



Rock Climbing Rescues in Boulder County, Colorado and Eldorado Canyon State Park, Colorado, 1998 – 2011.

Daniel A. Lack; Alison L. Sheets; Jacob M. Entin; David C. Christenson

Rocky Mountain Rescue Group, 3720 Walnut Street, Boulder, Colorado, USA, 80301

Email: Contact@RockyMountainRescue.org

Published: Summer 2012 @ www.RockyMountainRescue.org

Abstract: An article published in the *Wilderness and Environmental Medicine* journal, and available online at [www.rockymountainrescue.org/Climbing Rescues Causes Injuries Trends Boulder.php](http://www.rockymountainrescue.org/Climbing_Rescues_Causes_Injuries_Trends_Boulder.php), summarized trends in rock climbing rescue causes, timing, and injuries in Boulder County for the years 1998 – 2011. In this addendum to that article we compare data for Boulder County and Eldorado Canyon State Park to provide more detailed assessment of rock climbing rescues for climbers.

1 Introduction

There are many popular rock-climbing areas in the United States, with few having sufficient concentrations of both easily accessible climbing and large numbers of local rock climbers to make the regular collection and analysis of accident data for a specific location viable. Consistent data collection on climbing accidents has taken place in Boulder County, Colorado, due to the convergence of accessible and popular climbing areas and the high numbers of climbers. Other valuable resources for climbing and mountaineering accidents include the American Alpine Club [1], a summary from Australia [2], and data from US National Parks [3-6]. A number of studies also report details of rock climber injuries when treated in hospitals [7-11].

Using data gathered from Rocky Mountain Rescue Group (RMRG) incident reports, we present an analysis of the most common causes and trends of recreational rock climbing accidents within Boulder County compared to Eldorado Canyon State Park (ECSP), a specific and popular climbing area within Boulder County.

2 Methods And Definitions

This study covers rescues within Boulder County involving incidents while rock climbing or at climbing areas, which we define as including: technical roped climbing, un-roped climbing (free-soloing or scrambling), mountaineering, bouldering, or incidents involving bystanders at climbing areas. Data were collected from RMRG rescue reports, between the years of 1998 to 2011, which contain the following data: date and time of incident activation, number of victims, location, climbing activity, incident cause, and most serious injury type. Incident cause, or primary contributing factor, was determined from interviews with victims, belayers, bystanders, and through RMRG investigations of the incident scene. Injury types were determined from RMRG reports, and are based on first aid assessments made in the field. Definitions specific to this investigation are provided in Panel 1. Figures 2 through 12 present averages of data from 1998 – 2011.



Belay: “A system of using a rope to stop a fall if one should occur” [12], by exerting friction on the rope. Also used to mean the place where the belayer is anchored.

Bouldering: “Climbing close to ground level, where an unchecked fall is not necessarily serious” [13]. Undertaken without a rope and normally limited to short vertical distances.

Climbing: Any rock climbing activity; includes technical climbing with ropes and (rock) protection, bouldering, or scrambling. Includes climbers lost after completion of a climb.

Lead Fall: A fall by the climber placing (rock) protection as they ascend a climb trailing a rope. Falls are generally arrested by a belayer and belay device below the climber.

Medical: Illness or injuries that are not from a traumatic event such as a fall. This includes exacerbation of pre-existing injuries, such as repeated shoulder dislocation.

Mountaineering: Climbing mountain peaks at higher elevations that may involve one or all methods of climbing, including: technical roped climbing, un-roped climbing, bouldering, and technical approaches to vertical terrain. Separated from other types of climbing because of the combination of many different types of climbing.

Rappel: Descending a rope by controlling speed with friction on the rope [12]. The climber is suspended by, and dependent on the rope.

Technical Roped Climbing: Climbing using, specialized climbing shoes, harness, ropes, and removable and/or fixed rock protection.

Un-roped Climbing: Climbing without ropes or protection by experienced climbers or inexperienced scramblers.

Victim: An individual involved in an incident where mountain rescue was called and provided some assistance. May not always involve an injury or evacuation.

Panel 1, Definition of terms used in this investigation.

