Altitude sickness

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SUMMARY. Ten climbers were studied trekking from 1,950 to 4,650 m (6,500 ft to 15,500 ft) in the Nanda Devi Sanctuary of the Garwhal Himalaya. All developed altitude sickness, one seriously. Pulse, blood pressure, and peak flow rate were monitored daily in an attempt to predict the onset of altitude sickness. Prediction was uncertain though the one climber who became seriously cyanosed at 4,200 m (14,000 ft) had a consistently higher blood pressure than his colleagues.

Introduction

ALTITUDE sickness, acute mountain sickness or puna, once one of the rarest conditions affecting only the most intrepid mountaineers, is now a subject on which advice from informed general practitioners is often sought. In one month in 1975, 648 tourists trekked through the Nepalese village of Pheriche on their way to Everest base camp (Hackett *et al.*, 1976). Two years later many more high altitude treks have been opened up and Himalayan holidays increase in popularity. For most people altitude sickness is little more than an inconvenience but every year some die and, as Rennie (1975) points out, the victims are often the fit, the enthusiastic, the audacious, and the physically hardworking.

Oxygen tension is reduced to 50 per cent at 5,400 m (18,000 ft) but altitude sickness occurs in as many as half the people climbing above 3,600 m (12,000 ft) (Hackett *et al.*, 1976). For most the condition is trivial and consists of headache, nausea, anorexia, insomnia, giddiness, ataxia, lassitude, shortness of breath at rest, irritability, and personality change. More severe cases show peripheral oedema or the rapidly fatal forms of pulmonary or cerebral oedema.

Many theories have been proposed about the reasons why it occurs (*Lancet*, 1976), but the precise cause remains unknown. It seems, however, that everyone has a ceiling beyond which some aspect of altitude sickness will develop. This ceiling is rarely below 2,700 m (9,000 ft) and may be raised by slow ascent; how slow is again a matter of opinion. Rennie (1975) states that a flight to 3,000 m (10,000 ft) then a rest of two days followed by a rate of climb of 300 m (1,000 ft) a day to 4,200 m (14,000 ft) and then 150 m (500 ft) daily is safe. Houston and Dickinson (1975) set the limit at 150 m (500 ft) a day above 2,700 m (9,000 ft), with rest days at 4,200 m (14,000 ft) and 5,400 m (18,000 ft). There is no sex difference in incidence but, unusually, older climbers have an advantage over younger ones.

Anglo-Scottish Garwhal Trek

I was invited to accompany a group of Scotsmen and Englishmen from the Midlands to explore the Outer Sanctuary of Nanda Devi in the Garwhal Himalaya of India. The goal was the base camp for Mount Trisul at 7,008 m (23,360 ft). Access to the sanctuary lies in the Rishiganga river which cuts through the surrounding mountains to a depth of 1,500 m (5,000 ft). Much of this river is impassable and a high level route bypasses the lower reaches of the river by ascending very steeply to 4,200 m (14,000 ft) and then dropping to join the river in its higher reaches. This route, though well used by professional mountaineers, had not been explored by trekkers and has been described by Bonington and his colleagues (1975) as the worst 'walk-in' they know. Table 1 shows the composition of the team and the route is shown in the map (Figure 1).

As medical officer my chief concern was the real possibility of altitude sickness. The most dangerous period of the trek was undoubtedly between day six and day eight when we were due to sleep at 2,700 m (9,000 ft), 3,630 m (12,100 ft), and 4,200 m (14,000 ft). These exceed Rennie's limits and far exceed those of the more cautious Houston and Dickinson. Attempts were made before leaving England and again before the trek began to lessen this rate of climbing. On each occasion we were assured that these camps were unavoidable as they were the only available sources of wood and water.

Method

Before leaving England we decided to try to predict

Table 1. Personal characteristics of the climbers.

