8-2012

Helmet Use Among Outdoor Recreational Rock Climbers Across Disciplines: Factors of Use and Non-use.

Kevin Henri Hogan Soleil
ksoleil@utk.edu

To the Graduate Council:

I am submitting herewith a thesis written by Kevin Henri Hogan Soleil entitled "Helmet Use Among Outdoor Recreational Rock Climbers Across Disciplines: Factors of Use and Non-use.." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Recreation and Sport Management.

Angela J. Wozencroft, Major Professor

We have read this thesis and recommend its acceptance:

Steven N. Waller, James H. Bemiller

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Helmet Use Among Recreational Rock Climbers Across Disciplines: Factors of Use and Non-use.

A Thesis Presented for
The Master of Science
Degree
Recreation and Sport Management
The University of Tennessee, Knoxville

Kevin Henri Hogan Soleil
August 2012

Dedication

This work is dedicated to my fellow climbers for whom it will benefit most. I would like to thank Dr. Steven Waller for his support and guidance, Holly Smolenski and the Access Fund for their assistance in collecting data and Cary Springer for her patience and technical support during the statistical analysis. Thank you also to Dr. Angela Wozencroft and professor James Bemiller for your valued feedback in the revision process. Thanks to Benjamin Darnell for your hard work, inspiration and understanding. Thanks to my parents Donald and Sandra Hogan for instilling in me an appreciation for the many dangers in life while also encouraging me to experience things to their fullest. Most of all, thank you to my wife Emily Soleil for your love, support, patience and reassurance. This project would have never happened without you.

Abstract

The use of helmets in outdoor recreational rock climbing is a risk management practice meant to offer some protection to climbers in the event of falls and falling objects. Helmets are used inconsistently across many disciplines of rock climbing including top-rope, sport lead, traditional lead and belay. Though climbing accidents involving head injuries are rare, many tend to be severe. The purpose of this study was to assess the rate at which helmets are being used, discover the most significant personal and environmental factors that influence use and non-use and differences between disciplines. The study surveys (N = 1481) climbers across the U.S. regarding their helmet use as well as human and environmental factors in their perceptions of risk. Major findings include helmet use rates (on a 1-5 likert scale [1] never [5] always) for disciplines of top-rope (M = 2.71), sport lead (M = 3.41) and traditional lead (M = 4.16) with corresponding belays means slightly lower in sport and traditional lead. Major factors influencing helmet use includes slope, difficulty, rock quality, attitudes, values and beliefs, peer influence, training, learning venue, age and experience. Significant differences in groups based on discipline are found for every influencing factor. All groups generally report helmet use levels that correspond to the relative hazard and risk levels associated with each discipline of climbing. The results can be used to inform current climbing culture, marketing strategies, education, peer mentoring and above all personal risk management practices of climbers. Recommendations are made against mandatory helmet use policy and in favor of increased education, qualified instruction and situational awareness.

Table of Contents

List of Tables

CHAPTER 1: INTRODUCTION

Technical outdoor rock climbing is a multifaceted and dynamic sport derived from mountaineering in which participants ascend cliffs using various types of equipment to protect them as they climb. The basic safety system according to Eng and Van Pelt (2010) includes rope, helmets, harnesses, runners and carabineers. Numerous observations of rock climbers and climbing media currently run counter to this.

Rope, harnesses, carabineers, and runners are still present at almost every technical outdoor rock climb however helmet use is significantly less prevalent. Current data estimates that about one in three climbers regularly wear a helmet (Gerdes, Hafner, & Aldag, 2006). Rock climbing helmets are designed to protect the climbers head from falling objects such as rocks, ice or dropped gear and contacts with hard surfaces such as the rock in a leader fall, swing or sudden upward movement. Helmets can even provide some level of injury protection in the event of a ground fall (Eng & Van Pelt, 2010). Despite the fact that one or more of these events is possible to some degree on just about every climb, many climbers opt to go without wearing a helmet. The purpose of this study was to gage helmet use among recreational roped climbers and determine what factors play a part in the decision of climbers to wear or not to wear a helmet. The data can then be used to discuss potential changes in the current climbing culture, marketing and education strategies, and individual risk management practices.

Overview of Rock Climbing

The Outdoor Industry Association's (2011) *Outdoor Recreation Participation Report* estimates show some 4,770,000 people participated in indoor/bouldering/sport climbing and some 2,198,000 people participated in traditional/ice/mountaineering in

2010. Trends from the last few years show these numbers as steady if not slightly increasing since 2006. While many forms and variations of climbing exist, each with their own inherent set of injury rates and primary injury mechanisms, this study will focus efforts on exploring helmet use in outdoor top-rope, sport and traditional free climbing as they are the most prevalent forms of rock climbing today and are perceived as having the most varied helmet use practices.

Rock Climbing Disciplines

Top-rope climbing is a form of climbing where the climber is protected by a rope that passes through an anchor point that is above them at all times. In the event of a fall the climber will fall a minimal distance and be caught by the rope. Top-roped climbing generally occurs on pitches anywhere from 25 – 200 feet high. Climbers following a leader up multiple pitches are also considered to be top roped. Hazards include falling objects from above and swings from falls.

Lead climbing is where the climber starts with the rope at their level and clips the rope to protection periodically using carabineers and slings as they climb. This protection is either permanently attached to the rock such as bolts (*Sport Climbing*) or removable such as chocks and spring-loaded camming devices (*Traditional Climbing*). While leading, a climber has the potential of falling at least twice the distance to their last piece of protection plus the stretch of the rope. A major consideration between sport and traditional climbing is that protection in sport climbing is generally placed in regular intervals so as to provide maximum safety while protection on traditional climbs is placed subject to availability, thus sport climbers generally will experience shorter falls than traditional climbers. Lead climbing using either sport or traditional protection is generally done in a free climbing style. Free climbing refers to the climber using their own body to ascend the wall in contrast to aid climbing where climbers use primarily mechanical means to ascend.

Most forms of roped climbing involve a climber and a *belayer. The belayer's* job is to take in or pay out rope for the climber in order to minimize the severity of a fall. The belayer for a leading climber is generally positioned below the climber exposing them to the risk of hazards such as falling objects and strong pulls on the rope in the case of a leader fall. For further information refer to *Mountaineering Freedom of the Hills* (Eng & Van Pelt, 2010).

CHAPTER 2: LITERATURE REVIEW

Rock Climbing Injuries

Rock climbing is dangerous and has the potential for serious injury or death, however on the whole rates of injury are far lower than many mainstream sports. A study by Schöffl, Morrison, Schwarz, Schöffl and Küpper (2010) *Evaluation of Injury and Fatality Risk in Rock and Ice Climbing* compared injury rates from various disciplines of climbing to those of other popular sports through an extensive retrospective compilation of epidemiological studies. Their study compiled and reported adjusted injury rates per 1000 hours of sport participation time. They reported injury rates of (37.5) for traditional climbing 20 years ago, (.56) for mountaineering and traditional climbing and (.079) and (.027) for indoor climbing. Neuhof, Hennig, Schöffl, and Schöffl (2011) reported (.20) injuries per 1000 hours for sport climbing. Compared with injury rates of popular mainstream sports such as youth rugby (57), American football (15.7) or Basketball (9.8) injury rates for climbing sports appear modest (Schöffl et al., 2010).

The International Federation of Mountaineering and Climbing (UIAA) injury severity scale (Schöffl, Morrison, Ullrich, & Küpper, 2011) provides a way to consistently report injuries by outcome terms of seriousness of injuries. Schöffl et al. (2011) reported UIAA III injuries (major, not life-threatening) occurring at (.04) and UIAA IV-VI injuries (major, life-threatening non-mortal and mortal, immediate death) at (.001) per 1000 hours in sport climbing. Backe, Ericson, Janson, and Timpka, (2008) reported only 7% of all climbing injuries were traumatic in nature. While this data shows that overall the probability of suffering a serious injury is low, death or serious injury do occur and call for further inquiry into specifics of injuries.

While discussing the use of helmets it is most pertinent to focus on head injuries. In regards to head injuries we will explore the discipline of climbing (i.e. sport, traditional, top rope), the frequency and severity of injuries, most common mechanisms of injury and the protection offered by helmets.

Frequency of head injuries.

The Nelson and McKenzie (2009) study entitled *Rock Climbing Injuries Treated in Emergency Departments in the U.S., 1990-2007* sampled (N = 40,282) patients showing that head, face and neck injuries account for 4910 (12%). Disciplines were not differentiated. Bowie, Hunt, and Allen (1988) reported on (N = 220) rock climbers visiting the emergency room clinic at Yosemite National Park. Of 451 injuries, 25 were to the skull and brain and 10 to the face and neck, overall comprising 6% and 2% of injuries respectively. Traditional climbing was the most prevalent style in Yosemite at the time. Backe et al., (2008) reported from a sample of (N = 606) Swedish Climbing Association members, that traumatic head and neck injuries account for one in six traumatic injuries occurring during traditional climbing, 1 in 188 total injuries across disciplines. The Backe et al. study included overuse injuries, which are the most common. Paige, Fiore and Houston (1998) reported injury rates of (N = 251) climbers over a five-year period. Four head injuries are reported: two (4%) while practicing traditional climbing and two (3%) while sport climbing. Gerdes et al. (2006) reported head injuries at a rate of 3.9%. Lower percentage findings in Backe et al. (2008), Paige et al. (1998) and Gerdes et al. (2006) were due to the inclusion of non-traumatic and overuse injuries. It should be noted that only one of these studies, Bowie et al. (1988) included data on

UIAA severity 6 (immediate death) injuries, where 9 out of 14 deaths involved head trauma, roughly 4% of the injured climbers.

Severity of head injuries.

While head injuries seem to be some of the less common, they have the potential to be very severe. "Six percent of single most severe injuries were attributed to head trauma, but 9 of these 14 were fatal… The pathologist who did the autopsies on most of the fatalities believes that helmet use might have prevented some deaths from trauma" (Bowie et al. 1988, *p*.174-175). In addition, Nelson and McKenzie (2007) found 24.1% of head injuries result in hospitalization.

Mechanism of head injuries.

Reports on the mechanism of injury in emergency room related climbing injuries indicated falls as the primary mechanism of injury at 77.5% from Nelson and McKenzie (2009) and 66% from Bowie et al. (1988). According to the American Alpine Journal (2011) publication, *Accidents in North American Mountaineering,* accident reports gathered between the US and Canada from 1951-2010 showed falls on rock account for 4035 of 7714 (52.3%) total accidents. Paige, Fiore and Houston (1998) list the most common mechanism for traditional climbing injuries as falls at 43% however, falls were not the dominant mechanism for sport climbers at 12%. It is important to keep in mind that Paige et al. includes various severity levels of climbing injuries including less severe overuse of tendons and joints. It should be noted that falls greater than 20 feet as a mechanism for serious injury were 10 times more likely to result in hospitalization than falls of 20 feet or less (Nelson & McKenzie, 2009)

Paige et al. (1998) reported being hit by a falling object caused 11% of injuries in traditional climbers and 8% of injuries in sport climbers. Falling objects caused 10% of injuries reported by Bowie et al., (1988) and 6.4% of injuries and where “falling objects were 3.87 times more likely to injure the head than another part of the body and 2.8 times more likely to result in hospitalization” (Nelson & McKenzie, 2007, p. 197). Other pertinent mechanisms included striking a hard surface was listed in Nelson and McKenzie (2007) as causing 7% of injuries.

Function of helmets.

For the sake of this study it is worth looking at how much protection helmets offer users in the event of an incident to determine if it’s even worth the trouble to wear one. A summary of the UIAA safety standard number 106 and European Committee for Standardization (CEN) document 12492:2002 found at theUIAA.org (2011) relating the testing standards for mountaineering helmets states relates a variety of ways that helmets are tested. Helmets are tested using a rounded 5kg mass dropped from a distance of 2m on the top of the helmet. This drop may produce no more than 10kN (CEN) or 8kN (UIAA) of force on the neck of a head form wearing the helmet. Helmets must also pass side tests where a flat 5kg object is dropped from .5m on the front, back and sides of the helmet and is attenuated to produce no more that 10kN (CEN) and 8kN (UIAA) to the head form. Helmets must also pass tests that involve a sharp 3kg mass dropped from 1m prevented from contacting the head form as well as slippage pull tests that ensure that helmets will stay on the head within a force range of a 5kg dropped from .5m pulling on it. Certified helmets conform to these standards as a minimum.

These lab tests are meant to mimic some of the real life scenarios faced by climbers. They represent small objects (rocks, gear or ice) falling from relatively short distances and relatively short falls. In practice, falling objects may range from carabineers and pebbles of a few grams to massive rock or ice blocks. Fall distance of objects or climbers may range anywhere from a few to hundreds of meters. Climbers must recognize that while protections do exist by way of helmet use, there are limitations to the protection of a helmet. Wearing a helmet may reduce the force of whatever impact a climber may incur, however some impacts will cause injury or fatality regardless.

So how many are wearing helmets? From the Bowie et al.'s (1988) sample of 220 emergency room patients, only 6 were wearing helmets. Gerdes et al. (2006) showed out of 1887 self-reports some 36.3% of climbers report wearing helmets all or most of the time and 19.3% never wear helmets. Apart from this data there is relatively little scholarly research on climbers use of helmets.

Helmet use in related activities.

In the past two decades other outdoor recreation activities, mainly cycling and downhill snow skiing and snowboarding have been studied in regard to helmet use and were then the focus of subsequent helmet use campaigns.

Rivara, Thompson, Patterson, and Thompson (1998) conducted a very through literature review on cycling injuries and helmets use. They showed that helmet use ranged from less than 2% in the mid 1980's to up to 20% in children and up to 50% in adults in the mid 1990's (Rivera et al., 1998). Rivera et al. cite Baker, Fowler, and Dannenberg (1993) stating there were approximately 67,000,000 cyclists, 500,000 injuries treated in emergency departments, and 900 deaths annually. Head injuries accounted for “one third of emergency department treated bicycle injuries, two thirds of hospitalizations, and three fourths of bicycle deaths. Motor vehicle collisions are responsible for one third of bicycle related brain injuries and (90%) of bicycle fatalities” (Rivara et al., 1998, p.294). Helmets are shown to be very effective in preventing head injuries, brain injuries and severe brain injuries. “…Bicycle helmets decrease the risk of head injury by (85%)” (Rivara et al., 1998, p.295). Conclusions included that helmet use increase was prompted by a combination of education, legislation and subsidies as well as environmental modifications such as the additions of bicycle lanes have been proven to significantly decrease injury and fatality rates.

Cundy et al. (2010) report similar conditions in snow sports for skiers and snowboarders regarding injury and helmet use rates. Highlights from their literature review include “head injury is the leading cause of hospital admission, serious morbidity and fatality in snow sports…[And that the] protective effect in reducing head injuries ranges from between 25% and 60%” (p. 1486). Other findings reveal helmet use is measured at 16% for adults and 67% of children. Moreover, 71% of helmet users always use them and while 16% reported use helmets most of the time. Cundy et al. (2010) reports low experience, recent instruction, incident experience and concurrent use of other safety equipment significant predictors of helmet use. Attitudes toward helmet use were also measured with respondents saying “to be safe, to keep my head warm, not compulsory and never considered” as the most popular reasons for and against wearing helmets. Cundy et al. (2010) have speculated as to the contributing factors of helmet use increases in the last decade including factors of safety awareness programs, diffusion of seasonal trends by professional athletes and other recreationalists, increased availability and local marketing and recent fatal accidents of high profile participants.

