynovitis, tendon lesions, joint contractures, and nerve entrapments. The following information will begin to explain in detail very specific overuse injuries expected among climbers. The injuries discussed below will be found in the hand, wrist, elbow, and shoulder.

A rock climber has the possibility of developing many different overuse injuries in the hand. They include, but may not be limited to, fingertip injuries, strains to the insertion points of the flexor digitorum superficialis ("climber's finger") and flexor digitorum profundus, a disruption of the finger flexor pulley system ("bowstring finger"), proximal interphalangeal (PIP) joint contractures, avulsion of the flexor digitorum profundus ("jersey finger"), and chronic stenosing tenosynovitis ("trigger finger"). Each of these injuries will be explained in terms of etiology, signs and symptoms, and management.

A fingertip injury in rock climbing as described by Cole (1990) “consists of damage to the skin of the finger tips caused by prolonged extreme rock climbing” (p. 14). The appearance of this injury, as generally seen on the index and middle fingers, is red skin with minor serous exudate (Cole 1990). This may turn white with extremely thin skin, and if climbing is continued, the skin may split (Cole 1990). Recovery generally occurs within one to two weeks of rest, which is the best method of management for this injury (Cole 1990).

Though the following four injuries can appear separately, it is possible that one may lead to the other. The first injury includes a strain to the flexor digitorum superficialis insertion, which is now called “climber’s finger”. The second injury is a strain to the insertion of the flexor digitorum profundus. The third injury is a disruption of the finger flexor pulley system, which in lay terms can produce a “bowstring finger”. Finally, the last related injury is a proximal interphalangeal (PIP) joint contracture.

The flexor digitorum superficialis is responsible for PIP flexion, metacarpal-phalangeal (MCP) flexion, and wrist flexion. It finds its origin on the medial epicondyle via the common flexor tendon, and its insertion is in the side of the middle phalanx on all four phalanges. While face climbing, an extra load is transferred off of the flexor digitorum profundus and onto the flexor digitorum superficialis (Rooks, 1997; Bollen, 1988). The reason this occurs while face climbing is because the “crimp” grip is commonly employed. The crimp grip places the PIP joint into flexion while hyper-extending the distal interphalangeal (DIP) joint. This places the flexor digitorum profundus at a mechanical disadvantage (Bollen, 1988). The extra load is what may

result in micro-tears, or a strain, at the superficialis insertion. These micro-tears could also be responsible for the development of tendinitis (Starkey & Ryan, 1996). Since this is a phenomena found primarily among rock climbers, this injury has been termed “climber’s finger” (Rooks, 1997; Bollen, 1988). Management for this injury should include rest and ice. If a person continues to climb, it is helpful to tape the finger in order to apply circumferential compression (Rooks, 1997; Bollen, 1988). However, if the injury is severe enough (avulsion or near-avulsion), surgical repair may be necessary.

Another injury to climbers caused by the popular “crimp” grip is a strain to the insertion of the flexor digitorum profundus. The profundus finds its origin on the anteromedial proximal three-fourths of the ulna and associated interosseous membrane, and it finds its insertion on the distal phalanx of the four phalanges. Its action is DIP flexion, PIP flexion, and wrist flexion. If a strain is severe enough to cause an avulsion of the tendon from its insertion, this injury is termed “jersey finger”. This results from a forced hyperextension of the DIP joint against an actively contracting flexor tendon (Hoffman & Schaffer, 1991). Again, this action accurately describes the “crimp” grip used while climbing. Management of a jersey finger involves placing the DIP joint in an extension splint for six weeks continually without removing the splint.

The two previous injuries discussed can occur in conjunction with a disruption to the finger flexor pulley system. Each phalange has five annular pulleys (A1-A5), which are actually retinacular thickenings that function as pulleys. These pulleys are very strong and act as band-like structures to keep the tendons and their sheaths close to the phalange (Jebson & Steyers, 1997). Essentially, they help to prevent

tendon bowstringing during active flexion. Tendon bowstringing is when the finger is flexed and the tendon does not travel next to the bone. Instead the tendon bows out wherever the pulley is not holding it in. Often, when the flexor digitorum superficialis insertion suffers a strain (or tear) the A2 pulley also suffers damage (Rooks, 1997). This allows the finger to bowstring, and again the term “climber’s finger” is applied to this injury (Haas & Meyers, 1995). Injury to the A2 pulley has become a very common injury among rock climbers (Gabl et al., 1998; Jebson & Steyers, 1997; Rooks, 1997; Haas & Meyers, 1995; Bollen & Gunson, 1990). Apparently, the ring and middle fingers are the most vulnerable to this injury (Bollen, 1988). If this injury is severe, physician referral is recommended (Jebson & Steyers, 1997). However, if minor pain is persistent, this could be indicative of future problems and firm taping around the proximal and middle phalanxes may be beneficial (Bollen & Gunson, 1990).

As discussed above, a contracture is a pathological shortening of muscle fibers which limits the length of a muscle. A PIP joint contracture is a common injury seen among rock climbers (Jebson & Steyers, 1997). This generally occurs secondary to flexor digitorum superficialis and profundus strains, pulley ruptures, and bowstringing (Rooks, 1997). Jebson and Steyers (1997) have stated that this injury is usually seen bilaterally and most common in the ring finger. Treatment involves rest, ice, stretching, anti-inflammatory medication, and a dynamic PIP joint extension splint (Jebson & Steyers, 1997). Severe conditions may require surgery.

One of the most common forms of tenosynovitis is “trigger finger” (Arnheim & Prentice, 1997). This is also called chronic stenosing tenosynovitis. This occurs when repetitive friction from a tendon passing under an annular pulley causes a narrowing (stenosing) of the pulley (Schwartz & Weinstein, 1996). As the pulley narrows the tendon may often become caught up in the pulley, which feels as though it is sticking. Thus the name “trigger finger”. Often times those suffering from this will complain that as the finger is flexed there is resistance to re-extension, and a palpable and audible snapping may be present (Arnheim & Prentice, 1997). Treatment includes immobilization, rest, cryotherapy, and anti-inflammatory medications (Arnheim & Prentice, 1997). However, if these methods are failing, steroid injections followed by surgery are an option (Schwartz & Weinstein, 1996).

Though not as many climbing injuries are found in the wrist as in the hand, the wrist is still susceptible to injury. Generally, the injuries most likely to occur in a climber’s wrist include tendinitis in the flexor digitorum and carpal tunnel syndrome. Both of these injuries will be viewed in terms of etiology, signs and symptoms, and management.

It is common in sports that require repetitive pulling movements to produce tendinitis in the flexor digitorum muscles. Though this was discussed in the finger injury section, this particular tendinitis can also be found in the wrist. This happens to be a potential precursor to carpal tunnel syndrome. Tendinitis found in the flexor digitorum muscles in the wrist may arise from “an increased magnitude or increased duration of activity” (Glazebrook et. al, 1994; p. 677). Swelling will not be noticed due to the

tendons running deep within the arm. However, tenderness will be felt during normal wrist range of motion. Management for this includes rest, cryotherapy, and anti-inflammatory medications (Arnheim & Prentice, 1997).

Carpal tunnel syndrome is an overuse injury, which can result from a rock climber's repetitive, sustained wrist flexion (Arnheim & Prentice, 1997; Jebson & Steyers, 1997; Haas & Meyers, 1995). The carpal tunnel is formed by the carpal bones on the floor of the tunnel and the transverse carpal ligament on the roof of the tunnel. The flexor tendons as well as the median nerve then fill the tunnel (Arnheim & Prentice, 1997). It is when the flexor tendons become inflamed within this small space that the nerve becomes entrapped. Often times this injury will result in occasional numbness of the thumb, index, and middle fingers, and if the injury continues unattended, weakness in a pinch grip can be noticed (Arnheim & Prentice, 1997; Jebson & Steyers, 1997). Initial treatment includes avoiding climbing, possibly splinting the wrist at night, and anti-inflammatory medications (Arnheim & Prentice, 1997). If the problem persists, steroid injections and surgery may be of benefit.

Injuries to the elbow will be discussed next. Climbing injuries to the elbow include medial epicondylitis, lateral epicondylitis, and brachialis tendinitis ("climber's elbow"). These will be explained in terms of etiology, signs and symptoms, and management.

Of the three elbow injuries mentioned, medial epicondylitis is the least common among rock climbers (Bollen, 1988). In general, medial epicondylitis is

about twenty percent as common as lateral epicondylitis (Birrer, Garrick, & Hench, 1989). Medial epicondylitis is an irritation and inflammation of the medial epicondyle (Arnheim & Prentice, 1997). To be more specific, it is the inflammation of the common flexor tendon, comprised of the flexor carpi radialis, flexor carpi ulnaris, and palmaris longus muscles (Glazebrook et al., 1994; Birrer et. al, 1989). Medial epicondylitis is caused by excessive, and often explosive, wrist flexion (Arnheim & Prentice, 1997; Birrer et. al, 1989). Glazebrook et. al, (1994), however, suggests there may be three possible explanations for both medial and lateral epicondylitis. The first is that individuals execute their sports skill in a manner that is biomechanically inefficient. Second, the cause may be an overuse of muscles that attach to the medial epicondyle or lateral epicondyle with little relative rest. Third, there may be a change in the biochemistry of the tendon (Glazebrook et. al, 1994). Regardless of the cause, pain is found around the medial epicondyle on active flexion or passive extension. Often times there is point tenderness and mild swelling in the same area (Arnheim & Prentice, 1997). Conservative treatment of this injury includes rest, cryotherapy, ultrasound, anti-inflammatory medications, and a curvilinear brace (Arnheim & Prentice, 1997). Alternatively, Brenner (1987) would suggest the most important aspect of managing any epicondylitis would be to apply a progressive resistance exercise program to strengthen the forearm extensor muscles.

