HOW FAST IS TOO FAST? ATTEMPTS TO DEFINE A RECOMMENDED ASCENT RATE TO PREVENT ACUTE MOUNTAIN SICKNESS

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Of the recognised risk factors for the development of acute mountain sickness (AMS), rate of ascent is one of the most important. Slow, graded ascent allows sufficient time for acclimatisation to occur and reduces the incidence and severity of AMS.

While few people would question the importance of ascent rate as a risk factor for AMS, only a small number of studies have compared different ascent schedules in the same setting. In Nepal, trekkers who walked from Kathmandu (1300 m) to Pheriche (4243 m) over 14-18 days had a lower incidence of AMS (31-42%) compared to those who flew to 2800 m and walked up over 4-6 days (49-60%) [1,2]. In the same region, 84% of guests who flew directly to Hotel Everest View (3860 m) from Kathmandu developed AMS, while the incidence was 61% among those who walked up from 2800 m over 3-4 days [3]. Remarkably similar results were recorded among Indian soldiers transported from sea-level to 3500 m [4]; 84% of subjects who had flown directly over one hour experienced symptoms of AMS, compared to 51% of those who travelled by road over 4 days.

While encouraging people to ascend in a slow, graded fashion forms the cornerstone of AMS prevention, the ideal ascent rate (if such a thing exists) remains uncertain. One recommendation is to ascend on average no more than 300 m per day between sleeping sites when above 3000 m, and to incorporate rest days (i.e. two nights at the same altitude) every two or three days (or every 1000 m) [5]. This rule of thumb has been widely quoted in both the medical literature and in travel guides, yet its efficacy has not been directly tested. Even its origin remains relatively obscure.

The recommendation appears to have arisen from the work of Peter Hackett and others on the Mount Everest trekking route in Nepal. Following their 1975 study [1], preventative measures were adopted to reduce the impact of AMS. These included increasing awareness of AMS by the dissemination of information, and advising trekkers to ascend slowly and spend to two consecutive nights at the same altitude twice during the ascent from 2800 m to 5400 m [6]. For a trekker following these guidelines along the Everest trail, this would usually mean spending consecutive nights in villages at altitudes of 2800 m, 3440 m, 3440 m, 3867 m, 4243 m, 4243 m, and 4930 m. A follow-up survey in 1977 showed that a greater proportion of trekkers were staying two nights at Pheriche (4243 m) than in 1975 and the incidence of AMS was less [6]. Furthermore, over the same time period, helicopter evacuations and deaths from altitude illness in the region had decreased. The recommendation has since been widely promoted by the Himalayan Rescue Association [7] and has been taken to heart by many trekking agencies in Nepal.

Should this recommendation be adopted as a guideline for all high altitude areas of

the world? While ascending approximately 300 m per day above 3000 m may be reasonable advice along the Mount Everest trekking route where villages are conveniently located, for many other areas of the world this is regarded as too conservative and impractical. Furthermore, given the marked individual variation in susceptibility to AMS, ideal ascent rates to prevent or minimise AMS are likely to vary from person to person making it difficult to provide a single blanket recommendation.

In an attempt to determine an ideal ascent rate at high altitude, and to test the 300 m per day recommendation, data from a previously published study were re-examined.

Subjects and Methods
As recorded in detail previously [8], symptoms of AMS were recorded daily in 302 trekkers in the Mount Everest region of Nepal between August 1991 and May 1993. Sleeping altitudes were also recorded, as well as the highest altitude reached. Nineteen of the subjects were excluded because they were taking acetazolamide as prophylaxis against AMS, leaving data from 283 subjects available for analysis.

The Lake Louise diagnostic criteria were used to define AMS; viz., in the setting of a recent gain in altitude, the presence of headache and at least one of the following symptoms: gastrointestinal (anorexia, nausea, vomiting), fatigue or weakness, dizziness or lightheadedness, difficulty sleeping [9]. The average ascent rate was calculated between 2800 m (at which altitude every trekker enters the region) and the highest sleeping altitude. When ascent to a high point was followed by a descent of more than two days and then reascent to a higher sleeping altitude, the ascent rate was calculated to the first high point. All trekkers spent at least one night at an altitude of about 2800 m before ascending further.