3 Results

3.1 Climbing Incidents and All Search And Rescue (SAR) Activity (Figure 1)

Since 1998, RMRG has responded to 1857 SAR incidents involving 2198 victims. Boulder County climbing incidents accounted for 345 of all SAR incidents, and climbing victims accounted for 428 (19.5%) of all SAR victims. ECSP climbing incidents accounted for 110 of all SAR incidents, and ECSP climbing victims accounted for 141 (6.4%) of all SAR victims.

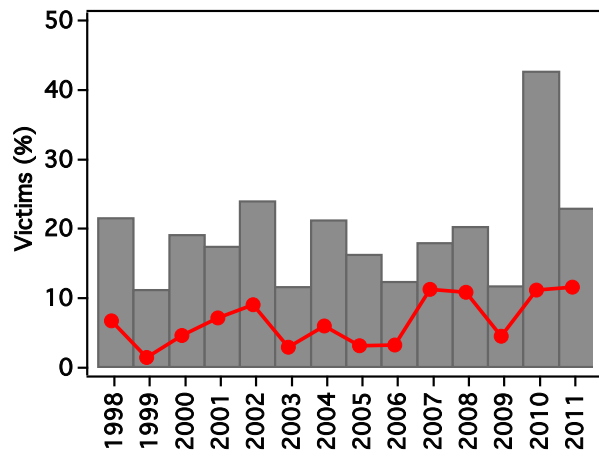


Figure 1, SAR victims that were involved in climbing (Boulder County – grey, ECSP – red).



3.2 Victim Demographics (Table 1)

Of the 428 climbing rescue victims across Boulder County, 78% were male and victims in the 20-29 age group accounted for the largest percentage of victims (46.5%). ECSP show similar trends in demographics to those for Boulder County (Table1).

Table 1, Victim Demographics: Age & Gender (1998 – 2011)

Age (Years)	% - Boulder	% - ECSP	Gender	% Boulder – ECSP %
0 - 9	0.5	0	Male	78 – 82.5
10 - 19	21	8.5	Female	22 – 17.5
20 - 29	46.5	51.5		
30 - 39	15	22		
40 - 49	10	11.5		
50 - 59	4.0	4		
60 - 69	2.5	1		
70 - 79	0.5	1		

3.3 Incident Location And Timing (Figure 2, 3, 4, 5)

Most climbing incidents (90%) occur in the popular climbing areas around Boulder: Eldorado Canyon State Park, Boulder Canyon, and the Flatirons (Figure 2). The remaining 10% are at less popular climbing areas, or on mountaineering routes. For Boulder County and ECSP most incidents occur from May through October (Figure 3), on weekends (Figure 4), and between 8am to midnight, with a median time of about 3pm (Figure 5).

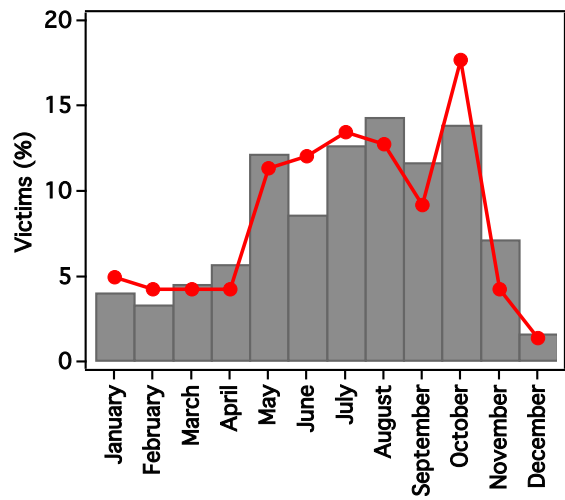
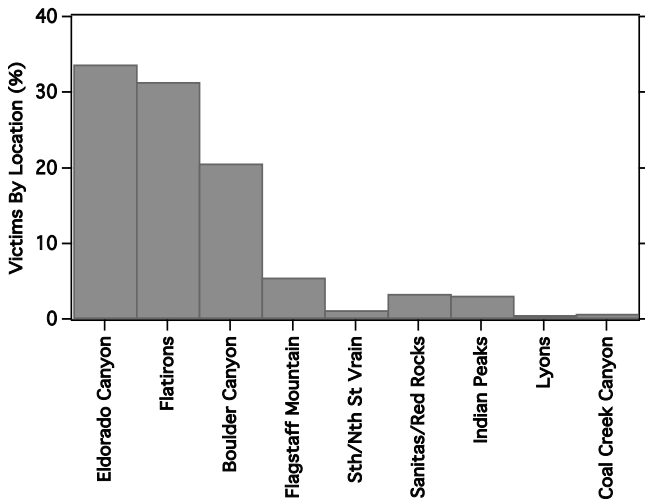


