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Self-Assessment of Acute Mountain Sickness in Adolescents: A Pilot Study

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Objective.—To perform a pilot study exploring the prevalence of acute mountain sickness (AMS) in adolescents on ascent to altitude and evaluating whether this age group is capable of self-assessment of AMS using the Lake Louise scoring system.

Methods.—Twelve teenagers aged 15 to 18 years old (5 girls) traveled for 21 days between 2400 and 5500 m. Each member of the expedition completed a Lake Louise self-assessment questionnaire on a daily basis. Group leaders (nonmedical) were informed about any subject with a score of 3 or more. Appropriate treatments were then initiated. Detailed analysis of data was undertaken on return to the UK.

Results.—There was 100% completion of 252 questionnaires. Eleven of the 12 subjects (91.7%) had symptom scores greater than or equal to 3, consistent with a diagnosis of AMS, on at least one day (range, 0–8). Symptoms of AMS were more common in the female group members ($P = .041$).

Conclusions.—AMS seems to be a common problem among adolescents. There are increasing numbers of adolescents traveling to high altitudes, and there seems to be a lack of information about the prevalence of AMS in this age group. Motivated adolescents seemed capable of self-monitoring for AMS using the Lake Louise questionnaire. Combined with an appropriate ascent profile and support, we feel this approach may contribute to safety in the mountains and merits further study.

Key words: adolescents, acute mountain sickness

Introduction

Increasing numbers of adolescents are traveling to high altitudes on school expeditions, school adventure holidays, and during gap years. There is little information about the prevalence, severity, and disease course of acute mountain sickness (AMS) in this age group.

A common clinical problem, AMS affects otherwise fit individuals of all ages who ascend to high altitudes. All travelers to altitudes over 2500 m (8000 feet) are potentially susceptible to AMS.[1,2] Symptoms include headache, lethargy, shortness of breath, sleep disturbance, loss of appetite, and nausea and vomiting, and they usually appear within the first 3 days of being in a high altitude.[3,4] In the Himalayas, the prevalence of AMS has been reported to vary from 43% to 63%[3] and from 9% to 69% in the Alps.[5] The sickness severity depends upon a number of factors, including rate of ascent, the altitude achieved, recent previous acclimatization, and the susceptibility of the individual to the syndrome.

Severe symptoms from AMS in both children and adolescents have been reported.[6] Compared with the amount of literature concerning adults, the prevalence and disease process of AMS in children and adolescents has not been studied as well.[7] Wu[8] studied 464 children (0–15 years old) traveling across the Tibetan plateau and found that 34% had AMS and 1.5% had high altitude pulmonary edema. The prevalence was very similar to

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Table 1. Daily Lake Louise acute mountain sickness (AMS) scores for the group ($n = 12$)

Day	*Altitude*	*Altutude gain*	*Headache*	*Dizziness*	*GIT**	*Sleep*	*Activity*	*AMS score (total)*
1	3250 m	+3250 m	7	7	2	3	4	23
2	3250 m	0 m	8	6	2	3	2	21
3	3500 m	+250 m	4	6	4	3	2	19
4	3500 m	0 m	8	3	5	1	2	19
5	3000 m	−500 m	1	0	1	1	0	3
6	4200 m	+1200 m	5	5	3	6	5	24
7	3900 m	−300 m	5	1	2	6	3	17
8	2400 m	−1500 m	3	1	1	3	3	11
9	3250 m	+850 m	2	1	4	3	3	13
10	3700 m	+450 m	4	0	4	1	3	12
11	4600 m	+900 m	7	7	7	2	7	30
12	4800 m	+200 m	6	4	5	7	9	31
13	5200 m	+400 m	7	8	6	5	6	32
14	4500 m	−700 m	2	3	6	2	2	15
15	5100 m	−600 m	4	3	6	2	7	22
16	4800 m	−300 m	4	2	1	2	6	15
17	5500 m	+700 m	6	3	3	1	5	16
18	4600 m	−900 m	0	0	0	1	0	1
19	3700 m	−900 m	0	0	0	1	0	1
20	3250 m	−450 m	0	1	0	0	0	1
21	3250 m	0 m	0	0	0	0	0	0

*GIT, gastrointestinal trace symptoms.

the 5355 adults he also studied.[8] However, children may be more susceptible to the syndrome because its prevalence seems to decrease with increasing age.[3,9] There is also evidence that although AMS among adolescents is less common than in children, it may be more common than in adults.[10] Pulmonary edema also seems to be more common among children ascending to high altitudes with a recent or active viral respiratory illness.[11] A death from high altitude pulmonary edema in a 15-year-old was reported,[12] but we suspect there may be other deaths or serious events that are currently not formally reported.

It was the purpose of this pilot study to explore the prevalence of AMS in adolescents at altitude and to assess the practicality of using the self-assessment Lake Louise questionnaire in this age group.

