ORIGINAL RESEARCH

Can People with Raynaud's Phenomenon Travel to High Altitude?

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Objective.—To determine whether high altitude travel adversely affects mountain enthusiasts with Raynaud's phenomenon.

Methods.—Volunteers with Raynaud's phenomenon were recruited using announcements disseminated by organizations dedicated to climbing or wilderness travel and Internet discussion boards dedicated to mountain activities to complete an online, anonymous survey. Survey questions addressed demographic variables, aspects of their Raynaud's phenomenon, and features of their mountain activities. Respondents compared experiences with Raynaud's phenomenon between high (>2440 m; 8000 feet) and low elevations and rated agreement with statements concerning their disease and the effects of high altitude.

Results.—One hundred forty-two people, 98% of whom had primary Raynaud's phenomenon, completed the questionnaire. Respondents spent 5 to 7 days per month at elevations above 2440 m and engaged in 5.4 ± 2.0 different activities. Eighty-nine percent of respondents engaged in winter sports and only 22% reported changing their mountain activities because of Raynaud's phenomenon. Respondents reported a variety of tactics to prevent and treat Raynaud's attacks, but only 12% used prophylactic medications. Fifteen percent of respondents reported an episode of frostbite following a Raynaud's phenomenon attack at high altitude. There was considerable heterogeneity in participants' perceptions of the frequency, duration, and severity of attacks at high altitude compared to their home elevation.

Conclusions.—Motivated individuals with primary Raynaud's phenomenon, employing various prevention and treatment strategies, can engage in different activities, including winter sports, at altitudes above 2440 m. Frostbite may be common in this population at high altitude, and care must be taken to prevent its occurrence.

Key words: high altitude, hypoxia, Raynaud's phenomenon, frostbite, calcium channel blockers

Introduction

Given the large and increasing numbers of people traveling to high altitude for work or pleasure, it is reasonable to expect that many travelers will have underlying medical problems that could be affected by the high altitude environment. At the same time, the literature contains limited information on the manner in which many common diseases are affected by high altitude. Some reviews have considered this question as it pertains to

patients with pulmonary, cardiac, and other underlying conditions,¹ but there are many diseases for which we still lack information regarding the risks of high altitude travel and disease management in this environment. One such common disease for which we currently have little information is Raynaud's phenomenon.

Raynaud's phenomenon is a disorder of abnormal vasomotor control, which can occur as an isolated problem (primary Raynaud's phenomenon) or in conjunction with collagen vascular diseases such as scleroderma or systemic lupus erythematosus (secondary Raynaud's phenomenon).² The hallmark of the disorder is episodic pallor or cyanosis of the distal extremities due to vasospasm

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Figure 1. Photograph showing an example of the clearly demarcated areas of pallor commonly seen in the distal extremities during attacks of Raynaud's phenomenon. This photo was provided by one of the study participants, and permission has been granted for its publication.

and limitations in arterial blood flow (Figure 1). These symptoms may be accompanied by pain, numbness, and burning sensations and are often, but not always, followed by reactive hyperemia as circulation is restored. Symptoms typically occur bilaterally, more commonly affect the fingers than the toes, and can be triggered by a variety of stimuli including cold temperatures, moisture, vibration, and stress.³

Given the role that peripheral arterial vasospasm and limitations in blood flow play in this disease, there is reason to question whether travel to high altitude could adversely affect people who experience this problem. The cold temperatures at high elevations might trigger more frequent attacks while the low ambient oxygen conditions, in conjunction with impaired blood flow, might limit oxygen delivery to the tissues and, as a result, predispose the affected individual to distal extremity ischemia, frostbite and possibly gangrene. Some sources warn about the possibility of such problems⁴ but the data supporting such recommendations are limited; no studies have established the risk of more frequent or severe attacks or adverse consequences at high altitude.