Figure 2, All climbing victims distributed by accident location for Boulder County.

Figure 3, Climbing victims distributed by month (Boulder County – grey, ECSP – red).

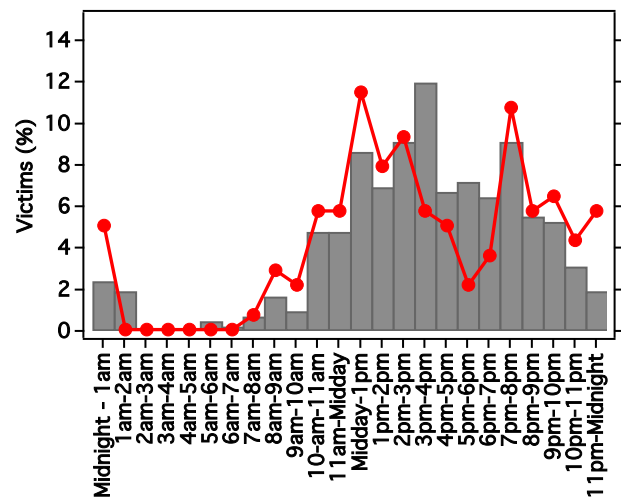
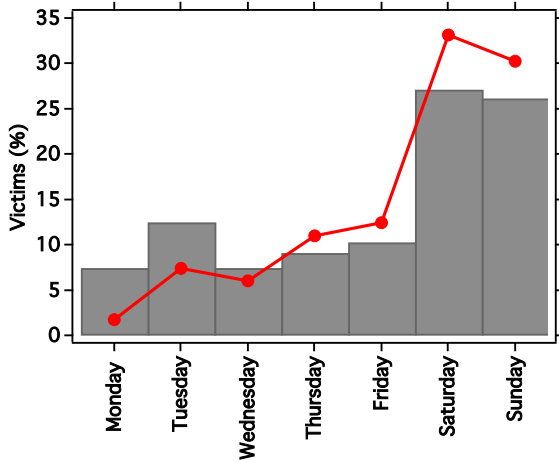


Figure 4, Climbing victim distribution by day of week (Boulder County – grey, ECSP – red).

Figure 5, Climbing victim distribution by time of day (Boulder County – grey, ECSP – red).

3.4 Climbing Activity Type (Figure 6)

For Boulder County, 58% of climbing victims were involved in technical roped climbing, and 34% were un-roped climbers. For the remaining victims, bouldering accounts for 6% while only 1.5% of victims were mountaineering. Additionally, a further 1% were bystanders involved in rock fall incidents at climbing areas (Figure 6). For ECSP, 87% of incidents were due to technical roped climbing while only 6% were due to un-roped climbing (see discussion).

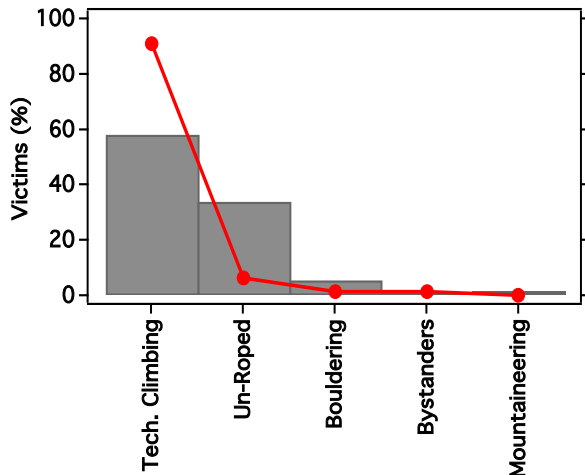


Figure 6, Climbing victim activity distribution (Boulder County – grey, ECSP – red).

