ORIGINAL RESEARCH

Appalachian Trail Hikers' Ability to Recognize Lyme Disease by Visual Stimulus Photographs

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Background.—Lyme disease is the most common vector-borne infectious disease in North America. With nearly 2,500 Appalachian Trail (AT) hikers entering the endemic area for as long as 6 months, exposure to the disease is likely. The characteristic exanthem of erythema migrans (EM) should be a trigger for seeking medical treatment, and its recognition in this relatively isolated environment is important.

Objective.—The purpose of this study was to determine the ability of AT hikers to identify EM, the exanthem of Lyme disease.

Methods.—Hikers were administered a photographic stimulus in this Internal Review Board–approved pilot study. Historical hiking data, basic demographics, and self-reported treatment and diagnosis were collected.

Results.—In all, 379 responses were collected by 4 researchers at 3 geographically separate locations at or proximate to the AT from June 2011 to May 2012. Fifty-four percent of respondents (206 of 379) were able to recognize the photographs of EM/Lyme disease; 46% could not. Of those who did recognize EM, 23 (6%) had seen it either on themselves or on another hiker while on the AT. A total of 37 hikers stated that they had been diagnosed with Lyme disease while hiking, and of these, 89% were treated with antibiotics. Thirteen of these 37 hikers (35%) diagnosed with Lyme disease had visualized an embedded tick. Nine percent of all respondents reported they had been diagnosed with Lyme disease by a healthcare practitioner, whether from EM, symptomatology, or by titer.

Conclusions.—This study suggests that hikers are poorly able to recognize the characteristic exanthem of Lyme disease but have a high exposure risk.

Key words: Appalachian Trail, hikers, erythema migrans, recognition of exanthem, photographic stimulus, Lyme disease

Introduction

The purpose of this study was to determine the ability of hikers of the Appalachian Trail (AT) to recognize erythema migrans (EM), the exanthem characteristic of Lyme disease. The rationale for this study derives from the annual convergence of national and international hikers directly into the endemic area for Lyme disease in the United States. Early stage treatment of Lyme disease depends in part upon recognition of EM, and we sought to determine whether the average hiker is able to identify the characteristic rash.

The AT is a 2180-mile footpath along the Appalachian mountain range in the United States with termini at Springer Mountain, Georgia, and Mount Katahdin,

Maine, passing through 14 states (Figure 1).¹ Data from 2012 indicate 2897 hikers attempted the through-hike, with 665 completing more than 2000 miles, an average of 23% to 27% success.² Add to this millions of visitors, day hikers, and section hikers who enter and leave the trail at variable locations every year, and the interaction between hiker and tick is likely.

In 2011, more than 30,000 confirmed or probable cases of Lyme disease were reported to the Centers for Disease Control and Prevention. As seen in Figure 2, the majority of cases are concentrated along the northeast coast of the United States, with 94% of cases in 2010 reported within 12 states.³ The spirochete pathogen *Borrelia burgdorferi* is transmitted by the nymph stage of the *Ixodes scapularis* tick (commonly known as the deer tick) and *I pacificus* tick in the western United States.⁴ A common inhabitant of AT shelters is the white-footed mouse, *Peromyscus leucopus*, preferred

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Figure 1. Map of the Appalachian trail, which spans 2180 miles and 14 states of the eastern United States. Map courtesy of the Appalachian Trail Conservancy.

host and reservoir of *I. scapularis* larvae and nymph stage.⁵ Larger mammals and deer are the hosts for adult stage ticks. The first stage of infection is characterized by the EM lesion, a well-circumscribed erythematous macule, typically circular or ovoid with central clearing resembling a target or bullseye, 2 cm to 60 cm in diameter. There is an incubation period of 7 to 10 days, and an average duration of 28 days.⁶ The secondary stage is characterized by constitutional symptoms, including fever, malaise, and cephalgia. Symptoms of rash and fever may overlap, and a disseminated EM may occur (Figure 3). The tertiary stage of the disease includes neurologic findings including cranial nerve VII palsy, monoarticular arthritis, and cardiac manifestations such as conduction delays or myocarditis.

Reported Cases of Lyme Disease -- United States, 2011

Figure 2. Cases of Lyme disease as reported to the Center for Disease Control (CDC) in the year 2011. The map has one blue dot placed randomly within the county of residence for each confirmed case.

Methods

The study design and survey procedure was approved by the Internal Review Board of University of Pittsburgh Medical Center Hamot. Inclusion criteria were self-identified current or former hikers of the AT, further classified as a through hiker (completing more than 2000 miles in a single attempt) or a section hiker (traversing any portion of the trail). Nonhikers were excluded.