To gain further insight into this issue, we surveyed people with Raynaud's phenomenon who travel to altitudes above 2440 m (8000 feet) for a variety of activities such as climbing, skiing, backpacking, or hiking. The goal of the survey was to characterize features of their Raynaud's phenomenon and disease management and their activities in the mountains, including the altitudes reached during these activities and whether they have altered their activities because of their disease. We also sought to determine whether travel to these altitudes af-

fects the frequency and severity of their attacks or has led to severe complications such as frostbite or gangrene.

Methods

After obtaining approval from the Institutional Review Board at the University of Washington, we recruited volunteers to complete a web-based, anonymous survey by posting announcements about the study on Internet discussion boards dedicated to activities that involve mountain travel, such as cascadeclimbers.com, nwhikers.net, mountainproject.com, and supertopo.com. Announcements about the study were also placed in newsletters for the Alpine Club of Canada, American Alpine Club, and Wilderness Medical Society. Eligible participants included men and women with a history of either primary or secondary Raynaud's phenomenon who had traveled to altitudes above 2440 m (8000 feet). This threshold was chosen because it is the altitude used in consensus criteria for the diagnosis of acute mountain sickness.⁵ In addition, physiologic studies indicate that important adaptive responses, such as hypoxic pulmonary vasoconstriction and the hypoxic ventilatory response, begin at altitudes of 1500 to 2000 m,⁶ whereas clinical studies indicate that individuals are at risk for acute mountain sickness or high altitude pulmonary edema at altitudes as low as 1500 to 1900 m.^{7,8} Because our study threshold of 2440 m is above these altitudes, it is likely that study participants have been exposed to ambient conditions that trigger physiologic responses that may affect their Raynaud's phenomenon.

Interested individuals were asked to contact one of the investigators (A.L.) who emailed the individual additional information about the study and a link to the URL for the anonymous survey (available at: <https://catalysttools.washington.edu/webq/survey/aluks/46577>). The additional information satisfied the requirements of the informed consent process. The survey was completed at the discretion of the individual. The online survey included a mechanism whereby the investigators could track those who completed the survey without attaching their name to any of the data. Those individuals who did not complete the survey within 2 weeks of receiving the study information received a single email reminder asking them to complete the survey.

The diagnosis of Raynaud's phenomenon was based on participant report, and no confirmation was required for study participation. If interested individuals expressed doubt about the accuracy of their diagnosis, we solicited information by email to determine if they met criteria for the diagnosis, including episodic pallor or cyanosis of the distal fingers or toes in response to triggers such as cold or stress.³ Those individuals whose

symptoms did not fit this description (eg, cold sensitivity without color changes in the digits) were not included in the study and did not receive the survey URL. We do not have records of the total number of people excluded for this reason. After 30 participants had responded to the survey a question was added to the survey asking how the patient received the diagnosis of Raynaud's phenomenon (self-diagnosis or physician). Responses to this question were not used for screening purposes or to eliminate participants' responses from the data analysis. Two individuals completed the survey but had not traveled to altitudes above 2440 m; their data were not included in the data analysis. Five of the survey respondents reside above our target elevation of 2440 m but were included in the study because their mountain activities involved significant gains in elevation above their home elevation.

The survey comprised 33 questions and required 10 to 15 minutes to complete. In addition to soliciting information regarding age, gender, prior medical history, and any medication use, the survey included questions about various features of their Raynaud's phenomenon including affected extremities, triggers, and prevention and treatment strategies employed at home and in the mountains. Respondents were also asked about different aspects of their mountain activities including the frequency of travel to high altitude, the activities pursued, the altitudes attained, and any changes in their patterns of activity based on their Raynaud's phenomenon. The questions in these categories were structured such that respondents checked off items on a predetermined list but also had the opportunity to write in free responses if their answer was not present in the list. Finally, respondents compared their experiences at high and low altitude and stated their level of agreement with statements about their Raynaud's phenomenon and how it might be affected by the high altitude environment. Three- and five-point Likert scales were used to assess responses to these last 2 categories of questions.