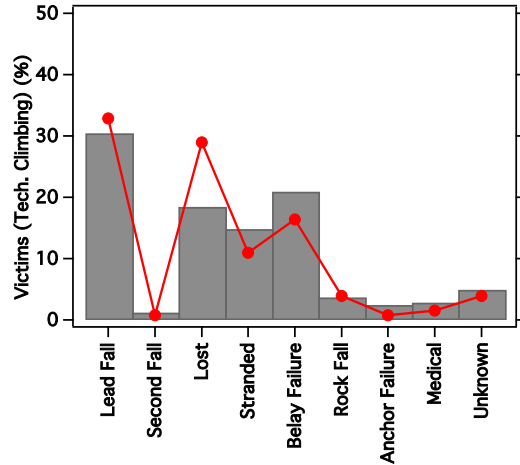


Figure 7, Technical climbing victim cause distribution (Boulder County – grey, ECSP – red).



3.5 Roped Climbing (Figure 7, Figure 8)

For all rescues of persons involved in technical roped climbing, lead falls are the dominant accident cause (30%), followed by belay incidents (21%), and then climbers that became lost during the descent (18.5%)—predominantly after sunset. Stranded climbers accounted for 15% of those technical climbers rescued. Falls by seconding climbers, failure of anchors, and medical conditions also contribute to technical roped climbing victims (Figure 7). ECSP shows mostly similar trends to Boulder County. We have one record of a lead climbing fall that resulted in a fatality where the climbers rope was cut on rock during the dynamic loading of the rope [14].

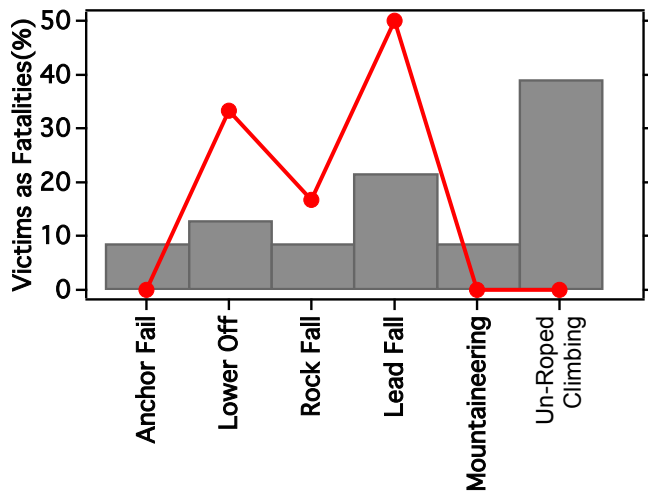


Figure 8, Climbing fatality cause distribution (Boulder County – grey, ECSP – red).

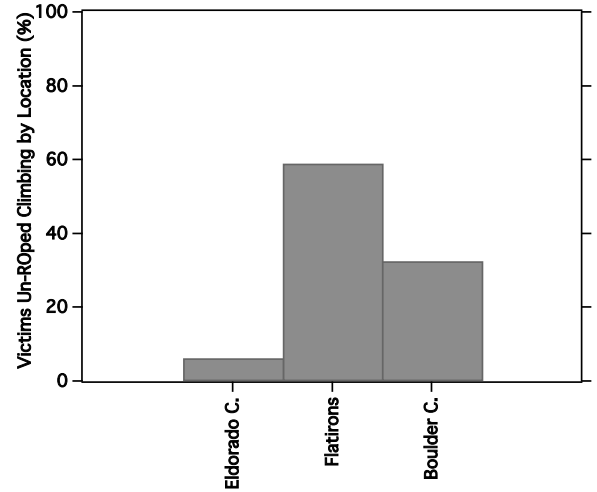


Figure 9, Un-roped climbing victim distributed by top three climbing locations.

