

1903

Cold as a causal factor in the blood changes due to high altitude

John Weinzirl

Follow this and additional works at: https://digitalrepository.unm.edu/unm_bulletin

Recommended Citation

Weinzirl, John. "Cold as a causal factor in the blood changes due to high altitude." *University of New Mexico biological series, v. 2, no. 8, Bulletin of the Hadley Climatological Laboratory of the University of New Mexico, v. 2, no. 8 2, 8* (1903).
https://digitalrepository.unm.edu/unm_bulletin/13

This Article is brought to you for free and open access by the Scholarly Communication - Departments at UNM Digital Repository. It has been accepted for inclusion in UNM Bulletins by an authorized administrator of UNM Digital Repository. For more information, please contact disc@unm.edu.

BULLETIN

OF

The Hadley Climatological
Laboratory

OF THE

UNIVERSITY OF NEW MEXICO.

Volume II., Number 8.

Reprinted from the American Journal
of the Medical Sciences.

AUGUST, 1903.

COLD AS A CAUSAL FACTOR IN THE BLOOD CHANGES DUE
TO HIGH ALTITUDE.

BY JOHN WEINZIRL, M.S.,

VICE-DIRECTOR, HADLEY CLIMATOLOGICAL LABORATORY, UNIVERSITY OF NEW MEXICO.

IN an earlier paper¹ the writer called attention to the fact that the increased counts of red corpuscles in the blood due to high altitude are temporary, contrary to the generally accepted opinion that the blood counts in high altitudes are practically normal or at most only slightly above. At least such is the case for the moderately high altitude of five thousand feet.

Up to the present time no satisfactory explanation for these altitude changes has been offered. The more commonly accepted theory is, that it is due to diminished atmospheric pressure, or that a greater number of red cells is required to furnish sufficient oxygen to the tissues under the diminished oxygen supply of high altitudes. While this appears quite plausible at first thought, it must be admitted that serious difficulties stand in the way of its acceptance. In the first place, the oxygen absorption by the red cells is a chemical phenomenon, and as such is independent of the partial pressure of oxygen save at extreme limits. Secondly, the partial pressure of oxygen in the air cells of the lungs differs from that in the external air, and as yet we have no data to show that the two vary directly. Thirdly, it is not at all plain why an increased number of red cells should be required to carry a given amount of oxygen, for, as Paul Bert has shown, the amount of oxygen actually used by an animal is constant, even when the supply is diminished by one-half, or when the animal respire pure oxygen. Fourthly, this theory cannot account for the fact which I believe has been proved, that the increase in red cells due to altitude is only temporary. And if it is objected that lung expansion neutralizes the necessity for the increased number of red cells, it may be said that the two changes did not occur together in some cases that I have observed.

In addition to the above a number of other hypotheses have been offered, of which the following may be mentioned:

1. The blood is concentrated by loss of moisture from the body due to dryness of mountain climates. This produces an increase in the number

¹ Bulletin Hadley Climatological Laboratory, vol. iii., No. 3.

of blood cells per cubic millimetre, though the total number of cells in the body remains practically constant, that is, the increase is only apparent.

2. Another hypothesis states that the cells are actually increased in numbers but reduced in size, their total volume remaining constant.

Before discussing farther these statements, the writer's work may be advantageously presented. The work was undertaken very largely to test these hypotheses. To this end an elaborate experiment was planned as follows: Three healthy, male, common white rabbits, which were full grown, were taken from the laboratory pen for the experiment. Care was observed that the feed was not changed during this time. The following factors were determined at the beginning of the experiment, again before the animals were sent to the mountains at an increased altitude of two thousand feet, and also immediately upon their return. The factors are: weight, specific gravity of the blood, percentage of hæmoglobin, volume of red corpuscles as determined by the hematokrit, diameter of the red cells, and the number of red and white cells per cubic millimetre, respectively. Care was taken to keep a constant method throughout the experiment. This, however, was not possible in the case of the hematokrit tests, as an accident rendered necessary the employment of two different machines during the work.

The experiment being undertaken during the cold weather of the month of February, as a further precaution and in order to make conditions as nearly uniform as possible, the animals were removed from the relatively warm basement of the laboratory to the open air, where they were exposed to approximately the same conditions as in the mountains. The full data of the three examinations are given in the following table.

TABLE I.—BLOOD COUNTS OF RABBITS KEPT IN COLD AND LATER SENT TO A HIGHER ALTITUDE, BUT AT APPROXIMATELY THE SAME TEMPERATURE. PART I.