The t test was used to compare mean ascent rates and the chi-square test was used to compare incidences of AMS. Confidence Interval Analysis computer program [10] was used to calculate confidence intervals and relative risks.

Results
Of the 283 subjects, there were 148 males and 135 females, with a mean age of 31.5 years (range 15-65). Mean highest altitude reached was 5340 m (range 3900-6200 m), with a mean highest sleeping altitude of 4753 m (range 3900-5944 m). Overall, 160 (57%) of the subjects developed AMS.

Figure 1 shows the overall mean ascent rates of trekkers and the proportion developing AMS. The overall mean ascent rate for those who developed AMS was 333 m/day (SD 117; range 133-650), compared to 320 m/day (SD 119; range 79-650) for those who did not (95% CI for the difference = -14 to 41 m/day; $p = 0.36$). It is unclear from the records whether any trekkers reduced their ascent rate because they developed AMS, thus decreasing their overall ascent rate to the highest altitude reached. To allow for this possibility, mean ascent rates from 2800 m were calculated for each day of the trek. As shown in Figure 2, mean ascent rates for those who developed AMS for most days were higher than those who had not developed AMS at the same stage. For those who developed AMS, the mean ascent rate up to the time that symptoms of AMS started was 438 m/day (SD 166; range 133-1160).

Overall, 216 (76%) trekkers incorporated rest days into their itineraries. The incidence of AMS among these trekkers was 57%, compared to 55% for those who had no rest days (95% CI for the difference = -15 to 12%; p = 0.77). For those who trekked for at least 6 days above 2800 m, the incidence of AMS was 55% for those who followed the 300 m/day recommendation (including the 2 rest days) or ascended at a slower rate, compared to 61% for those who ascended faster than this recommendation (95% CI for the difference = -21 to 10%; p = 0.45).

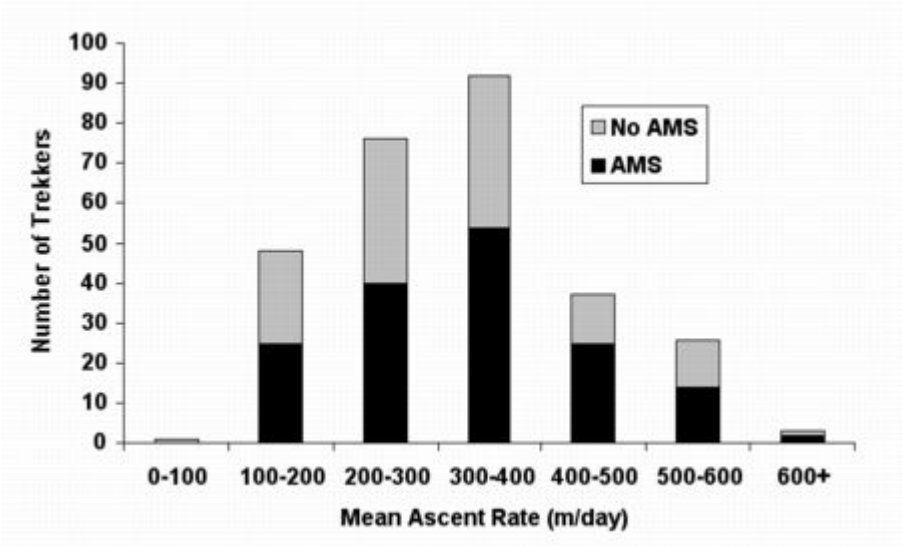
Twenty-eight (10%) of trekkers developed AMS on day 1 after ascending the unavoidable 640 m climb to the village of Namche. Figure 3 shows the incidence of AMS for the remaining trekkers ascending at 3 different mean ascent rates (<300 m/day, 300-400 m/day, >400 m/day) for days 3 to 6. On day 4, the relative risk of developing AMS if ascending at >400 m/day compared to ascending at <300 m/day was 4.0 (95% CI = 1.2 to 12.7). The corresponding relative risk on day 5 was 2.6 (95% CI = 1.1 to 6.2).

Discussion

One of the main findings from this study is to confirm that ascent rate is a risk factor for AMS, as has been shown in previously [1-4,11]. Trekkers who developed AMS were ascending faster than those who did not at the time they developed symptoms and AMS was particularly common for those ascending at greater than 400 m/day. After 4 days ascent above 2800 m, trekkers with a mean ascent rate of greater than 400 m/day had 4 times the risk of developing AMS compared to those ascending less than 300 m/day.