The parallels of cycling and downhill snow sports, while not exact, will help to validate the direction of our approach. Looking at epidemiologic data gathering, benchmarking expected use rates, observing and measuring attitudes inform the possible ways to influence attitudes and use rates.

Conceptual Framework

Standard of care.

Risk management is a concept that is at the forefront of all climbing activities. In addition to climbers wanting to manage risks to keep themselves safe, land managers and climbing providers such as guide services need to manage risk as well. Risk to land managers and climbing providers generally comes in the form of legal liability and is a direct product of the relationship they maintain with climbers. Examining these relationships and the corresponding standards of care gives us insight into why current trends of helmet use are allowed to occur.

Land managers, either public or private benefit from laws that encourage recreation on their lands. The Access Fund is the largest non-profit climbing access organization in the U.S., According to risk management literature from the Access Fund that discussed legal protection for governmental entities:

> As a general rule, political subdivisions of the government, including federal and state agencies, municipalities, and county governments, and their employees are generally protected from liability for acts conducted within the scope of their

> duties and employment unless expressly waived by statute. This is also referred to as sovereign immunity. (Access Fund, 2005, p.2).

Sovereign immunity can be waived in certain cases, including tort claims under the Federal Tort Claims Act (1945). This waiver is subject to the "discretionary function exception" which serves to further protect governmental employees and entities from legal action ". . .based upon the exercise or performance or the failure to exercise or perform a discretionary function or duty. . ." (28 U.S.C. § 2680; Access Fund, 2005, p.2). Sovereign immunity along with state and regional recreational use statutes make litigation against government entities more difficult (Access Fund, 2005).

Recreational use statues, which exist in some form in all 50 states, serve to reduce governmental and private landowners liability and promote public recreational use of private lands (Access Fund, 2005). For example, the Tennessee State Code referring to land subject to conservation or public use easement states:

> **(a)** An owner of any land, which is subject to a conservation easement or public use easement, granted to or acquired and held by the state or any agency thereof, owes no duty of care to keep that land safe for entry or use by others or to give warning to any person entering or going upon such land of any dangerous or hazardous conditions, uses, structures or activities thereon. (Tenn. Code Ann. § 11-10-103, 2012)

The Access Fund (2005, p. 4) explained that "Recreational use statutes generally provide that a landowner does not owe either a duty of care to keep the property safe for entry or use, or a duty to give any warning of a dangerous condition, use, structure, or activity on their property to anyone using his of her property *for recreational purposes and without* *charge*." Where a landowner does charge a fee, the relationship changes and their duty becomes elevated where invitees have "the right to expect that the premises are reasonably safe and that warnings will be given about any conditions on the premises that cannot be made safe by the landowner" (Access Fund, 2005, p.6).

In both cases public and private, where falls, falling objects, technical abilities and specific equipment use of climbers are concerned a landowner or manager's standard of care is at most to warn climbers of dangers beyond their control. According to the Access Fund (2005), land managers are discouraged from adopting specific policies and attempting to regulate climbing practices or training, as this would increase their liability and standard of care. This increased risk of liability is likely why land managers do not require helmet use despite it's potential to reduce injuries. Furthermore, the Access Fund (2005, p.5) sites assumption of risk doctrine stating "People assume the risk of injury or damage if they voluntarily or unreasonably expose themselves to injury or damage with knowledge or appreciation of the danger and risk involved."

In the case of commercial climbing providers we find the opposite approach. The commercial climbing industry is practicing the use of climbing helmets across outdoor roped climbing disciplines. The American Mountain Guides Association (AMGA) is the most authoritative source for climber instructor and guide certification as well as climbing provider accreditation in the United States. The AMGA is the only recognized member of the International Federation of Mountain Guides Association (IFMGA) in the United States. While the AMGA has no prescriptive policy regarding helmet use, they recognize and teach that the use of helmets for all types of outdoor roped climbing is the industry standard for commercial providers. AMGA accreditation criteria state that an organization must have a policy that specifies helmet use requirements during services provided. Additionally their instructor and guide certification programs emphasize personal judgment, working within the scope of best practices and adhering to accepted industry norms (E. Crothers, AMGA Accreditation Dir., personal communication, May 10, 2012). In addition, the Association for Experiential Education (AEE) offers accreditation standards for adventure programs. The AEE (2009) standards for rock climbing require that "The program follows practices that are accepted within the industry. These practices might include, but are not limited to… using helmets" (p. 37). These positions on helmet use assist in establishing the standard of care for litigation involving clients in outdoor commercial climbing activities.

Risk management for recreational climbers.

Where the standard of care is low for government agencies or not for profit private land managers and standards from the AMGA or AEE do not apply directly, individual recreational climbers are free to make their own risk management decisions regarding helmet use. Spengler, Connaughton and Pittman (2006) present a basic three-step risk management framework in which (1) hazards are identified, (2) risk is evaluated by probability and severity then (3) risk management measures are put in place. The way each climber approaches this process will largely depend on their personal background and the environment they are in.

Hazard identification.

According to Priest and Gass (2005) hazards are the conditions and circumstances of a potential loss such as loose terrain or long protection intervals. Hazardous conditions expose climbers to peril. Perils are the cause or source of potential loss such as a falling rock or massive leader fall. Danger consists of hazards and perils (Priest & Gass, 2005)

Priest and Gass (2005) adapt an accident potential model from Williamson and Meyer (1979) to include environmental dangers, client dangers, and leadership dangers, which when combined, provide for the potential for an accident. Since this study focuses primarily on recreational users who often play the role of client and leadership, we will group these categories together into human dangers. Eng and Van Pelt (2010) point to extensive incident reports in Attarian et al. (2011) *Accidents in North American Mountaineering* where human hazards such as poor decision making, poor state of mind due to ignorance, casualness, distraction, inadequate skill, and inadequate fitness are contributing hazards in most mountaineering accidents. Environmental hazards include rock quality, climbing discipline, terrain, difficulty, protection, geography, weather conditions, partner ability and other people. Every climb and climber will have a different set of dangers that will influence the risk of an accident.

Risk evaluation.

Priest and Gass (2005) define risk as " …the potential of loosing something of value. The loss may lead to harm that is physical, mental, social or financial." "Accidents are unexpected occurrences that result in a loss" (p.18). Loss in the present case regarding rock climbing and helmet use generally comes in the form of head trauma secondary to a fall or falling object. The level of risk can be calculated as a product of the probability of an accident, (likelihood, exposure) and the severity of an accident (Priest & Gass, 2005). Through the analysis of head injury data, it was generally found that the probability of head injuries were low; however, severity of those incidents when they occur could range from mild injury to immediate death. This reflects the mountaineering incident pyramid, (Eng & Van Pelt, 2010) where for every 200,000 unsafe acts, we will generally see about 2000 near misses, 200 minor injuries, 20 major injuries, and 1 fatality. Spangler et al. (2006, p.9) writes, "Where the risk of severe injury from a hazard is high but its likelihood is low, it is still wise to take a serious look at developing appropriate safety measures."

Risk management.

Prudent rock climbers would ideally evaluate each and every situation and determine the most appropriate risk management practices for that situation. This decision boils down to three general courses of action; accept, mitigate or avoid risk.

The decision to wear a helmet or not is one risk mitigation practice that exists in conjunction with many other risk management decisions that occur on any given climb. However unlike the use of ropes, harnesses, carabineers and slings, helmet use is highly variable. Some climbers adopt helmet use practices that are on the conservative side, choosing the most cautious practice of using one at all times. Some take a more casual approach simply accepting all risks and choosing never to use a helmet. Again, rock climbing is a dynamic sport and takes place in a wide variety of venues and spans a wide variety of disciplines, each with its own inherent dangers. When a climbers' approach to risk management stays static as dangers change, the window for an accident may grow or shrink accordingly.

Spengler et al. (2006) discusses factors to consider when deciding to implement a risk management plan including self-evaluation with an emphasis on personal perception of risk. Powell (2007) pulls from the work of many other scholars and authors to outline a framework for considering personal factors that contribute to outdoor adventure enthusiasts' personal perception and management of risk. This framework is validated in part by the framework of Spengler et al. (2006) and the findings in literature studying helmet use in cycling, and alpine snow sports (Rivera et al. 1998, Cundy et al. 2010). Powell (2007) lists factors that include plural rationalities, reporting of risk, attitudes, values and beliefs, the rewarding of risk, and the role of the group. This study will adopt much of Powell's framework (explained in greater detail, see p.16) as a means to present and explore the specific personal factors that may contribute to helmet use.

The framework for environmental factors will draw from various instructional texts such as *Mountaineering: Freedom of the Hills* (Eng & Van Pelt, 2010) and *Rock Climbing: Mastering Basic Skills,* (Luebben, 2004) as well as other literature. Environmental factors include rock quality, climbing discipline, terrain, difficulty, geography, weather conditions, partner ability and other people.

Personal factors.

Plural rationalities.

Powell (2007) wrote, "differing views of risk may be based upon rational but alternative assessments" (p.11). It stands to reason that a professional mountain guide and a novice teenager would have different experience sets with which to reflect on and evaluate risk situations. Powell (2007) wrote, "views of risk produced by expert systems may be marginalized or not seen to be applicable or being blanket responses that do not account for specific circumstances" (p.11). Organizational standards such as those of the American Mountain Guides Association (AMGA, 2011) and the Association for Experiential Education (Smith et al., 2009) strongly encourage helmet use on outdoor rock climbing courses; however, many peer groups do not. These professional organizations have seen that there is a need for helmet use; whereas, many peer groups may not have. Respondents were questioned regarding indoor or outdoor venues where climbers first learned to climb, climbing and medical training they have attended and influences in their current practices.

Reporting.

A climber's perception of risk may vary according to the news media, magazines, books, videos and other media that he or she is exposed to and how head injury and helmet use is portrayed in this media. For example if a famous climber dies of a head injury from a falling rock and is widely publicized, suddenly perceptions of risk may rise even if there is no change in the overall pattern of fatalities and head injuries. Conversely, if media portrayal of helmets is marginal, inconsistent, casual or unnecessary we may expect media consumers to have a diminished perception of risk (Powell, 2007). Respondents were questioned about media consumption and impressions of media regarding portrayal of helmet use.

Attitudes, values and beliefs.

Drawing upon the work of Alhakami and Slovic (1994), Powell (2007) writes "if an activity is liked, the benefits are judged to be high and the risks low. If an activity is disliked, the benefits would be perceived as low and the risks high [which highlights] the influence of one's belief systems and the avoidance of cognitive dissonance" (p. 11). Applying this logic to helmet use, if helmets are perceived as negatively impacting performance or uncomfortable and bulky, climbers are likely to attenuate their perception of risk in order to accommodate this view and not wear helmets. If climbers see helmets as beneficial, socially excepted and safe they are more likely to wear them. Respondents in this study were questioned on attitudes, values and beliefs regarding functional and aesthetic aspects of helmet use.

Rewarding of risk.

Climbers' perception of risk is based on past experiences: positive and negative. Powell (2007, p.12) notes, "Each time an incident does not occur, the avoidance of the inconvenience and discomfort of preventative and precautionary action may reinforce behavior" (referring to Slovic et al., 1978). Experience or inexperience with potentially dangerous events such as rockfall or previous head injury will reinforce perceptions of risk. Respondents in this study were asked to report past experience with rockfall, near misses, injuries and deaths.

Role of groups.

Powell (2007, p.12) observed that "Group norms and social acceptability of behavior may act as powerful determinants of risk-taking behavior." Peer attitudes and habits in regard to helmet use may play a role in an individual's attitude toward wearing them. Referring to Celsi at al. (1993) Powell (2007) states "High risk activities that may initially be regarded as extreme come to be viewed as the norm" (p.12) A novice climber may wish to join a group of more experienced climbers who do not wear helmets. In the context of joining this group the novice climber is likely to accept the attitudes and beliefs of the group in the process. Respondents were asked to report the general attitudes and habits of their peers regarding helmet use.

Normalization of risk.

Over time, as experience accumulates the perception of risk may diminish for some participants. Risks are accepted much more readily by those who have lived with them longer. (Powell, 2007) Novice climbers may perceive a much greater risk than experienced climbers and choose to wear helmets more frequently than experts. Risk normalization may also play a role in a climber's progression through increasingly hazardous disciplines and climbs over the course of their experience. Creyer, Ross & Evers (2003) find that "As experience is acquired, the perceived risks associated with a risky activity diminish while the affective outcome expectancies become increasingly positive. . .As experience is acquired, many participants 'push the envelope'." Respondents in this study reported years climbing experience overall as well as for various disciplines.

Demographic factors.

In addition to Powell's framework, personal risk factors such as age and sex have emerged in many studies of rock climbing injuries. Climbers between the ages of 20 and 40 accounted for more than half of all injuries and males accounted for 71.8% in Nelson and McKenzie (2007). Respondent demographic information including age, sex, state was collected.

Environmental factors.

Climbing discipline.

Each discipline of climbing, top-rope, sport or traditional, has its own inherent subset of objective hazards and risks. The level of risk generally associated with each corresponds roughly to the order they are listed above with top-rope being low risk to traditional as high risk. Schöffl et al. (2011) provides examples of fatality risk classification, disciplines listed as sport II (few objective dangers), traditional III (high objective danger). As pointed out in Paige et al. (1998) injury subsets for sport and traditional climbing vary by location on the body and mechanism of injury. Climbers may base their helmet use decisions on the discipline of climbing they practice. Helmet use data was collected for top-rope, sport lead and traditional lead as well as belay for each. Climbers also identified a most frequent discipline, which was used to compare climbers in different discipline groups.

Rock quality.

The quality of rock that climbing occurs on may make a large difference to some people as they make a choice to wear a helmet. The difference may be that of soft desert sandstone versus bullet hard granite or between climbing and cleaning debris from a brand new route with many loose rocks versus climbing a well-established popular sport route that gets lots of traffic. The differing quality and types of routes and rock will dictate different objective hazards and risks. Respondents were asked to identify the quality of the rock they most frequently climb including hardness, presence of loose rock, and frequency of travel.

Terrain.

Since the main mechanism of injury is falling, terrain is an important consideration. Are the routes straight up, vertical or overhanging with clean falls? Are the routes wandering, less than vertical and full of ledges and corners? Is protection ample or sparse? Respondents were asked to identify the types of terrain they most often climb on including slope, and protection interval.

Difficulty.

When climbers push their limits they are more likely to take falls. Since personal limits differ from climber to climber, there is no number grade difficulty where we can say climbers are more or less likely to fall. Respondents were asked about whether or not they push their limits and take regular falls or climb within their abilities to avoid taking falls. Respondents were asked to use the Yosemite Decimal system to identify the difficulty of the routes they climb regularly without falling (on-sight) as well as the frequency and length of falls.

***Commitment*.**

Climbing and being injured at a crag next to a road, only a few minutes away from a major medical facility has much different risk implications than climbing a remote wall many miles from a road away from cell service. Thus, geographic risk factors may make climbers more or less careful when choosing to wear helmets. Respondents were asked to identify the commitment grade I-V their outings range as well as an average time to nearest hospital.

Weather.

