Operation Everest, 1946

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DURING the spring and summer of 1946, the U. S. Navy conducted one of the most unusual expeditions in mountaineering history. It was a small (but immobile) party of four climbers, with 40 men in support. Two members of the climbing party reached 29,025 ft. on the 33rd day, and the entire ascent was made without setting foot on ice or snow. The party experienced perfect weather for the entire period: the temperature never fell below 65° F., and there was no snow, rain, or even wind. Furthermore, the climbers slept between sheets in comfortable beds, ate three hot meals a day, and took hot baths at night.

How come? Well, the "expedition" was conducted in a steel altitude chamber at the Naval Air Station, Pensacola, Fla., in which the four volunteers lived for 34 days. Each day the pressure within the 12 by ten by seven foot chamber was reduced by a small amount, to simulate an ascent of 500 to 2000 ft. The "support party" of 40 doctors, mechanics and technicians operated pressure and ventilation controls, kept the subjects under 24-hour observation, and made numerous tests of their condition. Ten or 15 times a day a small communicating pressure lock was "taken up" to the main chamber with food and baths, or with technicians and doctors to perform the multitude of tests for which the project was planned.

The purpose of the five-week test—known as Operation Everest by the Navy—was to study physiological changes at altitudes so high as to cause unacclimatized man to faint within a few minutes from lack of oxygen. We did not try to improve our climbers' tolerance for lack of oxygen by drugs or diet—that will come later, perhaps—for the prime purpose of this "reconnaissance" was to study the normal, unaltered adaptations. True, this has been done before, in the Alps, Andes and Himalayas. Operation Everest differed from these great scientific expeditions in three important respects: first, the men went higher than man has gone before; second, many more numerous and complex studies could be made under the test-tube conditions of the project than under the rugged conditions encountered at the same altitudes in the mountains;

and, finally, the observers who studied the men at high altitudes were not themselves affected by lack of oxygen, and therefore could be more precise and impartial in their observations.

The four months of preparation concerned matters not ordinarily associated with expeditions: installation of comfortable beds, toilet and bath within the chamber; overhaul of heavy pumps and air conditioning equipment; and installation of diesel-powered electric generators to provide auxiliary power in case of accident. A complete analytical laboratory was staffed and equipped; and a small kitchen was organized, complete with an excellent dietitian, to provide the best possible food for the "climbers." A crew of 14 technicians stood watches around the clock to operate chamber controls and to observe the subjects. The various laboratory tests were performed by different teams according to an intricate program. All these preparations were extensive, even though they dealt with not a single piton, ice-axe, tent or sleeper.

After the take-off on July 1st, the four men "climbed" 2000 ft. each day up to 9000 ft. Then their rate of ascent was slowed to 1000 ft. a day up to 15,000 ft. Above this altitude they climbed only 500 ft. each day, occasionally spending two days at the same level until "high camp" was reached, at 22,500 ft. The period spent between 5000 ft. and 22,000 ft. was approximately the same as that spent by the successful Kamet and Nanda Devi expeditions. These expeditions, however, remained for several weeks between sea level and 5000 ft.

After a week above 20,000 ft., the four men made a "dash for the summit" on July 31st, climbing at the rate of 1000 ft. per hour throughout the day. At 27,000 ft. two requested oxygen, but the other pair continued on, reaching 29,025 ft. at 4 o'clock. There they remained for 30 minutes before dropping back to high camp for the night. On the following day two of the men wearing standard service oxygen equipment spent several hours above 45,000 ft. and reached 50,000 ft. for a few minutes, an altitude several thousand feet higher than has ever before been attained without pressurized oxygen apparatus.

During the whole month, the greater part of each day was occupied with blood tests, X-rays, physical fitness tests, exercise periods (on a bicycle), psychological tests, and brief periods of recreation (beer and movies nearly every night, for example). Tests were made of their ability to climb steps at a certain rate, both

with and without oxygen, at their high camp; and records of heart action were taken during this work. And of course each man's pulse, blood pressure, weight, and food intake were recorded every day.

What did it all prove? Can Everest be climbed? Will oxygen help? How can acclimatization be measured and improved? Some of these questions can be answered directly; others are still undecided. A great number of respiratory and circulatory measurements were made, some for the first time at altitude. And, for the first time in history, normal, sea-level men were able to study acclimatized men at very high altitude, and to note beyond all doubt that, although the men themselves felt well and considered themselves in good shape, they were in fact far from normal. Contrary to some prior observations, the men were definitely blue from lack of oxygen and not from cold; there were undeniable signs of dulling of thought. These observations alone would have made the project worthwhile. In addition there are, beyond the scope of this report, numbers of records and measurements which will gradually appear in the scientific literature.