PROCEDURE

Subjects were first presented 3 photograph stimuli representative of EM (see Figure 4) followed by an 11-point or 13-point questionnaire (depending on their classification of current or former status) administered by 4 trained researchers (J.M.K., A.C.R., C.M.B., G.A.B.) (see online Supplementary material). Data collected included the following: 1) ability to identify photograph stimuli; 2) historical hiking activity; 3) demographics; 4) self-reported rash or disease development; and 5) medical treatments received. Sampling site was based on researcher access to the trail and subject clusters during peak hiker activity, obtained at the Appalachian Trail Conservancy and Visitors Center, Harpers Ferry, Virginia, and three events: Trail Days in Damascus, Virginia; The Gathering in North Adams, Massachusetts; and Hiker's Feast in Duncannon, Pennsylvania, from June 2011 to May 2012. Data analysis consisted of the generation of summary statistics (means, rates as percentages). The χ^2 test was used to compare

Figure 3. Disseminated erythema migrans, present on this patient's back. This occurs when the pathogen disseminates within the patient's blood, in the secondary stage of the illness.

rates of hikers who could identify the EM rash based on hiking status (current vs former) and areas traveled (through hiker vs section hiker). Medical intervention and antibiotics were compared across these subgroups for hikers who had the rash on the AT; *t* tests were used to compare ages within these subgroups. The threshold for significance was set at 0.05. For analysis, SPSS software version 12.0 for Windows (SPSS, Chicago, IL) was used.

Results

A total of 379 hikers, 184 former and 195 current, were surveyed. Their average age was 44.5 years (Tables 1 and 2). Current hikers were significantly younger than former hikers ($P < .001$), and through hikers were significantly younger than section hikers ($P < .001$). Despite these age and experiential differences, the rates of EM identification were similar (50% to 59%, $P > .079$). Overall, 54% of respondents (206 of 379) were able to recognize the photographs shown to be that of EM/Lyme disease, whereas 46% could not. Of these, 59% of the former hikers were able to identify the rash of EM compared with the 49% of current hikers. Of all hikers surveyed, 6% (23 of 379) said the rash developed while they were hiking the AT. Of those who stated they had the rash, 82% of former hikers (13 of 17) and 80% of current hikers (4 of 5) indicated receiving antibiotic therapy ($P > .999$). Surprisingly, section hikers were less likely to seek medical treatment than through hikers (50% vs 94%, $P = .046$). Nine percent of all hikers (37 of 379) received oral antibiotics either for the rash or for suspected Lyme disease. Recall of an embedded tick was greater for section hikers (67% vs 38%) but failed to attain significance ($P = .348$).

Discussion

The ability of the average hiker to identify the rash of EM has never been previously studied. We found that 54% of all hikers were able to identify EM, a surprisingly low percentage. Rash misinterpretation is likely frequent (Figure 5). "Fred," a current hiker subject was unaware his rash was EM (personal communication to G.A.B., June 2012). Misidentification for arthropod inoculation or tinea corporis is likely, as in this instance.

Occult tick attachment and areas of difficult inspection such as the back, scalp, and buttocks should be recognized by the hiker, and the discipline of daily self-inspection and partner inspection as routine practice is important. The duration of tick attachment relates to the likelihood of disease transmission, which is more likely if the tick is attached longer than 72 hours.⁷ Other methods of inspection may include a mirror or the novel use of cell phone photography (personal communication, "Kingcrawler" to J.M.K, May 2012).

In regard to a hiker's ability to identify *I scapularis*, the use of the tick identification card⁸ is a handy carry-along resource. (As a part of the education piece of this study, we provided interested hikers with the card and a brief review of the images on it.) With respect to recall of an imbedded tick, we found that of subjects who did have the rash while hiking, less than half, 47% of former hikers (8 of 13) and 40% of current hikers (2 of 5) recalled an imbedded tick, similar to other studies. We did not directly explore the method of tick removal or timing of antibiotic administration, but the literature supports appropriate tick removal as soon as possible with the administration of a single 200 mg dose of doxycycline, if the tick is *I scapularis*. Nadelman et al⁹ determined that timely administration of a single dose of doxycycline 200 mg had an efficacy of 87% after a recognized bite from *I scapularis*.

For unclear reasons, we found that section hikers are much less likely to seek treatment than through hikers. Perhaps section hikers wait for rash resolution on its

Table 1. Hikers ability to identify the erythema migrans rash by visual stimulus. Rash identification, all hikers surveyed.

