Were They Just Too Exhausted? An Analysis of Stranding Emergencies While Ski Mountaineering From the Swiss Alps

Stranding in ski mountaineering

Benedikt Gasser, Dr. med et Dr.rer.pol
University of Basel - DSBG
Birsstrasse 320B
CH-4052 Basel – Switzerland

Abstract

Introduction

Ski mountaineering is becoming increasingly popular. There are dangers in ski touring, especially on multi-day tours, in addition to avalanches. This leads directly to the objective of the study, to analyze the cases of stranding during ski mountaineering from 2009-2018.

Material and Methods

Based on the central registry of mountain emergencies of the Swiss Alpine Club (SAC) all stranding events in the ten-year period were analyzed. The term "stranding" refers to all emergencies in which mountaineers are no longer able to continue their tour on their own due to exhaustion, excessive demands, loss of material or other mishaps. The stranding emergencies were quantified with NACA-Score (National Advisory Committee for Aeronautics). Effects of age, sex and altitude using multiple linear regressions were analyzed. The case reports of all stranding emergencies were in addition analyzed in detail concerning causes.

Results

A total of 408 (311 male and 97 female) cases of stranding events in the period from 2009-2018 were analyzed. The mean NACA-Score for women was 0.6 ± 1.6 and for men 0.3 ± 1. The average altitude of the stranding analyzed was 2633 ± 698 meters. A highly significant positive relationship between NACA-Score and age as well as NACA-Score and altitude was identified. Based on further analysis of case reports, exhaustion was the main reason for a stranding event.

Discussion

Ski touring groups rather than usually alarm rescue organizations before getting into serious trouble. However, they may just have insufficient reserves of energy to complete the tours. We recommend careful tour planning matching the physical abilities of the participants keeping the likely difficulties in mind.

Introduction

The tragic accident of a 14-person ski mountaineering group two years ago in the night from Saturday to Sunday, April 29, 2018, which ran into a storm on the La Serpentine route that caused 7 deaths is a sad memory for alpinists[1,2].The group left from the Cabane des Dix. (2928m) with the goal of reaching the Cabane des Vignettes (3160m) via Pigned'Arolla [1,2]. The group was close to the hut, when the weather changed suddenly with thick fog, strong winds and heavy snow[1,2]. Although the distance between the group and the hut was only a few

hundred meters, the conditions made it impossible for the group to reach the protective Cabane des Vignettes[1,2].

This sad event illustrates that despite modern technology such as GPS watches and mobile phones ski mountaineering is still a sport with potentially large subjective and objective dangers that should not be underestimated [3,4,5,6]. Nevertheless, ski mountaineering has become increasingly popular in recent years. It is estimated that around 200,000-300,000 ski mountaineers are active per year in the Swiss Alps[7,8]. From a physiological point of view, ski touring is a combination of an endurance element for the ascent with stimulation of the cardiovascular system and a predominantly motoric eccentric element for the descent[9-17]. Despite these positive effects of ski mountaineering tremendous risks such as avalanches or stranding exist[18-20]. Stranding are mountain emergencies in which mountaineers are no longer able to continue their tour on their own due to exhaustion, excessive demands, loss of material or other mishaps [8].

Bad weather and increasing altitude make stranding more likely. Due to the increased physiological requirements due to the reduced oxygen partial pressure, it can be assumed that the demands placed on mountaineers increase regardless of other relevant dangers such as falling rocks, fresh snow, winds, overestimation or group dynamics [21].The aim of the study: to comprehensively analyze the cases of stranding in the Swiss Alps over the past ten years. We hypothesized that factors such as increasing altitude, weather changes, exhaustion but also constitution of alpinists such as age have an influence on the likelihood of stranding [22].

Material & Methods

Data source

All mountain emergencies while ski mountaineering caused by stranding were analyzed in detail by the SAC central registry for the period 2009 to 2018. The central registry includes data from the Swiss Air Rescue Service (REGA), Air Glaciers Lauterbrunnen, Air Glaciers Sanenland, SAC registry, cantonal rescue organization of Valais, Snow and Avalanche Research Institute Davos and the cantonal police registries. The term "*mountain emergency*" encompasses all incidents in which mountain climbers request rescue of the mountain rescue services or are affected by subjective and objective mountain dangers[8]. The term "*stranding*" refers to all emergencies in which mountain climbers are no longer able to continue their tour on their own due to exhaustion, excessive demands, loss of material or other mishaps, which also includes illnesses and evacuations of uninjured mountaineers. Each stranding case contained the rescue organization, the chosen emergency number, the date, location, canton, the nationality, the date of birth, the gender, the place of residence, the coordinates and a briefcase report as well as the NACA-Score (National Advisory Committee for Aeronautics) (Tab. 1)[23].