The second most common elbow injury among climbers is lateral epicondylitis. General epicondylitis statements as made above also apply to lateral epicondylitis. This

condition, which is the inflammation of the extensor carpi radialis brevis, is the most common upper-extremity overuse injury seen in sports (Birrer et. al, 1989). The onset is generally gradual (Birrer et. al, 1989) and due to repeated forearm flexion and extension (Arnheim & Prentice, 1997), or possibly to forearm traction (Foley, 1993). Forearm traction occurs when a person is hanging from the hand or pulling with the hand as in pull-ups or climbing. Haas and Meyers (1995) believe this “condition is produced by isometric contraction of the wrist extensors when the elbow is placed in an extended position” (p. 203). Tenderness is noted at the lateral epicondyle (Arnheim & Prentice, 1997; Birrer et. al, 1989) as well as pain during resisted wrist dorsiflexion and full extension of the elbow (Arnheim & Prentice, 1997). Conservative treatment of this injury includes rest, cryotherapy, ultrasound, anti-inflammatory medications, and a curvilinear brace (Arnheim & Prentice, 1997). Bogard, et al. (1992) suggest that most who suffer from lateral epicondylitis will benefit from Mill’s maneuver, which is a treatment for this condition. Mill’s maneuver requires the patient to flex and pronate the forearm while flexing the wrist and then extending the forearm.

Finally, the last elbow injury has been reported to be the most common among rock climbers (Bollen, 1988). The technical term for this injury is brachialis tendinitis, however, due to its uniqueness to climbers, it has been termed “climber’s elbow” (Haas & Meyers, 1995; Bollen, 1988). Also because of its uniqueness to climbers, there is not much known about this injury. The brachialis muscle originates on the distal one-half of the anterior humerus and its insertion is the coronoid process of the ulna. Its main action is elbow flexion. It seems that if a climber is exhibiting improper climbing technique by

holding their arm in a pronated, semi-flexed position, this places much stress on the brachialis muscle thereby causing tendinitis (Haas & Meyers, 1995; Bollen, 1988).

However, if a climber climbs with proper technique this will place the forearm in traction and possibly cause lateral epicondylitis as discussed above. “Climber’s elbow” will cause point tenderness over the brachialis muscle as well as illicit pain during elbow flexion with the forearm in a pronated position. Care for this injury is much the same as discussed above with the other elbow conditions, which includes rest, cryotherapy, ultrasound, and anti-inflammatory medications.

Next, shoulder injuries will be discussed. As shown, the further away from the hand the injury is, it seems fewer injuries occur. There will be two injuries mentioned concerning the shoulder. However, the first injury can potentially lead to the second, and will therefore be discussed together. They are rotator cuff tendinitis and impingement syndrome.

Impingement syndrome has been reported to be a condition that rock climbers can acquire (Haas & Meyers, 1995; Bollen, 1988). A “shoulder impingement involves a mechanical compression of the supraspinatus tendon, the subacromial bursa, and the long head of the biceps tendon, all of which are located under the coracoacromial arch” (Arnheim & Prentice, 1997) (p. 571). If compression of these structures continues, they will become irritated and inflamed (Arnheim & Prentice, 1997). Therefore, a process takes place with this injury, which develops in stages. The major symptom found in Stage I is tenderness over the supraspinatus or biceps tendon insertions (Arnheim & Prentice, 1997; Brunet, Norwood, & Sykes, 1997). Stage II is the thickening of these

tendons, otherwise known as tendinitis (Arnheim & Prentice, 1997; Brunet et al., 1997). Stage III generally occurs in athletes who have exhibited signs of Stage I and Stage II for years and it consists of partial- or complete-tears of the involved tendons (Arnheim & Prentice, 1997; Brunet et al., 1997). An individual can incur this injury by reaching above the head while flexing the muscles at the same time (Arnheim & Prentice, 1997). There will be tenderness around the acromion as well as the subacromial space (Arnheim & Prentice, 1997). Generally the external rotators will be weaker than the internal rotators, there may be a positive impingement sign, and both the empty can test and drop arm test may illicit pain (Arnheim & Prentice, 1997). For early signs of shoulder impingement, strengthening of the rotator cuff muscles is beneficial. Also, rest, ice, electrical stimulation, ultrasound, and anti-inflammatory medications have proved useful (Arnheim & Prentice, 1997).

The previous discussion about injuries included many different injuries with many different specific causes. However, they are all overuse injuries. It is possible that those types of injuries could be the result of a biomechanical fault or a muscle-chemical imbalance. However, if a person works within his or her limits it may be possible to avoid many of these injuries. With that in mind, the following discussion will focus on proper training protocols.

General Training

The following training protocols will provide a climber with a two-fold benefit. The first is the potential to excel as a climber, and second the climber may better avoid injury. The second benefit may be much more appealing to the climber who climbs

simply for the enjoyment of the activity. Regardless of whether a person is a competitive climber, or one who enjoys it as leisure activity, there is benefit in awareness of training protocols. Therefore this section will touch on general training guidelines that are associated with stretching, warming-up, muscle balance, training intensity, training volume, training frequency, periodization, and overtraining.

The topics of stretching and warming-up are a good place to begin. A general warm-up is important for increasing heart rate, blood flow, deep muscle temperature, respiration rate, viscosity of joint fluids, and perspiration (Baechle, 1994). Stretching is often considered effective in lowering the rate of injury (Bompa, 1999; Baechle, 1994). Therefore, it is important to begin any exercise session with a general warm-up. This may consist of five to ten minutes of a light jog or bicycling. This general warm-up should be followed by five to ten minutes of sport stretches, such as shoulder and forearm stretches for climbers. Following this a sport specific warm-up can take place, which may include climbing a couple “easy” routes. Ideally, stretching should be performed before activity in order to assist in warm-up, but also after activity to help assist in increasing range of motion (Baechle, 1994). Post-exercise stretching allows the muscles to stretch further than usual (because of increased muscle temperature) thereby enhancing flexibility (Baechle, 1994).

Muscle balance is a concept that could positively benefit rock climbers. “Muscle balance is the strength, power, or endurance of one muscle or muscle group relative to another muscle or muscle group” (Baechle, 1994) (p. 424). Climbing is a sport that requires much strength from the upper back muscles, biceps, and wrist flexor muscles.

However, it does not require much from the pectorals, triceps, or wrist extensor muscles, which are the antagonists to the aforementioned body parts, respectively. As the prime movers for climbing are strengthened through the activity itself, the antagonists are placed under greater stress as well as the joints they both pull on (Baechle, 1994).

Therefore, ideally, the antagonists should be strengthened in order to aid in performance as well as prevent injury (Baechle, 1994). It has been suggested that wrist extensor/flexor strength should be close to a 1:1 ratio in order to avoid injury to structures associated with the wrist (Brenner, 1987). Elbow flexion/extension should be 1:1, and shoulder flexion/extension should be approximately 2:3 in order to avoid injury to these structures. By maintaining these ratios, or ratios close to these, a climber may improve performance as well as avoid injury (Baechle, 1994).

The next few principles are best explained together. These principles include training intensity, training volume, and training frequency. These concepts should be explained together because they are critical concepts within the idea of periodization. Simply put, periodization organizes training into cycles of training objectives and content in order to prevent overtraining and optimize peak performance (Baechle, 1994). Its key method is variation with the objective to change stimulus so staleness or overtraining do not develop (Fleck & Kraemer, 1987). Periodization has been developed based on the General Adaptation Syndrome (GAS) theory. The GAS theory suggests that three stages of training exist (Baechle, 1994). Stage I is the alarm phase in which the body is introduced to a new training stimulus. Therefore, one to two weeks of soreness, stiffness, and decreased performance result. Stage II is the resistance or adaptation phase. In this

phase the body adapts in every way possible, which leads to increased strength and performance. Stage III is the maladaptation phase in which adaptations are no longer taking place and staleness and overtraining set in. It is the final stage that an athlete wishes to avoid. In order to avoid this stage periodization manipulates training intensity and volume through various cycles (Baechle, 1994; Fleck & Kraemer, 1987). A cycle can last from one week to a few years depending on the goal (Baechle, 1994). Generally, cycles begin with high volume and low intensity and gradually build to high intensity and low volume (Bompa, 1999; Baechle, 1994). When the cycle is complete, it is hoped that the athlete will have a higher fitness level than previously, and allow for a higher start point in the next cycle. Though all this information is scientific in nature, it is generally accepted that the construction of a periodization program is largely an art form based on individual and sport characteristics (Fleck & Kraemer, 1987). To further understand periodization, training frequency, training intensity, and training volume will be explained.

Training frequency is the number of completed activity sessions in a certain amount of time (Baechle, 1994). Training frequency can be a highly individual matter. It may depend largely on the intensity and volume of the previous session, the current fitness level of a person, or the fact that some muscle groups recuperate faster (Baechle, 1994). Also, athletes who engage in multiple joint muscle activities need more recuperation time compared to single joint movements before the next heavy loading session on the same muscle group (Baechle, 1994). Another important concept concerning frequency is that a person can train more frequently if lighter loading sessions

are spaced between heavy sessions (Baechle, 1994). In fact, Baechle suggests that frequency may depend primarily on the intensity of the surrounding sessions.

Traditionally, athletes have alternated days of resistance exercise between the upper body and lower body to enhance recovery; however, other research suggests that resistance exercise on the same body part alternating every three days is optimal (Baechle, 1994).

The traditional method involved individuals lifting weights on Monday, Wednesday, and Friday to achieve full recovery (Fleck & Kraemer, 1987). If an individual did lift weights on every day, then different body parts would be selected daily in order to adequately recover (Fleck & Kraemer, 1987). These methods would be implemented to decrease soreness over a twenty-four hour period (Fleck & Kraemer, 1987). It has been suggested that when strength training and weight training tax the same energy system (or same muscles) that the next training session should be at least 48 hours later in order to allow for full glycogen restoration (Bompa, 1999). One author observed that no difference in strength gains existed for those who lifted weights one day per week compared to those who lifted weights two, three, or five days a week as long as the total volume per week was consistent (Baechle, 1994). Therefore, it was suggested that only one workout session per week at maximum resistance is needed to maintain strength (Baechle, 1994).

To relate to climbing, one author has suggested that a novice climber can climb daily, but a more experienced climber who climbs on more difficult routes should climb only two to four days per week (Horst, 1997). However, the above information indicates that a climber should climb every other day, and possibly only every third day.

Training intensity is “recognized as the most critical aspect of a conditioning regime” (Baechle, 1994) (p. 435). In terms of weight lifting, training intensity is the amount of weight per repetition, or it can be described as a person’s repetition maximum (Baechle, 1994). It is a person’s maximum exerted effort to lift a certain amount of weight one time. In terms of climbing, training intensity could be considered a person’s best onsight ability. To onsight a climb is to climb a route on the first try without falling and without prior information concerning the route. This could be considered training intensity because it is a person’s maximum exerted effort to climb a route on the first attempt. However, the climbing difficulty does not readily translate to a quantifiable number.