Many climbing areas are subject to the freeze thaw cycle where upon water seeps into the cracks, freezes, expands and leverages blocks loose each winter, increasing the chances of rockfall. High winds in some areas also contribute to potential rock falls. In addition, many areas are prone to sudden afternoon thunderstorms with rain that can upset precarious rock and make rock slick increasing the chances of falling. Respondents were asked to identify weather conditions they climb in.

Partner quality.

Climbing is most often done in a team of two, sometimes more. The abilities, experience and competence of one's climbing partner(s) are important considerations when managing the risk of a situation. A climber taking first time friends who have never belayed before may take additional precautions for their own safety, putting on a helmet where they do not usually wear one. Conversely a seasoned team who has relied on each other for years may be confident enough in each other to take additional risks or forego certain safety practices such as helmet use. Respondents were asked to provide a general evaluation of their partner's ability, experience and competence.

Research Questions

Based on the review of literature and theoretical framework the following research questions have been developed to explore helmet use in recreational rock climbing:

1. What are the current trends in helmet use among outdoor recreational rock climbers?
2. Does helmet use differ between climbers' most frequent disciplines of top-rope, sport lead and traditional lead?
3. How are personal factors related to helmet use and do they differ by most frequent discipline?
4. How are environmental factors related to helmet use and do they differ by most frequent discipline?

CHAPTER 3: METHODS

Study Design

This study is primarily descriptive and exploratory in nature. The study largely utilizes quantitative metrics supplemented by optional written comments at the beginning and end of a questionnaire.

Pilot questionnaire.

The primary researcher designed the questionnaire. Prior to the launch of the study, a small mixed group of climbing peers 9 and professionals 7 were sent a pilot questionnaire to review for content validity as well as question construction. 4 and 3 responses respectively were returned. All responses affirmed the validity of the content and question construction was revised as needed.

Online questionnaire.

Rock Climbers across the United States were asked to take part in a survey by filling out an online questionnaire during the spring season of 2012. The Access Fund, a major non-profit organization focused on access issues in North America, distributed a small advertisement and link to the questionnaire in the March e-newsletter and via social media. The primary researcher offered to make a donation to the Access Fund of $1 for each response up to $500 as incentive in exchange for responses.

Sample

Distribution through the Access Fund was utilized because the need for a venue to climb and access preservation is common of all outdoor rock climbers across disciplines. Other commonalities among the sample are estimated to include climbers' perception of the value of local climbing areas, involvement in climbing advocacy groups and Internet use. The sample group is expected to be adequately diverse in most or all areas related to this study including helmet use patterns, past personal experiences and environmental considerations. The sample is expected to be representative of the target climbing population of approximately 6.9 million, with the exception of 18-24 year olds who would be underrepresented as determined by comparison of respondent demographics from a recent Access Fund survey using similar distribution methods (Smolenski, H., personal communication, February 8th, 2012) to climbing participation and overall outdoor recreation participation trends (Outdoor Foundation, 2011). The Outdoor Foundation study included information on indoor climbing gyms grouped with outdoor climbing. This may have served to inflate outdoor climbing reporting rate. Age groups 17 and under were not measured.

Data Collection

The Access Fund e-newsletter was distributed on March 15th to 15,372 email addresses. Of these 3,719 newsletters were opened and (*N* = 635) valid responses were collected between the 15th and 19th for a response rate of 17% for those emails opened. On March 20th the questionnaire link was featured on the Access Fund's Facebook and Twitter social media channels. The Facebook page had 12,338 likes at that time and the link was shared from their site 28 times by a variety of climbing equipment manufacturers including Petzl (74,925 likes), and Metolious (9,418 likes) as well as local climbing coalitions, guide services and individuals. The Access Fund twitter feed had 2438 subscribers. Social media distribution resulted in (*N* = 846) usable responses from March 20th – 30th. Due to the nature of social media it is difficult to calculate an exact response rate.

Data Analysis

Data was analyzed using IBM SPSS software. Descriptive statistics were generated for each section. Pearson correlations were generated for each factor overall to determine relationship with helmet use. Independent and paired samples T-tests, ANOVAs and MANOVA were used to analyze group differences between most frequent disciplines with regard to factors. Additionally, Tukey HSD post hoc tests were used to identify specific significant differences between groups. To determine if there were associations between key nominal level variables, Pearson's chi-square tests for independence were used to produce descriptive statistics of distribution of most frequent discipline subgroups according to independent variables.

CHAPTER 4: RESULTS AND DISCUSSION

Results

This study was primarily exploratory in nature. The purpose of this study was to assess the rate that helmets are being used in outdoor recreational rock climbing across disciplines as well as expose and explore the contributing personal and environmental factors. The results are presented from the most general to specific in conjunction with research questions. For each factor relationships to helmet use are presented followed by differences in most frequent discipline groups relating to that factor.

Q1: What are the current trends in helmet use among outdoor recreational rock climbers?

A total of $N = 1481$ responses were collected where $N = 1279$ completed the entire survey. During data analysis each section was calculated according to the completed responses for that section, thus N will vary slightly between sections as respondents dropped out of the survey. Respondents ranged in age from 18-87 years old with a mean age of (M=35.9) years. Respondents reported an overall years experience ranging from <1 year to 57 years with a mean of ($M = 11.86$). Respondents were predominately male (74.7%). Most respondents were residents of the United States (92.7%), with high responses rate from California (15.1%), Colorado (10.9%), and Washington (7.5%). Most other states were represented roughly according to size and climbing resources. International responses accounted for less than ten percent of the total number of responses (7.3%).

Respondents were asked to identify helmet use frequency for each discipline of climbing they participated in using a zero through five likert scale response grid. Zero represented “I don’t do this activity” and one through five represented “never” to “always.” Responses of zero were omitted and therefore *n* represents only the respondents who answered one through five. This data serves to give an overall helmet use rate for disciplines of top-rope, sport lead, traditional lead and corresponding belays as well as show the number of respondents who participate in each (see Table 1, p.80).

RQ2: Does helmet use differ between climber’s most frequent disciplines of top-rope, sport lead and traditional lead?

Respondents were asked to identify the climbing discipline they participated in most often. Their responses were then grouped by the discipline they identified and means were found based on their earlier self-reported frequency of helmet use for that discipline; top-rope (n = 310, M = 3.26, SD = 1.47), sport lead (n = 612, M = 3.20, SD = 1.44), and traditional lead (n = 556, M = 4.38, SD =.97). An ANOVA found differences in mean helmet use of all groups of most frequent discipline $F(2,1475) = 141.38$, $p < .001$. A Tukey HSD post hoc multiple comparisons test showed significant mean differences in helmet use were found from traditional lead to top-rope and sport lead at significance ($p < .001$).

Qualitative data was collected to add meaning to the quantitative data collected. The two questions “What is your main reason for using a helmet?” and “What is your main reason for not using a helmet?” were posed to respondents directly following the initial questions on helmet use and most frequent discipline. Comments were reviewed and coded based on factors explored in this study and common objective hazards in climbing. Code categories included differences in discipline, falls, falling objects, attitudes, values and beliefs, incident experience, ownership of a helmet, medical training, climbing training, role, learning venue, influence, peers, media related issues, difficulty, fall habits, protection intervals, commitment grade, time to medical care, rock quality, partner quality, weather, slope or terrain, primary instructors, concern for others, and overall experience. Subgroups based on helmet use frequency were formed ("never" to "sometimes" and "sometimes" to "always") and comments were tallied from the corresponding question use/non-use category in order to gain insight to different use habits in each discipline. Comments from respondents answering "sometimes" to helmet use frequency were included from both helmet use and non-use questions.

Respondents' comments were tallied from the subgroup reporting they most frequently top-rope and who use helmets from "sometimes" to "always" (*n* =203). Among the most frequent responses were (*n* = 85) respondents concerned with falling objects, (*n* = 76) respondents concerned with general safety, and (*n* = 37) respondents commenting regarding fall protection. Some examples of comments are "Falling rock and other debris is unpredictable" "[I] don't want to get seriously injured" "[To protect my head from] accidental impact with the rock face from falls, especially while traversing or in a swinging fall scenario." Less common topics included (*n* = 12) comments regarding previous incidents and (*n* = 7) comments about loose rock and suspect rock quality concerns.

Comments were tallied from the sub-group of respondents who reported they most frequently top-rope and who use helmets "never" to "sometimes" (*n* = 147). The most common comment code was (*n* = 49) respondents referring to attitudes, values and beliefs such as comfort, visibility, heat and looks. Examples of comments included "Uncomfortable, make you look like a tool"; "Annoying, clammy, can be tight.

Looks/style"; "It's heavy and cumbersome, and looks bad." Other themes in this group included (*n* = 29) respondents commenting that helmet use was unnecessary due to minimal risks, (*n* = 23) respondents commenting helmet use was dependent on the discipline, (*n* = 19) said rock quality was a factor where routes were typically clean and well traveled, and (*n* = 19) said falling objects were unlikely or not a concern. Some examples of comments were: "If the rock quality is good, then I won't wear a helmet." "Climbing in places where the risk of falling rocks, crud etc. is low and I'm top-roping."

Comments were tallied from respondents who reported most frequently sport lead climbing and using helmets from "sometimes" to "always" (*n* = 392). This sub-group commented similarly to the corresponding top-rope pro-helmet sub-group; (*n* = 183) were concerned with falling objects, (*n* = 132) commented about concern with protection during falls including potential inversion, and (*n* = 89) commented about general safety. Examples of comments include "[I wear a helmet for] situations that have higher probability of gear, rock or other debris falling from above" and "As a climber, fear of hitting my head if I fall. [I have a] particular concern about ground fall early in the route and flipping upside down anywhere on the route."

Comments were tallied from respondents who reported most frequently sport lead climbing and using helmets "never" to "sometimes" (*n* = 309). (*n* = 144) respondents commented about attitudes, values and beliefs including comfort, heat, reduced sport performance, effectiveness, expense, a "feeling of freedom" and "coolness." Some comments include: "Climbing helmets do not protect the sides/back of the climbers head." "Inhibited field of vision, disruption of equilibrium, general discomfort." "[I] don't like most of the styles." "[It] doesn't look cool." There were also many comments regarding objective hazards; (n = 45) respondents in this group talked about good rock quality, (*n* = 39) noted minimal risk, and (*n* = 35) climbers noted that they made their decision based on discipline of top-rope vs. lead or sport lead vs. traditional lead. Some comments included “Sport areas are well traveled and usually free of any [loose] rock” and “Steep sport climbing has minimal risk of head injury if a fall were to occur.”

The subgroup for helmet use “sometimes” to “always” (*n* = 501) was the vast majority of the respondents reporting most frequently climbing traditional lead. Comments from this subgroup included (*n* = 291) respondents commented regarding protection from falling rocks/equipment, (*n* = 191) were concerned about falls, and (*n* = 117) respondents commented about general safety and protection. Examples of comments included “protecting my head on climbs where I could take long/awkward falls i.e. run-outs or sketchy [protection]” and “[I] judge potential fall lines for hazards that may create an inverted or swinging fall.”

Comments were tallied from respondents reporting most frequently traditional lead climbing and using helmets “never” to “sometimes” (*n* = 71). This subgroup’s comments primarily reflected attitudes, values and beliefs where (*n* = 37) respondents listed comfort, habit, sport performance and weight or bulk for reasons not to wear a helmet. Some examples of comments include: “During recreational climbing. I don't like the feel of it. I like the freedom of not wearing one as long as there are limited objective dangers.” “[A helmet] impedes movement against the rock and compromises range of motion for sight.” “[I] Don't like helmets.”

RQ3: How are personal factors related to helmet use and do they differ by most frequent discipline?

Data was gathered on a wide variety of personal factors including demographics, climbing experience, attitudes, values and beliefs, recreational and professional roles, climbing training, medical training, sources of instruction, influence, media consumption, experience with accidents, and perception of peer habits regarding helmet use. In general descriptive statistics were produced for each factor. Factors were then tested for correlation to helmet use using respondents' helmet use for their most frequent discipline. The sample was then divided into subgroups by most frequent discipline (top-rope, sport lead or traditional lead) and tested for significant differences regarding that factor.

Age.

The sample (N=1280) ranged in age from 18 to 87 years with a mean age of (M = 35.95, SD 12.52). A significant Pearson correlation was found between age and helmet use where, $r = .181$, $p < .001$. As age increased so did helmet use. Results of an ANOVA identified age differences between most frequent discipline groups, $F(2,1277) = 36.158$, $p < .001$. A Tukey HSD post hoc analysis found significant differences between top-rope and sport lead ($p = .018$) and between traditional lead and both other disciplines ($p < .001$). The sport lead group was the youngest (n = 539, M = 32.98, SD = 11.37), followed by top-rope (n = 251, M = 35.53, SD = 12.82) then traditional lead (n = 490, M = 39.44, SD = 12.73)

Sex.

An independent T-test found no significant difference in helmet use overall between males (n = 956, M = 3.68, SD 1.37) and females (n = 324, M = 3.78, SD 1.35), *t*(1275) = 1.14, $p = .257$ (see Table 2, p.80). Noteworthy differences were present in the distribution of sex between disciplines $\chi 2 = 45.62$, (df = 2, $p < .001$). Where the overall ratio of males to females is approximately 3:1, the top-rope subgroup claims a ratio where the two sexes are almost equally represented and traditional lead has a much higher concentration of males.

Climbing experience.

The Sample ($N = 1382$) was asked to provide years experience overall and for each discipline (see Table 3, p.80). Pearson correlation tests found that overall years of experience as well as years in each discipline have a significant correlation with helmet use. Results of an ANOVA showed that differences exist in overall experience of climbers in each most frequent discipline group, $F(2,1379) = 92{,}743$, $p < .001$. A Tukey HSD post hoc test revealed significant mean differences in groups from traditional lead to top-rope and sport lead at ($p < .001$).

Influence.

The sample ($N = 1351$) was asked to report the level of influence different sources had on their current climbing practices using an one to six likert scale where one represented none and two through six represented very low to very high. Sources with the largest influence were friends and peers, self and instructional media. Pearson correlation tests found significant positive relationships to helmet use influence from instructional media, professional guide services and various professional climbing instruction associations and programs (see Table 4, p.81). Climbing gym influence was shown to have a negative relationship with helmet use.

A general linear model MANOVA showed significant mean differences in at least one of the areas of influence between most frequent discipline groups, $F(10,1338) = 10076.890$, $p < .001$. Individual ANOVAs found differences for categories of self, climbing gym, professional guide services, Internet, American Mountain Guide Association/Professional Climbing Instructor Association (AMGA/PCIA) and National Outdoor Leadership School/Outward Bound (NOLS/OB) programs. Tukey HSD post hoc tests showed significant mean differences outlined in table 5, (p.81). Influence from "self" differed significantly from top-rope to sport and traditional lead ($p < .001$), while sport and traditional lead also differed significantly ($p = .002$). Influence from climbing gyms differed from traditional lead to sport lead and top-rope at ($p < .001$). Influence from professional guide services differed from sport lead to top-rope and traditional lead ($p = .005$; $p = .001$ respectively). Influence from Internet sources differed from traditional lead to top-rope and sport lead ($p = .038$; $p < .001$, respectively). Influence from AMGA/PCIA differed from traditional lead to top-rope and sport lead ($p = .026$; $p < .001$, respectively). Finally, influence from NOLS/OB differed from traditional lead to top-rope and sport lead ($p = .092$; $p = .074$, respectively).

Primary learning environment.