3.6 Un-Roped Climbing (Figure 9)

Un-roped climbing is the second most common climbing activity requiring rescue (34%) (Figure 6), and most often leads to uninjured but stranded victims. As our rescue reports do not always reflect the differences between experienced free-solo climbers and inexperienced scramblers, all victims are considered un-roped climbers. Un-roped climbers are also the most common victims involved in fatal incidents, with 39% of fatalities resulting from this activity (Figure 8). Most un-roped climbing victims were climbing in the Flatirons (59%), Boulder Canyon (33%), or Eldorado Canyon State Park (7%) (Figure 9).



3.7 Belay/Rappelling Related Incidents (Figure 10)

In our data set, 51 technical climbing victims (21%) were a result of a belay or rappelling related incidents. Belay and rappelling incidents where the rope was not long enough for the climber to reach the ground accounted for 21 victims. Only 8 victims resulted from a belayer losing control of the rope where sufficient length of rope was available, while 20 victims were stranded on a climb due to an inability to continue to rappel, including ropes becoming stuck. ECSP had a similar distribution of belay and rappelling incidents, but had a slightly higher occurrence of rappels becoming stuck (Figure 10).

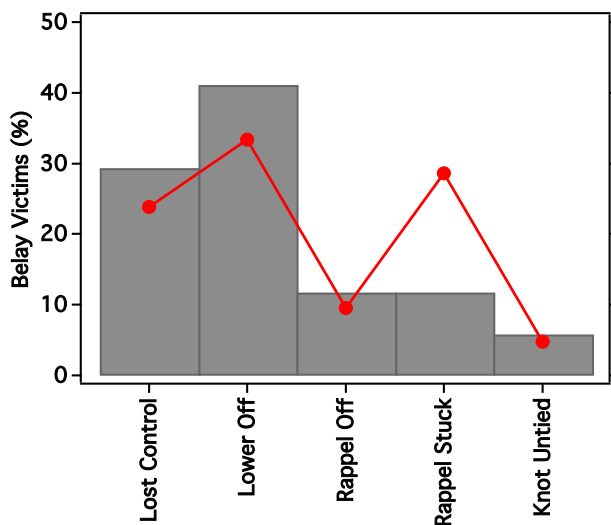


Figure 10, Belay accident distribution (Boulder County – grey, ECSP – red).

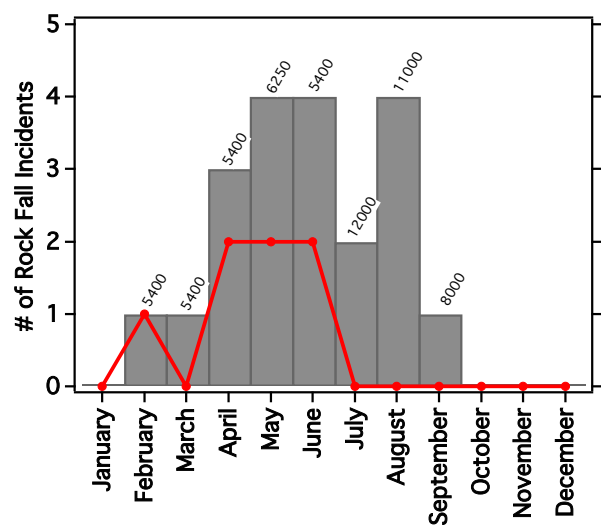


Figure 11, Rock fall climbing victims by month. Average altitude of incident included. (Boulder County – grey, ECSP – red).

3.8 Rock Fall Incidents (Figure 11)

Rock fall accounted for 16 victims (3.5%) in which climbers were hit by rock, or fell off a climb as a result of falling rock. A further 4 victims hit by rock fall were bystander climbers. Rock fall incidents have mostly occurred during the freeze thaw cycles of Spring (for lower elevations) and Spring/early Summer (for higher elevations) (Figure 11). Figure 11 also shows the average elevation (feet above sea level) where the incidents occurred. Boulder sits at 5,400 feet elevation, while the highest peak in RMRG's primary response area is 13,500 feet. The incidents in February – June occurred at an average elevation of 6,000 feet, while those in July, August, and September occurred at elevations above 8,000 feet. The incidents during August are at an average elevation of 11,000 feet. Rock fall incidents in ECSP occurred during the Spring freeze thaw cycles as the park sits at a relatively lower elevation (roughly 7,000 feet) (Figure 11).