Scientific studies have attempted to set guidelines for intensity (Baechle, 1994). However, intensity is also a highly individualistic variable. One study suggested that an athlete should exert maximum intensity once a week and surround that session with light to moderate intensity sessions (Baechle, 1994). It was also suggested that to implement maximum training intensity during every session was ineffective (Baechle, 1994). The gradual and progressive overloading of muscle is believed to be the key to accomplishing strength gains (Bompa, 1999; Fleck & Kraemer, 1987). However, the previously mentioned study suggested that it would not be effective to continuously apply a heavier intensity. Therefore, periodization is important in order to provide optimal recovery (Baechle, 1994).

Training volume is described in weight lifting as the total amount of weight lifted in a workout session (Baechle, 1994). For example, if a person lifts 50 pounds. for two

sets of twenty repetitions, the volume they have lifted is 2000 pounds. Therefore, for climbing purposes, training volume could be considered the total amount of climbing a person has done in one session. For example, if a person climbs five routes that are 30ft. long, his/her training volume would be 150 ft. for that day.

As periodization has been discussed, it is suggested that volume be frequently adjusted to avoid overtraining (Baechle, 1994). In fact, volume, like frequency and intensity is also a highly individualistic variable. Training volume can be manipulated depending on the desired goal. High volume lends itself to increasing muscular endurance and/or maximum strength, whereas a medium volume is suitable for increases in power (Bompa, 1999). It has been suggested that training volume can increase as a person adapts to the exercise (Baechle, 1994). However, if there is a dramatic or abrupt increase in volume, fatigue, low muscular gains, or injury could result (Bompa, 1999). A progressive plan as implemented with periodization can help to avoid this (Bompa, 1999). Thus, it is important for volume to be considered in order to assist in proper periodization for rock climbers.

As discussed above, periodization is important. It allows an athlete to continually progress by means of continual adaptation to progressive overloads. Yet, at the same time it adjusts important variables, such as training intensity, volume, and frequency in order to avoid overload. Generally, a weight lifter would not lift the heaviest load possible in five separate sets every single day. First of all, the lifter would likely not advance, and second, the risk of injury would be high. Yet, it seems many climbers

attempt to climb as hard as they can every time they climb (Maitland, 1992). It is this type of training that can potentially lead to an overtraining syndrome.

Baechle (1994) defines overtraining syndrome as “excessive volume or intensity of training, or both, resulting in fatigue” (p. 459). Baechle has also shown that early stages of overtraining may just affect neuron functions and motor unit recruitment and show no negative effects on performance. But if left unaltered, later stages can decrease motor coordination thereby decreasing performance, decrease muscle glycogen (affecting strength), increase resting heart rate and blood pressure, alter immune function and hormonal concentration, as well as incite mood disturbances. This can lead to sickness, emotional disturbances, and sleep disturbances (Baechle, 1994).

The ill side effects mentioned above can be easily avoided by a system of periodization. Although, there are no set rules for any sports as to the proper amount of training frequency, intensity, and volume, general guidelines do exist. This is especially true for the sport of rock climbing. Though a few published books have accurately depicted proper training protocols for climbing, it would be beneficial to follow general guidelines. If those general guidelines as stated above are followed by a rock climber with individual characteristics and goals in mind, benefits should be evident. In additions to those benefits, injuries associated with rock climbing, as discussed below, could possibly be avoided.

Recent Related Studies

Many different authors have published information regarding climbing injuries over the last thirteen years. These published works begin as early as 1986 with the last one being published in 1998.

In an article entitled *Upper Limb Injuries Associated with Rock Climbers*, Bannister and Foster (1986) reported four cases where overuse climbing injuries went unnoticed due to the “unawareness of the range of injuries seen in high grade rock climbing” (p. 55). This article pointed out that proper injury information and proper training for “conventional” sports was available, but not for rock climbing. Bannister and Foster (1986) then explained four overuse injuries acquired by rock climbers in their study, which included tendinitis, profundus avulsion, and tenosynovitis. Finally, the authors concluded that “traditional injuries” such as broken bones and head injuries were quite rare due to advances in safety equipment. Bannister and Foster (1986) also noted that due to the increase in gym climbing and indoor winter climbing, many injuries associated with climbing were training related injuries associated mainly with the upper limbs. However, this study only surveyed four individuals, which limits its generalizability.

The next related article, published in 1988 by Bollen, was entitled *Soft Tissue Injury in Extreme Rock Climbers*. Bollen (1988) agreed that many traumatic injuries were now rare having been replaced by “increasingly common” overuse injuries. Bollen (1988) believed this was due to many climbers training many winter days and “every possible day in the summer” (p. 148). Therefore, a survey was developed “to look at the

injuries sustained during intensive periods of climbing or training” (p. 145). The questionnaire was restricted to climbers climbing at the “extreme” standard of the British rating system E1 to E6 (This roughly equates to the Yosemite Decimal System’s 5.10a to 5.12d). Males returned seventy-six of the questionnaires and females returned ten questionnaires. Seventeen reported no injuries. Of the 86 individuals surveyed, 115 injuries were reported as symptomatic for ten days or longer. Fifty-four of these occurred during training. Eighty-nine percent of these injuries involved the upper limb. There were 16 shoulder injuries, 19 elbow injuries, and the other half (34) reported hand and wrist injuries. Of the hand injuries, the most vulnerable digits were the ring and middle finger (42% and 53% of cases respectively). Only 21 sought medical attention, and 16 of them visited a general practitioner. Those who did not seek a professional opinion received a “tentative diagnosis” by the researcher based on the returned questionnaire. This procedure appears hard to reproduce accurately. Bollen (1988) also reported there was ignorance within the sport of climbing concerning training methods. To support this point, the article stated that 45% of climbers do not warm-up before climbing, and those that do only warm-up for an average of eight minutes. At one point, Bollen (1988) stated there was “no correlation between standard of difficulty of climbing and number or type of injury” (p. 145) (Bollen investigated climbers who climb at a range between 5.10a and 5.13a). However, the author made no attempt to support this statement with a statistical analysis. Since other studies as discussed below did not agree with Bollen’s statement regarding climbing intensity and type of injury, the current study will attempt to address Bollen’s findings statistically.

Bollen joined with Gunson in 1990 to publish *Hand Injuries in Competition Climbers*. This was meant to be a follow-up study to the previously mentioned study by Bollen. In this study, 67 male competitors in the British Open climbing competition were examined for signs of previous hand injury. Eighteen climbers (26%) exhibited signs of bowstringing on the proximal phalanx of the ring finger. This indicated possible injury to the A2 pulley. Sixteen climbers (24%) exhibited signs of PIP joint contractures affecting ten to fifteen degrees of extension. The mean age of climbers affected by this problem was 29 years of age. Two climbers (3%) showed signs of flexor digitorum superficialis tendinitis. Again, Bollen and Gunson (1990) concluded that climbers know little about training schedules and techniques. They also noted climbers do not acknowledge the need to stretch. This could be important since a proper warm-up and stretching in conjunction with other sports has been shown to reduce the chance of any type of injury (Baechle, 1994).

Cole (1990) reported on *Fingertip injuries in Rock Climbers*. This study surveyed a group of rock climbers who had been climbing for a week in Australia. It was determined that fingertip injury consisted of damage to the skin of the finger tips caused by prolonged rock climbing. Cole (1990) reported that those who rested only one to two days per climbing week were affected by this injury. Those who rested two to four days per climbing week were not affected. This may be the case for most all overuse climbing injuries. In any case, this particular finger tip injury healed within one to two weeks' rest (Cole, 1990).

Maitland (1992) conducted another survey in order to assess the injuries associated with rock climbing. Questionnaires were distributed both by the researcher as well as mailed. A total of 148 climbers responded (115 males, 33 females). The climbers ranged from recreational to competitive, with an age range of 15 to 54 years old. The median hours of climbing per week for off-season were 1 – 3 hours, and for peak season were 4 – 6 hours. The difficulty level ranged between 5.8 and 5.11. There were a total of 124 injuries reported with 102 of these being overuse injuries. Overuse injuries to the hand (28%), the elbow (19%), and the shoulder (8%) were reported. However, 23% of respondents had injuries to more than one body part. Maitland (1992) agreed with previously mentioned studies that overuse injuries primarily in the upper limbs are most common. Maitland (1992) concluded that traumatic injuries occurred at one fifth the rate of overuse injuries among rock climbers. Another conclusion was that an “analysis of the individual’s training techniques and activity patterns . . . may elucidate the mechanism of overuse injury and lead to modifications” (Maitland, 1992) (p.72). The author also noted that the study was limited by the imprecise nature of data collection via surveys as well as the fact that respondents were not from a random sample of climbing wall users.

Bollen and Wright (1994) conducted a study to assess whether radiographic changes occurred in climbers’ hands at a faster rate than control groups. The authors argued this as a plausible theory since climbers place great demands on their hands as weight bearing structures. Thirty-six rock climbers were given radiographs of each hand. These radiographs were then compared to a control group of similar men who work with

their hands daily. Climbers displayed small spurs at the bases of the middle phalanges, which became detached as the age of the climber increased. Pronounced scalloping of the necks of the proximal phalanges was also seen in twelve of the climbers. However, none of these conditions appeared in the control group. This study also stated that these effects take place in climbers who climb at a low level for many years as well as those who climb at high levels for a few short years (Bollen & Wright, 1994).

Haas and Meyers (1995) published an article entitled *Rock Climbing Injuries* in an attempt to review the etiology and prevalence of rock climbing injuries. These authors have agreed with previous authors concerning overuse injuries being prevalent as a result of increased training levels. Haas and Meyers (1995) assert that overuse injuries could be due to excessive exercise, too heavy a workload too fast, improper training techniques, or inadequate rest. They also state that climbers do not rest enough between climbs and they tend to climb while injured, which predisposes them to stress-related injuries. Haas and Meyers (1995) also commented on the “equivocal” condition of the statement by Bollen (1988) concerning no correlation between climbing difficulty and injury. These authors also made two very important suggestions within this article. The first was that climbers need medical attention from those who are familiar with both sports medicine and climbing. The second is that previous studies focused mainly on the “aetiology of rock climbing injuries,” and therefore, “recognition and further study of overuse injury patterns observed in rock climbers are required which will help reduce injury and

enhance rehabilitation” (Haas & Meyers, 1995) (p. 204). Although the observances and suggestions from this article are very good, they lack the strength and power that can be added through the statistical analysis of a problem.

