How can acute mountain sickness be quantified at moderate altitude?

G Roeggla MD M Roeggla MD A Podolsky MD[1] A Wagner MD A N Laggner MD

J R Soc Med 1996;**89**:141–143

Keywords: *AMS; oxygen saturation; Hackett*

Reports of acute mountain sickness (AMS) at moderate altitude show a wide variability, possibly because of different investigation methods. The aim of our study was to investigate the impact of investigation methods on AMS incidence. Hackett's established AMS score (a structured interview and physical examination), the new Lake Louise AMS score (a self-reported questionnaire) and oxygen saturation were determined in 99 alpinists after ascent to 2.94 km altitude. AMS incidence was 8% in Hackett's AMS score and 25% in the Lake Louise AMS score. Oxygen saturation correlated inversely with Hackett's AMS score with no significant correlation with the Lake Louise AMS score. At moderate altitude, the new Lake Louise AMS score overestimates AMS incidence considerably. Hackett's AMS score remains the gold standard for evaluating AMS incidence.

INTRODUCTION

Lowland dwellers who rapidly ascend to high altitude may develop one or more unpleasant symptoms such as headache, anorexia, and insomnia. If several of these symptoms, which may progressively include vomiting, shortness of breath, severe headache, and ataxia, are present, the syndrome is defined as acute mountain sickness (AMS). Physical examination of these patients may disclose tachypnoea, pulmonary rales, and periorbital as well as peripheral oedema.

The incidence of AMS was first reported in 1976; Hackett and colleagues found 53% of 278 unacclimatized hikers to suffer from AMS at 4.173 km altitude in the Himalayas of Nepal[1]. Various studies found similar results at high altitude. The situation at moderate altitude is not yet clear. Two European studies based on Hackett's established AMS-score (a scoring system consisting of a structured interview and physical examination by an experienced investigator) report an AMS incidence of 3.1% at 1.98 km to 9% at 2.82 km[2,3], whereas an American study based on the new Lake Louise consensus document on definition and quantification of AMS, which determines the incidence of AMS on a self-reported questionnaire[4], reports an AMS incidence of 25% at 1.89–2.91 km[5]. This variability could be related to the different investigation instruments used[6]. The aim of our study was to investigate the impact of the different investigation methods on the reported incidence of AMS.

METHOD

The study was performed at 2.94 km altitude in the Hohe Tauern in the Austrian Alps as a randomized, prospective, cross-over trial. All tourists who had reached the summits without aid of a cable car on the investigation days were asked to participate. After 20 min rest, the alpinists were randomized to the Lake Louise AMS-questionnaire or Hackett's AMS evaluating system. Arterial oxygen saturation (S_aO_2) was measured by pulse oximetry (μ-Ox Pulsoximeter, MCC, Karlsruhe, Germany). Immediately afterwards, subjects crossed to the other study branch and the other evaluating system was performed. In the Lake Louise-AMS-questionnaire loss of appetite, vomiting, shortness of breath, dizziness or light-headedness, unusual fatigue and headache were recorded. Each symptom was counted as one point, a score of three or more being defined as AMS. Hackett's AMS-evaluating system consists of a short structured interview and physical examination. Each tourist was asked about headaches (light = one score point; severe = two score points), nausea (one point), vomiting (two points), dizziness (one point). Physical examination put emphasis on periorbital or peripheral oedema (one site = one point, more than one site = two points), respiratory rate (more than 25 breaths/min = one point), pulmonary rales (slight = one point, severe = two points) and ataxia (Romberg-test, finger nose test, two points). Presence of AMS signs was always checked by a second examiner. Severity of the altitude adaptation disorder was quantified by adding up the score points. Subjects without any sign and

Department of Emergency Medicine, University of Vienna, [1]Department of Sports Medicine, University Clinic of Internal Medicine IV, University of Vienna, Waehringer Guertel 18-20, A-1090 Vienna, Austria

Correspondence to: G Roeggla MD

symptom of AMS were considered healthy, those with one or two score points were considered to be moderately affected, and those with three or more score points were regarded as suffering from AMS. Not all the alpinists had slept at altitude, so sleep disturbance was not recorded in either test. Age, gender, medical history, individual history of AMS, smoker or non-smoker, altitude of home residence and number of alpine tours per year were noted.

