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ARTICLE

Prevalence and Time Course of Acute Mountain Sickness in Older Children and Adolescents After Rapid Ascent to 3450 Meters

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What's Known on This Subject

Although AMS represents an important problem for adults traveling to high altitude, little is known about the prevalence and time course of this disease in older children and adolescents.

What This Study Adds

In this controlled study, we found that symptoms of AMS in older children and adolescents were relatively mild and resolved rapidly without treatment. We suggest that children planning to ascend rapidly to 3500 m may not need AMS prophylaxis.

ABSTRACT

OBJECTIVE. Acute mountain sickness is a frequent and debilitating complication of high-altitude exposure, but there is little information on the prevalence and time course of acute mountain sickness in children and adolescents after rapid ascent by mechanical transportation to 3500 m, an altitude at which major tourist destinations are located throughout the world.

METHODS. We performed serial assessments of acute mountain sickness (Lake Louise scores) in 48 healthy nonacclimatized children and adolescents (mean ± SD age: 13.7 ± 0.3 years; 20 girls and 28 boys), with no previous high-altitude experience, 6, 18, and 42 hours after arrival at the Jungfraujoch high-altitude research station (3450 m), which was reached through a 2.5-hour train ascent.

RESULTS. We found that the overall prevalence of acute mountain sickness during the first 3 days at high altitude was 37.5%. Rates were similar for the 2 genders and decreased progressively during the stay (25% at 6 hours, 21% at 18 hours, and 8% at 42 hours). None of the subjects needed to be evacuated to lower altitude. Five subjects needed symptomatic treatment and responded well.

CONCLUSION. After rapid ascent to high altitude, the prevalence of acute mountain sickness in children and adolescents was relatively low; the clinical manifestations were benign and resolved rapidly. These findings suggest that, for the majority of healthy nonacclimatized children and adolescents, travel to 3500 m is safe and pharmacologic prophylaxis for acute mountain sickness is not needed. *Pediatrics* 2009;123:1–5

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Key Words
acute mountain sickness, altitude, adolescents, prevalence

Abbreviation
AMS—acute mountain sickness

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FACILITATED BY MODERN transportation systems, travel to high-altitude destinations has become increasingly popular. Therefore, large numbers of persons, including increasing numbers of children and adolescents, are being exposed to high altitude-related medical risks. Among the altitude-related medical problems, acute mountain sickness (AMS) is by far the most common. Its main symptoms are headache, anorexia and nausea, fatigue, dizziness, and sleep disturbance. It affects otherwise-healthy persons of all ages who ascend to altitudes of >2500 m. The rate of ascent, the absolute altitude reached, individual susceptibility, and previous acclimatization are important determinants of the incidence and severity of AMS.[1] The importance of the first 2 factors is illustrated by the observation that, after rapid ascent by plane from 1300 m to a tourist destination located at 3740 m, 84% of an adult population was reported to suffer from AMS.[2] More recently, age also has been proposed as a risk factor.[3] It has been suggested that the incidence and severity of AMS may be inversely related to climbers' age; brain swelling may be better tolerated by elderly individuals because of the smaller brain/cranial vault volume ratio.[4,5] There are few clinical data to substantiate this speculation,[6] however, and there is no information from a controlled study on the prevalence and time course of AMS in adolescents after rapid ascent by mechanical transportation to altitudes of ~3500 m, at which major tourist destinations are located throughout the world. Therefore, we performed serial assessments of AMS in 48 healthy nonacclimatized children and adolescents with no previous high-altitude experience who rapidly ascended from 568 m to 3450 m by train and then spent 48 hours at that altitude.

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METHODS

Study Group

Our study group consisted of 48 healthy Swiss children and adolescents (age: mean ± SD: 13.7 ± 0.3 years; range: 10–17 years; 20 girls and 28 boys). All except 2 (who lived at 1100 m) were living at altitudes of <800 m. None of the participants had slept at altitudes of >1500 m in the 2 months preceding the study, none had ever spent a night at altitudes of >2000 m, and none was taking any medication at the time of the study. The experimental protocol was approved by the institutional review board on human investigation of the Centre Hospitalier Universitaire Vaudois. All parents provided written informed consent.

The participants ascended to the high-altitude research station with a 2.5-hour train ride that took them from 568 m to an altitude of 3450 m. They then spent 2 days and 2 nights at the laboratory. All participants received the same diet, and care was taken to ensure adequate fluid intake. On the day of arrival, the participants rested quietly and visited the research station and the adjacent installations. In the afternoon of the second day, all participants made an easy 2- to 2.5-hour walk to the Mönchsjoch hut located at 3650 m. On the morning before descent, the subjects had no particular physical activity. The presence of AMS was evaluated 6, 18, and 42 hours after arrival at the high-altitude research laboratory.