Another study by Rooks et al., (1995) entitled *Injury Patterns in Recreational Rock Climbers* attempted to help clarify the common injuries seen among climbers. They agree, once again, that rock climbing injuries are more likely to occur from overuse rather than falls. Thirty-nine participants (30 men, 9 women) answered a questionnaire at a sport climbing competition in Georgia in 1993. Thirty-six of these participants also were given an examination to verify injuries. Upon examination, 20 climbers had an overuse injury of the upper extremity. Seventeen of them had hand and wrist injuries. Evidence of an impingement syndrome was evident in 13 of the climbers, and 10 showed signs of epicondylitis. Four showed signs of carpal tunnel syndrome and all of these participants were younger than 30 years of age. Rooks et al., (1995) determined that the “presence of tendinitis appears to be unrelated to the climber’s age or climbing experience” (p. 685). This study seemed to hold a different opinion from that of Bollen (1988) concerning injury being unrelated to climbing difficulty. This is shown in two ways. First, 50% to 69% of elite climbers displayed signs of PIP joint trauma or annular pulley injuries compared with only 19% of the recreational climbers. Second, “31 (79%) climbers regularly attempted climbs at very difficult levels where overuse injuries were most likely to occur” (p. 684). However, this article made no attempt to clarify “elite”, “recreational”, or “very difficult levels”. Rooks et. al, (1995) also stated that climbers less than 30 years of age in this study had a 10% incidence of carpal tunnel symptoms.

The study noted that three quarters of rock climbers can be expected to develop an upper extremity overuse injury. This assertion was made based on 89% of climbers in this study exhibiting signs of upper extremity overuse injuries as well as 74% of climbers in another study quoted by this researcher. Therefore, “appropriate stretching, weight training to increase strength, and rest for injuries and strains should be emphasized” (Rooks et. al, 1995) (p. 685).

Jebson and Steyers (1997) published an article concerning *Hand Injuries in Rock Climbing*. Although a few articles and a few surveys had been published by this point, this article continues to simply state that overuse hand injuries can be expected. However, there is one statement in this article that is of particular importance. Jebson and Steyers (1997) state that “injuries can be closely correlated with the duration and frequency of climbing and with the climbing technique used” (p. 55). Though this may be a true statement, it has yet to be examined statistically. This may be a significant point, which further research could pursue.

Summary

Previous literature has repeatedly reported that rock climbers exhibit signs of upper extremity overuse. However, little has been done to explain what specifically is the cause for this. In an effort to clarify proper training protocols, ideas related to stretching, warming-up, muscle balance, training intensity, training volume, training frequency, periodization, and overtraining have been reviewed. In addition to this, seven hand injuries, two wrist conditions, three elbow conditions, and one shoulder syndrome were explained in detail. Overuse conditions acquired by rock climbers and general

overuse conditions were also explained. Since research has already indicated what type of injuries to expect with the climbing community, new research should grapple with climbers injuries as well as training schedules in an effort to provided information helpful in understanding when and how these injuries arise.

Chapter III

Methods

Introduction

This chapter contains detailed information on the subjects, instruments, procedures, and analysis of data for this study. It also includes information on how the main question and related questions were approached. The main question was: Is there a significant relationship between training frequency, training volume, training intensity, warm-up time, overall training score obtained from the 17 Likert-scaled items and injury status (overuse injuries vs. no overuse injuries)? Related questions pertained to the relationship between injury status and items such as gender, climbing intensity, warm-up and Likert-scale scores.

Subjects

Subjects for this study consisted of recreational climbers found in the San Francisco Bay area. There were no restrictions for participants based on gender or the difficulty level each participant was capable of climbing. However, this study did not include those who primarily participate in indoor bouldering (climbing that is performed without a belay rope at the base of a cliff or on small boulders). This was done to include only climbers with similar experience. Also, in order to sample climbers who had been climbing long enough to have the possibility of developing an overuse injury, participants must have been climbing for at least six months. Participants must have been at least 18 years of age in order to obtain a sample that was as homogeneous as possible

with respect to training resources and experience. Pilot study subjects consisted partially of climbers from one gym in northern California ($n = 17$). The remaining 23 surveys collected for the pilot study ($N = 40$) were obtained from staff at a second gym in northern California. The primary study was a clustered sample of 156 climbers who climb at a gym in northern California as well.

Instrument

Instrument Development

Items found on the pilot study survey (see Appendix A) including injured body part and the number of restricted climbing days were adapted from the NCAA Individual Injury Surveillance Form. Survey items concerning years climbing, climbing frequency, pain intensity, and pain duration were adapted from the survey used in a research study conducted by Murray Maitland (1992). Remaining items concerning type of climbing, climbing intensity, climbing volume, climbing warm-up, additional exercises, age, gender, body weight, and severity of most severe injury were constructed by the researcher. There were twenty-one general questions. In addition, the researcher originally constructed twenty-five Likert-scaled questions. The Likert-scaled questions were intended to fall into four different categories called factors. The four factors were climbing frequency, climbing intensity, climbing volume, and warm-up procedures. The Likert-scale portion of the survey was constructed in order to provide a valid and reliable measure of training/climbing habits.

Initially, the survey was analyzed qualitatively. Two certified athletic trainers as well as one climbing gym manager with extensive climbing knowledge reviewed the

items found within the survey for clarity and specificity. Following this, the three individuals separated the Likert-scale questions into categories. The separation process was based on the definition of each category and the way each question read. This was done as a check to ensure each question retrieved the information it was intended to. Revisions were then made based on the qualitative check.

Following the qualitative check a pilot study took place in order to quantitatively assess the survey's structure. The data from the pilot study was analyzed quantitatively using a factor analysis to examine content validity. After the factors were clarified by the factor analysis, coefficient alpha was used to estimate the reliability of the data within each factor.

Pilot Study Procedures

Subjects

Before the pilot study began, approval was obtained from the Institutional Review Board for human subjects at San Jose State University. The pilot study subjects consisted partially ($n = 17$) of climbers from a climbing gym in northern California. The remaining 23 surveys collected for the pilot study ($N = 40$) were obtained from the staff at a different climbing gym in northern California. The management at both gyms were first contacted in order to obtain permission to survey at each gym. The surveys at the first gym were collected on Wednesday, January 12th and again on Friday, January 14th. The staff at the second gym were surveyed following a staff meeting on Monday, January 17th. A total of 40 participants were surveyed for the pilot study.

Procedures

Climbers, after checking into the first gym, were approached and invited to participate in the study relating to climbing injuries. Staff at the second gym were invited to participate following their meeting. The survey took approximately fifteen minutes to complete. Subjects were asked to read and sign an informed consent form (see Appendix B), asked for questions, and given the survey (see Appendix A). The researcher was available the entire time to answer questions about the survey. The survey was administered to four or five climbers at once and to the entire staff at the meeting.

After the pilot study surveys were collected, the data were analyzed quantitatively using a factor analysis to examine content validity. After the factors had been clarified by the factor analysis, coefficient alpha was used to estimate the reliability of the data within each factor. Once appropriate changes had been made based on the analyses completed, the primary study began.

Pilot Study Results

Forty surveys were collected from climbers at indoor gyms in the San Francisco Bay area. The 24 males and 16 females who participated had a mean age of 32.4 years $\pm$ 9.1 years. Time climbing spanned from 10 months to 26 years with an average of 7 years $\pm$ 6.5 years. Participants classified 67.2% of reported injuries as overuse injuries. The Likert-scale items, which were to reflect good training habits if scored high, revealed an average of 81.425 $\pm$ 9.23. The total possible on the Likert-scaled items was 125.

Table 1

Pilot Study Factor Matrix

<u>Actual Results</u>			<u>Expected Results</u>	
Factor	Item #	Factor Loading	Factor	Item#
Work-out intensity	45	0.792	Climbing Frequency	22
	39	0.726		35
	38	0.716		36
	30	0.638		41
				44
Warm-up procedures	43	0.849	Climbing Volume	26
	42	0.807		27
	33	0.702		28
	31	0.528		29
	23	0.449		34
				40
				46
Climbing volume	26	0.796	Climbing Intensity	23
	28	0.764		24
	27	0.652		25
	32	0.523		37
Climbing related to feelings	36	0.919		38
	35	0.857		39
Climbing specific intensity	34	0.931		45
	41	0.695	Warm-up	30
Difficulty of climbs	25	0.780		31
	24	0.767		32
Moderate climbing	37	0.836		33
	22	0.717		42
				43
Climbing tenacity	44	0.558		
	40	0.553		
	46	0.546		
	29	0.538		

Results of the principal component analysis compared to expected clusters revealed a marked difference (see Table 1). Initially, four factors were expected, however, the analysis revealed eight factors. The four factors expected were climbing frequency (questions 22, 35, 36, 41, 44), climbing intensity (questions 23, 24, 25, 37, 38, 39, 45), climbing volume (questions 26, 27, 28, 29, 34, 40, 46), and warm-up procedures (questions 30, 31, 32, 33, 42, 43). The factor analysis revealed eight different factors including, work-out intensity (questions 45, 39, 38, 30), warm-up procedures (questions 43, 42, 33, 31, 23), climbing volume (questions 26, 27, 28, 32), climbing days as a relationship to feelings (questions 35, 36), climbing specific intensity (questions 34, 41), difficulty of climbs (questions 24, 25), moderate climbing (22, 37), and climbing tenacity (questions 29, 40, 44, 46).

Survey Modifications Based on Pilot Data

The pilot study collected information from participants regarding the last six months of climbing experience. Many participants remarked that the survey was missing important injury information that dated one-year back. Therefore, the survey was revised to acquire information from the last year of a participant's climbing experience. In addition, participants remarked negatively concerning the four-page length of the survey. Therefore, through proper revisions, efforts were made to shorten the survey.