Hiking Status			
Former (184)	54.3 (20, 89)	59% (109)	10% (18)
Current (195)	35.5 (18, 71)	50% (97)	3% (5)
Area Travelled			
Thru (282)	42.2 (18, 89)*	55% (156)	6% (17)
Section (95)	50.8 (20, 79)	52% (49)	6% (6)
Unknown (2)	73.5 (70, 77)	50% (1)	0% (0)
All Hikers (379)	44.5 (18, 89)	54% (206)	6% (23)

* Based upon 275 responses.

Table 2. The percentage of hikers that reported a rash while on the Appalachian trail.

<i>Hiker Classification (N)</i>	<i>Percent that sought medical treatment (N)</i>	<i>Percent treated with antibiotics (N)</i>	<i>Percent that recalled an embedded tick (N)</i>
Hiking Status			
Former (17)	82% (13)	82% (13)	47% (8)
Current (5)	80% (4)	80% (4)	40% (2)
Area Traveled			
Thru (16)*	94% (15)	94% (15)	38% (6)
Section (6)	50% (3)	50% (3)	67% (4)

* Data for one hiker missing.

own, knowing that their time on the trail is limited; perhaps through hikers are focused on trail completion success and are therefore vigilant for any illness that may prevent it. We can only speculate, but in either case, long-distance hikers' access to medical treatment is challenging, especially if ill. Boulware et al¹⁰ in 2003 studied reasons for AT hikers to leave the trail and found that 4% of the hikers (11 of 280) reported physician-diagnosed Lyme disease, a bit less than our finding of 6%. For medical professionals, the Infectious Disease Society Guidelines for Lyme Disease indicate that "clinical findings are sufficient for the diagnosis of erythema migrans,"⁴ and surveillance diagnosis by Centers for Disease Control and Prevention definition

requires exposure to ticks in an endemic area and an EM lesion, diagnosed by a physician, larger than 5 cm, as part of the National Notifiable Diseases Surveillance System.¹¹ Treatment for EM or primary Lyme syndrome requires the administration of doxycycline 100 mg twice daily, or for nonpregnant adults, amoxicillin 500 mg three times a day, or cefuroxime 500 mg twice daily for children or pregnant women. Duration of treatment is 10 to 28 days.^{4,11} In this respect, a sealed pack of antibiotics "to go" is an interesting idea and could be administered if, for example, a hiker is able to transmit an image of the rash to a healthcare provider or if symptoms are strongly suggestive of Lyme disease. Rational treatment should be directed by a healthcare provider if possible.¹²

Figure 4. Visual stimulus photographic collage distributed to the participants during the data gathering portion of the study, in order to determine if the subject was able to identify the erythema migrans rash.

Figure 5. Photograph of a misidentified EM rash taken during data collection that the subject believed to be from toxicodendron species exposure (poison ivy, oak, sumac). This patient was provided with doxycycline antibiotic treatment but was lost to follow up.

While not specifically studied, we believe that the constitutional symptoms of Lyme disease may be misinterpreted by hikers. Although trail fatigue is common, a febrile illness should prompt the hiker to seek treatment as soon as possible.

STUDY LIMITATIONS

This study was limited by a number of factors, including a nonvalidated study design and self-reported medical history. The identification of EM was based on a hiker's ability to recognize it on the photographic stimulus from prior image exposure, experience, or education. The presentation of the rash in pictorial format creates an artificial contextual environment; however, medical education uses this type of simulation frequently and effectively. Subjects were selected at random from hiker gatherings at yearly events, so the study may self-select for healthy hikers, or for those who attend gatherings.

Conclusions

An AT hiker's ability to recognize the rash of EM by visual stimulus photographs is poor, with only 54% able to identify this surrogate marker for Lyme disease. We found that 6% of those surveyed had the rash, and that 9% of the hikers surveyed had received oral antibiotics for the treatment of Lyme disease, whether the rash was visualized or not. Of those who did see the rash, 35% visualized an embedded tick. Section hikers are less likely to seek treatment for EM than through hikers, for unclear reasons. Limited access and barriers to evaluation require novel diagnosis and treatment. Continued education of the hiking community by electronic media, printed material at seminars, large gatherings, hiker hostels, shelters, and outfitters is necessary to educate the average hiker in rash identification of erythema migrans. We also emphasize the need for self-inspection and the importance of early Lyme disease treatment.

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Supplementary data

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.wem.2013.09.009>.

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