Symptoms of AMS

On the evening of the day of arrival and on the 2 following mornings, symptoms of AMS were assessed with a French version of the Lake Louise self-assessment questionnaire,[7] under the supervision of a trained examiner. Briefly, for each of the 5 items (headache, gastrointestinal symptoms, fatigue, dizziness, and sleep disturbance), the participants noted a score between 0 and 3, with 0 indicating the absence of the symptom, 1, mild symptoms, 2, moderate symptoms, and 3, severe incapacitating symptoms. For children <12 years of age, a verbally adapted version of the score was used (Lake Louise age-adjusted symptom score). Clinical symptoms (change in mental status, ataxia, and the presence of edema) were assessed by one of us (Dr Bloch) immediately after completion of the questionnaire. Participants were considered suffering from AMS if they were experiencing headache and scored ≥3 on the self-assessment questionnaire (the maximal score for the questionnaire being 15).

Statistical Analyses

Statistical analyses were performed by using the paired, 1-tailed, Student's *t* test and the McNemar test. Data are expressed as mean ± SD. A *P* value of <.05 was considered to indicate statistical significance.

RESULTS

All subjects completed the daily questionnaires (Table 1). Figure 1 shows that the majority of cases of AMS (66%) developed during the first few hours at high altitude. On the evening of the day of arrival, 12 (25%) of the 48 subjects suffered from headache and had symptom scores of ≥3 (range: 3–7). Over the subsequent 36 hours at high altitude, the prevalence of AMS decreased progressively and significantly ($P < .05$). On the morning of day 2, AMS had resolved for 7 of the 12 participants who suffered from AMS on the evening of the first day, it persisted for 5 of those participants, and it developed in 5 new subjects; therefore, 10 (21%) of the 48 subjects met the criteria for AMS (range of scores: 3–7). On the morning of day 3, AMS had disappeared for all except 3 subjects, and it developed in 1 new subject; therefore, only 4 subjects (8%) still had symptoms of AMS (range of scores: 3–5). The overall prevalence of AMS was 37.5%, and rates were similar for boys and girls; 7 (35%) of the 20 girls and 11 (39%) of the 28 boys had an AMS score of ≥3 on ≥1 occasion. Independent of whether AMS was present, fatigue (day 1) and fatigue together with sleep disturbances (days 2 and 3) were the leading complaints of the participants.

Among the subjects who suffered from AMS, the disease was relatively mild; the mean scores were 4.0 ± 1.2 on day 1, 5.0 ± 1.5 on day 2, and 3.7 ± 1.0 on day 3. Only 1 of the 48 subjects scored 3 (severe incapacitating symptoms) on 1 of the items of the questionnaire. Finally, 5 subjects suffering from AMS were given a single dose of paracetamol for headache. The symptoms responded well to this symptomatic treatment. In the clinical assessment part of the Lake Louise scoring system, the signs also were mild and decreased significantly during the stay; the mean score was 0.3 ± 0.6 (range: 0–2) on day 1, 0.1 ± 0.4 (range: 0–1) on day 2, and 0.1 ± 0.4 (range: 0–1) on day 3 ($P < .05$, day 1 versus day 3).

DISCUSSION

With steadily increasing numbers of children and adolescents arriving by modern transportation systems at tourist destinations located at altitudes comparable to the one used in our study, it becomes important to have reliable data on the prevalence, incidence, and time course of AMS in this age group. Here we show that, in healthy nonacclimatized children and adolescents who were brought rapidly to 3450 m, the overall prevalence of AMS during the first 3 days at this altitude was 37.5%. Moreover, the prevalence decreased at each measurement, the symptoms were relatively mild, and the majority of cases resolved without treatment. These data indicate that, for children and adolescents with no previous high-altitude experience, the clinical manifestations of AMS are benign and the time course is brief.

Two thirds of the cases of AMS developed during the first few hours at high altitude. The prevalence of AMS was maximal on the evening of the day of arrival and then decreased progressively during the next 2 days at high altitude. Among those who were sick, the Lake Louise scores represented mild illness and the symptoms responded well to symptomatic treatment. None of the subjects needed to be evacuated to a lower altitude or experienced progression of AMS to high-

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TABLE 1 **Individual Lake Louise Scores**