Statistical analysis

Missing values were imputed for the regression analyses [24,25]. Mean imputation was conducted for the variable age (4.6 percent missing values, n = 19) and for the altitude (14.2 percent missing values, n = 58) [24,25]. The study was conducted in the form of a retrospective

anonymized analysis and was in line with the regulatory requirements of the local ethics board in Switzerland. In a first step, descriptive statistics for the number of cases per year were calculated, the same procedure was carried out for the NACA-Score[26,27]. In order to analyze differences between men and women concerning NACA-Scores and again a first step Kolmogorow-Smirnow tests were conducted for analyzing potential normal distribution. If normal distribution was not given Mann-Whitney U tests for analyzing significance of differences instead of student t-Tests were conducted. To assess the severity of the injury, a multiple linear regression of the form $NACA_i = age_i + sex_i + altitude_i$ with calculation of the coefficient of determination (R^2) was employed. As model assumption (e.g. normal distribution) were not fulfilled for all criteria in addition Pearson correlation coefficients were calculated between altitude of the stranding event and NACA-Scores in a sex-separated manner. The case reports were further analyzed descriptively. The calculations were carried out with Microsoft Excel (Microsoft Inc., Redmond, Washington, USA) and Graphpad Prism (GraphPad Software, Inc., La Jolla, California, USA).

Results

A total of 408 cases, 97 female and 311 male cases of blockage were analyzed, which corresponded to an annual average of 40.8 ± 11 cases. The average NACA-Score for women was 0.613 ± 1.57 and for men 0.314 ± 0.983. Since the calculated Kolmogorow-Smirnow test rejected the hypothesis of a normal distribution, Mann-Whitney U test were employed, which did not lead to a significant difference between males and females ($p = 0.4777$).

The average altitude of the stranding event was 2611.3 ± 709.3 meters for men and 2704.1 ± 658.4 meters for women. Across the entire sample analyzed, the average altitude of the stranding analyzed was 2633.1 ± 697.9 meters above sea level. The employed Mann-Whitney U test as a result of rejection of the assumption of a normal distribution did not result in any significant difference between males and females ($p = 0.389$). Over a third (34.7%) of the stranding were found at an altitude of 2000 to 2800 meters and a total of about 60 percent below 3000 meters (Fig. 1). The mean age was 48 ± 13 years, with no significant difference between males and females.

A highly significant ($p < 0.001$) positive effect on NACA was identified for age and for the altitude, however regression weights of 0.0000291 and 0.00039 seem very low, which is for methodological reasons as altitude was used as raw value (every meter counts, i.e. at 4000 m the altitude in the regression model has the value 4000 x 0.0000291 = 0.1164). No significant effect for gender was identified in the model ($p = 0.0578$). A relatively small coefficient of determination of $R^2 = 0.0655$ was identified for the model. Correlation analyzes were also performed due to the partial violation of the model assumptions of regression analyzes (e.g. normal distribution). The calculated Pearson correlation coefficients between the NACA-Score and the localization altitude of the event was 0.325 for women and 0.100 for men implying the higher the altitude the higher the NACA-Score.

Further information was found in the case reports, which were analyzed in detail, and the following pattern was identified: for around 60 percent of the case reports (56.9%) an identification of a cause was possible, whereby especially exhaustion was very often, which allows to make directly a link to the skills of the alpinists(Tab.2).

Furthermore, it is to mention that some tours were simply very dangerous. Typical examples such as skiing down with skis after normal ascent over the north face of a 4000 m peak, crossing several 4000 m peaks or the case of a stranding event on the twin glacier between Castor and Pollux or the descent over Schwarztor glacier, which are both known for their dangerous crevasses imply this fact. Climate changes also seem to play a role. For example, there were cases on the path to the Monte Rosa hut, which is a prime example of a once snow-covered and accordingly safe hut path with when still taking the original path lots of crevasses and in consequence increased difficulty to find the route.

Discussion

The aim of this study was to analyze the stranding cases in the Swiss Alps in the last ten years. Based on the findings the altitude of a stranding event shows an association with altitude. Furthermore, based on findings from the case reports weather changes have an influence on the likelihood of stranding. The most frequent mention was exhaustion in the case reports which is probably also caused by altitude. It is recognizable from case reports that sometimes extremely difficult tours were causing the stranding events. However, mean NACA Scores were very low. This puts up the question why so trivially injured mountaineers have to be rescued. The main reason is probably to minimize further or more severe injuries. The work of the rescue organization seems to have a preventive effect and is in some cases easy to perform with a helicopter. Negatively formulated, the physical resources and the alpine experience often lacks especially if environmental factors change such as sudden fog comes up or snowfall starts. There is in addition evidence from the case reports that personal skills often were overestimated. In certain stranding events, an ascent rate of more than 500 meters per hour was necessary for safe completion of the whole tour, which is too sportive for average alpinists and the choosing of such routes is in some cases a clear sign of overestimation. The identified relevance of exhaustion for stranding events and the association with altitude is probably also an effect of the decreasing oxygen partial pressure. In principle, the decrease in the oxygen partial pressure at an altitude of 2000-3000 meters should lead to a compensable adaptation reaction of the human body if the organism has enough time for an adequate adaptation [28]. To sum up, the most common reason for a blockage was exhaustion, which implies that a better training state could prevent the emergency. It might be concluded, that alpinists often do not have simply enough physical resources to absolve the respective tours. Furthermore, the increase in severity with higher altitude can presumably be attributed partly to the decrease in oxygen partial pressure. Accordingly, it follows that an acclimatization should not be neglected and appropriate time for this process would lead to a correspondingly increase in security.