Respondents were not required to answer every question in the survey. As a result, we did not have 142 responses to every question. When reporting percentages below, any question for which we did not have 142 responses is noted where appropriate. All values presented are mean $\pm$ SD.

Results

A total of 164 people who expressed interest in completing the survey were eligible to participate and received the additional study information and survey URL. One hundred and forty two (62 men, 79 women, 1 no

Table 1. Basic information about study participants

<i>Variable</i>	<i>Result</i>
No. respondents	142
Average age (y)	43.7 $\pm$ 11.8
Gender*	
Men	62 (44%)
Women	79 (56%)
Past medical history	
None	70 (49%)
Musculoskeletal problems	16 (11%)
Hypertension	12 (8%)
Allergies	10 (7%)
Hypercholesterolemia	9 (6%)
Asthma	9 (6%)
Hypothyroidism	9 (6%)
Collagen vascular disease	3 (2%)
Cancer	3 (2%)
(+) Antinuclear antibody without diagnosis	2 (1%)
Coronary artery disease	2 (1%)
Deep venous thrombosis	2 (1%)
Inflammatory bowel disease	2 (1%)
Fibromyalgia	1 (<1%)
Sarcoid	1 (<1%)
Atrial fibrillation	1 (<1%)
Cold urticaria	1 (<1%)
Medication usage	
None	69 (51%)
Regular medications†	73 (49%)
Calcium-channel blocker use	13 (9%)

*One individual did not provide a response to this question.

†This total includes 2 respondents using beta-blockers, 5 taking angiotensin-converting enzyme inhibitors, 2 taking angiotensin receptor blockers, and 3 using thiazide diuretics for blood pressure control.

response) of these people completed the survey (response rate 87%).

DEMOGRAPHIC DATA AND MEDICAL HISTORIES OF RESPONDENTS

Basic information about the study participants is provided in Table 1. Only 3 respondents (2%) reported a history of collagen vascular disease. Thirteen respondents (9%) were on calcium channel blocker therapy, 7 of whom stated that the medication was used only before trips to the mountains in cold weather to prevent attacks of Raynaud's phenomenon. The other 6 did not specify whether they used calcium channel blockers for their Raynaud's or for blood pressure control. Twelve respondents used other medications with vascular effects for the control of blood pressure, including beta-blockers

Table 2. Characteristics of Raynaud's phenomenon in survey participants

<i>Variable</i>	<i>Number (%)</i>
How was Raynaud's phenomenon diagnosed? (<i>n</i> = 112)*	
Self-diagnosis	53 (47%)
By a physician	59 (53%)
Age at time of diagnosis (y; mean $\pm$ SD)	28.7 $\pm$ 11.6
Affected extremities (<i>n</i> = 141)	
Hands and feet	80 (57%)
Hands only	60 (43%)
Feet only	1 (<1%)
Primary triggers for Raynaud's phenomenon attacks†	
Getting hands/feet cold	126 (88%)
Getting hands/feet wet	64 (45%)
Exposure of hands/feet to the wind	56 (39%)
Whole body becomes cold	13 (9%)
Post-exercise	11 (8%)
Sweating	5 (4%)
Extremity contact with cold surface	4 (3%)
Stress	4 (3%)
Vibration	2 (1%)
Gripping objects tightly	2 (1%)

*Question was inserted into survey after data collection was underway.

†Subjects were allowed to report more than 1 trigger.

(2), angiotensin-converting enzyme inhibitors (5), angiotensin-receptor blockers (2), and thiazide diuretics (3). No respondent reported routine use of phosphodiesterase inhibitors. Table 2 presents data on the basic characteristics of Raynaud's phenomenon in the survey respondents.

HIGH ALTITUDE EXPERIENCE AND ACTIVITIES

Table 3 presents information about the altitude experiences of the survey respondents. Forty-six percent of respondents have ascended to elevations above 4570 m (15 000 feet) and 11% have ascended to elevations above 6100 m (20 000 feet). A single respondent has successfully summited Mt Everest (8850 m).