One major shortcoming of this study is the relative lack of trekkers ascending at rates greater than 500 m/day, especially those ascending greater than 600 m/day. It would be useful to calculate relative risks for the development of AMS in this group compared to slower ascent rates. All that can be concluded from the results of the present study is that the incidence of AMS appears to increase steeply at rates beyond 400 m/day. The exact relationship between ascent rate and incidence of AMS, however, is unclear. Given that rapid ascent by plane to 3500-3860 m (ascent rate of 700-1060 m/day above 2800 m) is associated with an incidence of AMS of 84% [3,4], this relationship appears to be approximately linear. These findings need to be confirmed by further studies.

Figure 1. Mean overall ascent rate for trekkers from 2800 m to highest sleeping altitude



Trekkers who incorporated rest days into their itineraries had a similar incidence of AMS compared to those who did not. This suggests that overall ascent rate is more important than the rest days per se. Rest days, however, should still be encouraged as they are an important means of slowing overall ascent rate and aiding acclimatisation. Additional rest days should also be taken if symptoms of AMS persist, i.e. further ascent should not occur in the presence of AMS. Staging ascent by remaining at intermediate altitude for a few days before ascent to high altitude can also be helpful in preventing AMS [12-14].

What ascent rate should we be recommending to travellers to high altitude? The results from the present study suggest that AMS is particularly common when ascending on average greater than 400 m/day. As mentioned previously, further studies are needed to determine the precise incidences of AMS at mean ascent rates greater than 500 m/day. Regardless, to formulate a recommendation, "unacceptable risk" needs to be defined. At what stage is the risk of AMS considered unacceptable? This concept is very subjective, circumstantial and difficult to assess. To complicate matters further, most studies focus on AMS rather than the life-threatening forms of altitude illness (high altitude cerebral oedema (HACE) and high altitude pulmonary oedema (HAPE)). The main purpose of preventative measures is to avoid deaths from altitude illness. Although, intuitively, measures used to prevent AMS should also prevent HAPE and HACE, this relationship has not been directly tested. For example, it is possible that measures that result in a moderate reduction in the incidence of AMS may cause a much greater reduction in the incidence of HACE and HAPE. This may be the case for the Mount Everest trek between 1975 and 1977, when there was a moderate reduction in the incidence of AMS from 53% to 43% and a sizeable decrease in helicopter evacuations from 15 to one [6]. A moderate risk of AMS may be tolerated if the incidence of HACE and HAPE is low.

Should the 300 m/day mean ascent rate recommendation be discarded for something less conservative? I would be reluctant to do so for the trekking routes in the Nepal Himalaya where this recommendation is well-established and satisfying itineraries have been built around it. It has been an invaluable guideline that has encouraged trekking companies and individual trekkers to ascend gradually. Suggesting changes

to the recommendation at this stage may prove more trouble than it is worth. For many other parts of the world this ascent rate is impractically slow and more flexibility is required.

On the basis of current knowledge, I would recommend trying to average less than 400 m/day for the first few days above 3000 m. I suspect that this recommendation could be safely increased to 600 m/day, but this has not been adequately tested. I would also encourage people to spend a night or two at intermediate altitudes below 3000 m before ascending further. Ascent rate is only one risk factor for AMS. Individual susceptibility to AMS is clearly important and those who have readily developed AMS on previous high altitude journeys should plan to ascend relatively slowly. The need to recognise symptoms and signs of altitude illness should be emphasised more than rigid ascent rate recommendations. Travellers should be instructed not to ascend further in the presence of altitude illness and encouraged to incorporate additional days in their itinerary to accommodate unscheduled rest days.

Encouraging gradual ascent remains the most effective strategy to prevent AMS. Ascent rate guidelines are powerful tools for this purpose. Further research and discussion are required to refine existing recommendations and to formulate consensus guidelines.