Specific changes were made based on the difference between information expected to be retrieved and the information actually retrieved. Questions one through five remained the same. The words "Use one number", with "one" being in bold, were added to question number six in order to avoid participants answering with a range of

numbers. Similarly, the same words were added to question number seven for the same purpose. In addition, the word “average” in question #7 was removed because it conflicted with the word “total”. In order to answer questions eight through ten a group of ratings ranging from 5.8 to 5.14d had been provided. Since no participants indicated a rating above a 5.12c, and a 5.7 was indicated, the new group of ratings went from 5.7 to 5.13a. Again, in order to avoid ranges, the word “one” was added and marked in bold for questions eight through ten. Questions eleven and twelve remain unchanged. The word “total” was added in bold prior to the word “injuries” in question thirteen, and the bracket containing the words “pre-existent or new” was removed. Question fourteen remained unchanged. Question fifteen remained unchanged, but the words “how many times” were put in bold print. Also, many of the body parts to choose from were removed due to a low number of participants indicating injury to those body parts. The new survey contained the shoulder, elbow, forearm, finger(s), and knee to choose from as well as the ability to mark “other” and indicate the specific body part. Question sixteen then had the words “most severely injured” in bold print. The pilot study survey presented a box that instructed the participant to answer questions seventeen through twenty-one with respect to each participant’s most severe injury. Therefore, each question used the phrase “this injury”. This was changed in questions seventeen through twenty to read “your most severe injury”. Question twenty-one stated “indicate the severity of the injury”, and following revision read “what was the severity of your most severe injury”. The revised questionnaire can be seen in Appendix C.

The Likert-scale section now contained seventeen questions, since nine original questions were removed and one was added. Some original Likert-scale questions loaded onto two or more factors, therefore, those questions were deleted (question #23) or modified (questions 29, 32, 40, 44, and 46). In addition, Likert-scale question 25 was removed since Likert-scale question 24 had been reworded and retrieved similar information. Also, Likert-scale questions 42, 43, and 45 were removed since they asked feeling questions as opposed to behavioral questions. Likert-scale question thirty-eight was added in order to retrieve information regarding whether a person climbs too high a volume too often.

Main Study

Instrument Content

The researcher developed nine directed questions and 17 Likert-scaled questions in order to obtain specific data to explore the main question. The main question was: Is there a significant relationship between training frequency, training volume, training intensity, warm-up time, total training score (from the 17 Likert-scale questions) and injury status (overuse injuries vs. no overuse injuries). The following information will explain how items found on the survey (see Appendix C) retrieved the required information to answer the main question appropriately. The dependent variable for the discriminate analysis was whether a person had developed overuse injuries or not. Question #14 on the survey, “how many . . . injuries were a result of overuse?”, provided this information. If a person responded to question #14 with any number other than zero (0), they were considered to have an overuse injury.

There were five independent variables included in the discriminant analysis. The first variable was training frequency, which was answered by question #6 on the survey. Question #6 asked “the typical number of days per week” a person climbs.

In order to understand how the measures for training intensity and training volume were established, the rating scale found on the survey between question #7 and question #8 must first be explained. The ratings presented are the accepted ratings used for climbing in America. The ratings, starting with 5.0 and ending with 5.14d, are derived from the Yosemite Decimal System (Y.D.S.). The YDS is used to rate all climbs in which a climber would use a rope to climb a route. This system is used and understood by climbers, and therefore was used in this study. However, the ratings in this system do not readily translate to a quantifiable number. Therefore, a numerical interval scale was first assigned to the Yosemite Decimal System (Y.D.S.) in order to establish a quantity for each rating. A number 1 was assigned to 5.0, a number 2 to 5.1, and so on until the number 30 was assigned to 5.14d. With this numerical interval scale established, the training intensity and training volume measures can be explained.

The second independent variable in the discriminate analysis was training/climbing intensity. Question #8 on the survey provided information for the training intensity by retrieving the total number of routes climbed at each rating during a typical climbing session. The researcher then transferred the ratings to the interval scale number as indicated above. Those numbers were added, and the mean intensity was determined. The mean was then used as a person’s typical intensity level per workout.

For example, if a person climbed two 5.10a (11 on interval scale), three 5.11a (15), and two 5.12a (19), the total is 105. The mean intensity would therefore be 15 ($105/7$).

Training/climbing volume was the third independent variable. Training volume for climbing would be the total number of feet a person climbs in a workout session. For example, if a person climbs five routes that are 30ft. long, his/her training volume would be 150 ft. for that day. Question #7 on the survey asked “What is the average number of feet you climb in a typical training session?”.

The fourth independent variable was the amount of time spent on warm-up prior to a climbing session. Question #11 on the survey retrieved this information by asking, “how much time (in minutes) do you typically spend warming up prior to climbing?”.

The fifth and final independent variable was the overall training score. The researcher developed 17 Likert-scaled questions that dealt with training frequency, training volume, training intensity, and warm-up procedures. The overall training score was the total of the responses to the 17 Likert-scaled items. A total score of 85 was possible, and the higher the number, the better the training habits. However, when scores were recorded, the researcher reversed the scoring for questions #23, and #34 - #38 in order for the positive aspect of the questions to agree with other questions.

Subjects

The primary study began on February 29th and continued on March 1st, March 8th, March 13th, March 14th, and March 20th. One hundred, fifty-six climbers were surveyed at a climbing gym in northern California. Management was contacted for permission to conduct the study at the gym.

Procedures

As in the pilot study, climbers, after checking into the gym, were approached and invited to participate in the study relating to climbing injuries. Participants were asked to read and sign an informed consent form (see Appendix B), asked for questions, and given the survey (see Appendix C). The survey took approximately five minutes to complete. The researcher was available the entire time to answer questions about the survey. The survey was administered to four or five individuals at once. If a survey was completed by a participant who mainly participates in indoor bouldering, it was discarded ($n = 12$). In addition, all surveys that were completed by those who had been climbing less than 6 months were discarded ($n = 6$). Approximately 18 hours were needed in order to survey all participants.

Analysis of Data

Summary information was provided on the subjects as a whole as well as on each separate group of subjects. Categorical information including subjects' gender (question #3) was summarized using frequency distribution tables. Continuous information about subjects, including age (question #1), body weight (question #2), years climbing (question #5), current best onsight level (question #9), current best redpoint level (question #10), number of injuries (question #13), and the number of overuse injuries (question #14) was summarized using central tendency and variability.

Survey Items

Summary information was obtained for each survey item. Most severe injury (question #16), type of most severe injury (question #17), number of climbing days

missed due to most severe injury (question #18), and pain duration (question #20), and the type of climbing warm-up performed by climbers (question #11) were summarized with frequency distribution tables. Climbing frequency (question #6), climbing volume (question #7), length of climbing warm-up (question #12), and overall training score from the 17 Likert-scale questions were summarized using central tendency and variability.

Main Question

The main question was: Is there a relationship between training frequency, training volume, training intensity, warm-up time, overall training score obtained from the 17 question Likert-scale and injury status (overuse injuries vs. no overuse injuries)? This relationship was examined using a discriminant analysis procedure. The assumption that the independent variables were unrelated was first checked by correlating each variable.

Related Questions

The first related question was concerned with the relationship between the injury status (overuse injuries vs. no overuse injuries) of an individual and his/her overall training score. The overall training score was the average of the responses to the 17 Likert-scaled items. A score of 85 was the total possible, and the higher the number, the better the training habits. The training score was correlated with injury status using a point biserial correlation. The overall training score was also correlated with the number of overuse injuries as well as the total number of years rock climbing using a pearson product moment correlation (PPMC) for both correlations.

The relationship between the number of overuse injuries and current best on-sight ability of a climber as well as the current best redpoint ability of a climber was also examined. The on-sight ability and redpoint ability were quantified by recording participants' information in terms of the Yosemite Decimal System (or V-scale for bouldering). A PPMC was used to assess these relationships.

Also, the relationship between the severity of the most severe injury and current best on-sight and current best redpoint of a climber was examined. The severity of an injury was determined by the answer to item 21 on the survey. These relationships were assessed using a PPMC.

Additionally, the relationship between age and the number of overuse injuries, age and training score, body weight and injury severity, body weight and number of overuse injuries, and years rock climbing and number of overuse injuries were separately assessed using a PPMC. Also, a point biserial correlation was calculated for gender and number of overuse injuries, gender and overall training score, and injury status and time spent on warm-up.

Chapter IV

Results

Introduction

The purpose of this study was to determine the impact of training patterns on the development of overuse injuries among rock climbers. This chapter will explain results of the primary study.

Main Study Results

Descriptive Statistics

Collectively, the participants of this study were on average $32.28 \text{ years} \pm 7.94 \text{ years}$ old. Most of the 156 subjects were male ($n=105$). Forty-six subjects were female and five did not report their gender. The average weight reported was $154.54 \text{ pounds} \pm 26.29 \text{ pounds}$. On average the participants of this study had climbed $6.36 \text{ years} \pm 7.11 \text{ years}$ for an average of $2.2 \text{ days/week} \pm 1.08 \text{ days/week}$. During a typical climbing session the participants averaged $316.06 \text{ feet/session} \pm 173.72 \text{ feet/session}$, and typically climbed on average a 5.10a (ranging between 5.8 and 5.10d). The average onsight ability was 5.10c (ranging between 5.9 and 5.11b), and the average redpoint ability was 5.10d (ranging between 5.9 and 5.11d). All continuous variables are summarized in Table 2.

With respect to warm-up, 76.3% ($n=119$) incorporated two or three climbs at an easier grade, 73.1% ($n=114$) incorporated an upper body stretch, 67.3% ($n=105$) incorporated a lower body stretch, 30.8% ($n=48$) incorporated a general body warm-up, and 9% ($n=14$) incorporated yoga. Overall, the participants spent $14.27 \text{ minutes} \pm 11.47 \text{ minutes}$ on a warm-up. All categorical variables are summarized in Table 3.

Table 2

Means and Standard Deviations of Continuous Variables

	<u>M</u>	<u>SD</u>	<u>n</u>
Age	32.28	7.94	150
Weight	154.54	26.29	151
Yrs Climbing	6.36	7.11	156
Climbing Frequency	2.2	1.08	155
Climbing Volume	316.06	173.72	155
Climbing Intensity*	11.71 (5.10a)	2.24	154
Onsight Ability*	6.22 (5.10c)	3.41	156
Redpoint Ability*	7.44 (5.10d)	3.7	156
Warm-Up Minutes	14.27	11.47	156
Total likert-scale score	53.22	7.22	150

Note. * indicates the numbers used are part of the numerical interval scale explained in Chapter 3. The number in parenthesis to the right is the near equivalent from the Y.D.S.