The sample ($N = 1363$) was asked to identify a primary learning venue between outdoor sites and man-made indoor venues (see Table 6, p.81). An independent T-test showed that climbers learning indoors ($n = 467$) showed a mean helmet use of ($M = 3.46$, SD 1.43) where those learning outdoors ($n = 896$) wore their helmets significantly more ($M = 3.81$, SD 1.34), $t(1361) = -4.482$, $p < .001$. Subgroups of top-rope and sport lead were roughly evenly split according to their learning environment, however the traditional lead subgroup tended significantly toward learning in outdoor venues, $X^2 = 129.251$, (df = 2, $p < .001$).

Climbing training.

Technical climbing training among the sample (*N* = 1364) varied widely from little or nothing, to multi-pitch instructor courses or high angle rescue training among others. For the purposes of analysis the majority of respondents training were consolidated into the categories of none, introductory/single pitch course or advanced training (see Table 7, p.82). An ANOVA found differences in helmet use of groups in each category: none (*n* = 456, *M* = 3.49, *SD* = 1.46); introductory/single pitch (*n* = 373, *M* 3.57, *SD* 1.37); and advanced (*n* = 535, *M* 3.95, *SD* 1.29), $F(2,1361) = 15.51$, $p < .001$. Mean helmet use increased as training increased. A Tukey HSD post Hoc tests showed significant mean difference from the "advanced" group to the "none" group and "introductory/single pitch" group ($p < .001$).

Pearson's chi-square test for independence revealed significant differences in the distribution of technical training by discipline with an emphasis on advanced training for traditional leaders, $X^2 = 68.758$, (df =4, $p < .001$). Top-rope fell centered around introductory/single pitch with a generous amount in the "advanced" category. Sport lead was fairly evenly dispersed with slightly more in the "none" category than others.

Medical training.

Similarly to climbing training, the sample (*N* = 1364) reported a wide variety of medical training which was consolidated into categories of none, CPR/1st aid, and Wilderness First Responder, Emergency Medical Technician (WFR, EMT) or higher (see Table 8, p.82). An ANOVA found differences in helmet use for groups in each category:

none (n = 249, M 3.57, SD 1.37); CPR/1st aid (n = 654, M = 3.62, SD = 1.43); and WFR, EMT or higher (n = 458, M = 3.88, SD = 1.27), $F(2,1358) = 6.07$, $p = .002$. Again mean helmet use went up as training increased. A Tukey HSD post hoc test found significant differences in helmet use from the WFR/EMT or higher group to both no training and CPR/1st aid and groups ($p = .013$; $p = .006$ respectively).

Pearson's chi-square test for independence revealed most frequent discipline groups of top-rope and sport lead were similarly distributed with about half of each subgroup having had CPR/1st aid training and around a quarter in the more advanced, $X^2 = 52.423$, (df = 4, $p < .001$). Traditional lead by comparison had a much larger percentage in the WFR, EMT or higher group and fewer with no training.

Attitudes, values and beliefs.

Respondents (N = 1367) were asked to evaluate a series of statements regarding helmet use on a likert scale from one (strongly disagree) to five (strongly agree) (see Table 9, p.82). Pearson correlation tests showed that all the items being evaluated had significant correlation to helmet use ($p < .001$).

A general linear model MANOVA showed differences between groups of most frequent discipline on attitudes, values and beliefs, $F(7,1358) = 17333.51$, $p < .001$. Individual ANOVAs showed differences in most groups, with sport lead expressing the least support for helmets and traditional lead the most (see Table 10, p.83). A Tukey HSD post hoc test showed significant differences in each aspect between various disciplines. Sport climbers differed significantly in beliefs about the "effectiveness of helmets" from traditional lead climbers ($p = .005$). Differences were present in attitudes toward "the necessity of helmets" from sport lead to top-rope and traditional lead ($p < .001$).

Differences in attitudes of comfort from sport lead to top-rope and traditional lead (*p* = .003; *p* < .001 respectively). Differences occurred in fashion values from sport lead to top-rope and traditional lead (*p* < .001). Differences in attitudes and beliefs regarding "helmets reducing sport performance" occurred between sport and traditional lead (*p* < .001). Differences in values where "helmets are too expensive" were observed from traditional lead to top-rope and sport lead (*p* = .002; *p* = .001). Finally differences in aesthetic values occurred from sport lead to top-rope and traditional lead at (*p* = .012; *p* < .001 respectively).

Peers.

In this section, the sample (*N* = 1335) responded, on a likert scale, one (strongly disagree) to five (strongly agree), to the statement "Helmet use in my peer group is viewed as positive and encouraged." The sample responded slightly less than "agree" (*M* = 3.76, *SD* 1.01). According to a Pearson correlation test this measure of attitude was significantly correlated with helmet use (*r* = .434, *p* < .001). Using a general linear model MANOVA differences were found in groups of most frequent discipline, *F*(2,1331) = 29200.85, *p* < .001. Individual ANOVAs found differences in peer attitudes of all three; top-rope (*M* = 3.75), sport lead (*M* = 3.55), and traditional lead (*M* = 4.00). A Tukey HSD post hoc multiple comparisons test showed that significant differences were present from sport lead to top-rope and traditional lead (*p* = .015; *p* < .001).

Respondents also rated peers on the frequency of their helmet use on a likert scale, one (never) to five (always), for each discipline as well as belay in general (see Table 11, p.83). Nonparametric correlations revealed that the reported peer use was significantly correlated with respondents helmet use in each instance (*p* < .001). Responses in peer habit for "belay in general" were compared with respondents reported helmet use for belay for each discipline.

Paired samples T-test showed that when comparing means for peer helmet use and self helmet use respondents in sport and traditional lead reported higher self use than peers in each discipline (see Table 12, p.83). Differences were not evaluated for groups separated into most frequent discipline because data was gathered pertaining to all disciplines in this section.

Incident exposure.

Respondents (*N* = 1346) were asked to report the number of incidents they had experienced in categories including "near miss incidents that could have resulted in injury or death" "minor injuries to yourself or someone else that required no immediate medical attention" "major injuries to yourself or someone else that required immediate medical attention" and "death of someone else." Pearson correlation tests showed that significant correlation of incident experience only exists with the major injury category, ($r = .06$, $p = .020$), (see Table 13, p.84).

Since numbers of incidents varied widely, responses were consolidated based on natural groupings. Chi-squared tests for each type of incident provided a distribution scheme based on most frequent discipline (see Table 14, p.84). The general pattern for each type of incident was that top-rope group had experienced the least, followed by sport lead and traditional lead had the most experiences.

Role.

The sample (*N* = 1366) was asked to identify different roles they may have in regard to climbing including recreational, professional instructor, professional guide, industry professional, professional athlete, and other. The majority ($N = 1077$) responded with only recreational roles. The others ($n = 289$) varied with a smattering in each category, however for comparison purposes were consolidated into a professional category. The results of a T-test indicated only a marginal difference in helmet use between the recreational only group ($M = 3.68$, SD 1.40) and professionally involved group ($M = 3.75$, SD 1.30) where the more frequent helmet use was associated with having a professional role, $t(1364) = -.835$, $p = .404$.

RQ 4: How are environmental factors related to helmet use and do they differ by most frequent discipline?

Data was gathered on a wide variety of environmental factors including rock quality, slope, terrain, difficulty/climber ability, protection interval, fall habits, commitment grade, time to medical care, partner quality, and weather. In general descriptive statistics were produced for each factor. Factors were then tested for correlation to helmet use using respondents' helmet use for their most frequent discipline. The sample was then divided into subgroups by most frequent discipline (top-rope, sport lead or traditional lead) and tested for significant differences regarding that factor.

Rock quality.

The sample ($N = 1303$) was asked to respond to questions about rock quality on a likert scale, one (strongly disagree) to five (strongly agree) (see Table 15, p.85). Pearson correlation tests showed that four of the five statements had significant correlation to helmet use.

A general linear model MANOVA was used to determine if differences exist between groups of most frequent discipline compared to each statement about rock quality $F(5,1229) = 30875.96$, $p < .001$. Individual ANOVAs found mean differences between groups for each statement (see Table 16, p.85). A Tukey HSD post hoc test found significant differences from traditional lead to top-rope and sport lead in statements of “I find loose rocks up on the cliffs” “ I climb well traveled routes” and “I witness rockfall” ($p < .001$). Differences in “first ascents” were found from traditional lead to top-rope and sport lead ($p < .001$) and between top-rope and sport lead ($p = .009$). No significant difference between groups was found in the “rock is solid and does not break” statement.

Slope.

The sample (N= 1311) was asked to identify the slope of routes that they most often climbed with options of less than vertical, vertical or overhanging (see Table 17, p.85). An ANOVA was used to test differences in helmet use of groups who identified different slope preference, $F(2,1305) = 88.29$, $p < .001$. Tukey HSD post hoc test revealed significant differences between all slope preferences ($p < .001$).

Pearson’s chi-square test for independence found significant differences in the distribution of slope preference between groups of most frequent discipline, $X^2 = 179.29$, (df = 4, $p < .001$), (see Table 17, p.85). Sport lead most preferred vertical and overhanging terrain where top-rope and traditional lead preferred less than vertical and vertical terrain.

Protection interval.

The sample ($N = 1312$) was asked to rate statements regarding protection interval, on a likert scale, one (strongly disagree) to five (strongly agree) (see Table 18, p.86). A Pearson correlation test determined that significant negative correlation with helmet use was present with the statement "the routes I climb are generally well protected" (r = -.10, $p < .001$).

A general liner model MANOVA was used to determine differences in protection interval reports in groups of most frequent discipline, F (3,1307) = 31450.86, $p < .001$ (see Table 19, p.86). Individual ANOVAs found differences in all groups with regard to mean reports of protection interval. A Tukey HSD post hoc test found significant differences from traditional lead to top-rope and sport lead in "The routes I climb are generally well protected" ($p < .001$). Significant differences were found between all disciplines for "I lead climb routes that include an R rating" ($p < .001$). Significant differences were found for " I lead climb routes that include an X rating" from traditional to top-rope and sport lead ($p < .001$) and between sport lead and top–rope ($p = .004$). This distribution reflects the fact that traditional climbers place their own protection at intervals where it is available whereas sport climbs are pre-equipped with protection points, presumably at regular intervals.

Fall Habits.

The sample (N = 1311) was asked to respond to statements regarding fall habits using a likert scale, one (strongly disagree) to five (strongly agree). A Pearson correlations test found significant correlations to helmet use for all statements (see Table 20, p.86).

A general linear model MANOVA was used to test for differences in fall habits of groups of most frequent discipline (see Table 21, p.86), F(4,1308) = 10377.52, $p < .001$. Individual ANOVAs found differences in fall habits for all groups. A Tukey HSD post hoc test showed significant differences between disciplines regarding fall habits.

Differences in “I stick to grades that I can on-sight climb without falling” were present from sport lead to traditional lead and top-rope ($p < .001$). Differences in “I regularly push my limits and take lead falls” and “I regularly push my limits and take lead falls less than 20 feet” were found between all groups ($p < .001$). Differences in “I regularly take lead falls more than 20 feet” were found from top-rope to sport lead and traditional lead ($p < .001$) and between traditional and sport lead ($p = .001$).

Difficulty.

The sample ($N = 1314$) was asked to provide their current average on-sight ability (difficulty of climbs they can ascend on their first try without falling) for their most frequent discipline (see Table 22, p.87). ANOVA found differences in the helmet use frequency between groups with different on-sight abilities where helmet use decreases with increased difficulty of on-sight climbing ability, $F(4,1306) = 26.175$, $p < .001$. A Tukey HSD post hoc test found significant helmet use mean differences between many difficulty levels. 5.8 or under differed significantly from 5.10 at ($p = .016$). 5.8 or under, 5.9 and 5.10 differed from 5.11 and 5.12 or over at ($p < .001$). Homogeneous subgroups identified helmet use groupings of 5.8 or under, 5.9 and 5.10 “usually”; 5.11 “sometimes”; 5.12 or over “seldom” to “sometimes.”

A Pearson chi-square test for independence was used to determine significant differences in distribution of on-sight ability among groups of most frequent discipline, $X^2 = 195.97$, (df = 8, $p < .001$) (see Table 23, p.87). Distributions differed with top-rope ability heavy in 5.10 and under, sport lead showing the most ability for on-sight climbers in the 5.10 and 5.11 range, and traditional lead fairly evenly spread between 5.8 and under and 5.11 with twice the number of climbers on-sighting in the 5.10 difficulty range.

Commitment.

The sample (N = 1296) was asked to report the commitment grades they regularly climbed as part of their most frequent discipline (see Table 24, p.87). With many climbers reporting multiple grades, responses were sorted by highest grade. An ANOVA found differences in helmet use of groups based on highest grade $F(4,1288) = 13.40$, $p < .001$. A Tukey HSD post hoc test found significant differences in helmet use between grade I and all other grades; ($p = .001$) for grades II and V+; ($p < .001$) for grades III and IV. Grades II through V+ showed no significant mean differences to each other.

Due to many comments that differentiated helmet use with commitment using language of single pitch verses multi-pitch and to results listed above, groups were consolidated to reflect single verses multi-pitch. The new groups were also based on highest grade climbed; grade I (n = 502, M = 3.38, SD = 1.43), generally consists of single pitch climbs and grade II through V+ (n = 740, M = 3.92, SD = 1.27), generally multi-pitch climbs. Results of an independent T-test showed significant differences in mean helmet use of these two groups, $t(1240) = -6.98$, $p < .001$. The single-pitch group helmet use was measured in the "sometimes" range where multi-pitch measured at "usually."

Chi-Square tests were run to determine distribution of highest grades by climbers most frequent discipline for both configurations grades I – V+, $X^2 = 277.77$, (df = 8, $p < .001$) and single pitch versus multi pitch, $X^2 = 185.34$, (df = 2, $p < .001$) (see Table 25, p.88). Differences in groups showed that the top-rope group primarily could be found on grade I climbs, however about a third ventures into higher grades. Sport lead followed a similar pattern where half had a highest commitment of grade I and the rest tapered off as commitment increased. Traditional lead is clearly distributed more in the higher grades with the greatest number of climbers reporting highest grades in the III and IV range or "multi-pitch" range.

Time to medical care.

The sample (N = 1296) was asked to estimate the time to definitive medical care (hospital) from their most frequent climbing areas including the approach (see Table 26, p.88). ANOVA was used to determine if differences in helmet use were present among groups with different times to care, $F(3,1289) = 10.19$, $p < .001$. Tukey HSD post hoc test showed that significant differences were present between the "30 minutes or less" group and "1-3 hours" group ($p = .021$). Significant differences were also present from the "3 hours or more" group to the "30 minutes or less" and "1 hour or less" groups ($p < .001$) and "1-3 hours" group ($p = .002$). The longer the time from medical care the more likely respondents were to wear helmets.

A Chi-Square test for independence found significant differences in groups of most frequent discipline for time to definitive medical care $X^2 = 79.25$, (df = 6, $p < .001$). In general all three groups frequently climb between "1 hour or less" to "1-3 hours" from medical care. Top-rope and sport lead had about twice the responses of traditional lead for areas "30 minutes or less" from medical care, while traditional had more in the "over 3 hours" category.

Weather.