Figure 2 describes the mountain activities of the survey respondents during their high altitude travel. Respondents participate in an average of 5.4 ± 2.0 different activities and spend an average of 5.3 ± 5.4 days/month above 2440 m between the start of December and the end of March and an average of 7.1 ± 6.0 day/month above 2440 m between the beginning of May and the end of September. One hundred and twenty six respon-

dents (89%) reported doing activities that would be classified as winter sports by virtue of the time of year or exposure to snow and/or ice (ice climbing, resort or backcountry skiing, cross-country skiing, snow camping). Twenty-nine respondents (*N* = 132; 22%) reported changing their pattern of activities because of their Raynaud's phenomenon. The most common changes in activity patterns included eliminating or doing less ice climbing (*N* = 6), backcountry or resort skiing (*N* = 5), or winter camping (*N* = 7); changing climbing goals (*N* = 5); and making fewer trips in cold temperatures (*N* = 6).

TACTICS TO PREVENT AND MANAGE EPISODES OF RAYNAUD'S PHENOMENON

Figure 3 describes the tactics survey respondents use to prevent episodes of Raynaud's phenomenon during their high altitude activities. Eighty-nine percent of respondents reported using multiple strategies on any given trip, and the average number of strategies used per person was 3.7 ± 1.6 . Only 14 respondents (*N* = 127; 12%) used pharmacologic prophylaxis, with the majority (8) of these people using calcium channel blockers; 2 respondents use Ginkgo biloba, whereas single respondents used alpha-blocker therapy, niacin, an unspecified antihypertensive medication, and a Chinese herbal remedy known as Si Ni San. One respondent reported an impending change to prophylaxis with a phosphodiesterase inhibitor. Figure 4 describes the tactics used by survey respondents when they experience an attack of Raynaud's phenomenon at sea level or high altitude. Eighty-nine respondents (63%) reported no change in treatment strategies when Raynaud's episodes occur at elevations above 2440 m. Among those who use different treatment strategies at high altitude, the most frequent changes involved the use of chemical hand-warmers. Many respondents also commented that at high altitude they lack easy access to warm water for rewarming their extremities and cannot use this strategy to the same extent as if an attack occurred at lower elevations (eg, at home or at work).

EFFECT OF SEASON ON SYMPTOMS OF RAYNAUD'S PHENOMENON

When asked whether the frequency of episodes of Raynaud's phenomenon at a given elevation above 2440 m varied based between the summer (end of May to beginning of September) and winter months (beginning of December to the end of March), 62% reported higher frequency during the winter, whereas 7% reported higher frequency during the summer and 31% reported no dif-

Table 3. Altitude experiences of the survey respondents

Variable	Result
Residence	
Average elevation	708.6 $\pm$ 813.6 m
Minimum	Sea level
Maximum	2866 m
Number living above 760 m	49 (35%)
Number living above 1525 m	34 (24%)
Number living above 2440 m	5 (4%)
Peak lifetime elevation above 2440 m	
Average peak elevation achieved	4873.5 $\pm$ 1080.8 m
Maximum reported peak elevation	8850 m
Experienced Raynaud's attack at peak altitude	41 (29%)
Travelers above 4570 m	
Number of respondents exceeding 4570 m	65 (46%)
Average number of trips above this elevation	5.8 $\pm$ 8.7
Number reporting Raynaud's attack above 4570 m	35 (54%)
Travelers above 6100 m	
Number of respondents exceeding 6100 m	16 (11%)
Average number of trips above this elevation	2.7 $\pm$ 2.6
Number reporting Raynaud's attack above 6100 m	5 (31%)
Altitude of worst Raynaud's phenomenon episode	1980.4 $\pm$ 1529.1
Number whose worst episode of Raynaud's phenomenon occurred below peak altitude attained ($n = 112$)	111 (99%)
Number whose worst episode occurred below 150 m in elevation	24 (17%)

ference between the 2 seasons. When asked a similar question with regard to the severity of their symptoms, the percentage of respondents reporting worse symptoms in the winter, summer, or no difference between the 2 were 62%, 7%, and 31%, respectively.