3.9 Climber Injuries (Figure 12)

Of the 428 climbing victims requiring rescue in Boulder County, 57% sustained one or more injuries. Of the non-fatal injuries, those affecting a lower extremity dominated followed by head, spinal, and upper extremity injuries. Of the 23 fatalities, 9 were from unroped climbing, 5 from lead falls, 3 from anchor failures, 3 from being lowered off the end of the rope, 2 from mountaineering, and 2 from rock fall. Victims in ECSP had a similar distribution of injuries (Figure 12).

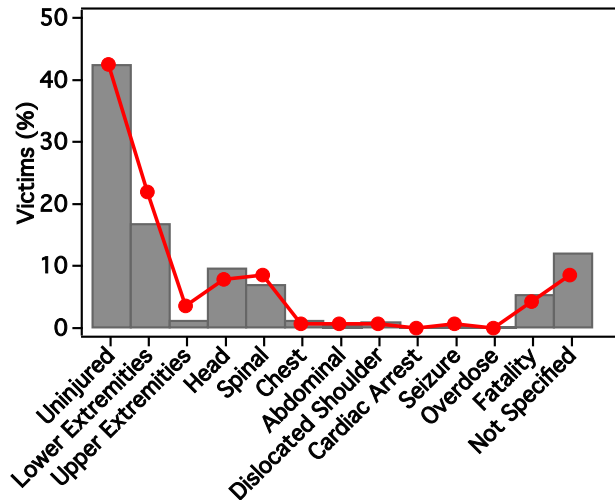


Figure 12, Climbing victim injury distribution (Boulder County – grey, ECSP – red).

4 Discussion

For a complete discussion for all of Boulder County, please refer to the WEMJ article.

The total number and percentage of climbing incidents compared to all SAR incidents for Boulder County is comparable to Yosemite National Park (19% of SAR incidents for both areas [15]), and shows no significant trends since 1998. Hikers accounted for 45% of RMRG SAR victims each year (compared to 52% for Yosemite National Park [15]). Fatalities comprised 5.5% of Boulder climbing victims (compared to 6% for Yosemite National Park [3]). For reference, the British Health and Safety Executive [16] reports that the climbing fatality risk is 1 in 320,000 climbs.

Un-roped climbing most often leads to stranded, uninjured victims. Almost half of climbing fatalities resulted from un-roped climbing. Anchor failure contributed to 2.5% of technical roped climbing victims for Boulder. Notable anchor failures include: the movement of an ~550 lb boulder that had been slung with webbing; the failure of a top-rope anchor due to the climbing rope being threaded directly through the anchor webbing; and the failure of an anchor built from webbing spliced together using masking tape [17]. RMRG does not have any records of bolted anchor failures. Data from both Yosemite National Park and Australia report anchor failures contribute to 1% or less as the cause of climbing incidents [2, 3].



Belay-related climbing incidents (51 individuals) included 8 belayers losing control of the rope while lowering and 20 climbers stuck on rappel. Both of these mechanisms point to inadequate attentiveness and technical skills, although some stuck rappel incidents were a result of high winds leading to stuck ropes. Insufficient rope length on lowering and rappel accounted for 22 victims, 16 of whom had severe or fatal injuries and 3 of whom received severe rope burns while belaying. One victim was taken off belay through a misunderstanding due to strong winds hampering communication. The most effective prevention measure for belay incidents—regardless of experience, equipment, or familiarity with the climb—is to control of both ends of the rope. Other simple safety measures include rappelling with back-ups, such as a prussik or other auto block device, and consulting the latest available information about fixed anchor location. Easily identifiable rope middle marks may also help prevent rappelling incidents.