Several observations deserve special emphasis. First of all, our subjects were not in as good physical condition as are most mountaineers at the same altitude and after roughly the same period of ascent. This observation came as a surprise; for we believed that their comfortable living conditions, excellent meals and moderate exercise would put them far ahead of the mountaineer, buffeted by storm, often cold, and usually tired and hungry. We attribute the difference to the fact that climbers are forced to do severe, often exhausting work, a stress which, superimposed upon lack of oxygen, probably stimulates the process of acclimatization more than does simple residence at altitude. The lesson was clear to us—heavy work unquestionably speeds adaptation to altitude.[1] On the other hand, none of our four subjects developed signs of mountain sickness, headache, vomiting, dizziness, which have been

[1] In his fascinating paper on "Mountain Sickness and its Probable Causes," written in 1906, Dr. T. G. Longstaff stated that poor physical condition and the excessive fatigue of climbing are the major factors responsible for mountain sickness. Conversely, he believed that seasoned guides and veteran climbers experienced few or no ill effects at high altitude because of their extraordinary physique and resistance to fatigue. He considered that mountain lassitude, due to lack of oxygen, affects nearly everyone, but that only the untrained or greatly fatigued climber would suffer mountain sickness. He did not consider that acclimatization to lack of oxygen itself occurs.

noted so often in train or car passengers in the Andes, Rockies and Alps.

When our subjects breathed pure oxygen at 22,000 ft., they instantly felt and looked much better, and their ability to work (as measured on the step test) increased. But—and this is a big "but"—even with oxygen they could not equal their sea-level performance. There was no question that oxygen helped them greatly, but it did not abolish the effects of altitude for these acclimatized men as it does for the unacclimatized man. Their main difficulty during work, shortness of breath, was not much improved by breathing oxygen—a phenomenon which is probably due to specific physio-chemical changes which occur in the blood as part of acclimatization. By the nature of this process, the better acclimatized to oxygen lack a man may become, the less reserve alkali will he have in the blood, and (since it is this reserve which protects him from shortness of breath during work) the more he will puff while climbing. Breathing oxygen relieves only the lack of oxygen; it does not alter the breathing difficulty. We must therefore conclude, partly from our observations and partly from theory, that the better acclimatized a man may become, the less benefit will he obtain from added oxygen.

The fact that our men could spend four hours above 25,000 ft., of which half an hour was spent at 29,000 ft., indicates that there is nothing critical, physiologically speaking, about the summit of Everest. That altitude is a little worse than is 28,000 ft., but not much.

The results of the dietary study were less definite. All four men lost weight (an average of eight pounds apiece), but they also lost interest in their excellent meals, which was definitely an altitude effect. Suggestive evidence indicated that vitamins, particularly C, increase the ability of the blood to carry oxygen. The red blood cell count increased moderately in all men, but there was no relation between the amount of this increase and the success of a man's acclimatization as compared to that of his companions. The blood count would possibly have increased more rapidly had the men been given supplemental iron, but for several reasons we do not consider an increase in the red blood count to be an essential, or even a very important, part of acclimatization. Some of our findings, taken with previous reports and analyses, support the belief that a high carbohydrate diet will increase altitude tolerance by

several thousand feet. Fats and proteins should, however, he added to the diet during sojourns at lower camps to replenish the body stores. We found no evidence of enlargement of the heart or serious changes in the electrocardiograms of these moderately working men as high as 25,000 ft.

Definite benefit was obtained by voluntarily increasing the depth of breathing by a small amount (perhaps 25%), and this was true during work and at rest. Even, rhythmic breathing was more effective than irregular, gasping respirations. But voluntary overbreathing must be practiced with caution, for it can cause most unpleasant results, even though it confers dramatic benefits.

From Operation Everest, then, we believe that there are no insurmountable physiological obstacles to keep man from reaching the summit of the Himalayas. Other conditions being equal, that climber who works the hardest during his slow ascent will acclimatize the best—though obviously one must not overdo this. At great heights a diet almost exclusively carbohydrate, with added vitamins, and iron (if tolerated well), has some advantages. Overbreathing, practiced only moderately if bad effects are to be avoided, is of definite and perhaps critical value at extreme altitudes, but it is a method which must be used with care. Finally, oxygen is of undoubted benefit, but it does not relieve the most annoying handicap of altitude, breathlessness on exertion; and there is reason to believe that the better adapted a man is, the less help will he receive from it.