Climber	Age	Height	Weight	Occupation	Comments
1	46	1.81 m (5′ 11½″)	85.95 kg (191 lb)	General practitioner	Partially fit
2	56	1.78 m (5′ 10″)	88.2 kg (196 lb)	Engineer	Fit
3	41	1.73 m (5′ 8″)	71.1 kg (158 lb)	Solicitor	Fit
4	54	1.79 m (5′ 10½″)	78.75 kg (175 lb)	Iron and steel industry	Fit
5	52	1.70 m (5′ 7″)	74.25 kg (165 lb)	Builder	Partially fit
6	45	1.68 m (5′ 6″)	66.6 kg (148 lb)	Motor industry	Fit
7	43	1.75 m (5′ 9″)	69.3 kg (154 lb)	Psychologist	Very fit Smokes 50 cigarettes/day
8	25	1.63 m (5′ 4″)	72.45 kg (161 lb)	Accountant	Very fit Smokes 10 cigarettes/week
9	46	1.81 m (5′ 11½″)	73.35 kg (163 lb)	Local government officer	Fit
10	53	1.66 m (5′ 5½″)	56.7 kg (126 lb)	Photographer	Very fit

altitude sickness by monitoring pulse rate, blood pressure, and respiratory function. Accordingly each morning at breakfast-time pulse was recorded for 15 seconds, blood pressure was measured on an aneroid sphygmomanometer, and peak flow rate was estimated by a peak flow gauge. The gauge we used was a robust, easily handled instrument, on loan from Allen and Hanbury, which was not influenced by low barometric pressure (Meyers, 1976; Pines, 1976). It may seem that such readings are relatively unsophisticated, and so they would be at sea level. The fact that they were recorded consistently is a tribute to the hardiness of the climbers: stripping for upper arm blood pressure readings at high altitude and very low temperature requires dedication. In addition, blood counts from volunteers were requested before and after the trek.

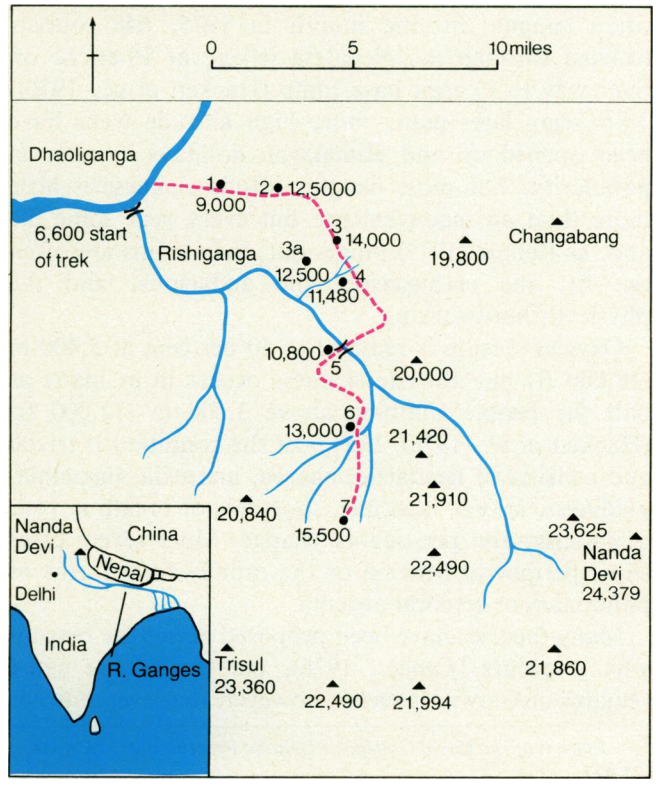
Results

All members of the party developed symptoms of altitude sickness, particularly headache, nausea, anorexia, breathlessness, vertigo, ataxia, and bad temper. Psychological change was difficult to assess and is described elsewhere (Hull, 1978). At the highest camp eight climbers developed peripheral oedema which in each case affected the dorsum of the hands and in some cases was marked. Five suffered Cheyne-Stokes respiration at 4,650 m (15,500 ft). Climber nine developed mild cyanosis (or possibly facial chilling) and climber five developed severe central cyanosis at 4,200 m (14,000 ft) on the third day. Most of the others had air hunger. Because of these respiratory difficulties the party descended 450 m (1,500 ft) to camp at 3,750 m (12,500 ft). This is shown as Camp 3a on the map. This descent rapidly cured climber five who rested on reaching camp. When examined later that evening both climbers five and nine had dry lung bases. The following morning apart from a slight cough climber five was well with no respiratory signs and climber nine looked in excellent shape.