Statistical methods

Spearman rank correlation and Mann–Whitney-rank-sum-test. $P<0.05$ was considered significant.

RESULTS

Ninety-nine alpinists volunteered to participate: 70 men and 29 women (age range 18–66, mean age 35.4 ± 13.8; 23 smokers; no subject had a medical or AMS-history; no subject took any medication; subjects had made 9.0 ± 3.4 alpine tours per year; all subjects had a home residence below 0.9 km altitude); and they were examined in similar weather conditions between 1100 h and 1300 h. Hackett's AMS scores and Lake Louise AMS scores correlated significantly ($n = 99$, $r = 0.846$, $P<0.01$), but Hackett's AMS scores were significantly lower ($P<0.01$), AMS-incidence with Hackett's score was lower and the number of unaffected alpinists higher than with the Lake Louise-AMS questionnaire (Table 1). The most common AMS-signs and symptoms in the Hackett AMS-score were dizziness followed by tachypnoea and headache; the most common AMS symptoms in the Lake Louise-AMS questionnaire were fatigue followed by dizziness and shortness of breath (Tables 2 and 3). Results within the respective AMS scores did not differ according to the order of the evaluating instruments. Arterial oxygen saturation in subjects with an AMS score $\geqslant 1$ correlated inversely with Hackett's AMS score ($n = 27$, $r = -0.478$, $P<0.05$) with no significant correlation to the Lake Louis AMS score ($n = 49$, $r = -0.148$, $P =$ NS). Oxygen saturation of all mountaineers is listed in Table 4. Smoking habit, age, gender and number of alpine tours per year did not differ in alpinists with and without signs and symptoms of AMS.

Table 1 **Distribution of acute mountain sickness (AMS)-score and mean AMS-score in 99 alpinists at 2.94 km altitude. Figures are numbers of alpinists**

	Hackett score	*Lake Louise score*
0	72	50
1–2	19	25
$\geqslant 3$	8	24
Mean score	0.54	1.10
SD	0.99	1.30

Table 2 **Lake Louise consensus on definition and quantification of acute mountain sickness (AMS) questionnaire of 99 alpinists at 2.94 km altitude. Figures are number of alpinists**

AMS-symptom	*No*	*Yes*
Loss of appetite	87	12
Vomiting	98	1
Shortness of breath	78	21
Dizziness	76	23
Unusual fatigue	54	45
Headache	90	9

Table 3 **Hackett's acute mountain sickness (AMS) score of 99 alpinists at 3.94 km altitude. Figures are numbers of alpinists**

AMS sign/sympton	*No*	*Yes*
Headache slight	91	8
Headache severe	99	0
Nausea	94	5
Vomiting	98	1
Dizziness	89	10
Tachypnoea	90	9
Oedema one localization	93	6
Oedema >1 localization	99	0
Pulmonary rales slight	94	5
Pulmonary rales severe	99	0
Ataxa	96	3

Table 4 **Arterial oxygen saturation in the total alpinist population and in the subgroups with signs and symptoms of acute mountain sickness (AMS) at 2.94 km altitude**

	SaO_2% Range	*SaO_2% Mean ± SD*
Total alpinist population	82–97	94.3 ± 2.2
Hackett-AMS score 1–2	92–96	95.0 ± 1.1
Lake Louise-AMS score 1–2	92–97	95.0 ± 1.2
Hackett-AMS score $\geqslant 3$	82–90	88.4 ± 2.3
Lake Louise-AMS score $\geqslant 3$	82–96	93.0 ± 3.7

DISCUSSION

Scientific research in alpine medicine has dealt primarily with small groups of healthy athletic persons at above 4 km altitude, even though most mountain tours are at moderate altitude (i.e. 2–4 km) and most mountaineers are not trained

athletes. Lately more emphasis has been put on a general tourist population at moderate altitudes. For many years Hackett's AMS score was the only established method of evaluating altitude adaptation disorder. Leading experts on altitude medicine have recently inroduced a new self reporting system of evaluating AMS in the Lake Louise consensus document on definition and quantification of AMS. The aim of our study was to validate both methods by comparison.

