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# Blood lactate changes during exercise at high altitude

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**Summary: Blood lactate concentrations were measured in 18 normal subjects at the end of an exercise test designed to maintain heart rate at 85% of maximum for 15 minutes. Blood lactate concentrations were reduced at high altitude (4846 m) and correlated positively with basal pH and negatively with basal $Pa,O_2$ levels. Blood lactate concentrations tended to be lower in those subjects on acetazolamide but were not correlated with the severity of acute mountain sickness or with the workload of the exercise test. We conclude that the pH changes are probably the most significant factor in reducing lactate concentrations.**

## Introduction

Increases in blood lactate concentration in response to exercise are enhanced by acute hypoxia[1] but reduced by chronic hypoxia without any significant change in basal levels.[2] At least four factors have been suggested to account for this effect of chronic hypoxia, including pH effects on rate limiting enzymes of the glycolytic pathway such as phosphofructokinase, diminution in muscle glycogen and a greater use of free fatty acids, slower release of lactate, and a reduction in muscle blood flow.[3]

In this study we assessed the effect of acetazolamide treatment and the resulting changes in pH and blood gases on the blood lactate response to exercise at high altitude.

## Methods

Eighteen normal subjects (9 on placebo and 9 on acetazolamide 500 mg/day) walked to 4846 m over 11 days.[4] Exercise studies were carried out after they had stayed at 4846 m for 2 to 4 days. Subjects were tested at least 90 minutes after any food. Exercise testing on a bicycle ergometer was designed to maintain heart rate at 85% of maximum for 15 minutes.[5] Venous blood was taken just before the start and at the end of exercise and pipetted immediately into 5% perchloric acid. Samples were kept at ambient temperature and blood lactate measured by a lactate dehydrogenase method on return to Birmingham. Arterialized capillary blood was taken for blood gas measurements[6] before exercise. Acute mountain sickness was assessed by a peer review method in which subjects ranked all members of the expedition on a 20 cm line.[7] Eight of the subjects performed similar exercise testing at sea level at a work load to give 85% of maximum heart rate but without acetazolamide.

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## Results

Blood lactate response to exercise a high altitude was reduced in all subjects. The mean (± s.d.) concentration at the end of exercise at high altitude was 2.7 ± 1.0 mmol/l compared with 5.9 ± 2.6 mmol/l at sea level ($P < 0.01$, paired $t$ test). Blood lactate concentrations at the end of exercise at high altitude

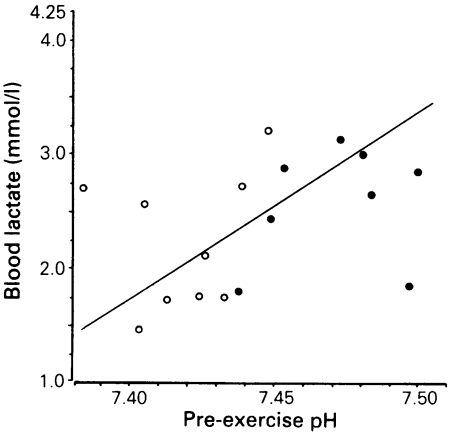


**Figure 1** The blood lactate concentrations at the end of exercise at high altitude and pre-exercise arterialized capillary pH ($r = +0.52$, $P < 0.05$). ●, Subjects on placebo; ○, subjects on acetazolamide.

were not significantly different in subjects on acetazolamide ($2.2 \pm 0.6$ mmol/l) compared with those on placebo ($2.8 \pm 0.8$ mmol/l) ($P < 0.2$, unpaired $t$ test). However, blood lactate concentrations at the end of exercise correlated with both the pre-exercise pH ($r = +0.52$, $P < 0.05$; Figure 1) and pre-exercise $Pa,O_2$ ($r = -0.55$, $P < 0.02$).

Blood lactate concentrations did not correlate with severity of acute mountain sickness or with the workload achieved during the test (Wilcoxon rank order test).

## Discussion

Our results confirm that there is a reduction in blood lactate concentrations on exercising at high altitude[2,8] and suggest that of the various mechanisms proposed, the pH changes are the most important. This is consistent with the striking reduction in lactate concentrations in normal subjects exercising whilst acidotic on ammonium chloride.[7] Our subjects were not acidotic under basal conditions but pH levels were not measured during exercise. It might be expected that the acetazolamide group, having higher hydrogen ion concentrations than the placebo group would have had lower lactate responses. This trend was present but not significant with the relatively small numbers involved. The reduction in workload during the test of approximately 30% at high altitude and may have contributed to the lower lactate concentrations. However, the reduction in lactate concentrations was more than 50% compared with sea level. There was no evidence of any relationship between the severity of acute mountain sickness and the blood lactate concentrations.

## References

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