Pulse rate

Many factors influence pulse rate. Most members of the party admitted to anxiety about their ability to cope with an arduous trek, many suffered severe gastroenteritis in addition to the exertion of climbing and the effect of altitude. Figure 2 shows the pulse rates of climbers three and eight (who did not suffer gastroenteritis) and of climber five and the relationship between pulse rate and altitude. Pulse rates are superimposed on the curve showing altitude of camps and of heights climbed, where these are different.

Figure 1. Route of trek with heights of camp sites in feet (1,000 ft ≏ 0·3 m).



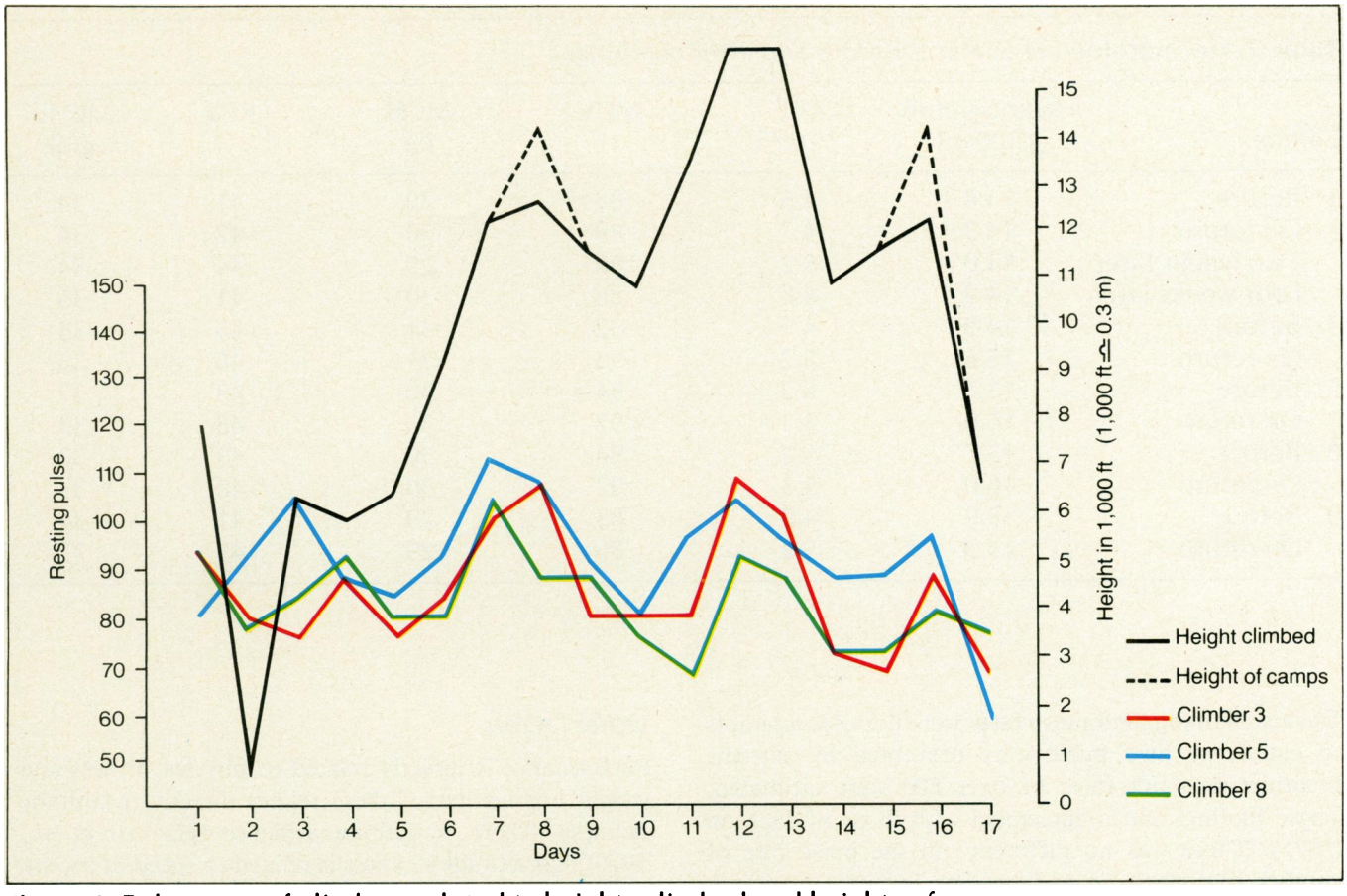


Figure 2. Pulse rates of climbers related to heights climbed and heights of camps.