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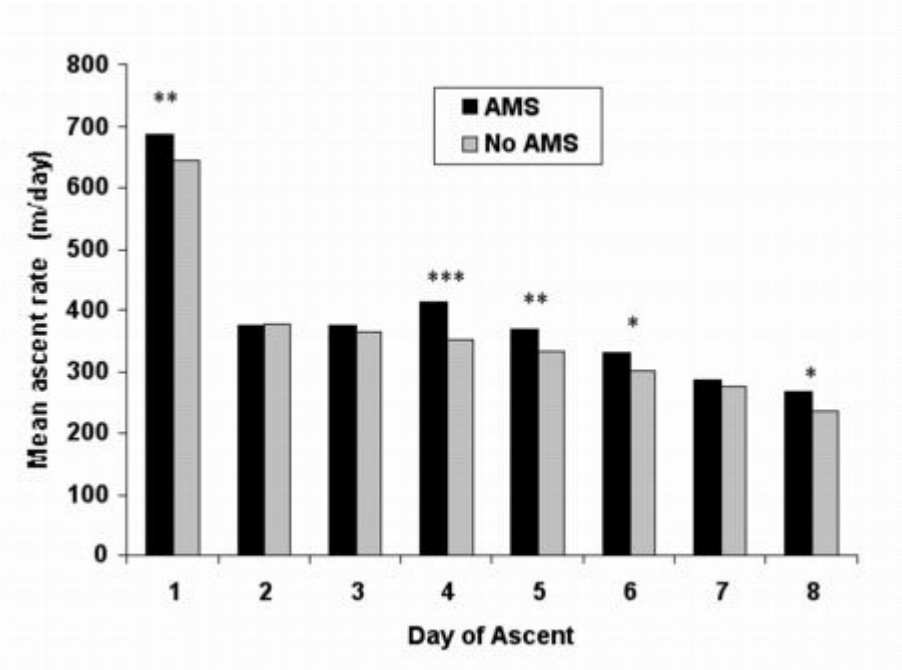
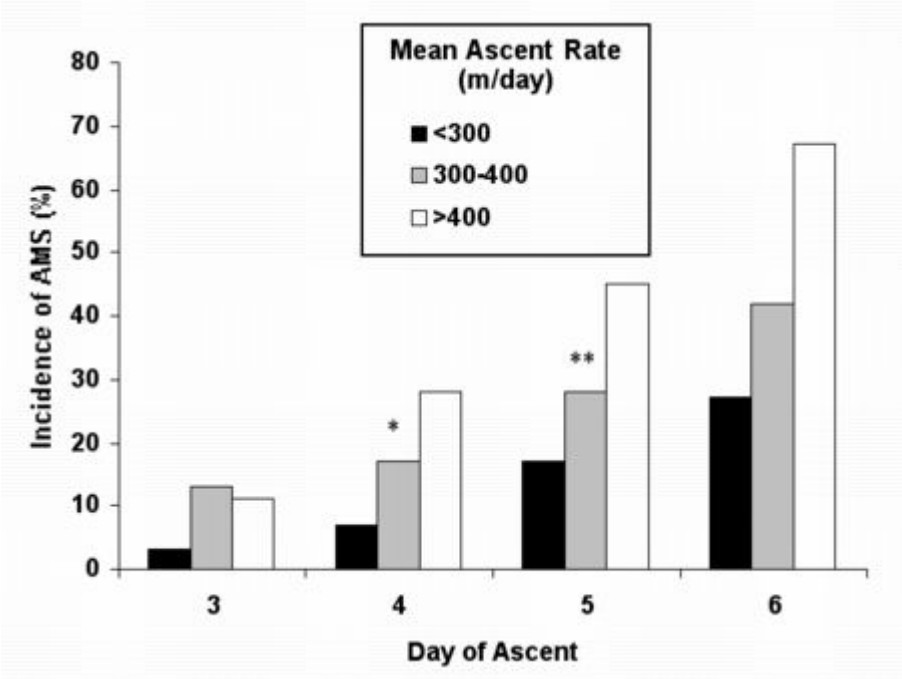
Figure 2. Mean ascent rates for trekkers with and without acute mountain sickness (AMS) on specific days above 2800 m



NB Data from trekkers who developed AMS were excluded from analysis for the days after symptoms started. * $p<0.05$; ** $p<0.01$; *** $p<0.001$

Figure 3. Incidences of acute mountain sickness (AMS) up to days 3-6 above 2800 m for different ascent rates



NB * p<0.01 for the difference between <300 m/day and >400 m/day
** p<0.05 for differences between <300 m/day and >400 m/day, and between 300-400 m/day and >400 m/day

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