Subject No.	Gender	Age, y	Lake Louise Scores																						
			Day 1								Day 2								Day 3						
			Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS	Drugs	Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS	Drugs	Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS
1	F	16.9	1	0	1	0	0	2			1	0	1	0	1	3	X		0	0	2	0	0	2	
2	F	10.9	0	0	2	0	0	2			1	1	2	0	2	6	X		1	1	2	0	0	4	X
3	F	13.0	0	0	1	0	0	1			0	0	1	0	1	2			0	1	0	0	0	1	
4	F	11.0	2	1	1	1	0	5	X		1	2	2	2	0	7	X		1	1	1	0	0	3	X
5	F	13.9	1	0	1	0	0	2			1	1	0	0	0	2			0	0	0	0	0	0	
6	F	12.9	0	0	1	0	0	1			0	0	0	0	2	2			0	0	0	0	0	0	
7	F	13.9	0	0	1	0	0	1			0	1	1	0	1	3			0	1	1	0	1	3	
8	F	14.4	0	0	1	0	0	1			0	0	0	1	1	2			0	0	1	0	0	1	
9	F	13.3	0	0	0	0	0	0			1	1	0	0	0	2			0	1	0	0	0	1	
10	F	10.8	0	0	0	0	0	0			0	0	0	0	1	1			0	0	1	0	1	2	
11	F	14.3	0	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	
12	F	11.8	0	0	0	0	0	0			0	0	0	0	1	1			1	0	0	0	2	3	X
13	F	11.5	2	0	1	2	0	5	X		0	0	1	0	1	2			0	0	0	0	0	0	
14	F	11.8	0	0	2	1	0	3			0	1	2	0	2	5			0	0	0	0	1	1	
15	F	13.0	2	0	2	0	0	4	X		1	1	1	0	2	5	X		0	0	0	0	0	0	
16	F	12.2	1	0	2	0	0	3	X	P	1	1	2	0	2	6	X		0	0	1	0	0	1	
17	F	13.7	0	0	1	0	0	1			0	1	1	0	2	4			0	1	0	0	1	2	
18	F	13.8	1	0	1	0	0	2			0	0	1	0	1	2			0	0	0	0	0	0	
19	F	14.4	0	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	
20	F	14.6	0	1	2	0	0	3			0	0	0	0	2	2			0	0	0	0	0	0	
21	M	13.2	0	1	2	0	0	3			0	0	1	0	0	1			0	0	0	0	0	0	
22	M	14.9	0	0	2	0	0	2			0	0	0	0	1	1			0	0	0	0	1	1	
23	M	12.3	2	3	2	0	0	7	X		0	1	0	0	0	1			0	0	0	0	0	0	
24	M	11.8	1	0	1	0	0	2			1	0	0	0	0	1			0	0	0	0	0	0	
25	M	12.2	0	0	1	0	0	1			1	0	0	0	0	1			0	0	0	0	0	0	
26	M	15.9	0	0	1	0	0	1			0	0	0	0	0	0			0	0	0	0	0	0	
27	M	13.1	1	0	1	0	0	2			0	0	0	0	0	0			0	0	0	0	0	0	
28	M	15.6	0	0	1	0	0	1			0	0	0	1	1	2			0	0	0	0	0	0	
29	M	17.7	1	0	2	0	0	3	X		2	0	2	0	2	6	X	P	0	0	0	0	1	1	
30	M	16.7	0	0	1	1	0	2			1	0	1	0	1	3	X	PP	0	0	1	0	0	1	
31	M	15.4	0	0	0	0	0	0			0	2	2	2	1	7			0	0	1	0	1	2	
32	M	15.2	0	0	1	0	0	1			0	0	1	1	1	3			0	0	0	0	1	1	
33	M	12.7	1	1	1	0	0	3	X		0	1	0	1	0	2			0	1	0	0	0	1	
34	M	12.7	0	2	2	0	0	4			0	1	0	0	0	1			0	0	0	0	1	1	
35	M	12.8	2	0	1	0	0	3	X		0	0	0	0	0	0			0	0	1	0	0	1	
36	M	15.2	0	0	1	0	0	1			0	0	1	0	1	2			0	0	1	0	1	2	
37	M	15.1	2	1	1	0	0	4	X		2	0	1	0	2	5	X	PP	1	0	2	0	2	5	X
38	M	12.0	0	0	1	0	0	1			1	1	1	0	0	3	X		0	0	0	0	0	0	
39	M	13.7	1	0	1	1	0	3	X		0	1	1	0	1	3			0	0	1	0	1	2	
40	M	11.8	1	0	0	0		1			1	2	0	1	0	4	X		0	0	0	0	0	0	
41	M	14.0	0	0	1	0	0	1			0	0	0	0	0	0			0	0	0	0	1	1	