Participants on average experienced 1.3 ± 1.25 total injuries within the last year and 0.85 ± 0.92 overuse injuries within the last year. The three most severe injuries were reported to the fingers (21.8%) followed by the elbow (10.9%) and then the shoulder (9.6%). Eighty-five (54.5%) acknowledged that their most severe injury was also an overuse injury, and 21 (13.5%) stated that their most serious injury was not an overuse injury. Thirty (19.2%) participants took no time off for their most serious injury. Nineteen

Table 3

Frequencies (%) of Categorical Variables

<u>Variable</u>	<u>Total</u>					<u>Missing</u>
<u>Gender</u>	<u>Male</u>	<u>Female</u>				
	67.3	29.5				151 5
<u>5 Most Injured Body Parts</u>	<u>Fingers</u>	<u>Elbow</u>	<u>Shoulder</u>	<u>Knee</u>	<u>Forearm</u>	
	21.8	10.9	9.6	5.1	3.8	80 76
<u>Injury Type</u>	<u>Overuse</u>	<u>Non-overuse</u>				
	54.5	13.5				106 50
<u>Climbing Days Missed</u>	<u>No Time</u>	<u>3-6 Days</u>	<u>7-10 Days</u>	<u>11-13 Days</u>	<u>>14 Days</u>	
	19.2	12.2	8.3	5.8	23.7	108 48
<u>Pain Duration</u>	<u>< 1 Week</u>	<u>1 Week - 1 Month</u>	<u>1 Month - 3 Months</u>	<u>> 3 Months</u>		
	14.1	30.1	14.7	10.9		
<u>Warm-Up Types</u>	<u>Yoga</u>	<u>General Body</u>	<u>LB Stretch</u>	<u>UB Stretch</u>	<u>Easy Climbs</u>	
	9	30.8	67.3	73.1	76.3	156 0

(12.2%) took 3 – 6 days off, 13 (8.3%) took 7 – 10 days off, 9 (5.8%) took 11 – 13 days off, and 37 (23.7%) took 14 days or longer off. Forty-eight participants did not report how much time was taken off. Twenty-two (14.1%) participants experienced less than one week of pain in association with their most serious injury. Forty-seven (30.1%) experienced pain for a span of one week to one month. Twenty-three (14.7%) experienced pain for one month to three months, and 17 (10.9%) experienced pain for longer than three months. Forty-seven participants did not respond to the duration of pain item.

Finally, the participants responded to seventeen Likert-scaled items pertaining to training patterns. The higher the score, the better the respondent's training practices according to recent literature. The highest possible score was 85 while the lowest possible was 17. The average Likert-scale total score was 53.22 ± 7.22 (see Table 2).

Only one pattern of interest was present among the 17 Likert-scale questions answered. Over 50% of participants strongly agreed with question 30, which stated, “as part of a warm-up I complete a few climbs at a grade or two easier than my redpoint ability”. All other Likert-scale questions were answered in an evenly distributed manner.

Factor Analysis

Factor Analysis (Varimax rotation) of the responses to Likert items generated five factors. Reliability (alpha) of factors are illustrated in Table 4. The factors were labeled intensity (alpha = .76), frequency (alpha = .7112), sensible climbing (alpha = .6205),

volume ($\alpha = .5744$), and warm-up ($\alpha = .4314$). Intensity and frequency were the only two factors that displayed good ($\alpha \geq .70$) reliability.

Table 4

Primary Study Factor Matrix and Reliability Estimates (Coefficient Alpha)

Factor	Item #	Factor Loading	Alpha
Climbing Intensity	35	0.84	0.76
	36	0.726	
	38	0.705	
	34	0.695	
	23	0.52	
Climbing Frequency	33	0.828	0.7112
	32	0.814	
	37	0.63	
	22	0.612	
"Sensible" Climbing	24	0.744	0.6205
	31	0.636	
	25	0.624	
	30	0.538	
Climbing Volume	27	0.81	0.5744
	26	0.769	
Warm-Up	29	0.792	0.4314
	28	0.678	

Relevant Findings

Relevant findings pertaining to gender included whether or not the most severe injury was overuse, injury status, volume climbed per session, intensity level, and best onsight/redpoint capabilities. Fifty-nine of 71 (83%) men reported that their most severe injury was an overuse injury. Twenty-five of 34 (74%) females reported that their most severe injury was caused by overuse. Sixty-one of 104 (58.65%) men reported some type

of overuse injury, and a similar portion of the women (58.7%) reported an overuse injury. Most notably, men climbed on average 354.27 ± 188.33 feet/session, but women reported climbing 238.89 ± 106.30 feet/session. Men on average climbed at an intensity level of 5.10b. Women on average climbed at an intensity level of 5.10a. Men on average onsighted climbs with an intensity level of 5.10d, and on average redpointed 5.11a. Women on average onsighted 5.10b, and redpointed 5.10c.

Relevant findings pertaining to whether or not the most severe injury was an overuse injury included years climbing, frequency, volume, best onsight/redpoint, participant's weight, and intensity (see Table 5). For those whose most severe injury was an overuse injury ($n = 85$), $6.55 \text{ years} \pm 7.55$ years was the average years climbing, $2.36 \text{ days/week} \pm 1.05$ the average climbing days per week, $340 \text{ feet/session} \pm 176.06$ the average feet per climbing session, 5.10b was climbed on average, 5.10d was onsighted on average, and 5.11a was redpointed on average. For those whose most severe injury was not an overuse injury ($n = 21$), $4.53 \text{ years} \pm 7.02$ was the average years climbing, $1.71 \text{ days/week} \pm 1.06$ the average climbing days per week, $261.19 \text{ feet/session} \pm 130.02$ the average feet per climbing session, 5.9 was climbed on average, 5.10a was onsighted on average, and 5.10c was redpointed on average.

The following information pertains to whether or not a person had sustained any overuse injuries (see Table 6). Those in this study who had sustained overuse injuries ($n = 89$) on average were $33 \text{ years} \pm 7.71$ years of age, $150.62 \text{ pounds} \pm 25.65$ pounds in weight, had $6.15 \text{ years} \pm 6.93$ years of climbing experience, climbed $2.33 \text{ days/week} \pm$

Table 5

Summary Statistics for Those Whose Most Severe Injury Was Overuse (n = 85)
Compared to Those Whose Most Severe Injury Was Not Overuse (n = 21)

	<u>Most Severe Injury Was Overuse</u>		<u>Most Severe Injury Was Not Overuse</u>	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Years Climbing	6.55	7.55	4.53	7.02
Days/Week Climbing	2.36	1.05	1.71	1.06
Feet/Session Climbing	340	176.06	261.19	130.02
Onsight Ability*	7.28 (5.10b)	3.51	4.29 (5.9)	2.24
Redpoint Ability*	8.52 (5.10d)	3.71	5.67 (5.10a)	2.87

Note. * indicates the numbers used are part of the numerical interval scale explained in Chapter 3. The number in parenthesis to the right is the near equivalent from the Y.D.S.

Table 6

Summary Statistics for Those With an Overuse Injury (89) and without (66)

	<u>Those with Overuse Injury</u>		<u>Those Without Overuse Injury</u>	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Age	33	7.71	31.34	8.24
Weight	150.62	25.65	159.69	26.49
Years Climbing	6.15	6.93	6.7	7.44
Days/Week Climbing	2.33	1.04	2.02	1.12
Feet/Session Climbing	336.93	175.43	290	169.75
Onsight Ability*	7.29 (5.10d)	3.54	4.79 (5.10b)	2.69
Redpoint Ability*	8.48 (5.11a)	3.75	6.05 (5.10c)	3.14

Note. * indicates the numbers used are part of the numerical interval scale explained in Chapter 3. The number in parenthesis to the right is the near equivalent from the Y.D.S.

1.04 days per week, climbed 336.93 feet/session + 175.43 feet per climbing session, onsighted 5.10d on average, and redpointed 5.11a on average. Those who had not sustained an overuse injury ($n = 66$) on average were 31.34 years + 8.24 years of age, 159.69 pounds + 26.49 pounds in weight, had 6.7 years + 7.44 years of climbing experience, climbed 2.02 days/week + 1.12 days per week, climbed 290 feet/session + 169.75 feet per climbing session, onsighted 5.10b on average, and redpointed 5.10c on average.

Main Question

The main question was: Is there a significant relationship between training frequency, training volume, training intensity, warm-up time, overall training score obtained from the 17 question Likert-scale and injury status (overuse injuries vs. no overuse injuries)? This relationship was examined using a discriminant analysis procedure. The assumption that the independent variables were unrelated was first checked by correlating each variable. Results indicated there to be a moderate relationship between training frequency and training intensity [Pearson Product Moment Correlation (PPMC) = 0.519]. Therefore, each variable was separately correlated with injury status in order to determine which variable was to be left out of the discriminant analysis. Training intensity and injury status attained a higher correlation (PPMC = 0.317) than did training frequency and injury status (PPMC = 0.148). Therefore, training frequency was left out of the discriminant analysis.

Of the variables (intensity, volume, warm-up, and likert-scale score) entered into the step-wise discriminant analysis, intensity was the only variable that significantly

helped to discriminate between those with an overuse injury and those with no overuse injury.

Related Questions

The overall likert-scale score was correlated with injury status (-0.02) as well as total number of overuse injuries (-0.017), years rock climbing (0.093), and gender (-0.092). The total number of overuse injuries was correlated with best onsight rating (0.351), best redpoint rating (0.319), participant's age (0.014), years rock climbing (-0.089), participant's weight (-0.060), and gender (-0.032) (see Table 7). In addition, the severity of the most severe injury was correlated with the best onsight rating (0.058), best redpoint rating (0.049), and participant's weight (0.016). Finally, injury status was correlated with time spent on warm-up (0.019). All related question correlations are summarized in Table 7.

Table 7

Correlations For Related Questions

	Overall Likert-scale Score (n)	Number of Overuse Injuries (n)	Severity of Most Severe Injury (n)	Time Spent on Warm-Up (n)
Injury Status	-0.02 (149)			0.019 (155)
Number of Overuse Injuries	-0.017 (149)			
Years Climbing	0.093 (150)	-0.089 (155)		
Gender	-0.092 (145)	-0.032 (150)		
Onsight Ability		0.351 (155)	0.058 (108)	
Redpoint Ability		0.319 (155)	0.049 (108)	
Age		0.014 (149)		
Weight		-0.06 (150)	0.049 (107)	

Chapter V

Discussion & Conclusion

The purpose of this study was to determine the impact of training patterns on the development of overuse injuries among rock climbers.