Figure 3. Blood pressure of climbers related to heights climbed and heights of camps.

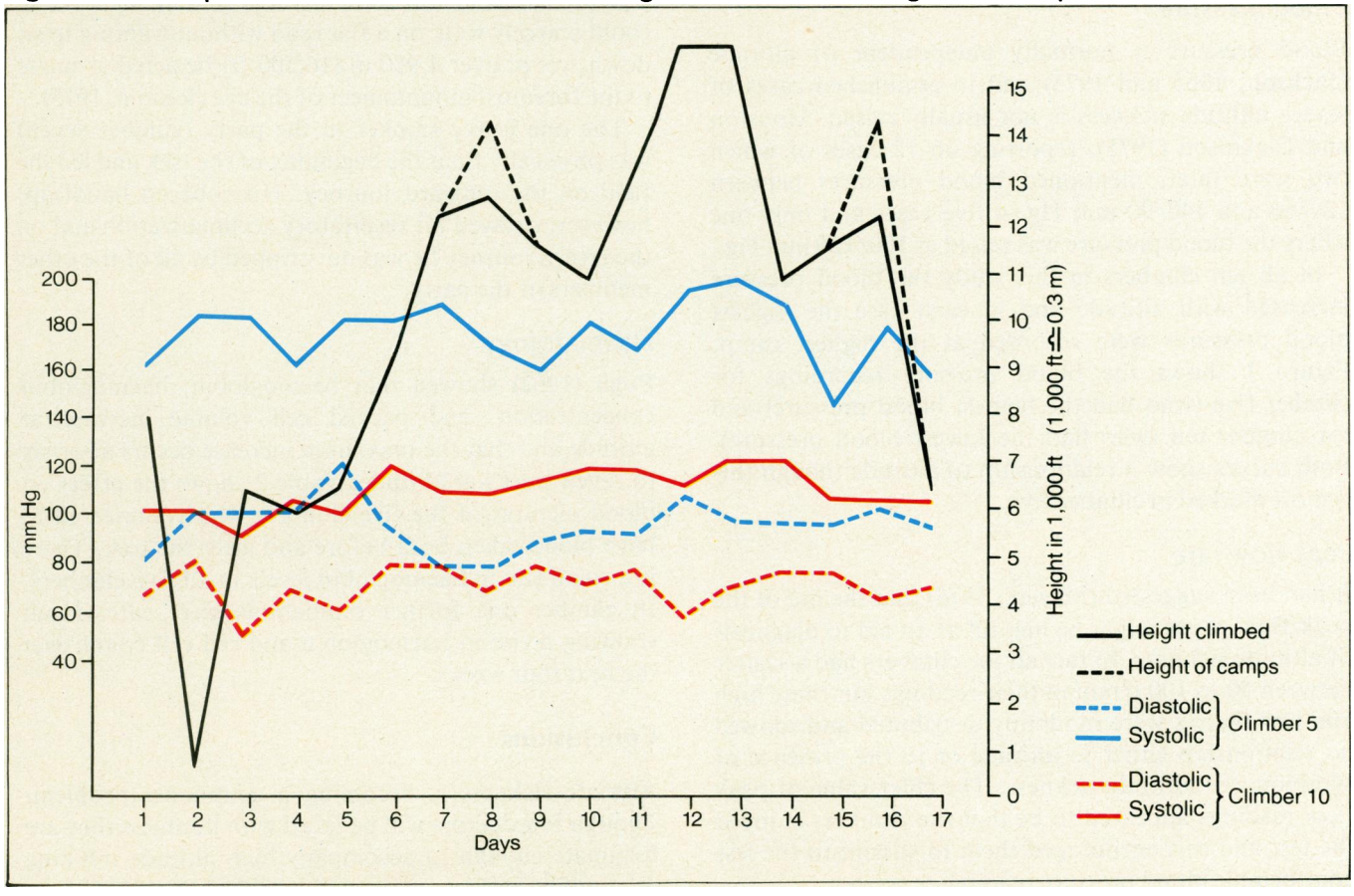


Table 2. Haematological analyses before and after climbing.