Conflict of interest

There is no conflict of interest

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NACA 0	No injury or disease. For example wrong alarm call
NACA I	Minor disturbance. No medical intervention is required. For example slight abrasion
NACA II	Slight to moderate disturbance. Outpatient medical investigation, but usually no emergency medical measures necessary. For example, fracture of a finger bone, moderate cuts, moderate dehydration.
NACA III	Moderate to severe but not life-threatening disorder. Stationary treatment required, often emergency medical measures on the site. For example femur fracture, milder Stroke, smoke inhalation.
NACA IV	Serious incident where rapid development into a life-threatening condition can not be excluded. In the majority of cases, emergency medical care is required. For example. vertebral injury with neurological deficit, severe asthma attack; drug poisoning.
NACA V	Acute danger. For example, third grade skull or brain trauma, severe heart attack
NACA VI	Respiratory and or cardiac arrest.
NACA VII	Death

Tab.1 *NACA-Score - all cases were classified by the rescue organizations directly after the event [23].*

	Men		Women		Total	
	number	percentages	number	percentagesl	number	percentages
Night respectively beginnig darkness	14	1.3%	400.0%	4.1%	1800.0%	13.5%
Fresh snow	10	9.2%	0.0%	0.0%	1000.0%	7.5%
Exhaustion	26	23.9%	300.0%	3.1%	2900.0%	21.6%
Rocky	4	3.7%	100.0%	1.0%	500.0%	3.7%
Fog & bad view (during day)	33	30.3%	300.0%	3.1%	3600.0%	26.9%
Loosing its way / missing orienteering skills	14	12.8%	600.0%	6.2%	2000.0%	14.9%
Steep terrain	8	7.3%	800.0%	8.3%	1600.0%	11.9%
Total	109		41		134	

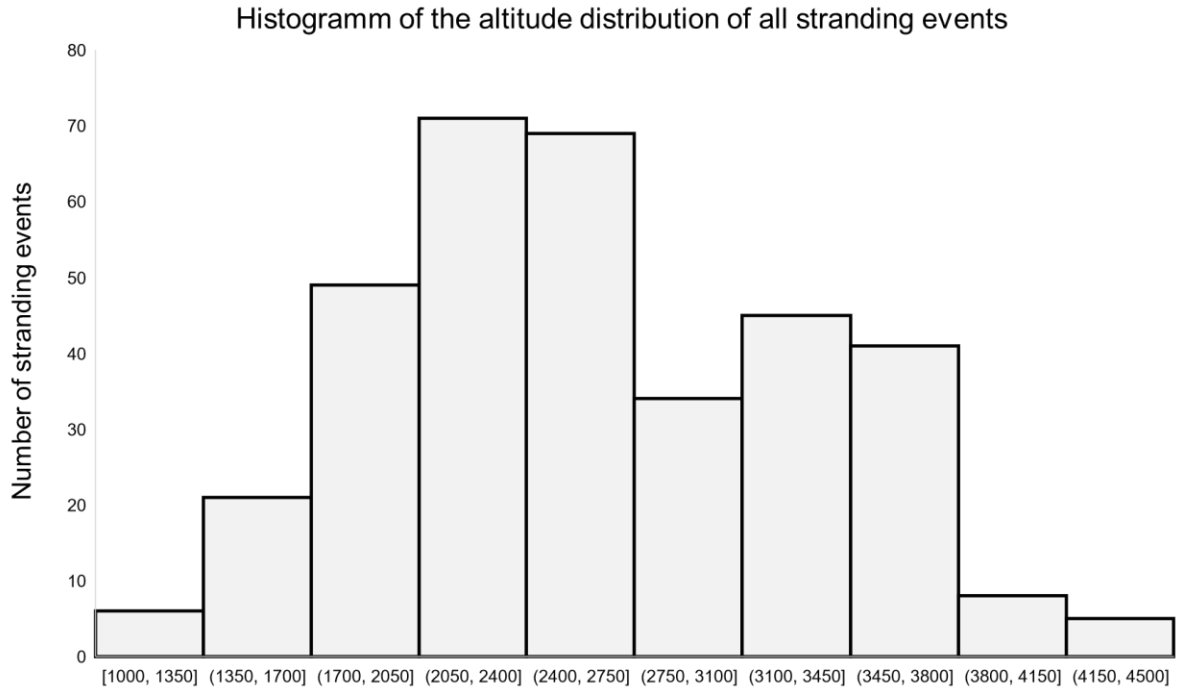**Tab. 2** *Causes of the blocking (cumulative mentioning possible in the case reports).*

Fig. 1 *Histogram of the altitude distribution of all stranding cases.*