Analysis revealed a survey instrument that requires further development if utilized for future research. Only 40 questionnaires were obtained for the pilot study. However, a greater number may have produced a more stable factor structure to base revisions on. Eight factors were identified instead of the proposed four. As a result, many questions were changed and a few were deleted. It is unknown exactly how many weaknesses in the questionnaire could have been resolved with a more effective pilot study.

A factor analysis of responses from the main study extracted five factors instead of the proposed four (see Table 8). These were labeled intensity, frequency, miscellaneous “sensible” climbing, volume, and warm-up. The intensity factor ($\alpha = .7600$) included questions 23, 34, 35, 36, and 38, and the frequency factor ($\alpha = .7112$) included questions 22, 32, 33, and 37. These were the only factors with an alpha reported to be good ($\alpha > .70$). “Sensible” climbing ($\alpha = .6205$) was labeled such because questions 24, 25, 30, and 31 were worded with phrases including the words “varying” or “fewer”. The volume factor ($\alpha = .5744$) consisted of only questions 26 and 27, which were a bit lengthy and confusing. The warm-up factor ($\alpha = .4314$) included only questions 28 and 29.

Despite the apparent problems with the likert scaled items, most of the remaining items obtained data as planned. One exception was an apparent lack of understanding regarding what an overuse injury was. This may be due to the fact that participants were

Table 8

Factor Analysis Results

<u>Proposed Factor Structure</u>		<u>Actual Factor Structure</u>	
Factor	Item #	Factor	Item #
Climbing Frequency	22	Climbing Intensity	35
	32		36
	33		38
	37		34
			23
Climbing Intensity	23	Climbing Frequency	33
	24		32
	34		37
	35		22
	36		
Climbing Volume	25	"Sensible" Climbing	24
	26		31
	27		25
	31		30
	38	Climbing Volume	27
Warm-Up	28		26
	29	Warm-Up	29
	30		28

asked to recall injury information themselves. Often times, people did not seek medical advice, and therefore were guessing as to whether they thought an overuse injury was present or not. This was despite the fact a definition was given within the survey. This might have been avoided had a trained orthopaedic given an assessment as part of the study.

With respect to climbing injuries and training patterns, some of the most interesting information was found within the category of those whose most severe injury was an overuse injury. Those with their most severe injury being an overuse injury climbed 340 ± 176.06 average feet per climbing session. Those with their most severe injury not an overuse injury climbed less (261.19 ± 130.02 average feet per climbing session). Intensity was also slightly higher among those whose severe injury was overuse. Those whose most severe injury was due to overuse reported their onsight a 5.10d on average, and redpoint a 5.11a on average. Those whose most severe injury was not due to overuse did not climb as intense climbs (onsight a 5.10a on average, and redpoint a 5.10c on average). Also, there was a noticed difference between those who had any type of overuse injury compared to those who did not. A person who had sustained an overuse injury climbed on average 336.93 feet/session ± 175.43 feet per climbing session, onsight 5.10d on average, and redpoint 5.11a on average. Those who had not had any type of overuse injury climbed less feet per session (290 feet/session ± 169.75 feet per climbing session), and did not climb as high of an intensity (onsight 5.10b on average, and redpoint 5.10c on average).

Surprisingly, some variables that were expected to be related to injury were not. The weight of an individual was one of these. The data showed that those who had an overuse injury for their most severe injury weighed on average 150.62 ± 25.65 pounds. Those who did not have an overuse injury for their most severe injury weighed more on average (159.69 ± 26.49 pounds). In addition, there was surprisingly no relationship seen between injury status and time spent on warm-up (0.019). There were also few

gender differences in any category. Though, most notably, men climb on average 354.27 feet/session $\pm$ 188.33 feet/session, and women reported climbing 238.89 feet/session $\pm$ 106.30 feet/session.

The null hypothesis associated with the main question for this study stated that there would be no relationship between the training pattern of rock climbers and acquired overuse injuries. To test the hypothesis a discriminant analysis was used. The independent variables were training volume, training intensity, warm-up time, and overall training score obtained from the 17 Likert-scaled items. The dependent variable was injury status (overuse injuries vs. no overuse injuries). The discriminant analysis revealed that intensity was the only variable that significantly helped to discriminate between those with an overuse injury and those with no overuse injury. All other variables did not contribute significantly and were therefore left out of the analysis. This does seem plausible, since with many sports as the intensity increases the chance for injury increases.

Thirteen related questions correlating the overall likert-scale score, injury status, the total number of overuse injuries, years rock climbing, gender, best onsight rating, best redpoint rating, participant's age, participant's weight, and the severity of the most severe injury were asked. Only two produced results suggesting a relationship. The total number of overuse injuries was correlated with best onsight rating (0.351) and best redpoint rating (0.319). This seems to indicate, as did the discriminant analysis, there is some relationship between how intense a person climbs and the number of overuse injuries a person can expect to develop. This finding is in direct opposition to Bollen's

(1988) finding that “there was no correlation between standard of difficulty of climbing and number or type of injury” (p.147). However, Bollen (1988) may have suggested this finding because his study was limited to what he referred to as climbers who climb at “extreme” standards (5.10a to 5.13a).

Overall, the study added some insights regarding the relationship between training and overuse injuries including the finding that climbing intensity appears to be related to the development of overuse injuries. In addition, two related questions suggest a relationship between the number of overuse injuries and the best onsight and best redpoint (both measurements of intensity). However, to what extent intensity was responsible was not determined.

There also seems to be a difference in climbing volume between those with and without an overuse injury. Those who had an overuse injury climbed on average 336.93 feet/session, and those who did not climbed on average 290 feet/session. There also seemed to be a marked difference in volume between those whose most severe injury was an overuse injury (340 feet/session + 176.06 average feet per climbing session) and those whose most severe injury was not an overuse injury (261.19 feet/session + 130.02 average feet per climbing session). Again, to what extent climbing volume can be held responsible for overuse injuries is unknown. According to the discriminant analysis, climbing volume was not as important as climbing intensity in distinguishing between those with and without an overuse injury.

Speculations as to what may be responsible for causing climbing injuries arise from this study as well as personal experience. It seems the variables considered in this

study could very well contribute to overuse injuries among rock climbers. However, the type of data collected (retrospective data) led to lapses in what was reported compared to what was expected. It seems that oral interviews could have helped clarify matters and collected more accurate data. When conversing with climbers on a casual basis, by logic, it seems that climbing intensity and climbing frequency are very much related to overuse injuries. At least more related than what this study determined.

In addition to collecting data in not quite the best manner, it is possible that other underlying factors could be responsible for the difference between findings and expectations. As mentioned, climbing is considered by many to be an extreme sport in nature. It seems the type of personality that would engage in this activity is often a bit reckless in nature. This could lead an individual to climb for some time without recognizing or treating an injury. It may even lead an individual to not associate an “ache” or “pain” with climbing, and especially not consider those sensations to be an injury. However, this is only speculation at the present time.

Future research building on the findings presented here should consider utilizing a different method of collecting data, such as oral interviews for clarification. Collecting data via first-hand interviews could limit misinterpretation and possibly result in obtaining more accurate information. Also, by conducting first-hand interviews it would be possible to better explain to participants the concept of an overuse injury, which was defined in the survey as an injury caused by one major event or several minor events that resulted in pain/irritation that lasted at least four weeks.

Future research should continue to examine the relationship between training patterns and overuse injury. The relationship between the strength ratios of pull/push muscles and injury should be examined. Future research could focus on orthopaedic evaluations followed by participants adhering to prescribed climbing exercise programs. This may help to quantify climbing volume as well as climbing intensity in hopes of finding at what point is the deciding limit. Since overuse injury may be the result of immeasurable repetitive stress on the upper body, which is not meant for supporting (carrying) body weight, future research could focus on the stress capabilities of the upper limbs. For instance, at what intensity could a climber expect to begin to develop symptoms of overuse? What type of climbing/training programs would be beneficial in guarding a climber against overuse injuries? Are there certain types of exercises that a climber should perform in order to guard against overuse injuries? Ideally, the shortcomings of this research as well as these ideas may be able to guide future research aimed at obtaining useful information to aid climbers in guarding against overuse injuries.

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Appendix A

Pilot Study Questionnaire

1. _____ Age 2. _____ Weight 3. Gender: ☐ M ☐ F

Please answer all of the following questions based on the last six months of your climbing experience.

4. Circle one of the following three which you most often participate in:

Indoor Sport Leading Indoor Bouldering Indoor Top Roping

5. _____ How long (months/years) have you participated in rock climbing of any sort?
6. _____ What is the typical number of days per week you climb?
7. _____ What is the average total number of feet you climb in a typical training session?

Use the following group of ratings in the space provided below to answer Questions 8 through Question 10.

Yosemite Decimal System:

____ 5.8 ____ 5.9 ____ 5.10a ____ 5.10b ____ 5.10c ____ 5.10d ____ 5.11a ____ 5.11b
 ____ 5.11c ____ 5.11d ____ 5.12a ____ 5.12b ____ 5.12c ____ 5.12d ____ 5.13a ____ 5.13b
 ____ 5.13c ____ 5.13d ____ 5.14a ____ 5.14b ____ 5.14c ____ 5.14d

8. To the left of each rating indicate the total number of routes climbed at that rating during a typical climbing session (leave blank if 0 is the number).
9. Using the ratings provided above put one circle around your best onsight (When a route is climbed the first try without prior information concerning the route and without falling).
10. Using the ratings provided above put one X through the number of your best redpoint (When a route is climbed entirely without falling on a second or subsequent attempt).

11. Indicate which of the following items you incorporate into a warm-up session (check all that apply).

☐ General body warm-up (bike or jog) ☐ Upper Body Stretching
☐ Two or three climbs at an easier grade ☐ Lower Body Stretching
☐ Yoga ☐ Other _____

12. _____ How much time (in minutes) do you typically spend on warming up prior to climbing?
13. _____ How many total injuries (pre-existent or new) have you dealt with in the last year while participating in any type of rock climbing?
14. _____ How many injuries were a result of overuse (caused by one major event or several minor events that resulted in pain/irritation that lasted at least 4 weeks).
15. Please indicate how many times you have injured each of the following body parts in the last six months (leave blank if 0 is the number).

