

TITLE: ACUTE HEMODILUTION OF POLYCYTHEMIC MOUNTAIN CLIMBERS: EFFECTS ON EXERCISE ABILITY AND PSYCHOMOTOR SKILLS

AUTHORS: F. Sarnquist, M.D., R. Schoene, M.D. and P. Hackett, M.D.

AFFILIATION: Department of Anesthesiology, Stanford University and the Palo Alto Veterans Administration Medical Center, Palo Alto, California 94303, and the Department of Medicine, University of Washington, Seattle, Washington 98195

**Introduction.** Polycythemia is an adaptive response to chronic hypoxia. However, in some illnesses producing hypoxia, polycythemia develops beyond an optimal level, and hemodilution is occasionally beneficial for such patients. At extremely high altitudes (> 4000 meters above sea level), well individuals often develop high hematocrits. A German group reported to the ASA in 1978<sup>1</sup> that hemodilution improved the physical performance and well being of healthy polycythemic mountain climbers at high altitudes. The 1981 American Medical Research Expedition to Mt. Everest provided us with an opportunity to objectively examine the effects of hemodilution on the mental and physical performance of polycythemic climbers. We attempted to define the level at which the increase in hematocrit with its attendant increased blood viscosity and increased systemic vascular resistance becomes detrimental rather than helpful to the hypoxic individual.

**Methods.** Four healthy climbers who had lived above 5400 meters elevation ( $P_b = 400$  torr) for greater than seven weeks and had developed hematocrits above 57% (19 gms of hemoglobin per 100 ml of blood or greater) were chosen. Informed consent was obtained from each. The protocol had institutional approval. None of the subjects was dehydrated. The subjects were given a group of psychomotor tests, including tests of memory, physical and mental dexterity, and attention span. They also exercised to exhaustion on a bicycle ergometer while blood oxygen saturation, ECG, and inspired and expired O<sub>2</sub> and CO<sub>2</sub> were continuously monitored. After the baseline measurements were made, an estimated 15% of each subject's blood volume was removed (between 800-900 cc in each case) and an equal volume of a 5% solution of human albumin (Cutter Labs) in saline was infused to maintain isovolemia. Sixteen hours after the hemodilution, the psychomotor and exercise tests were repeated. This study was carried out at a camp on the Khumbu glacier in Nepal, 5400 meters (17,600 feet) above sea level.

**Results.** The subject's hematocrits dropped 13.4% from a mean of 58.3% to a mean of 50.5%. Subjectively, the climbers were unable to detect this change in hematocrit. The table displays the results of the exercise tests and the figure displays the hemoglobin oxygen saturation changes during those tests. After hemodilution, heart rates were slightly higher at rest and at all levels of exercise. No other consistent changes were recorded. Subject 1 had an 18%

decrease in maximum O<sub>2</sub> uptake, but this parameter did not change in the other 3 subjects. There was a very small but consistent improvement in the scores of the psychomotor tests in all subjects after hemodilution.

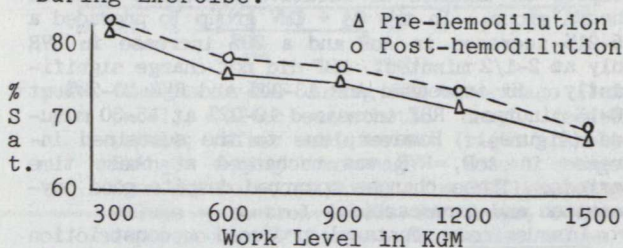
**Discussion.** These data do not reveal any important decrease in exercise tolerance or psychomotor skills when the hematocrits of asymptomatic individuals in a hypoxic environment (resting PaO<sub>2</sub> = 40-50 torr) were isovolemically reduced from 58% to 50%. We were unable to substantiate the German groups' anecdotal claim that moderate hematocrit reduction improved well-being and exercise ability at extreme altitudes. Despite a theoretical 13% decrease in the blood's capability for transporting oxygen after the hemodilution, none of our measurements suggested any deficiency of tissue oxygenation in the subjects. We conclude that isovolemic hemodilution, as conducted in this study, does not improve the exercise tolerance or psychomotor abilities of healthy polycythemic sojourners at extremely high altitudes. However, the fact that in this intensely hypoxic environment the higher hematocrit levels seemed to confer no advantage at rest or during exhausting exercise suggests to us that hematocrits of above 50% will rarely, if ever, benefit a climber or patient.

Table. Exercise Test Results  
(Mean values of all four subjects).

	Pre-Hemodilution	Post-Hemodilution
Hematocrit (%)	58.3	50.5
Max Work (KGM)	1500	1500
VO <sub>2</sub> (MAX) (L/M)	3.41	3.22
HR (900 KGM)	139	144
HR (1500 KGM)	148	151

KGM = Kilogram-meter/minute HR = Heart Rate

Figure. Hemoglobin - Oxygen Saturation During Exercise.



Reference.

1. Zink RA, Schaffert W, Brendal W, et al: Hemodilution in High Altitude Mountain Climbing. Abstracts of Scientific Papers, 1978 ASA Annual Meeting, p. 93-94.