In our study, AMS incidence by Hackett's AMS score was 8% at 2.94 km altitude. This corresponds very well to previous reports of AMS incidence at moderate altitude from the Swiss and Austrian Alps. AMS-incidence in the same alpinists in the same situation by the Lake Louise AMS score was 25%. A periodic effect (an effect of observation time on altitude adaptation) was ruled out by examining all subjects at stable conditions after 30 min rest and performing both AMS evaluating methods within 10 min, and, as the sequence of tests had no influence on the results, periodic effects as well as carry-over effects between both tests were unlikely. The main reason for the higher Lake Louise AMS-scores was the predominance of the symptom 'unusual fatigue', which is clearly difficult to differentiate from usual fatigue after many hours of strenuous ascent. The symptom dizziness was reported twice as often in the Lake Louise questionnaire. The high incidence of shortness of breath in the Lake Louise questionnaire did not correspond to an equivalent incidence of tachypnoea or pulmonary rales in Hackett's AMS score. Physicians are obviously more competent than alpinists by themselves in discriminating non-specific symptoms, which are mainly due to exhaustion, from directly AMS related signs and symptoms. Clinically, no alpinist suffered a severe form of AMS (i.e. high altitude pulmonary oedema or high altitude cerebral oedema). Lake Louise AMS score was $\geqslant 3$ in all alpinists with a Hackett AMS score of $\geqslant 3$. Oxygen saturation in patients with high altitude adaptation disorders is known to correlate inversely with AMS score[7]. This holds true for Hackett's AMS score in our study; no correlation with the Lake Louise AMS score was found.

The main finding of our study is that the new Lake Louise AMS score considerably overestimates the AMS incidence at moderate altitude. The importance of the new score is in our opinion in the easy self rating of possible high altitude adaptation disorders by alpinists. However, Hackett's AMS-score remains the gold standard for evaluating AMS incidence.

REFERENCES

1 Hackett PH, Rennie D, Levine HD. The incidence, importance and prophylaxis of acute mountain sickness. *Lancet* 1976;**ii**:1149–54

2 Roeggla G, Roeggla M, Hirschl MM, Wagner A, Laggner AN. The incidence of acute mountain sickness (AMS) in moderate altitude in the Austrian Alps. *Wien Klin Wschr* 1992;**104**(Suppl 194):7–10

3 Maggiorini M, Buehler B, Walter M, Oelz O. Prevalence of acute mountain sickness in the Swiss Alps. *BMJ* 1990;**301**:853–5

4 Lake Louise consensus on definition and quantification of altitude illness. In: Sutton JR, Coates G, Houston CS, eds. *Hypoxia: Mountain Medicine.* Burlington, Vermont: Queen City Press; 1992:327–30

5 Honigman B, Theiss MK, Koziol-McLaine J, Roach R, Yip R, Houston C. Acute mountain sickness in a general tourist population at moderate altitudes. *Ann Intern Med* 1993;**118**:587–92

6 Roeggla G, Roeggla M, Wagner A. Acute mountain sickness at moderate sickness at moderate altitudes. *Ann Internal Med* 1993;**119**:633

7 Baertsch P, Vock P, Maggiorini M. Respiratory symptoms, X-ray and physiological correlations at high altitude. In: Sutton J, Coates G, Remmers J, eds. *Hypoxia: the Adaptions.* Philadelphia: Decker, 1990:241–5

(Accepted 8 February 1995)