COMPLICATIONS OF RAYNAUD'S PHENOMENON

Twenty respondents (15%) responded in the affirmative in response to the question, "Have you ever experienced

Figure 2. Mountain activities pursued by survey participants during high altitude travel. Participants were able to report multiple activities. A list of potential activities was provided, and participants were also able to add activities not specified on this list ($N = 142$ respondents).

Figure 3. Strategies employed by survey participants to prevent attacks of Raynaud's phenomenon during high altitude travel. Participants were able to report the use of multiple strategies. A list of potential strategies was provided, and participants were also able to add strategies not specified on this list (N = 142 respondents).

frostbite following an attack of Raynaud's phenomenon at high altitude?" These episodes occurred at an average elevation of 3272 ± 1173 m. Five respondents (4%) reported experiencing an infarct and gangrene of a distal extremity after an episode of Raynaud's phenomenon at elevations above 2440 m. An average elevation could not be calculated because of insufficient data reporting by the respondents. None of these individuals had a history of collagen vascular disease or positive antinuclear antibody titres. An additional 4 individuals reported experiencing an infarct or gangrene but were not included in the reported total because the description they provided of their symptoms was inconsistent with the diagnosis of infarct or gangrene.

SUBJECTIVE ASSESSMENTS OF RAYNAUD'S PHENOMENON AT HIGH ALTITUDE COMPARED TO HOME RESIDENCE

Figure 5 displays the results of questions asking the respondents to compare their Raynaud's phenomenon episodes at elevations above 2440 m with episodes at their home residence. Figure 6 displays the results of questions in which respondents were asked to report their level of agreement with statements about their episodes of Raynaud's phenomenon.

Discussion

This is the first study to examine what, if any effect, exposure to high altitude has on people with Raynaud's phenomenon. Our survey results demonstrate that individuals with this disorder are capable of going to high altitude on a frequent basis to engage in a range of activities, including those that involve significant exposure

to cold temperatures and/or contact with snow. There was considerable heterogeneity among survey participants regarding the effect of high altitude on their disease; the majority of participants do not perceive differences in their symptoms at high altitude and report that the frequency, duration, and severity of their Raynaud's phenomenon episodes were not worse at high altitude compared to their home elevation, but a substantial minority of respondents expressed contrary opinions on each of these issues. Even though high altitude may adversely affect many participants, only 22% reported changing their pattern of mountain activities, suggesting that by employing a variety of prevention and treatment strategies they are still able to continue an extensive program of high altitude activities.

It must be noted that the conclusions of our study should only be applied to patients with *primary* Raynaud's phenomenon. Even though patients with secondary disease comprise between 10% and 29% of patients with Raynaud's phenomenon in some studies,^{9,10} only 2% of the participants in our survey reported a prior history of collagen vascular disease and would be considered as having secondary disease. The reason for the discrepancy is not clear, but one plausible explanation is that patients with secondary Raynaud's phenomenon may have severe problems in the mountains and have given up such activities. As a result, they may not have been captured by our recruitment methods that tended to target those who are still active in this environment.

It is also important to note that our study does not establish whether the hypoxia of high altitude affects Raynaud's phenomenon. A major problem that limits claims in this regard is the difficulty separating the effects of ambient oxygen conditions from those of low temperatures at high altitude. It is a well-recognized fea-

Figure 4. Strategies employed by survey participants to treat attacks of Raynaud's phenomenon once they occur at either high or low altitude. Participants were able to report the use of multiple strategies. A list of potential strategies was provided and participants were also able to add strategies not specified on this list (N = 142 respondents).

ture of high altitude that temperature declines as elevation gets higher.¹¹ Cold temperatures are also a major trigger for episodes of Raynaud's phenomenon. We attempted to account for the effects of cold by asking survey participants if they noticed a difference in their symptoms between trips taken to the same elevations during the summer and winter months. Sixty-two percent of participants reported that the severity and frequency of attacks were greater during the winter than during the summer. This result suggests, but by no means proves, that it may be the cold temperatures rather than the hypoxia at high altitude that is the key factor.