Methods

Twelve teenagers aged 15 to 18 years old (5 girls) traveled for 21 days between 2400 and 5500 m. The mean age of the subjects was 16.1 years. All members of the group were fit and healthy with no underlying medical conditions and normally resided at 100 to 200 m. None of the group had previous exposure to high altitude.

The group traveled by air from the UK, arriving in Cusco (3250 m) on day 1 and spent 4 days at 3000 to 3500 m acclimatizing. The group then trekked the Inca Trail to Machu Picchu (4 days) climbing to 4200 m. After a rest day in Cusco, the group trekked for 10 days around the peak of Ausengate. The group then ascended to a maximum height of 5500 m before returning to Cusco (Table 1).

SYMPTOMS AND SIGNS OF AMS

Every evening, each member of the expedition completed a Lake Louise self-assessment questionnaire.[13] This was collected and scored by a single investigator (C.H.K.). Group leaders (nonmedical) were informed about any person with a score of 3 or more. Treatment, descent, or both were then initiated. No prophylactic or therapeutic drug treatment for AMS was used during the expedition. Detailed analysis of data was undertaken on return to the UK.

STATISTICS

Statistical significance was assessed by unpaired *t*-tests, regression analysis, and Wilcoxon signed rank tests (StatView for Windows, Abacus Concepts Inc, Berkley, CA). P values $<.05$ were considered significant.

Table 2. Lake Louise active mountain sickness (AMS) scores by sex ($n = 12$)

	Headache	*Dizziness*	*GIT**	*Sleep*	*Activity*	*AMS score*
Male 1	10	4	3	0	2	19
Male 2	2	4	7	6	9	28
Male 3	3	5	0	0	0	8
Male 4	3	3	1	3	4	14
Male 5	0	0	0	0	0	0
Male 6	2	5	5	0	8	20
Male 7	11	8	6	4	3	32
Male total	31	29	22	13	26	121
Female 1	5	1	6	7	5	24
Female 2	9	3	6	5	11	34
Female 3	16	8	9	12	8	53
Female 4	8	9	14	8	6	45
Female 5	13	11	4	9	14	51
Female total	51	32	39	41	44	207

*GIT, gastrointestinal tract symptoms.

Results

All 12 subjects completed the daily questionnaires, as requested, over the 21-day expedition (252 questionnaires; 100% completion).

In this study, 11 of the 12 subjects had symptom scores greater than or equal to 3 on at least one day (after a recent increase in altitude and with an associated headache) consistent with a diagnosis of AMS (91.7%). The subjects had a score of 3 or more on 43 days of a possible 252 days (17.1%). However, onset, duration, and severity were variable (Table 1). During the trip, 3 of the subjects (all female) had to be carried by horse because of fatigue, and 1 of the subjects had to be taken down the mountain to a lower altitude because of AMS (Lake Louise symptom score of 7). The time course of AMS symptoms in this age group lasted 24 to 48 hours. The range of days when a subject had a score of 3 or more was 0 to 8. The AMS scores correlated with a recent gain in altitude (Table 1).

Table 3. Days with AMS score greater than or equal to 3 by sex ($n = 12$)

Male 1	2	Female 1	4
Male 2	3	Female 2	5
Male 3	1	Female 3	8
Male 4	2	Female 4	6
Male 5	0	Female 5	7
Male 6	2		
Male 7	3		
Male total	13	Female total	30

*AMS, acute mountian sickness.

AMS was more frequently reported in the female members of the group. Over the 21-day expedition, the 7 male subjects had scores of 3 or more on 13 days, whereas the 5 female subjects had a score of 3 or more on 43 days ($P = .041$). There was no difference in the incidence of headache ($P = .15$), dizziness ($P = .28$), or gastrointestinal symptoms ($P = .08$). The female subjects suffered more from poor sleep ($P = .043$) and a reduction in overall activities ($P = .043$) (Tables 2 and 3).

Discussion

With increasing numbers of adolescents traveling to high altitudes, more information about AMS in this age group is required. The largest published series to date that looks at morbidity in youth expeditions to developing countries has noted a huge increase in the numbers of adolescents undertaking adventurous travel.[14] In 1996, 945 young people traveled abroad with a major UK company; 4 years later, the number had increased to 2460.[14] The study was a retrospective review of the medical records of those that traveled in 1996. There was no specific assessment of AMS, but some information relating to the condition was available. Eighty-six percent of the individuals who traveled above 2500 m suffered from headaches, and this appeared more often in younger travelers. ?3