The sample (N = 1305) was asked to evaluate their frequency of climbing if weather conditions were present using a likert scale, one (never) to five (always). Pearson correlations found small significant correlations with helmet use increasing with increased and climbing in snow/ice and strong wind (see Table 27, p.88). A general linear model MANOVA was used to identify differences in groups of most frequent discipline for climbing habits for each weather condition, $F(8,1295) = 9229.69$, $p < .001$. Individual ANOVAs found differences among groups for all weather factors. Tukey HSD post hoc test found significant differences in frequency of fair weather between top-rope and sport lead ($p = .036$). Differences in frequency of climbing in cold were found between all groups, traditional lead to top-rope and sport ($p < .001$; $p = .012$ respectively); sport lead and top-rope ($p = .001$). Differences in frequency of climbing in wet/rain were found between all groups, sport lead differed from others ($p = .001$) and top-rope and traditional lead differed at ($p < .001$). Frequency of climbing in snow/ice conditions differed from traditional lead to both others ($p < .001$). All groups differed for climbing in strong wind and at night ($p < .001$). Finally differences were measured in fog climbing between traditional lead and both others ($p < .001$) and between top-rope and sport lead ($p = .001$). A pattern emerged where traditional lead was the most adventurous in terms of weather followed by sport lead, with top-rope the most selective.

Discussion

This study aimed to explore helmet use among recreational rock climbers across disciplines and the factors that influence it. In the discussion that follows it is important to remember that none of these factors work alone. Every time a climber makes a decision to wear a helmet or even bring one to the cliff with them, it may be influenced by any combination of factors found in this study and then some. Throughout the course of this discussion the risk management framework from Spengler et al. (2006) will be applied with respect to each factor as a prudent climber may use it; first identifying hazards and evaluating risks then analyzing the actions that are being taken to manage risk by either accepting it, mitigating it or avoiding the risk all together.

Overall helmet use.

The findings in the current study reflect a more detailed picture of helmet use reports from past studies has shown. For example, Gerdes et al. (2006) reported that 36.3% of the respondents in that study reported that they wore helmets most of the time while another 19.0% reported that they never wore helmets. Similarly, Attain (2002) reported that 14.0% “never” wore helmets, 22.0% “occasionally” 30.0% “often” and 34.0% “always” wore helmets. We see a significant rise in helmet use for traditional climbing from the accidents reported decades ago in Bowie et al. (1988) at Yosemite where only 6 of N = 220 climbers reported wearing helmets. The details of helmet use including discipline and belay in the studies referenced above were either obscure or unavailable.

Helmets are used to increase protection from impacts secondary to falls and falling objects. The amount of objective hazard and risk from falls and falling objects generally associated with each discipline increases from top-rope to sport lead to traditional lead (Schöffl et al., 2011). As shown in Table 1 (p.80), helmet use increases to mitigate risk as discipline of climbing becomes more dangerous. Helmets are being used slightly less than “sometimes” for top-rope, between “sometimes” and “usually” for sport lead and “usually” for traditional lead climbing. This general pattern is a positive sign that shows that many climbers are taking steps in the right direction to managing risks.

The lower helmet use reports for belay, which generally occurs below a climber for sport lead and traditional lead, reflect findings in Paige et al. (1998) and may indicate that climbers are more concerned about protecting themselves from impacts from falls in these activities than from falling objects. Paige et al. (1998) reported that the majority of injuries (including overuse) occurred while leading; 67% traditional lead, 79% sport lead, as opposed to 24%-17% on top-rope or 6-4% on belay. The results for belay indicate helmets are being used less than “sometimes” for top-rope, “sometimes” for sport lead, and “usually” for traditional lead. Again, this pattern shows increased risk management occurring in the right direction.

Helmet use by most frequent discipline.

As the sport of rock climbing has evolved the use of rope has been commonplace practice to mitigate the risks of falling. In traditional lead climbing the climber has the responsibility of placing solid protection subject to availability. Sport lead climbing is a way to mitigate some of the risk associated with leading where protection bolts are pre-placed. The need to fumble with heavy gear is reduced to clipping quickdraws to regularly spaced bolts, thus reducing the chances of long falls and falling objects such as gear. With the aspect of protection placement minimized, sport climbers are able to push the limits of difficulty, again increasing the chances of falls occurring. Top-rope climbing mitigates the risk of falling almost all together with the exception of swings.

In looking at differences based on respondents’ most frequent discipline it should be noted that there was a significant amount of crossover reported. For example in table 1 (p.80), of a total (N = 1481) respondents (n = 1439) reported top-roping, (n = 1401) sport leading and (n =1210) traditional leading. Many climbers participate in all three, some only two or one. Gerdes et al. (2006) reported similar crossover patterns for their sample at 79.8% top-rope, 77.4% sport, and 67.3% traditional. Gerdes et al. (2006) also included indoor, bouldering, ice climbing and mountaineering in their study. Given that the climbers who claimed that they "usually" wore helmets for traditional lead were many of the same who answered "sometimes" for sport lead and/or top-rope, we could conclude that helmet use does differ as individual climbers move between disciplines indicating that climbers perceive differences in the general hazards and levels of risk for each.

In order to further evaluate if helmet use differed as a function of climbing discipline, climbers were asked to identify a "most frequent discipline." This was used to group them to represent that discipline and was paired with their helmet use reported for that discipline. While this method did not allow us to track individual differences in helmet use, it allowed us to compare these three groups to identify differences in helmet use and differences in the majority of factors included in the study. Additionally many survey questions were geared specifically toward respondents' most frequent discipline.

This method resulted in three groups that represent the climbers in each discipline with large enough numbers in each to be generalizable to the population at large. Helmet use in these three groups followed the same general pattern as the earlier overall sample with some slight differences. Top-rope and sport lead groups reported helmet use at slightly more than "sometimes" and the traditional lead group again reported helmet use between "usually" and "always." The differences in helmet use again correspond to widely accepted differences in risk from top-rope to sport lead climbing to traditional lead.

In the literature, accounts of the differences in sport and traditional lead climbing often focus on aspects beyond the presence or lack of preplaced protection. Generalities are made with regard to environmental factors such as commitment, slope, rock quality or protection interval, which accentuate the differences between common cases of the two disciplines. These generalities, while mostly accurate, often neglect cases contrary to the norm and should be used with caution. Schöffl (2010) referring to Hochholzer & Schöffl (2003) and Schöffl (2006) states that in sport climbing "physical hazards (rock fall, weather changes etc.) are small and the neglect of wearing a climbing helmet is widely accepted" (p.660). While the current results affirm Schöffl's statement in part, they also show that many climbers continue to perceive and mitigate the risk in sport climbing with the use of helmets. On the other hand Schöffl (2010) again referring to Hochholzer & Schöffl (2003), describes traditional (alpine) climbing saying that "physical hazards are likely, the use of a helmet is mandatory" (p.660). Again the present study results affirm this generality. It is important that climbers recognize that basing their risk management practices on this generality may occasionally expose them to increased risk when faced with an atypical situation. It is important that climbers base their risk management on actual first hand hazard evaluation, specific to the environment and the climber, rather than generalities of hazards commonly associated with different disciplines.

Environmental and personal factors and differences by discipline.

The personal factors that had the strongest correlation to helmet use were attitudes, values and beliefs, and peers. Climbing and medical training, experience, age, and learning venue also contributed to significant mean differences in helmet use. The environmental factors with the strongest correlation or effect on helmet use were slope and difficulty followed by rock quality. Fall habits and commitment including time to medical care were also significant. In order to lay a solid foundation with which to explore personal factors, it is useful to first discuss environmental factors, which are the most immediate to managing risk.

Slope.

While concerned with the hazard of falling, recall that the results for slope split the sample into three groups according to slope preference; less than vertical, vertical and overhanging (see Table 17, p.85). Comments such as “If the terrain is steep enough, I feel there isn't much risk of hitting my head” “Protect my head against bad or dangerous falls on vertical or slabby terrain” or “If the route isn't very steep, I might wear a helmet to protect my head in case of a bad lead fall” illustrate the difference slope can make in the consequence of falls. Paige et al. (1998) confirms this relationship saying “On a climb that is less than vertical, a falling climber is more likely to strike a lower extremity on a ledge before being stopped by the rope. On a vertical or overhanging climb, a climber falls into the air and travels away from the rock before being stopped by the rope” (p.5). Helmet use went from “usually” in the less than vertical to less than “sometimes” for overhanging. This pattern shows that climbers are mitigating risk with helmet use in the appropriate direction; where terrain is more dangerous to fall on, helmets are being used more.

In terms of differences between disciplines, the majority of the sport lead group preferred vertical and overhanging terrain whereas traditional lead and top-rope preferred less than vertical and vertical terrain. Since falls on top-rope and overhanging sport climbs may be viewed as safer than lead falls in sport or traditional climbing no vertical or less than vertical terrain, climbers see a lower need to mitigate this risk with helmet use.

Difficulty.

The difficulty of a route is often associated with increasing slope of the terrain. Paige et al. (1998) noted, "The more difficult climbs today tend to be steeper…while offering cleaner falls" (p.5). On-sight ability, which is the difficulty level of routes that a climber could ascend the first time, without falling, was gathered as a measure to approximate the difficulty of routes that respondents regularly climb with confidence. In this study as difficulty increased, helmet use decreased (see Table 22, p.87).

Comments such as "If it is a sport route with solid rock and well within my ability I usually go sans helmet." and "uncomfortable and unnecessary for hard sport climbing" illustrate views of sport climbers who are climbing at high levels, possibly in the 5.10 to 5.12+ range. Again these difficult routes often feature vertical to overhanging terrain and which could potentially make falls somewhat safer. This high difficulty group only "seldom" or "sometimes" uses helmets. When these high performing climbers lead routes in the lower difficulty levels they may believe the likelihood that they will fall is low. The majority of top-rope, sport, and traditional climbers possess lower ability levels in the 5.10 range and down. At this ability or difficulty level which is associated with vertical or less than vertical terrain, injuries from falls could be more severe and helmet use is increased at the "usually" level. This pattern generally shows climbers mitigating risk with helmet use in the appropriate direction.

Fall habits.

Falling is an important and integral part of the sport of climbing. There are two main reasons to fall, first when pushing or exceeding the limit of one's sport performance and second, falling unexpectedly. The sample of climbers "sometimes" stuck to climbs they could do without falling and “sometimes” pushed themselves (See tables 20 & 21, p.86). These statements have interesting correlations with helmet use. On the one hand, the climbers who were climbing within their on-sight ability were more likely to use helmets; climbers who planned to push their performance and took more lead falls were less likely to use them. In addition, where climbers reported climbing routes that were generally well protected, there was a negative correlation with helmet use (see Table 18, p.86).

While on their own these results seem to be a little backwards, in the context of the discussion on slope and difficulty they start to make more sense. Falling while pushing one’s sport performance limit could have very different consequences for a sport climber on an overhanging route, a top-rope climber on a clean face or traditional leader climbing a jagged less than vertical arête. Where climbers were not pushing their limits, potentially on less than vertical, “easy” terrain, increased helmet use may be explained by wanting protection from unexpected falls. On overhanging terrain some of the non-use may be explained by climbers evaluating potential fall consequences, planning to fall, being used to regular lead falls and/or generally feeling in control in these situations. So again depending on the context of the falls the risk of striking a hard surface will vary. A more in-depth analysis of data between falls, slope, and is needed to say if risk is being managed appropriately regarding helmet use and fall habits.

When analyzing differences between disciplines, those in the sport lead group were most likely to push limits and take lead falls of less than 20 feet with responses between “sometimes” and “usually.” Traditional leaders were slightly more likely to stick to on-sight grades and “sometimes” took lead falls less than 20 feet. The top-rope group answered in ways that would suggest they "sometimes" climb within limits and "sometimes" push and take lead falls. Lead falls present in the top-rope group reflect the crossover in disciplines mentioned earlier and suggest that they venture into lead climbing disciplines occasionally. Nelson et al. (2009) reported that injuries from falls greater than 20 feet were 10 times more likely to result in hospitalization. All groups claimed they seldom took lead falls more than 20ft, however the sport lead group was highest of the three.

Since the vast majority of top-rope falls are safe regardless of slope or difficulty and lead falls are reported as a matter of crossover, conclusions are difficult to draw for the top-rope group with the current data. The sport lead group reported the highest ability, steepest slope, and regular protection intervals. In this general context, their lower helmet use with increased falls makes sense and could be deemed appropriate risk management. The traditional lead group faced more situations where protection was sparse or inadequate. Questionable protection intervals coupled with lower slope and difficulty preferences showed traditional climbers have a higher risk of injury from taking long dangerous falls, therefore their increased risk mitigation through helmet use is appropriate.

Rock quality.

Helmets are meant to protect the head from falling objects as well as falls. Falling objects due to rock quality were the primary concern addressed in comments across disciplines of those wearing helmets "sometimes" to "always." Comments such as "I use a helmet primarily for protection from incidental rock fall" "[…to] keep from getting hit by rock or dropped gear from above" or "when I don't think there's much of a chance of falling objects, I wont wear a helmet" illustrate the general findings relating rock quality to helmet use. Perceptions that rock quality was questionable, finding loose rocks on cliffs or witnessing rockfall were positively related to helmet use (see Tables 15 & 16, p.85). Perceptions that rock quality was solid or well traveled had negative correlations to helmet use. In light of these findings, it appears that risk is being mitigated with helmet use in the appropriate direction.

In order to minimize impacts on vegetation and debris at the top of cliffs, many sport climbs have anchors below the edge so that climbers do not disturb the material on top. Many top-rope climbs are made possible as a climber follows a route which another climber has lead, using the anchors of a climb below the cliff top. In some cases there is easy cliff top access where anchors can be set up without climbing. In the second instance, the top of the cliff may be clean and free of debris from previous climber traffic or as many comments noted are filled with debris and/or non-climbers who ignorantly throw objects off for fun. Many traditional climbs end in a "top-out" style where the climber reaches the top of the cliff and either walks off or rappels off using a tree or other natural material as an anchor which exposes the top of cliffs to erosion, loose rocks and debris hazards. In addition, where a crag may contain all of the above-mentioned types of climbs, the traditional lines may not see as much use as sport and top-rope routes and be dirtier and contain more debris.

In addition to the quality of rock, climbers should also be aware of the hazard posed by dropped gear. Many sport climbs employ anchors such as fixed quickdraws, quick clips or cold shuts to further minimize the need to deal with gear and reduce the chances of dropping it. Traditional lead climbers on the other hand have an increased potential to drop gear on their belayers or be climbing in areas where other parties above them drop gear and rocks with taller increased commitment routes. Climbers in all disciplines however are susceptible to some amount of dropped gear such as a belay device or locking carabineer from a climber cleaning anchors.

Of course each climbing area is unique and deserves to be evaluated for potential falling objects. Top-rope and sport lead groups generally perceived higher rock quality and lower occurrence of loose rock than the traditional lead group. Traditional climbers are also more frequently in environments where dropped gear and loose rock are more likely. Increased helmet use for traditional climbers is again affirmed with increased risk of falling objects.

Commitment.

There are many additional risks involved in multi-pitch climbing. In contrast to single pitch, belaying from the ground where a belayer can sidestep to avoid falling objects and easily lower an injured climber to the ground, a multi-pitch climb comes with added risk of falling objects from parties above, the belayer being anchored at a fixed position, and additional complicated procedures involved in getting down safely in the event that incident were to occur. A significant difference in helmet use was measured between groups with the highest commitment grade I and commitment grades II-V+ or essentially between single pitch and multi-pitch climbers (see Tables 24 & 25, p.87-88). Those climbers more likely to be on a multi-pitch climb were more likely to wear a helmet in their preferred discipline.