Other results that suggest the hypoxia of high altitude may not affect Raynaud's phenomenon are the fact that the participants' reported elevation of their worst attack (1980 ± 1529 m) was well below the average peak altitude attained in their lifetime (4873 ± 1080 m) and the fact that 99% of participants reported that their worst attack occurred below their lifetime peak elevation. If

hypoxia did have an effect on Raynaud's phenomenon, one might expect to see a dose-response relationship whereby higher elevations and greater degrees of hypoxia were associated with more frequent and/or more severe attacks. This was not seen in our study and suggests that hypoxia may not contribute to worsening symptoms. This is only indirect evidence, however, and further study in controlled conditions is necessary to determine if such a relationship exists.

Beyond issues regarding the frequency, severity, and duration of Raynaud's episodes at high altitude, an important concern is whether these individuals are at increased risk for complications, such as frostbite, in this environment. There is considerable evidence to suggest this patient population may be at increased risk for this problem. Raynaud's attacks are marked by vasoconstriction and decreased blood flow to the affected extremities, and patients with Raynaud's phenomenon have also been shown to have lower finger temperatures with body cool-

Figure 5. Participant comparisons of the frequency, severity, and duration of Raynaud's phenomenon attacks at home and at high altitude.

Figure 6. Participants' level of agreement with statements regarding their Raynaud's phenomenon at high altitude. For each statement displayed on the left, participants were asked to state whether they strongly agreed, agreed, had no opinion, disagreed, or strongly disagreed.

ing¹² and slower rates of skin temperature rise with rewarming when compared to healthy controls.¹³ Moreover, cold-induced vasodilation (also known as the "hunting response"), a protective response in which the peripheral vasculature dilates in response to very cold temperatures in an attempt to preserve peripheral blood flow and protect against local cold injuries, may be decreased at high altitude¹⁴ and in individuals with Raynaud's phenomenon.¹⁵

In our study, 20 participants (15%) reported an episode of frostbite after an attack of Raynaud's phenomenon at high altitude. Because our study lacks a control group of people who travel to high altitude but do not have a history of Raynaud's phenomenon, we cannot conclude that the risk of frostbite at high altitude is increased relative to the general population. It is plausible that individuals without Raynaud's phenomenon might have experienced frostbite to the same extent when exposed to the same ambient conditions.

Another study that included a control group has examined the risk of frostbite in the setting of Raynaud's phenomenon. Ervasti et al¹⁶ studied 5839 Finnish military recruits, 1274 of whom were labeled as having cold-provoked white-finger (CPWF) syndrome, another name for Raynaud's phenomenon. Of those individuals with CPWF syndrome, 18% (228) experienced an episode of frostbite during their lifetime, an incidence rate that corresponds to an odds ratio for frostbite among people with CPWF syndrome of 2.05 (95% CI: 1.72 to 2.44). It should be noted, however, that this odds ratio applies to all degrees of frostbite severity. When they focused more narrowly on "deep frostbite," defined in that study as frostbite accompanied by "blisters, ulcers, or gangrene," the risk of frostbite in CPWF syndrome was only increased in those individuals who smoked or were exposed to vibration.

Comparison between our data and those of Ervasti et al is difficult because our study focused on frostbite at high altitude whereas their study did not consider altitude as a variable. Unfortunately, comparison with other studies reporting frostbite incidence among the general population traveling to high altitude is also difficult, as the number of studies including such data is limited because of the lack of formal reporting mechanisms. In one of the only studies to address this issue, Harirchi et al¹⁷ surveyed 637 mountaineers and reported a mean incidence of 366/1000 population years. Until further controlled studies are performed to clarify the risks relative to that of the general population, the 15% incidence rate found in our study is high enough to suggest that people with Raynaud's phenomenon who travel to high altitude should be vigilant in their efforts to prevent this problem.