Although resident populations at high altitudes include adolescents, travel to high altitudes by lowland adolescent sojourners is often for the first time. They usually have little or no previous experience with such travel, so susceptibility to AMS is unknown. Supervision is usually by nonmedical group leaders. Objectives,

which may be entirely appropriate for most of the group, may not be suitable for those individuals more susceptible to AMS. There are also potential risks associated with group travel. Because the youth travelers are often below the age of consent, and their parents or guardians are usually not present at high altitudes with them (unlike with children), difficult decisions about drug prophylaxis or treatment must be made by the expedition organizers. Perhaps by increasing the awareness of AMS, both among the adolescents and the tour organizers, it may be possible to reduce such potential risks.[15]

In 2001, a Consensus Statement on behalf of the International Society of Mountain Medicine suggested that the prevalence of AMS in children was similar to that in adults.[6] Yaron et al[16] found no difference in the prevalence of AMS at a moderate altitude (3109 m) in preverbal children and adults. However, a recent publication looked at AMS in a small number of children, teenagers, and adults after an acute ascent by road to 3500 m, where one night was spent, and then a day trip to 4400 m.[10] The prevalence of AMS was 100% in the children ($n = 6$), 50% in the teenagers ($n = 10$), and 27% in the adults ($n = 15$). There is evidence that the prevalence of AMS seems to decrease with age. In a study of 615 subjects aged 8 to 51 years old ascending to the prospective shelters on Cotapaxi (4800 m) and Chimborazo (5000 m), the prevalence of AMS was more frequent in the 8- to 22-year-old group ($P < .01$).[17] In a large study of 558 children (aged 9–14 years old), the authors found AMS in 28% of them after ascent to 2835 m. However, it should be noted that 21% of the same group of children had symptoms traveling to a camp at sea level, suggesting the nonspecific nature of the symptoms. Girls tended to have more headaches, dizziness, shortness of breath, and insomnia.[18]

The Lake Louise acute mountain sickness scoring system was a consensus agreement that was introduced as a research tool in 1991 in an attempt to standardize assessment of AMS.[13] Given the nonspecific nature of the symptoms, signs, and laboratory findings, there is no gold standard for the diagnosis of AMS. In particular, whereas the questionnaire is a relatively sensitive tool, specificity can be variable, and false positives can be problematic.

This is the first report of self-assessment of AMS in adolescents. Despite no previous experience of either travel to altitude or the scoring system, the subjects found the scoring system to be quick and easy to learn, use, and interpret. They were able to determine from their assessment what members in their group had AMS, and they were then able to alert their group leaders so appropriate action could be taken. The AMS prevalence of 91.7% is higher than previously described in adults.[3,5] This may be caused by the small sample size or the particular ascent profile used in this study, or this percentage may represent a true higher prevalence of AMS in this age group.

Lake Louise AMS scores increased with recent significant ascent in altitude (Table 1). There is also evidence that after a period at altitude, subjects did acclimatize satisfactorily. From day 13 to day 18, there was a decrease in the Lake Louise scores, although the subjects continued to ascend, reaching the summit at 5500 m. As the group became more acclimatized, symptom scores reduced. This confirms observations published elsewhere.[19] Although none of the subjects was very ill with AMS, this condition remains a potentially serious condition.[20]

In this study, AMS was found to be more common in the female group members (Table 2). This observation could have several explanations. First, this could be true to form, and female adolescents may have a higher susceptibility to AMS. Girls in this age group may be more truthful in the reporting of mild or minor symptoms than boys. Alternatively, girls in this age group may have a higher background incidence of many of the symptoms, such as headaches. Fitness might affect the perception of the reduction in normal activities. No attempt to correlate AMS scores with menstrual cycle was made. There is evidence of a difference between sexes in the reporting of musculoskeletal injuries. Female marine corps recruits were 1.72 times more likely to report them than male recruits (95% CI, 1.29–2.30).[21]

Further information comparing the prevalence and severity of AMS in both adults and adolescents on similar ascent profiles is currently being sought. If the prevalence between the two age groups is similar, then we can be reassured that adequate attention is paid to graduated ascent in adolescents and that there is awareness of the disease so travel at high altitudes remains reasonably safe. However, if the adolescents have an increased prevalence or severity of AMS compared with the adults, then the safety of using adult ascent profiles in adolescents needs to be seriously questioned.

Adult studies demonstrate a variable susceptibility to AMS, and it seems likely that this is the case among adolescents. A blanket approach to the prevention of AMS in adults is not widely accepted, so understandably there are concerns about a similar approach among teenagers and those organizing their expeditions.

Conclusion

This study demonstrates that a motivated group of adolescents is capable of self-monitoring for AMS using the adult Lake Louise questionnaire. The Lake Louise

scoring system should be used to complement rather than replace standard techniques (such as alert leaders enquiring after students who appear unwell, who fail to come to meals, or who are late into camp). The scoring system is no substitute for common sense and experience; however, its simplicity, the involvement of the adolescent in self-assessment, and the increased level of awareness of the condition in both the individual and the group are likely to improve safety. Combined with an appropriate ascent profile and experienced support, we feel this approach may contribute to safer travel in the mountains and merits further study.

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