Some comments from the respondents included “I wear the helmet for multi-pitch [routes] (trad or sport) when someone is climbing above me and I am in a fixed location” and “I primarily use a helmet while belaying, to (hopefully) protect myself from rockfall. Using a helmet while belaying does not only increase the margin of safety for myself, but for my partner as well. While trad climbing, I'm usually doing routes that are longer than a single pitch, so I wear a helmet.” In groups of most frequent discipline 83.6% of traditional lead climbers regularly climbed multi-pitch routes where 49.7% of sport climbers and 37% of top-rope climbers ventured above pitch 1.

Another aspect of commitment is the time it would require to reach medical care if an accident were to occur (see Table 26, p.88). This time could vary based once again on commitment grade of a climb, single or multi-pitch but it could also vary based on factors such as the approach hike or drive to the climbing area or whether cliff access was top down or bottom up. The results reflect that the further a climbing area is away from medical care, the more likely climbers are to be wearing helmets. When looking at a climber’s most frequent discipline, the top-rope group estimated the least time from their most frequent climbing area followed by sport lead with traditional lead at the most again aligning increased helmet use where more risk was present.

Attitudes, values and beliefs.

In the attitudes, values and beliefs section, there were both strong positive and negative correlations to helmet use (see Table 9, p.82). In the positive, the view with the strongest relationship to helmet use was that “Helmets are a necessary piece of protective equipment for rock climbing.” This was followed by “Helmets are comfortable” “Helmets are acceptable fashion while climbing” and “Helmets are effective at reducing injuries when accidents occur.” On the negative side helmet use declined as climbers agreed with “Helmet use reduces climbing performance” “Helmets take away from the aesthetic look and feel of a climbing scene” and “Helmets are too expensive.”

While some comments were paired with objective hazard evaluation, many were not. There is nothing inherently wrong with holding unfavorable views against helmets, but is imperative though that climbers realize when their views keep them from making objective decisions that involve dangerous situations. Applying Powell’s (2007) discussion, when something such as the use of a helmet is disliked, views of risks pertaining to the use of helmets may be adjusted to suit those beliefs and justify the non-use behavior in light of present hazards. In many cases the benefits of social acceptance, sport performance, comfort and aesthetics are immediately available; however, benefits of helmet use in the case of an inverted lead fall or dropped objects are seen far less frequently. When a climber is more concerned about how they look than the probability and consequences of a bad fall they are making a risk management decision that has nothing to do with physical risk. In top-rope or sport disciplines incidents are infrequent and risks seem unlikely, there is far more room for this kind of flawed reasoning to occur.

A large amount of the comments from the survey question “what is the main reason for not wearing a helmet?” were not about the lack of hazards, they were about attitudes, values and beliefs. For example some included “Helmets can be hot and stifling. Also, climbing loses a certain aesthetic appeal with a helmet on.” “Socially uncommon to [wear a helmet]. [I] Feel like I stand out at the crag. It's "not cool." Also, [it’s] slightly less comfortable to climb with a helmet than without.” “I feel that if you are going to take a fall and potentially injury your head, a helmet would do minimal if any good at that point.” Overall, 458 comments to the question “what are your reasons for not wearing a helmet?" pertained in some way to one or more of the above attitudes on price, comfort, efficacy, aesthetics, sport performance, or social acceptability. The correlations of helmet use to attitudes values and beliefs show that there is some poor judgment occurring. Climbers need to exercise good judgment to ensure that they make risk management decisions based on valid inputs rather than attitudes irrelevant to risk.

When differences between disciplines were explored, the sport lead climbers consistently expressed views that were less supportive of helmets than the other two groups; however, not necessarily anti-helmet. These differences may be explained by differences in environmental risk in each discipline. In traditional climbing, the case for helmets is clear and helmet use is the norm. Top-rope and sport climbing have more room for debate because environmental risk factors may pose less of a threat.

Peers.

When there is a climber demonstrating superior ability on the rock it is natural for other climbers to emulate them or look to them as a mentor. This influence is clear and common to observe at any climbing area where a more experienced climber is teaching another. Peer helmet use had the largest correlation to helmet use of any factor in the study (see Table 11, p.83) where if peers used or did not use a helmet respondents were likely to do the same. In the section that explored influence on current climbing practices peer/friends ranked the highest (see Table 4, p.81). The reported frequency of peer verses self helmet use were similar in top-rope, slightly lower in traditional lead (MD = -.13) and lower in sport lead (MD = -.42).

Peer helmet use was reported at "usually" for traditional leaders. The majority of traditional climbers reported helmet use while climbing less than vertical or vertical terrain and in the 5.10 and under range. This is appropriate terrain for an experienced climber to mentor beginner to intermediate climbers who will take on their practices and habits. Helmet use for peers in sport climbing was reported at “sometimes.” In contrast, a high performing sport climber may be climbing on difficult overhanging terrain, pushing their limits, falling and not using a helmet. If this sport climber is mentoring peers they may be sending an inappropriate message to those performing at a much lower or introductory level. The top-rope group was significantly less influenced by “Self” than other disciplines, likely because peer influence was so high. The introductory nature of the top-rope discipline makes this group particularly vulnerable to the perils of poor instruction. Are peer mentors teaching correct, safe, reliable, tested and up to date practices? Are peers teaching each other effective risk identification, evaluation and management skills? More research is required to answer these questions, as they are important to the safety of climbers as a whole regardless of his/her discipline.

Overall response to the statement “Helmet use in my peer group is viewed as positive and encouraged” was slightly less than agree suggesting that some peer groups may be less accepting of helmet use than others. Replies to this statement were also significantly correlated with helmet use. A few comments referred to helmet non-use in sport climbing as part of the “culture.” Remarks such as “There is not much a culture of helmet use in sport climbing.” or “A culture change is needed in sport climbing for increased helmet use.” illuminate the influence peers have on each other on a large scale. Powell (2007) discussing Celsi et al. (1993) refers to a peer group’s tendency, for better or worse, to polarize views that may be otherwise moderate. Climbers need to be aware of the effect of peer mentors and groups and to what extent are decisions being made as a result of a “culture” rather than on risk evaluation. Peer pressure can bolster or obstruct the use of protective equipment and the results of this study show that both are occurring.

Influence and training.

While friends/peers and self were reported as having the highest influence on one’s current climbing practices, they did not show a significant Pearson correlation to helmet use (see Table 4, p.81). This is likely due to high rating of these categories among all respondents. Instructional books/videos rated “neutral” climbing gyms rated between “low” and “neutral” and professional guide services as well as the American Mountain Guides Association (AMGA) and Professional Climbing Instructors Association (PCIA) all rated “very low.” These factors had a statistically significant relationships to helmet use at ($p < .001$).

Instructional books and videos are an excellent supplement for the “self” taught climber. In contrast to some peers, this media is likely a more reliable and thorough source of information and instruction. The same can be said for many professional guide services, especially those which are accredited or who employ guides certified by an organization such as the AMGA. In the case of guide services and AMGA/PCIA even as they may not have a large effect on the majority of the population, those that are influenced by programs see increased helmet use.

Significant differences exist between disciplines in these influences where traditional lead was influenced more than others from AMGA/PCIA who primarily offer instructor training and utilize traditional climbing equipment and techniques. In sport lead climbing, where the skills required are significantly more simple than those for traditional lead climbing, less influence from professional guide services was reported.

Results from data gathered about the amount of technical climbing training respondents had reinforces the results regarding correlation of helmet use to professional guide services and instructional organizations such as AMGA or PCIA (see Table 4, p.81). Climbers with advanced training such as multi-pitch climbing or climbing instructor courses were more likely to use helmets while climbing recreationally. Helmet use increased with advanced training. Distributions for each discipline included 50.6% of the traditional lead group had some form of advanced training versus 30.5% of top-rope climbers and 32.9% of sport leaders (see Table 7, p.82). In other studies Gerdes et al. (2006) reported that more than half their sample received some type of technical training. Backe et al. (2009) reported 74.6% took some kind of course. These two inquiries into training may have been too general to recognize significant relationships with safety practices where this study only saw a significant difference occurring for advanced training.

Increased Medical training shared a similar relationship with increased helmet use where significant differences occurred at the high end of training. WFR, EMT or higher medical training was distributed among disciplines with 43.9% of traditional leaders, 28.4% of sport leaders and 24.9% top-rope climbers.

The results of the current study where helmet use increased with advanced training were consistent with Powell's (2007) discussion of plural rationales. Respondents that were exposed to expert evaluations of risk and mitigation practices were more likely to take on these views and practices. In general increased influence, instruction or training from a professional source is positively related to increased helmet use. Many manufacturers include a safety notice with any climbing equipment that

"Warning: Climbing is dangerous. Seek qualified instruction." The reason for this is not only to protect themselves from legal liability, but because qualified instruction can help climbers learn to navigate the dangers of climbing with increased likelihood of success. Powell (2007) refers to Slovic (2000) noting the potential for lay and expert assessment of risk to vary and influence risk perception. It is in the best interest for all of the above commercial entities (guide services, publishers, certifying bodies) to see to it that risk is managed in a reasonable and prudent manner. It protects their clients and their bottom line. In addition to helmet use, influences from these sources would also likely result in increased safety awareness in all aspects of technical climbing.

Primary learning environment.

Climbing gyms, which rated overall at "low to neutral" influence, were found to be correlated negatively to helmet use ($r = -.106$, $p < .001$). Additionally disciplines were split where top-rope and sport leaders reported significantly more influence "neutral" from them than traditional climbers "low." Primary learning environment data was gathered and determined that a significant difference in helmet use was present between groups who learned in a manmade venue such as a climbing gym and an outdoor venue with greater helmet use occurring in those who learned outdoors.

Indoor climbing gyms, while very effective at teaching techniques and rope work, generally lack many of the hazards that make helmet use necessary in natural venues. Eden & Barrat (2009) comment that for indoor climbing venues "the majority of risks are removed or designed out" (p.490). Breaking holds are very rare. Protection and anchor points are fixed to the wall eliminating the hazard from falling objects. Protection intervals are very close together and slope is generally vertical or overhanging. Climbing gyms like other businesses involved in climbing are very interested in minimizing risk. Climbers need to be aware of this difference in conditions when making the transition from gym climbing to outdoor climbing and recognize additional risks are present outdoors. Top-rope and sport lead climbers are more at risk of making erroneous assessments of risk in outdoor environments because they are more likely to learn their discipline indoors. Again, traditional leaders were significantly different with a far greater percent learning outdoors.

Age and experience.

Within the categories of age and experience both had positive correlation to helmet use. For age, (r = .181, $p < .001$) and overall experience (r = .110, $p < .001$) (see Table 3 p.80). When looking at differences of age and experience between disciplines, traditional climbers showed significant differences above both other groups. Mean differences showed that traditional climbers were about 4 years older than top-rope and 6.5 years older than sport groups. Years of overall experience of traditional climbers compared to both groups were slightly less than double. It is important to remember that this study only included climbers 18 and over. This exclusion may skew findings inflating helmet use overall as well as age and skew experience effects and relationships (see limitations p.72 for more detailed discussion on age).

It appears that in addition to traditional climbing being generally more hazardous, climbers in this discipline have had significantly more time and experiences with which to reflect on what it is they do. They have spent more hours on cliffs and seen more events. Traditional climbers have a high rate of risk mitigation regarding helmet use. In contrast the sport lead climbing group showed the youngest collection of participants and moderate experience and the lowest helmet use. Top-rope and sport climbing are less expensive, less skills intensive, and less committing which make them more accessible to a younger less experienced crowd. Where this entry-level accessibility is present in top-rope and sport lead climbing, helmets are not used as often.

In addition, those older climbers of any discipline may be in different stages of their lives. Some of the respondents' comments mentioned changes in climbing practices and helmet use that coincided with marriage or parenthood; "My husband makes me" or "… since having a child, the helmet-wearing frequency of both my husband and I is now at 100%. I hear from the same from other climbing peers" "Being able to be a dad is important to me and my family."

Incident exposure.

Experiencing a traumatic incident can have profound effects on one's outlook on risk. On the other hand, Powell (2007) referred to Slovic et al. (1978) noting "Each time an incident does not occur, the avoidance of the inconvenience and discomfort of preventative and precautionary action may reinforce behavior" (p.12). This is the case in rock climbing where incidents are not occurring frequently enough for the population of climbers to be dramatically affected by them. A marginally significant correlation was found linking increased helmet use and experience with major injuries. No other significant correlations were found in the near miss, minor injury or death categories though. Although there is no doubt that experiences of death of a climbing partner or nearby party could have a significant effect on safety practices, or even the cessation of climbing altogether, there is thankfully not a large enough effect to measure this at the current scale. This may also be a result of the sampling method where mostly active climbers were reached. It is unknown how many climbers experienced a major injury or death and quit climbing as a result.

Differences among disciplines for incident exposure were generally distributed where the top-rope group had the least experience with incidents followed by sport and traditional lead with the most where risk mitigation with helmet use is most prevalent. The majority of climbers overall had no experience with major injury or death.

Limitations

A major limitation in the sample was the exclusion of climbers 18 years old and under. This exclusion as well as the distribution through the Access Fund where members and followers tend to be more invested experienced climbers resulted in a sample skewed toward an older demographic with mean age at (*M* = 35.95, *SD* 12.52). Other web based studies that included the < 18 age group reported lower mean ages such as Neuhof et al. (2011) with (*M* = 32.82 ± 9.4), Gerdes et al. (2006) with (*M* = 29) and Backe at al. (2009) (*M* = 30). Nelson (2009) reports a mean age of (*M* = 26) for injured climbers. Additionally, the Outdoor Industry Association 2011 Participation Report showed that 33.2% and 16.1% of their population for sport/indoor climbing and traditional/mountaineering belong to the < 18 age group. 21% of the sample in Backe et al. (2009) and 29.6% of climbers reporting injuries in Nelson et al. (2009) were < 20 years old. Based on the positive correlation to age measured in this study this skew could have produced an inflated report of helmet use, especially in the sport lead and top-rope categories where this age group is more prevalent. Data was presented as is with no attempt to compensate for this limitation.

Limitations in methods included the study's inability to track individual differences in helmet use when factors change. For instance, given the large crossover between disciplines and the fact that many climbers practice their sport in a variety of unique locations with variable company, the factors of commitment, difficulty, protection interval, slope or rock quality, peer influence, and others may change helmet use for some individuals and not for others. Inclusion of these additional questions may have made an already long questionnaire longer, increasing dropout rate for questions late in the survey. Instead the study was very dependent on a one-time helmet use response for all respondents' most frequent discipline measured against each factor. In most cases, additional insight was gained from the respondents' comments, which validated results and illustrated correlations with individual use.

During the survey construction phase, detail and quantity of pilot survey responses were lower than hoped for. Some questions on the survey were poorly constructed or vague resulting in invalid data. Such questions including a section on medial influence were dropped from analysis for this reason. Some questions worded with "choose all that apply" where responses were later sorted by "highest" such as in the commitment grade section may have produced slightly different data if respondents were able to choose what best described their habits.

Finally, during the early stages of data review, some anomalies were removed, however, with a large data set some were present at the time of analysis. Sample size was believed to be large enough to accommodate what few deviant responses were included and still remain highly valid.