☐ Shoulder ☐ Elbow ☐ Forearm ☐ Finger(s) ☐ Knee
☐ Head ☐ Neck ☐ Wrist ☐ Upper Arm ☐ Hand
☐ Thumb ☐ Spine ☐ Ribs ☐ Upper Back ☐ Foot
☐ Ankle ☐ Toe(s) ☐ Heel ☐ Lower Leg
☐ Other _____ ☐ Other _____ ☐ Other _____

16. Circle the body part you believe to have been the most severely injured.

Questions 17 – 21 are to be answered with respect to your most severe injury as indicated in Question 16.

17. ☐ Y ☐ N Was this injury a result of overuse? (caused by one major event or several minor events that resulted in pain/irritation that lasted at least 4 weeks).

18. How long did this injury keep you from climbing?

No time off 3-6 days 7-10 days 11-13 days 14 days or longer

19. What was the pain intensity level of this injury (1 = minor; 5 = extreme)?

1 2 3 4 5

20. What was the pain duration of this injury?

<1 week 1 week – 1 month 1 month – 3 months >3 months

21. Based on the pain intensity and pain duration, indicate the severity of the injury?

(1 = least; 10 = most). 1 2 3 4 5 6 7 8 9 10

Answer the following statements with this scale in mind:
Never(1) ; Rarely(2) ; Sometimes(3) ; Often(4) ; Always(5)

22. Typically, I climb 2-3 days per week	☐	☐	☐	☐	☐
23. I vary the difficulty of climbs within a climbing session	☐	☐	☐	☐	☐
24. I vary the difficulty of climbs between different climbing sessions	☐	☐	☐	☐	☐
25. Every two to four weeks I rotate the difficulty of climbing done in each session.	☐	☐	☐	☐	☐
26. I vary the number of routes climbed per session from session to session	☐	☐	☐	☐	☐
27. I vary the number of routes climbed in each session based on how hard I climbed during my last session as well as how hard I plan to climb during my next session.	☐	☐	☐	☐	☐
28. As the number of climbing sessions per week increase, I decrease the number of routes completed in each climbing session.	☐	☐	☐	☐	☐
29. I climb the same number of routes every session in the same week, but the total number of routes change each week.	☐	☐	☐	☐	☐
30. I engage in a five to ten minute jog or bike for a general body warm-up before each climbing session	☐	☐	☐	☐	☐
31. I stretch before each climbing session	☐	☐	☐	☐	☐
32. As part of a warm-up I complete a few climbs at a grade or two easier than my redpoint ability.	☐	☐	☐	☐	☐
33. I climb more or fewer number of routes than normal based on how I feel that day.	☐	☐	☐	☐	☐
34. When I feel tired I climb fewer number of routes than normal.	☐	☐	☐	☐	☐
35. When I feel tired I climb fewer days per week.	☐	☐	☐	☐	☐

36. When my muscles are sore I climb less difficult climbs than normal. ☐ ☐ ☐ ☐ ☐
37. During every climbing session I climb at or near my redpoint ability. ☐ ☐ ☐ ☐ ☐
38. During every climbing session I climb at or above my on-sight ability ☐ ☐ ☐ ☐ ☐
39. I climb the same number of routes every climbing session every week. ☐ ☐ ☐ ☐ ☐
40. Typically, I climb more than three days per week. ☐ ☐ ☐ ☐ ☐

Answer the following statements with this scale in mind:
Never(1) ; Rarely(2) ; Sometimes(3) ; Often(4) ; Always(5)

	1	2	3	4	5
41. A good warm-up session, including a general body warm-up, stretching, and climbing a few easier grades will lead to improved climbing.	☐	☐	☐	☐	☐
42. A good warm-up session, including a general body warm-up, stretching, and climbing a few easier grades will help prevent injuries.	☐	☐	☐	☐	☐
43. Climbing as often as I can is the best way for me to improve as a climber	☐	☐	☐	☐	☐
44. Climbing routes that are the most difficult for me each climbing session is the best way for me to improve as a climber.	☐	☐	☐	☐	☐
45. If I climb as many routes as I can each climbing session I will improve as a climber.	☐	☐	☐	☐	☐

Appendix B

Consent Form

1. I have been asked by Carl Timm, graduate student at San Jose State University, to participate in a research study among rock climbers.
2. I have been asked to accurately and completely respond to the attached questionnaire concerning both my injuries within the last six months as well as my training methods.
3. I have been told that there are no foreseeable risks or discomforts to me associated with participating in this study.
4. Benefits associated with this study include the possibility for the entire climbing community to gain a better understanding of climbing injuries.
5. The results of this study may be published; however, no information that could identify any individual subject will be included.
6. There will be no directly received compensation associated with completion of this study.
7. Questions concerning this research may be directed to Carl Timm at (408) 522-2542. Complaints about the research may be presented to Bethany Shifflett, Ph.D., at (408) 924-3016. Questions or complaints about research, subjects' rights, or research-related injury may be presented to Nabil Ibrahim, Ph.D., Associate Academic Vice President for Graduate Studies and Research, at (408) 924-2480.
8. No service of any kind, to which I would otherwise be entitled, will be lost or jeopardized if I choose to "not participate" in the study.
9. I understand that consent is given voluntarily. I realize that I may refuse to participate in the study or any part of the study. If, however, I do decide to participate in the study, I understand I am free to withdraw at any time without prejudice to my relations with San Jose State University or any other participating institution.
10. I have received a signed and dated copy of the consent form.

Subject's signature

Date

Investigator's Signature

Date

- The signature of a subject on this document indicates agreement to participate in the study.
- The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.

Appendix C

Primary Study Questionnaire

Indoor Climbing Injury Survey

1. ____ Age 2. ____ Weight 3. Gender: __ M __ F

Please answer all of the following questions based on the last one year of your climbing experience.

4. Circle one of the following three which you most often participate in:

Indoor Sport Leading

Indoor Bouldering

Indoor Top Roping

5. ____ How long (months/years) have you participated in rock climbing of any sort?
6. ____ Use **one** number to indicate the typical number of days per week you climb?
7. ____ Use **one** number to indicate the total number of feet you climb in a typical training session?

Use the following group of ratings in the space provided below to answer Questions 8 through Question 10.

Yosemite Decimal System:

____ 5.7 ____ 5.8 ____ 5.9 ____ 5.10a ____ 5.10b ____ 5.10c ____ 5.10d ____ 5.11a
 ____ 5.11b ____ 5.11c ____ 5.11d ____ 5.12a ____ 5.12b ____ 5.12c ____ 5.12d ____ 5.13a

8. To the left of each rating place **one** number that represents how many routes you climb at that rating during a typical climbing session (leave blank if 0 is the number).
9. Using the ratings provided above put **one** circle around your best onsight (When a route is climbed the first try without prior information concerning the route and without falling).
10. Using the ratings provided above put **one** X through the number of your best redpoint (When a route is climbed entirely without falling on a second or subsequent attempt).

11. Indicate which of the following items you incorporate into a warm-up session (check all that apply).

☐ General body warm-up (bike or jog) ☐ Upper Body Stretching
☐ Two or three climbs at an easier grade ☐ Lower Body Stretching
☐ Yoga ☐ Other _____

12. _____ How much time (in minutes) do you typically spend on warming up prior to climbing?

13. _____ How many **total** injuries have you had in the last year while participating in any type of rock climbing?

14. _____ How many injuries were a result of **overuse** (*caused by one major event or several minor events that resulted in pain/irritation that lasted at least 4 weeks*)?

15. Please indicate **how many times** you have injured each of the following body parts in the last six months (leave blank if 0 is the number).

☐ Shoulder ☐ Elbow ☐ Forearm ☐ Finger(s) ☐ Knee
☐ Other _____ ☐ Other _____ ☐ Other _____

16. Circle the body part you believe to have been the **most severely injured**.

17. Y N Was your most severe injury a result of overuse? (caused by one major event or several minor events that resulted in pain/irritation that lasted at least 4 weeks).

18. How long did your most severe injury keep you from climbing?

No time off 3-6 days 7-10 days 11-13 days 14 days or longer

19. Please circle the pain intensity level of your most severe injury? (1 = minor; 5 = extreme)

1 2 3 4 5

20. What was the pain duration of your most severe injury?

<1 week 1 week – 1 month 1 month – 3 months >3months

21. Based on the pain intensity and pain duration, what was the severity of your most severe injury?(1 = least; 10 = most).

1 2 3 4 5 6 7 8 9 10

Answer the following statements with this scale in mind:
 Never(1) ; Rarely(2) ; Sometimes(3) ; Often(4) ; Always(5)

	1	2	3	4	5
22. Typically, I climb 3 days or less each week	☐	☐	☐	☐	☐
23. I climb as hard as I can during an entire climbing session	☐	☐	☐	☐	☐
24. I climb harder on some days than others.	☐	☐	☐	☐	☐
25. I vary the number of routes climbed per session from	1	2	3	4	5
session to session	☐	☐	☐	☐	☐
26. I vary the number of routes climbed in each session based					
on how hard I climbed during my last session as well					
as how hard I plan to climb during my next session.	☐	☐	☐	☐	☐
27. As the number of climbing sessions per week increase,					
I decrease the number of routes completed in each					
climbing session.	☐	☐	☐	☐	☐
28. As part of a warm-up I increase my body temperature					
by biking, jogging, rowing, or a similar activity.	☐	☐	☐	☐	☐
29. As part of a warm-up I stretch before each climbing session.	☐	☐	☐	☐	☐
30. As part of a warm-up I complete a few climbs at a grade					
or two easier than my redpoint ability.	☐	☐	☐	☐	☐
31. I climb more or fewer number of routes than normal					
based on how I feel that day.	☐	☐	☐	☐	☐
32. When I feel tired I climb three days or less each week.	☐	☐	☐	☐	☐

33. When my muscles are sore I climb three days or less
each week.

☐	☐	☐	☐	☐
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34. I climb as hard as I can as long as my body is not sore.

☐	☐	☐	☐	☐
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35. During every climbing session I climb at or near
my redpoint ability.

☐	☐	☐	☐	☐
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36. During every climbing session I climb at or above
my on-sight ability

☐	☐	☐	☐	☐
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37. Typically, I climb more than three days each week.

☐	☐	☐	☐	☐
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38. I climb as many routes as I can each climbing session.

☐	☐	☐	☐	☐
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