Rock fall incidents contributed to 4.5% of all Boulder County climbing victims, most occurring in established climbing areas on regularly climbed routes. While there is no certain method for identifying loose holds, a climber can qualitatively test a hold by tapping or pulling on the hold prior to weighting it. Increased caution during warm periods following freezing conditions is prudent. Additionally, belayers and others not actively climbing should try to avoid exposing themselves to areas directly below or in the fall line of active climbers. One notable rock fall incident involved a lead climber who pulled a large rock off the face of the climb resulting in internal injuries to the climber and multiple critical traumatic injuries to the belayer [18]. Of those climbers that were stranded, most experienced rappel difficulties, 10 were on climbs whose technical difficulty exceeded their ability, and one climber in ECSP got their knee stuck in a crack feature of a climb.

Almost half of Boulder County climbing victims were uninjured, and therefore lost or stranded on a climb or during the descent from a climb. In many cases prevention would have been possible by individual self-education and preparation, including consulting guidebooks prior to the climb, or carrying route descriptions and headlamps while engaging in the climb.

Comparing all climbing rescues, Boulder County and Yosemite National Park show similar rates of upper extremity and lower extremity injuries [3]. For the awareness of climbers, it should be noted that lower extremity, head, and spinal injuries make up 59% of climbing injuries—all of which are injuries that can make self and companion rescue unlikely due to pain, victim level of consciousness, and a high chance for exacerbating injuries. Calling for organized SAR assistance early is pivotal to getting the victim to definitive care as soon as possible. And as always, RMRG does not charge anything for its services.



Eldorado Canyon State Park Compared To All Of Boulder County.

ECSP incidents comprised 1/3 of all climbing incidents RMRG has responded to in the last 14 years (Figure 2). Age and gender distributions are similar between ECSP and Boulder County (Table 1), as are month (Figure 3), day of week (Figure 4), and hourly (Figure 5) distribution of climbing incidents. There does appear to be a spike in incidents in ECSP in October, possibly due to the lowering of daytime temperatures enabling more climbing on the south facing walls of the Canyon. There is also a second distribution of climbing incidents in ECSP (and not Boulder County) that occur after 7pm at night, which corresponds to lost or stranded climbers. ECSP has a number of long multi-pitch routes and forested down-climbs amongst cliff bands that likely account for this distribution.

The majority of climbing incidents in ECSP are from technical climbing (87%), with only 6% of victims involved in un-roped climbing compared to 58% and 34% respectively for the entirety of Boulder County (Figure 6). The trends between ECSP and Boulder County for the cause of technical climbing incidents are similar, with a slightly larger occurrence of lead falls and lost climbers in ECSP, and a lower incidence of belay failure for ECSP.

Fatalities present an interesting divergence between ECSP and Boulder County. There were no fatal climbing accidents in ECSP due to anchor failure or un-roped climbing; whereas ECSP had a higher rate of fatalities from lead falls, rock fall, and lowering off of ropes compared to all of Boulder County (Figure 8). Belay related incidents show similar trends with the exception of ECSP having almost 3 times the rate of climbers being stuck on rappel (Figure 10). Of the 15 victims of rock fall, 7 were climbing within ECSP—6 of which were in the months of April, May, and June. Injury type rates for ECSP are similar for all of Boulder County.

Limitations

This study is limited by the information available to RMRG at the time the report was completed. Incident cause, victim experience, length of fall, and events leading up to the incident may never become available to RMRG, or may vary according to eyewitness accounts. The primary medical diagnosis may change from pre-hospital to hospital care. Minor and repetitive-use climbing injuries are likely not reported to SAR and do not form part of this analysis. Experience level, difficulty of climb, and helmet use were sparsely recorded and are not included. Time of SAR activation may occur minutes to hours after the actual climbing incident, and may not always be an accurate reflection of incident timing.

5 Acknowledgments

The authors would like to acknowledge the contributions of the Rocky Mountain Rescue Group personnel involved in the rescues covered in this analysis of 14 years of data, and for selflessly volunteering their time and expertise for SAR in Boulder since 1947. Specific thanks to Steve Chappell, Clint Dillard, Drew Hildner, Tom Moyer, Les Sikos, Jeff Sparhawk, Lisa Sparhawk, Bijan Tuysserkani, Kevin Vranes, and Dale Wang for assistance and helpful comments.



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