Recommendations

The data gathered here regarding helmet use and the factors that influence it has many implications for individual recreationists, the professional industry, and the climbing community as a whole. In this community there exists many different viewpoints and values where helmet use is concerned. Understanding the role that each segment of the community has in influencing safety practices and keeping climbing access open will help managers choose a unified direction forward.

There is no single governing body in rock climbing that sets rules and mandates safety practices for all participants and venues. Land managers and owners, with potential input from the Access Fund and climbing community, make policy decisions for individual climbing areas. A general policy requiring helmet use may sound like a good idea at first glance, however there are some strong contraindications for this.

In light of sovereign immunity principles, recreational use statutes and assumption of risk doctrine, land managers have a limited duty and a low standard of care where climbers are concerned. The Access Fund (2005, p.8) states, "…specifying the type of equipment climbers can use, or implementing certification programs that attempt to "qualify" climbers, undoubtedly will increase such [liability] exposure. It should never be the intent of land managers or a climbing management program, to judge or physically control safety as it relates to rock climbing, climbing equipment, or the conditions present on climbing routes. Versteeg and Bemiller (2009) cite United States v. Carroll (1947) referring to the Hand formula "Before adopting a safety rule, we should determine whether the costs of adopting the rule outweigh the benefits of adopting it and vise versa" (p.60). Land managers need to compare the costs of the current status where accidents are sometimes high in severity but very low in frequency and liability costs to landowners are low against increased cost of implementing and enforcing helmet use policy, increased legal liability and costs saved from prevented injuries as a result of universal helmet use. The outcome of this analysis will vary between different climbing areas but is estimated to be generally not in favor of a general helmet use policy.

Policy makers and land managers can make positive contributions by promoting education and informing visitors about specific environmental hazards that may exist. When was the last rockfall or accident? Is the site susceptible to the freeze thaw cycle? Do hikers visiting the top of a cliff know there are climbers below? Do climbers know there may be hikers above? Engage with the local climbing organization, guidebook authors or the Access Fund as a way to convey messages and help inform visitors. These entities also often help to monitor and repair fixed protection anchors that keep climbing sites safe. A well-informed visitor is more able to make an appropriate decision about how they manage risk. This approach is within the scope of duty for landowners and will help increase the level of safety and awareness without increasing liability.

It is also recommended that land managers permit credentialed commercial guiding where resources will allow. Professional guides and instructors have a high standard of care that includes proven safety practices including helmet use for themselves and their clients. The presence and availability of certified guides and instructors would help to increase safety practices of clients, as well as recreational climbers who climb along side them. Professionals are encouraged to provide appropriate intervention and instruction when necessary to ensure the safety of those around them.

For manufacturers, the obvious marketing points include countering many of the views people have for not wearing helmets; heat, discomfort, unaesthetic, ineffectiveness or social stigma. Additionally, market segments of young beginners, top-rope, sport climbers and gym climbers transitioning to outdoors have room for growth. Many companies offer climbing starter kits that include a harness, chalk bag and belay device, why not include a helmet? As noted by many comments, current role models, many of them commercially sponsored climbers, especially in the sport discipline are not helping advocate the use of helmets. Manufacturers are encouraged to find positive and appropriate spokespeople for helmet use across disciplines.

Climbing media is the face of our sport to both participants as well as the public. It is important for media to represent our sport in a balanced and responsible way so that it may continue to grow and thrive attracting dedicated, contributing participants. While helmet use, risk evaluation and education may not be as glamorous as the latest difficult free solo; it is far more pertinent to the average climber. Regular features of accident reports, instructional sections and equipment reviews should continue to promote safe practices and available resources. Words and images should serve to send a message that promotes safety and responsibility as well as adventure.

The results of this study showed that peer influence has a significant impact on the safety practices of rock climbers. Mentors are strongly encouraged to evaluate the knowledge and skills they are passing on to other climbers. This can be accomplished by benchmarking practices to professional sources of qualified instruction such as climbing instructors, guides or comprehensive instructional texts. Mentors often share a relationship similar to that of a professional instructor and client. While legal duty and standard of care could be different for peers based upon compensation and other factors, mentors are nonetheless encouraged to approach their role seriously and cautiously.

The results of this study generally indicate some additional precautions being taken where additional risks are present, however this is not true for all individuals. Individuals are recommended to engage in a serious self-evaluation of personal factors including attitudes, values and beliefs, peer influence and experience weighed against environmental hazards of the activities they are engaged in. Risk management decisions should be made with valid inputs.

In summary, no specific top down helmet use policy is recommended for land managers due to increased liability and cost benefit reasons. Organizations and individuals responsible for instruction, manufacture and promotion of climbing equipment are encouraged to help raise awareness through increased education and presence. Climbers and mentors are encouraged to thoroughly evaluate their practices and the reasons behind them. This approach, if utilized will help strengthen the risk management practices of the climbing community as a whole, helping to keep the sport, access to resources and the people who practice it safe.

Recommendations for future research include more in-depth study of the factors that influence helmet use such as peer and self influence on climbing practices, attitudes, values and beliefs of climbers, incident experiences effect on individuals and typology of difficulty/ability and fall habits. Other useful studies may include site inventories of popular mixed discipline climbing areas for presence of environmental hazards and corresponding risk management practices of climbers. A comparative study on efficacy of various helmet models is also recommended.

CHAPTER 5: CONCLUSION

Helmet use is one of many risk mitigation practices employed by rock climbers. The data collected by this study shows that climbers are using climbing helmets some or most of the time. In general, as climbers are involved in disciplines generally higher in risk, such as traditional lead climbing, helmet use increases respectively.

The presence of environmental factors that affect the likelihood and severity of incidents occurring due to falls and falling objects have significant correlation to helmet use. Factors such as slope, terrain, difficulty, rock quality are shown to be extremely pertinent to helmet use. Other environmental factors of influence to helmet use include fall habits, commitment grade and time to medical care.

Personal factors that were heavily related to use of helmets include attitudes, values and beliefs regarding helmets and influence from peers. Instructional books, training both in technical climbing and medical emergency response, influence from professional guide services and guide and instructor certifying associations were also significantly correlated to helmet use. Increased helmet use was also associated with age, experience and marginally with incident experience. Decreased helmet use was associated with negative attitudes, values and beliefs as well as indoor learning environments.

Many significant differences exist between climbers in each preferred discipline including helmet use habits while climbing and on belay as well as in all of the above listed environmental and personal factors. It should be noted that the majority of respondents reported climbing across all three disciplines and that the following typology is based on climbers preferred discipline and corresponding helmet use.

Traditional lead climbers as a group reported the most helmet use at “usually.” This group generally preferred climbing on less than vertical or vertical terrain at moderate to low difficulty (5.10-), reported moderate fall habits and perceived the lowest rock quality on routes of the three groups. The vast majority were involved in multi-pitch commitment routes and this group had the longest time to medical care from their most common climbing areas. The views they expressed were the most in favor of helmet use. Influence from peers was similar to other groups, however, influence from professional sources of instruction was higher in traditional climbers. Traditional climbers reported less influence from gyms and fewer learned initially in indoor climbing facilities. As a group they are generally older and have more experience both with climbing and incidents than other groups.

Sport lead climbers reported helmet use between “sometimes” and “usually.” This group reported generally preferring vertical to overhanging terrain with moderate to high difficulty (5.10+) and perceived the high quality of rock and good quality of protection. Their fall habits were more liberal as the culture of this discipline is more about pushing sport performance limits than others. Approximately half of this group reported climbing on multi-pitch routes where about half only had experience in single pitch environments. Sport climbers reported the second closest averaged time to medical treatment. The attitudes, values and beliefs of sport climbers, while not condemning, were the least supportive of helmet use of the three groups. Influence from peers was high, similar to other groups, however reports of peer helmet use at “sometimes” were significantly lower than reports of self-use. Sport climbers were the group with the highest percentage of no technical climbing training however medical training was fairly evenly spread throughout the group. This group reported “high” influence from climbing gyms and almost half primarily learned to climb indoors. This group was the youngest and on average a year more experienced and had slightly more incident exposure than the top-rope group.

Top-rope climbers reported helmet use “sometimes.” This group reported generally preferring less than vertical or vertical routes of moderate to low difficulty (5.10-) and high rock quality with moderate to mild falls. Their attitudes, values and beliefs were in the middle of the groups regarding helmet use. Influence from peers was high similar to other groups however influence from self was significantly lower. This group reported the highest percentage (40.5%) in the introductory/single-pitch training category and with about a third in each none and advanced. Medical training was slightly lower than average. Half reported learning indoors and half in natural venues. This group was the middle in age however lowest in climbing experience and incident exposure.

All groups generally reported helmet use levels that correspond to the relative hazard and risk levels associated with each discipline of climbing. Depending on one’s viewpoint it may appear that overall risks are being managed appropriately, overly or insufficiently. It is beyond the scope of this study to approve or disapprove of the current conditions regarding individual helmet use. The study was exploratory in nature and primarily served the purpose of exposing information and relationships. It is the responsibility of the individual to make personal risk management decisions for themselves including whether or not to wear a helmet, which discipline of climbing to choose or even to accept the risk of rock climbing at all. Where climbers take on the responsibility of mentoring others they need to make them aware of tools and techniques that will help them climb safely and responsibly. This process should include awareness and objectivity regarding helmets.

REFERENCES

Alhakami, A. S., & Slovic *P*. (1994). A psychological study of the inverse relationship between perceived risk and perceived benefit. *Risk Analysis*, 14, 1085-1096.

AMGA, (2011) *AMGA single pitch instructor 2011 program manual.* Boulder, CO: American Mountain Guides Association.

Attarian, A. (2002). Rock climbers' self-perceptions of first aid, safety, and rescue skills. *Wilderness and Environmental Medicine,* 13, 238-244.

Attarian, A., Dill, J., Harder, C., Miller, D., Sheetz, J., & Williamson, J. (Eds.). (2011) *Accidents in North American mountaineering 2011*. Boulder, CO: The American Alpine Club

Backe, S., Ericson, L., Janson, S., & Timpka, T. (2009). Rock climbing injury rates and associated risk factors in a general climbing population. *Scand J Med Sci Sports*, 19, 850-856.

Baker, S. P., Li, G., Fowler, C., & Dannenberg, A. L. (1993). Injuries to bicyclists: A national perspective. *Johns Hopkins University Injury Prevention Center*.

Bowie, W., Hunt, T., & Allen, H. (1988). Rock climbing injuries in Yosemite national park. *The Western Journal of Medicine*, 149(2), 172-177.

Celsi, R. L., Rose, R. L., & Leigh, T. W. (1993). An exploration of high-risk leisure consumption through skydiving. *Journal of Consumer Research*, 20, 1-23.

Creyer, E., Ross, W., & Evers, D. (2003). Risky recreation: An exploration of factors influencing the likelihood of participation and the effects of experience. *Leisure Studies*, 22, 265-276.

Cundy, T., Systermans, B., Cundy, W., Cundy, P., Briggs, N., & Robinson, J. (2010). Helmets for snow sports: Prevalence, trends, predictors and attitudes to use. *Journal of Trauma*, 69(6), 1486-1490.

Eden, S., & Barratt, P. (2009). Outdoors versus indoors? Angling ponds, climbing walls and changing expectations of environmental leisure. *Area*, 42(4), 487–493.

Eng, R., & Van Pelt, J. (2010). *Mountaineering: The freedom of the hills (8th ed.)*. Seattle, WA: The Mountaineers Books.

Gerdes, E., Hafner, J., & Aldag, J. (2006). Injury patterns and safety practices of rock climbers*. J Trauma*, 61(6), 1517-1525.

Llewellyn, D., & Sanchez, X. (2008). Individual differences and risk taking in rock climbing. *Psychology of Sport and Exercise*, 9, 413-426.

Luebben, C. (2004). *Rock climbing: Mastering basic skills*. Seattle, WA: The Mountaineers Books.

Martha, C., Sanchez, X., & Gomá-i-Freixanet, M. (2009). Risk perception as a function of risk exposure amongst rock climbers. *Psychology of Sport and Exercise*, 10, 193-200.

Nelson, N., & McKenzie, L. (2009). Rock climbing injuries treated in emergency departments in the U.S., 1990-2007. *Am J Prev Med*, 37(3), 195-200.

Neuhof A., Hennig, F. F., Schöffl, I., & Schöffl, V. (2011). Injury risk evaluation in sport climbing. *Int J Sports Med*, 32, 794 – 800.

Outdoor Foundation (2011). *Outdoor Recreation Participation Report 2011*. Outdoor Industry Association: Retrieved from http://www.outdoorindustry.org/images/researchfiles/OIA_2011_OutdoorRecreationParticipationReport.pdf?146

Outdoor Foundation (2011). *Outdoor Recreation Participation Topline Report 2011*. Outdoor Industry Association: Retrieved from http://www.outdoorindustry.org/images/researchfiles/OIA_Participation2011Topline.pdf?133

Paige, T., Fiore, D., & Houston, J. (1998). Injury in traditional and sport rock climbing. *Wilderness and Environmental Medicine*, 9, 2-7

Powell, C. (2007). The perception of risk and risk taking behavior: Implications for incident prevention strategies. *Wilderness and Environmental Medicine*, 18, 10-15.

Priest, S., & Gass, *M.* (2005). *Effective Leadership in Adventure Programming*. Champaign, IL: Human Kinetics.

Rivara, F., Thompson, D., Patterson, M., & Thompson, R. (1998). Prevention of bicycle-related injuries: Helmets, education and legislation. *Annu. Rev. Public Health,* 19, 293-318.

Schöffl, V., Morrison, A., Ulrich, S., & Küpper, T. (2011). The UIAA Medical Commission injury classification for mountaineering and climbing sports. *Wilderness and Environmental Medicine*, 22, 46-51.

Schöffl, V., Morrison, A., Ulrich, S., Schöffl, I., & Küpper, T. (2010). Evaluation of injury and fatality risk in rock and ice climbing. *Sports Med*, 40(8), 657-679.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1978). Accident probabilities and seat belt usage: A psychological perspective. *Britain: Accid Anal Prev,* 10, 281-285.

Slovic, P. (2000). *The perception of risk.* London, England: Earthscan Publications.

Smith, P., Leemon, D., McLarty, S., Ajango, D., Gregg, R., Pace, S., & Tierney, S. (2009). *Manual of Accreditation Standards for Adventure Programs.* Boulder, CO: Association for Experiential Education.