Examination No.	Date.	Hour.	Place.	Altitude in feet.	Time in mountains.	Weight	Sp. gr.	Hæmoglobin.	Cell volume.	Cell diam.	No. of red cells.	No. of white cells.	Increase in red cells.	Remarks.
1901.														
1	Feb. 19	11.00 A.	Albuquerque	5000	.....	6 lbs.	1058	.....	44%	6.36 μ	6,290,000	17,000	.....	Kept in warm basement.
2	Mar. 25	3.30 P.	"	5000	See remarks	6 "	1060	75%	49%	6.52 "	6,730,000	7,500	+440,000	In cold 27 days.
3	Apr. 12	3.00 P.	Camp Whitecomb	7000	14 days	6 "	1060	75%	46%	6.33 "	6,658,000	10,000	-72,000	Exam. at Albuquerque.
1901.														
1	Feb. 28	.....	Albuquerque	5000	.....	4 lbs.	1060	.....	38%	6.1 μ	5,658,000	10,000	.....	Kept in warm basement.
2	Mar. 26	2.45 P.	"	5000	See remarks	4 1/2 "	1062	82%	54%	6.55 "	7,720,000	6,600	+2,062,000	In cold 26 days.
3	Apr. 13	10.45 A.	Camp Whitecomb	7000	14 days	4 1/2 "	1060	80%	47%	6.48 "	6,290,000	10,700	-1,480,000	Exam. at Albuquerque.
1901.														
1	Feb. 28	3.00 P.	Albuquerque	5000	.....	6 3/8 lbs.	1059	.....	52%	5.96 μ	6,564,000	7,000	.....	Kept in warm basement.
2	Mar. 28	2.00 P.	"	5000	See remarks	6 "	1060	83%	52%	6.55 "	6,689,000	9,000	+125,000	In cold 24 days.
3	Apr. 13	3.30 P.	Camp Whitecomb	7000	14 days	6 "	1059	82%	47%	6.9 "	5,884,000	13,000	-805,000	Exam. at Albuquerque.
PART 2.														
Rabbit No. 13. Female, full grown; had young about ten weeks old.														
1	Apr. 19	3.30 P.	Albuquerque	5000	.....	4 1/4 lbs.	1052	70%	39%	.....	5,449,000	.....	.....	Out-doors in cold 3 days.
2	May 3	3.15 P.	"	5000	See remarks	5 "	1058	76%	43%	.....	6,911,000	.....	.....	" " " 17 "
3	May 17	4.00 P.	Camp Whitecomb	7000	13 days	5 "	1060	77%	46%	.....	6,302,000	.....	+1,462,000	In from mount. to-day.
1901.														
Rabbit No. 14. Female, full grown; had young about fourteen weeks previous to experiment.														
1	Apr. 18	3.30 P.	Albuquerque	5000	.....	5 1/2 lbs.	1058	80%	51%	.....	6,773,000	.....	.....	Out-doors in cold 2 days.
2	May 3	10.45 A.	"	5000	.....	5 1/2 "	1058	72%	44%	.....	5,404,000	.....	-1,369,000	" " " 17 "
3	May 17	3.10 A.	Camp Whitecomb	7000	13 days	5 1/2 "	1058	80%	46%	.....	6,755,000	.....	+1,351,000	In from mount. to-day.
1901.														
Rabbit No. 15. Female, young, about fourteen weeks old.														
1	May 2	2.30 P.	Albuquerque	5000	.....	3 3/4 lbs.	1062	90%	49%	.....	7,363,000	.....	.....	Out-doors in cold 16 days.
2	May 18	9.00 A.	Camp Whitecomb	7000	13 days	3 3/4 "	1062	87%	50%	.....	7,297,000	.....	-71,000	In from mount. one day.

Two striking facts are revealed in this experiment. 1. The animals in passing from the warm basement to the colder temperature outside underwent the usual phenomena of high altitude changes, viz., increased specific gravity of the blood, increased volume of red cells, and increased number of red cells. 2. When the animals were sent to the mountains, no further increase took place in these factors.

These results were so unusual and unexpected that a repetition of the experiment seemed desirable. It was therefore repeated but under less favorable conditions. Male rabbits not being available, three females were used, two of which had had young ten and fourteen weeks previously, and the third was a growing rabbit. Then, too, owing to the warmer weather of April, the temperature change was not so marked. These circumstances, together with the fact that females are not favorable subjects for experiment generally, rendered this test somewhat uncertain. The data are embraced in Table I, Part 2.

Rabbit No. 13 conforms most closely to the results previously obtained, showing a marked increase in the various factors on being placed in the cold, and without a subsequent increase in the cell count on going to the higher altitude.

Rabbit No. 14 appears to violate the law, inasmuch as a decrease is shown in the various factors on being placed in the cold. However, no increase over the first results is shown when the animal was taken to the higher altitude. This animal was probably an abnormal subject.