Climber	Haemoglobin g/100 ml	RBC $\times 10^{12}$/l	MCV fl	MCH pg	PCV	MCHC g/dl
1. Before	13.8	4.6	88	30	41	34
On return	14.3	4.7	89	30	42	34
Two weeks later	15.0	5.1	86	29	44	34
Four weeks later	14.2	4.8	86	30	41	35
3. Before	14.9	4.9	92	31	45	33
On return	15.8	5.2	93	31	48	33
5. Before	15.7	5.2	94	30	49	32
On return	16.0	5.3	92	30	48	33
8. Before	13.7	5.2	94	30	49	32
On return	16.0	5.3	92	30	48	33
9. Before	13.9	4.9	83	29	41	34
On return	14.9	5.2	86	29	45	33

During climbing high pulse rates were noticed; attempts to count my own pulse were prevented by extreme breathlessness but rates of over 200 were estimated. These findings are in agreement with those of Jackson (1975). There was no difference in the pulse rate of climber five when he had become severely cyanosed, though the amplitude of pulse variation was more marked in him.

Blood pressure

Blood pressure is normally independent of altitude (Jackson, 1968 and 1975) and in established cases of severe altitude sickness is not usually raised. Houston and Dickinson (1975), reporting on 12 cases of which two were fatal, mentioned blood pressures between 120/60 and 140/90 mm Hg in five cases and only one where the blood pressure was raised at 190/120 mm Hg.

In all ten climbers in this study the blood pressure increased with altitude and in each case the highest blood pressures were recorded at the highest camp. Figure 3 shows the blood pressure recordings for climber five (who had the highest blood pressure) and for climber ten (who had the lowest blood pressure). Both curves show a relationship to altitude though this is most marked in climber five.

Peak flow rate

It had been suggested (Meyers, 1976) that the use of the peak flow gauge might be helpful as an aid to diagnosis of altitude sickness. In fact all the climbers had a scatter between 50 to 100 l/min in their readings but these high and low figures were randomly distributed and showed no relationship either to altitude or to the presence of symptoms of altitude sickness. The chief value of peak flow readings appeared to be that the climbers enjoyed the test and this encouraged them to submit to the less comfortable blood pressure reading.

Other factors

Performance is directly related to physical fitness and weight but neither of these relates directly to altitude sickness. There is definite evidence (Hackett *et al.*, 1976) that altitude sickness is related to speed of ascent, so in fact the heavy and unfit who usually ascend slowly may conceivably be at an advantage. Whymper was once helped through a bad attack of altitude sickness by a gentleman who was so debilitated that at sea level he could scarcely walk on a flat road without wanting to sit down, yet at over 4,950 m (16,500 ft) he acted as nurse to the foremost mountaineer of the age (Rennie, 1975).

The one heavy smoker in the party (climber seven) was physically fit at the beginning of the trek and led the field on the outward journey. His tobacco handicap, however, delayed his respiratory acclimatization and on the return journey he was outstripped by all of the other members of the party.

Haematology

Pugh (1962) showed that haemoglobin, haemoglobin concentration, and packed cell volume increase at altitude and that the maximum increase occurs after six to seven weeks at altitude. Table 2 shows the effect on blood pictures of the five climbers who volunteered to have blood taken both before and after the trek. There is a small rise in haemoglobin levels in all five climbers. In climber one further estimations were carried out showing a rise in haemoglobin and red cell count over the next four weeks.

Conclusions

Altitude sickness is becoming a commoner problem. Though few doctors will be faced with it, unless they are fortunate enough to accompany high altitude trekking or climbing parties, many will be asked to advise on it.

It is impossible to predict who will develop problems at what height. In this study one climber had consistently high blood pressure readings and developed cyanosis at 4,200 m (14,000 ft). If nothing else, physiological testing contributed to morale and consequently may have had a bearing on prevention.

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Evaluation of beta blockade, bendrofluazide and prazosin in severe hypertension

It seems to us easier to increase potassium intake by recommending certain potassium-rich articles of diet than by the use of potassium in tablet form. For instance the daily addition to the diet of a bowl of 'All Bran' breakfast cereal with milk, a helping of spinach, and one cup of instant coffee with milk gives 80 mmol of potassium equalling ten 'Slow-K' tablets. We have not observed any tendency for those with normal serum-potassium levels at four weeks to have lower levels after longer treatment.

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