Title 11. Natural Areas And Recreation, Chapter 10 Lease of Recreational Lands to State--Liability of Lessor, Tenn. Code Ann. § 11-10-103 (2012)

Title 28. Judiciary and Judicial Procedure, Part VI Particular Proceedings, Chapter 171 Tort Claims Procedure 28 U.S.C. § 1346(b), (1945)

UIAA (2011) *Pictorial on helmets UIAA 106.* Retrieved from http://www.theuiaa.org/safety_standards.php

United States v. Carroll Towing Co., 159 F.2d 169 (2d Cir. 1947)

Versteeg, R., & Bemiller, J. (2009). A Cost-benefit analysis of a pole vaulting helmet requirement: Why the NFHS and other rule making bodies should not adopt such a rule. *Journal of Entertainment & Sports Law*, 1, 55-72

Appendix A: Tables

Table 1
Overall Helmet Use Frequency All Disciplines

	N	Mean	*SD*
Top-rope	1439	2.71	1.4
Top-rope Belay	1450	2.75	1.33
Sport Lead	1401	3.41	1.41
Sport Lead Belay	1413	3.07	1.35
Traditional Lead	1210	4.16	1.16
Traditional Lead Belay	1262	3.86	1.21

Table 2
Sex, Mean Helmet Use and Distribution by Discipline

Sex	*N*	Mean Helmet Use	*SD*	Top Rope	Sport Lead	Traditional Lead
Male	956	3.68	1.37	59%	75.70%	81.60%
Female	324	3.78	1.35	41%	24.30%	18.40%

Table 3
Years Experience By Overall and Most Frequent Discipline

	N	Overall Mean	*SD*	Correlation to Helmet Use	Sig. (2-tailed)	Most Frequent *n*	Most Frequent Mean	*SD*
Overall	1382	11.86	10.36	0.110	< .001			
Top-rope	1382	11.48	10.15	0.112	< .001	276	8.32	8.61
Sport Lead	1382	8.45	7.75	0.063	0.019	577	9.42	8.44
Traditional Lead	1383	8.62	10.60	0.137	< .001	529	16.36	11.45

Table 4

Influence to Current Climbing Practices and Helmet Use.

	N	Mean	*SD*	Correlation to Helmet Use	Sig. *p*
Friends/Peers	1351	5.12	.876	-.021	.443
Self	1351	4.93	.956	.050	.064
Instructional Books/Videos	1351	4.16	1.206	.107	< .001
Climbing Gym	1351	3.61	1.482	-.106	< .001
Internet	1350	3.05	1.386	-.031	.255
Professional Guide Service	1351	2.32	1.690	.170	< .001
American Mountain Guides Association or Professional Climbing Instructors Association	1351	2.04	1.590	.141	< .001
School Program	1351	1.78	1.458	.001	.971
Outdoor Program such as NOLS or Outward Bound etc.…	1351	1.48	1.221	.073	.007
Scouts / Camp Programs	1351	1.36	.968	-.013	.629

Table 5

Influence Differences by Most Frequent Discipline

	Self	Climbing Gym	Pro Guide Service	Internet	AMGA / PCIA	NOLS / OB
Top-rope	4.642	4.071	2.489	3.086	1.981	1.317
Sport Lead	4.91	3.972	2.101	3.234	1.832	1.42
Traditional Lead	5.102	2.983	2.477	2.832	2.29	1.625

Table 6

Learning Environments for Most Frequent Discipline

	Indoor		Outdoor	
	N	%	*N*	%
Top-rope	135	50.20%	134	49.80%
Sport Lead	248	43.50%	322	56.50%
Traditional Lead	84	16%	440	84%

Table 7
Climbing Training by Most Frequent Discipline

	None		Intro / Single Pitch		Advanced	
	N	%	*N*	%	*N*	%
Overall	456	33.4%	373	27.3%	535	39.2%
Top Rope	78	29%	109	40.5%	82	30.5%
Sport Lead	212	37.1%	171	29.9%	188	32.9%
Traditional Lead	166	31.7%	93	17.7%	265	50.6%

Table 8
Highest Medical Training by Most Frequent Discipline

	None		CPR/1st Aid		WFR, EMT or Higher	
	N	%	*N*	%	*N*	%
Overall	249	18.30%	656	48.10%	459	33.70%
Top-Rope	65	24.20%	137	50.90%	67	24.90%
Sport Lead	125	21.90%	284	49.70%	162	28.40%
Traditional Lead	59	11.30%	235	44.80%	230	43.90%

Table 9
Correlations: Attitudes, Values and Beliefs and Helmet Use

Attitudes, Values and Beliefs	Mean 1-5	*SD*	Correlation to Helmet Use	Sig. (2-tailed)
Helmets are effective at reducing head injuries when accidents occur.	4.50	0.73	0.144	< .001
Helmets are a necessary piece of protective equipment for rock climbing.	4.03	1.02	0.524	< .001
Helmets are comfortable.	3.15	0.98	0.306	< .001
Helmets are acceptable fashion while climbing.	3.70	0.93	0.231	< .001
Helmet use reduces climbing performance.	2.05	0.99	-0.358	< .001
Helmets are too expensive.	2.46	1.02	-0.168	< .001
Helmets take away from the aesthetic look and feel of a climbing scene.	2.16	1.12	-0.323	< .001

Table 10
Attitudes, Values and Beliefs by Most Frequent Discipline

	Top-Rope Mean	Sport Lead Mean	Traditional Lead Mean
Helmets are effective at reducing head injuries when accidents occur.	4.47	4.44	4.58
Helmets are a necessary piece of protective equipment for rock climbing.	4.12	3.80	4.22
Helmets are comfortable.	3.25	3.01	3.25
Helmets are acceptable fashion while climbing.	3.81	3.54	3.82
Helmet use reduces climbing performance.	2.03	2.18	1.91
Helmets are too expensive.	2.57	2.54	2.32
Helmets take away from the aesthetic look and feel of a climbing scene.	2.10	2.33	2.01

Table 11
Peer Helmet Use

	N	Mean	*SD*	Correlation to Helmet Use	Sig. (2-tailed)
Top-rope	1284	2.51	1.18	.639	< .001
Sport Lead	1289	3.05	1.18	.628	< .001
Traditional Lead	1217	4.05	0.98	.530	< .001
On Belay in general	1327	2.93	1.05		
Top-rope Belay				.546	< .001
Sport Lead Belay				.560	< .001
Traditional Lead Belay				.465	< .001

Table 12
Differences Self to Peer Helmet Use by Discipline

	N	Self Use Mean	Peer Use Mean	MD	T	df	Sig. (2-tailed)
Top -Rope	1268	2.47	2.52	-0.22	-7.19	1267	< .001
Sport Lead	1249	3.46	3.04	-0.42	-13.22	1248	< .001
Traditional Lead	1101	4.22	4.10	-0.13	-4.38	1100	< .001

Table 13
Incident Exposure

	Mean	Std. Deviation	Correlation to Helmet Use	Sig. (2-tailed)
Near miss	3.97	13.76	0.022	0.420
Minor injury	7.17	18.42	-0.041	0.128
Major injury	0.74	4.07	0.064	0.020
Death	0.10	1.51	0.027	0.325

Table 14
Incident Exposure by Most Frequent Discipline

Near Miss	Top-rope		Sport Lead		Traditional Lead	
	N	%	*N*	%	*N*	%
0	128	47.90%	214	38.10%	124	24.00%
1 to 2	89	33.30%	221	39.30%	178	34.40%
3 to 4	20	7.50%	49	8.70%	75	14.50%
5 or more	30	11.20%	78	13.90%	140	27.10%

$X^2 = 81.524$, (df = 6, $p < .001$)

Minor Injury	*N*	%	*N*	%	*N*	%
0	85	31.80%	131	23.30%	93	18.00%
1 to 2	89	33.30%	195	34.70%	170	32.90%
3 to 4	30	11.20%	63	11.20%	52	10.10%
5 or more	63	23.60%	173	30.80%	202	39.10%

$X^2 = 29.310$, (df = 6, $p < .001$)

Major Injury	*N*	%	*N*	%	*N*	%
0	222	83.10%	408	72.60%	303	58.60%
1	34	12.70%	95	16.90%	102	19.70%
2 or more	11	4.10%	59	10.50%	112	21.70%

$X^2 = 68.451$, (df = 4, $p < .001$)

Death	*N*	%	*N*	%	*N*	%
0	266	99.60%	546	97.20%	491	95.00%
1 or more	1	0.40%	16	2.80%	26	5.00%

$X^2 = 12.711$, (df = 2, $p = .002$)

Table 15
Rock Quality Perceptions and Helmet Use

	Mean	Std. Deviation	Correlation to Helmet Use	Sig. (2-tailed)
The rock at the areas I most often climb at is solid and does not break.	3.68	0.71	-0.091	0.001
I find loose rocks up on the cliffs at the areas I most often climb.	2.87	0.86	0.238	< .001
The routes I climb most often are well traveled by other climbers.	3.89	0.65	-0.101	< .001
I witness rockfall occur either due to climbing activities or naturally.	2.58	0.80	0.223	< .001
The routes I climb most often are first ascents.	1.45	0.67	0.01	0.749

Table 16
Rock Quality Perceptions by Most Frequent Discipline

	Top-rope Mean	Sport Lead Mean	Traditional Lead Mean
The rock at the areas I most often climb at is solid and does not break	3.73	3.71	3.63
I find loose rocks up on the cliffs at the areas I most often climb	2.74	2.74	3.06
The routes I climb most often are well traveled by other climbers.	4.03	4.01	3.70
I witness rockfall occur either due to climbing activities or naturally.	2.36	2.48	2.79
The routes I climb most often are first ascents.	1.22	1.37	1.66

Table 17

Slope Preference and Helmet Use by Most Frequent Discipline

		Helmet Use		Top-rope		Sport Lead		Traditional Lead	
	N	Mean	*SD*	*N*	%	*N*	%	*N*	%
Less than vertical	341	4.18	1.16	82	31.70%	74	13.50%	187	37.00%
Vertical	682	3.83	1.27	154	59.50%	264	48.30%	264	52.30%
Overhanging	285	2.86	1.43	23	8.90%	209	38.20%	54	10.70%

Table 18
Protection Interval and Correlation to Helmet Use

	Mean	Std. Deviation	Correlation to Helmet Use	Sig. (2-tailed)
The routes I climb are generally well protected.	3.94	0.54	-.100	< .001
I lead climb routes that include an R rating.	2.09	0.84	0.039	0.155
I lead climb routes that include an X rating.	1.46	0.69	0.011	0.689

R rating generally refers to dangerous protection interval conditions should a leader fall. X rating generally refers to potentially deadly protection interval conditions should a leader fall.

Table 19
Protection interval by Most Frequent Discipline

	Top-rope Mean	Sport Lead Mean	Traditional Lead Mean
The routes I climb are generally well protected	4.06	4.03	3.79
I lead climb routes that include an R rating	1.53	2.06	2.42
I lead climb routes that include an X rating	1.26	1.42	1.62

R rating generally refers to dangerous protection interval conditions should a leader fall. X rating generally refers to potentially deadly protection interval conditions should a leader fall.

Table 20
Fall Habits and Helmet Use Correlation

	Mean	*SD*	Correlation to Helmet Use	Sig. (2-tailed)
I stick to grades that I can on-sight climb without falling.	3.00	1.17	.224	< .001
I regularly push my limits and take lead falls.	3.01	1.16	-.186	< .001
I regularly take lead falls less than 20ft.	3.04	1.29	-.152	< .001
I regularly take lead falls more than 20ft.	1.76	0.88	-.199	< .001

Table 21
Fall Habits by Most Frequent Discipline

	Top-rope Mean	Sport Lead Mean	Traditional Lead Mean
I stick to grades that I can on-sight climb without falling.	3.17	2.68	3.25
I regularly push my limits and take lead falls.	2.33	3.40	2.93
I regularly take lead falls less than 20ft.	2.37	3.49	2.9
I regularly take lead falls more than 20ft.	1.44	1.93	1.74

Table 22
On-sight Difficulty and Helmet Use

	N	Mean Helmet Use	*SD*
5.8 or under	194	4.13	1.21
5.9	222	4.01	1.18
5.10	521	3.79	1.33
5.11	309	3.34	1.39
5.12 or over	65	2.60	1.49

Table 23
On-sight Difficulty by Most Frequent Discipline

	Top-rope		Sport Lead		Traditional Lead	
	N	%	*N*	%	*N*	%
5.8 or under	76	29.20%	25	4.60%	94	18.50%
5.9	73	28.10%	62	11.30%	88	17.40%
5.10	93	35.80%	230	42.00%	199	39.30%
5.11	17	6.50%	182	33.30%	110	21.70%
5.12 or over	1	0.40%	48	8.80%	16	3.20%

Table 24
Commitment Grade Overall, Highest Grade and Helmet Use

	Overall		Highest Grade		Helmet Use	*SD*
	N	%	*N*	%	Mean	
Grade I, < 3 hours	1086	83.80%	503	34%	3.38	1.43
Grade II, 3-6 hours	651	50.20%	244	16.50%	3.81	1.34
Grade III, 6-8 hours	480	37.00%	219	14.80%	3.95	1.30
Grade IV, full day, min. difficulty 5.7	305	23.50%	215	14.50%	4.04	1.16
Grade V, day and a half, min. difficulty 5.8	108	8.30%	64	4.30%	3.91*	1.30*
Grade VI, multiday	51	3.90%	51	3.40%		

* Grades V and VI were consolidated for the purposes of ANOVA

Table 25
Highest Commitment Grade by Most Frequent Discipline

	Top-rope		Sport Lead		Traditional Lead	
	N	%	*N*	%	*N*	%
Grade I	160	63.00%	268	49.40%	75	15.00%
Grade II	40	15.70%	118	21.70%	86	17.20%
Grade III	32	12.60%	75	13.80%	112	22.40%
Grade IV	17	6.70%	59	10.90%	139	27.90%
Grade V+	5	2.00%	23	4.20%	87	17.40%
"Single Pitch"	160	63.00%	268	50.30%	75	16.40%
"Multi-Pitch"	94	37.00%	265	49.70%	383	83.60%

The valid *n* between calculations varied by 51 responses and caused differences in percentages for single/multi-pitch.

Table 26
Time to Medical Care and Helmet Use by Most Frequent Discipline

		Helmet Use		Top-rope		Sport Lead		Traditional Lead	
	Overall *n*	Mean	*SD*	*N*	%	*N*	%	*N*	%
30min or less	181	3.45	1.44	50	19.70%	91	16.80%	41	8.20%
1hr or less	516	3.62	1.38	122	48.00%	228	42.00%	166	33.30%
1-3 hours	508	3.79	1.33	76	29.90%	203	37.40%	231	46.30%
Over 3 hours	88	4.35	1.01	6	2.40%	21	3.90%	61	12.20%

Table 27
Weather and Helmet Use by Most Frequent Discipline

					Top-rope	Sport Lead	Traditional Lead
	Mean	*SD*	Correlation to Helmet Use	Sig. (2-tailed)	Mean	Mean	Mean
Fair Weather	4.39	0.62	0.017	0.542	4.32	4.44	4.38
Heat	3.72	0.73	-0.001	0.978	3.69	3.74	3.71
Cold	3.27	0.84	0.016	0.553	3.02	3.26	3.40
Wet/Rain	1.98	0.77	-0.025	0.363	1.74	1.95	2.13
Snow/Ice	1.90	1.01	0.07	0.012	1.62	1.72	2.22
Strong Wind	2.71	0.83	0.055	0.048	2.33	2.70	2.91
Night	1.93	0.84	-0.025	0.373	1.62	1.86	2.17
Fog	2.08	0.95	-0.028	0.321	1.75	2.00	2.34

Vita

Kevin Soleil grew up in Nashua, New Hampshire. He earned a Bachelor of Art degree in Music Performance and Sound Recording Technology from the University of Massachusetts in Lowell. He earned a Master of Science degree in Recreation and Sport Management from the University of Tennessee in Knoxville. He learned to climb at the crags of Bolton, Vermont and Rumney, New Hampshire. He has also lived, worked and climbed in Boulder, Colorado, St. George and Salt Lake City, Utah and Knoxville, Tennessee. Kevin is certified by the AMGA as a single pitch instructor. Kevin has worked in outdoor adventure, education and therapeutic programs as a guide and administrator for the last seven years.