There are several other noteworthy aspects of our study results. First, despite the fact that calcium channel blockers¹⁸ and other medications, such as phosphodiesterase inhibitors,^{19,20} have been shown to decrease the frequency and severity of episodes of Raynaud's phenomenon and may be used on an as-needed basis,²¹ only a small minority of participants use pharmacologic prophylaxis. The number of people who reported using calcium channel blockers to prevent attacks of Raynaud's phenomenon (8) was different than the number of people who reported using calcium channel blockers in the question regarding regular medication use. We suspect that the discrepancy resulted from differences in the wording of the questions, with one question emphasizing "regular" use and the other asking specifically about preventing Raynaud's episodes and therefore implying "as-needed" use.

Our survey did not elicit information to determine why so few of the respondents used pharmacologic pro-

phylaxis. One plausible explanation is that many of the participants in our study were self-diagnosed and, as a result, may not have had the opportunity for counseling from physicians about the prophylactic benefits of certain medications. Participants may have also found over time that their various nonpharmacologic strategies, such as maintaining body temperature, wearing gloves, and stress reduction, are effective in their particular cases and that pharmacologic prophylaxis is not necessary. Finally, respondents may have had discussions with their physicians about the use of prophylactic medications and decided that the risk:benefit ratio did not warrant their use. Another noteworthy feature of the data on treatment strategies was the fact that 96 participants (68%) reported using chemical hand-warmer packets to prevent episodes of Raynaud's phenomenon. This tactic has not been widely described in review articles on Raynaud's phenomenon thus far.^{3,21}

Another important feature of our data was that whereas stress, vibration, and exposure to cold and moisture are commonly noted triggers for attacks of Raynaud's phenomenon and all of these factors were noted to be triggers by the participants, there were large discrepancies between the numbers of people whose attacks were triggered by cold (88%) and moisture (45%) rather than stress (4%) or vibration (1%). Our participants also reported several triggers that have not been well described, including the period after exercise and sweating. It is possible that these factors trigger Raynaud's episodes by virtue of the fact that core body temperature may fall as a result of either process.

Finally, digital infarcts are generally thought to only be a feature of secondary Raynaud's phenomenon and are typically not seen in cases of primary disease.^{3,21} Five participants in our study reported experiencing infarcts following an attack of Raynaud's phenomenon at high altitude. None of these participants, however, reported a history of collagen vascular disease or positive antinuclear antibody titres, although it is possible that these individuals might develop manifestations of collagen vascular disease at a later time and transition to secondary disease.²² Caution must be applied in considering this finding, however, as the presence of infarcts was based on self-report, and no visual confirmation of the diagnosis was made as part of the survey.

There are several limitations of our study that warrant consideration. First, because we used a survey to collect information from the participants, our results are subject to the effects of recall bias, as the participants were being asked to recall events that may have occurred years earlier. Second, because of the particular methods used to recruit study participants, it is highly likely that our results are subject to selection bias. The websites used

for study recruitment are typically frequented by motivated, active mountain enthusiasts. It is, therefore, possible that we missed the opportunity to recruit people with Raynaud's phenomenon who no longer travel to the mountains because of the severity of their disease or other problems. In addition, our survey was published only in English and drew largely from a North American population. This geographic limitation may bias the results because individuals from other regions may access higher altitude mountain regions with different temperature profiles and because ethnic differences may affect the frequency, severity, and duration of Raynaud's phenomenon episodes.^{23,24}

Despite these limitations, our study represents the first attempt to answer questions about the effects of altitude on Raynaud's phenomenon and can serve as a basis for further research on this question. Our data indicate a considerable degree of heterogeneity in perceptions of the effect of high altitude on Raynaud's phenomenon but suggest that motivated individuals with primary disease, employing a variety of different strategies for prevention and treatment, can travel to and engage in many different activities, including winter sports, at altitudes above 2440 m. Until further data are available to clarify the risks of frostbite further, these individuals should be vigilant in their efforts to prevent this problem.

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