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TABLE 1 **Continued**

Subject No.	Gender	Age, y	Lake Louise Scores																					
			Day 1								Day 2								Day 3					
			Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS	Drugs	Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS	Drugs	Headache	GI	Fatigue	Dizzy	Sleep	Total	AMS
42	M	13.0	1	1	2	0	0	4	X		0	0	1	0	0	1			0	0	1	0	0	1	
43	M	14.2	0	1	1	0	0	1			0	0	0	0	0	0			0	0	0	0	0	0	
44	M	14.4	0	0	1	0	0	1			0	1	2	0	0	3			0	0	1	0	1	2	
45	M	12.4	0	0	0	0	0	0			0	0	0	0	0	0			0	0	1	0	0	1	
46	M	12.2	1	0	1	0	0	2			0	2	1	0	0	3			0	0	0	0	0	0	
47	M	16.7	0	1	1	1	0	3			0	0	0	0	0	0			0	0	0	0	0	0	
48	M	11.9	1	1	1	1	0	4	X	P	0	0	0	0	0	0			0	0	0	0	0	0	

GI indicates gastrointestinal symptoms; sleep, difficulty sleeping; *P*, received 500 mg of paracetamol; PP, received 1000 mg of paracetamol. The numbers of subjects with symptoms were as follows: day 1: headache, 19; gastrointestinal symptoms, 11; fatigue, 40; dizziness, 7; difficulty sleeping, 0; day 2: headache, 14; gastrointestinal symptoms, 18; fatigue, 23; dizziness, 7; difficulty sleeping, 24; day 3: headache, 4; gastrointestinal symptoms, 7; fatigue, 16; dizziness, 0; difficulty sleeping, 15.

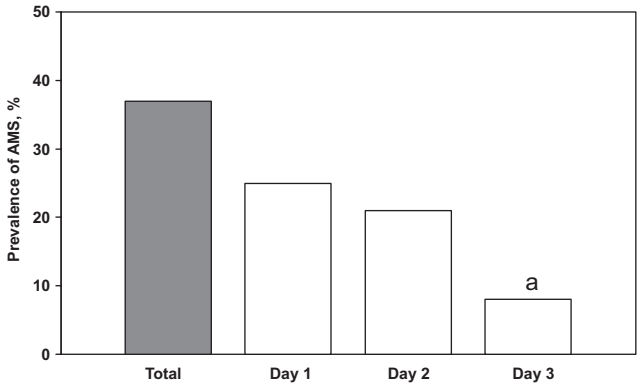

FIGURE 1
Total and day-to-day prevalence of AMS after rapid ascent by train to 3450 m among 48 healthy nonacclimatized children. AMS was assessed 6 hours after arrival (day 1) and on the morning of the next 2 days. [a] $P < .05$, day 1 versus day 3.

altitude cerebral edema, the most dangerous complication of AMS. None of the subjects developed high-altitude pulmonary edema. The trend for higher AMS scores on day 2 than on day 1 was related to the fact that, on day 2, insomnia contributed to the symptom scores; this symptom did not come into account on day 1 because the subjects had spent the night at home. Insomnia was related to altitude rather than sleeping in a dormitory setting, because the subjects slept in small bedrooms. Consistent with the rather low scores on the self-assessment questionnaire, the scores for the clinical assessment part of the Lake Louise scoring system also were low. This finding suggests that, for adolescents suffering from mild to moderate AMS, clinical evaluation does not seem to provide important additional information.

The prevalence of AMS among adolescents in the present study, although still representing a significant burden of disease, was considerably lower than the rate (84%) reported for an adult population after arrival by airborne transportation at an altitude that was comparable to the one in the present study.[2] The rate was similar to that reported for an adult population studied at much lower altitude.[8] This finding might suggest that young age does not represent a risk factor for AMS. The prevalence of AMS did not differ between female and male participants, which suggests that gender does not play a role for adolescents. As in adults, physical effort may represent a risk factor for AMS in children and adolescents. One of the strengths of the present study was that physical effort was highly standardized, with only mild physical effort on the day of arrival and moderate effort on the second day. This amount of physical effort may be quite comparable to that of children and adolescents arriving at high-altitude tourist destinations after rapid ascent with mechanical transportation. Therefore, the data on the prevalence, clinical manifestations, and time course of AMS in our controlled study probably also apply to this type of pediatric population.

For adults planning rapid ascent to high altitudes, current guidelines propose prophylaxis for AMS with

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drugs that may have significant adverse effects.[1] On the basis of the present findings, we suggest that, for children and adolescents with no history of moderate/severe AMS who plan to ascend rapidly to the study altitude, pharmacologic prophylaxis for AMS may not be needed and the use of pharmacologic agents should be restricted to the treatment of symptoms (mainly headache) if they appear.

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"Reports of serious adverse events and deaths in young girls and women following administration with Merck & Co.s Gardasil are likely not related to the cervical-cancer vaccine, federal health officials said Wednesday. A study looked at 375 000 doses of the vaccine from August 20, 2006, to July 20, 2008, in girls and women ages 9 to 26. 'Based on all of the information we have today, CDC and FDA have determined that the HPV vaccine is safe to use and effective in preventing 4 types of HPV,' the CDC said."

Dooren JC. *Wall Street Journal*. October 23, 2008

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