Rabbit No. 15 was not examined before being placed in the cold, but the subsequent changes conform to the rule, the various factors showing no further increase in the higher altitude.

In general, therefore, the experiment confirms the results of the first.

That cold produces higher blood counts is shown by the higher counts of the winter season over those of summer. In this connection a number of summer and winter counts, taken from the same individuals, are of interest. I have only thirteen cases which fall under this head, but the results are striking and are tabulated as follows:

TABLE II.—COMPARATIVE BLOOD COUNTS IN SUMMER AND WINTER SEASONS.

Case No.	Sex.	Age.	Condition.	Summer.			Winter.			Red cells.	Increase in winter.	
				Date.	Hour.	Sp. gr.	Date.	Hour.	Sp. gr.			
27	Male	Adult	Tuberculous; recovered	Aug. 5, 1900	11.00 A.M.	.....	4,757,000	Dec. 19, 1900	10.45 A.M.	1060	5,851,000	614,000
34	Male	28	Tuberculous; recovered	Aug. 4, "	6.15 P.M.	1055	3,640,000	Jan. 22, 1901	11.00 A.M.	1058	5,640,000	2,000,000
21	Male	Adult	Tuberculous	June 20, "	9.30 A.M.	.....	6,242,000	Jan. 24, "	12.15 P.M.	1061	5,738,000	-504,000
28	Male	25	Tuberculous	Aug. 1, "	2.45 P.M.	1060	5,091,000	Jan. 28, "	2.30 P.M.	1062	5,415,000	382,000
22	Male	41	Tuberculous	July 18, "	9.30 A.M.	.....	5,757,000	Jan. 30, "	10.40 A.M.	1059	6,200,000	463,000
32	Female	22	Pneumonia; recovered	Aug. 3, "	11.40 A.M.	1057	5,711,000	Feb. 2, "	11.00 A.M.	1059	5,920,000	209,000
31	Female	22	Tuberculous; recovered	Aug. 3, "	9.30 A.M.	.....	3,422,000	Feb. 2, "	11.15 A.M.	1058	5,085,000	1,613,000
10	Male	Adult	Tuberculous	May 11, "	10.15 A.M.	.....	6,072,000	Feb. 4, "	3.45 P.M.	1058	5,980,000	-92,000
6	Male	22	Normal	May 28, "	2.00 P.M.	.....	5,000,000	Feb. 18, "	11.00 A.M.	1062	5,431,000	431,000
33	Female	27	Tuberculous; recovered	Aug. 3, "	4.30 P.M.	1055	4,147,000	Feb. 23, "	2.30 P.M.	1060	4,844,000	697,000
24	Male	15	Normal	July 20, "	12.00 M.	.....	5,404,000	Mar. 3, "	3.15 P.M.	1062	5,493,000	89,000
38	Male	15	Normal	Aug. 25, "	10.00 A.M.	.....	4,764,000	Mar. 7, "	2.20 P.M.	.....	5,162,000	398,000
20	Female	Adult	Tuberculous; recovered	July 19, "	11.00 A.M.	.....	4,822,000	Mar. 21, "	3.30 P.M.	1058	4,885,000	13,000
											Average	485,000

From the foregoing it is seen that eleven of the thirteen cases show higher winter counts. The two cases showing lower winter counts are tuberculous subjects, while two other tuberculous subjects conform to the general rule. Taking all the cases, the average of the winter counts over those of summer is 485,000 cells.

If we observe the specific gravities we again find higher figures for the winter season. Unfortunately, only four determinations were taken in both seasons; but these four all show an increase in winter, the average being three points higher. Results similar to the above have been obtained by other investigators.

It appears quite remarkable that the above facts have never been applied in explaining the altitude phenomena as exhibited in blood changes. Yet it is true that the temperature change in passing from a lower to a higher altitude is usually quite marked. If the cold of winter produces higher blood counts, then it is only reasonable to expect that the cooler temperature of higher altitudes should also produce higher counts. The foregoing animal experiments which show an increased count when the animals were taken from a warm to a cold temperature, and which showed no material increase when subsequently taken to a higher altitude, but at approximately the same temperature,¹ would seem to lend material strength to the theory that cold is an important causal factor in the blood changes due to high altitude.

Regarding the ultimate question as to whether the increase in red cells is due to physical or physiological causes, or, in other words, whether the increase is apparent (being due to blood concentration) or real, the writer is not prepared to say from the data at hand. My opinion is that it is probably due to both factors. And why not? It is generally conceded that the blood is denser in winter than in summer—a fact supported by our experiments. This should increase the cell count and the other factors as well. It is also a fact that general nutrition is improved in cold weather, as is shown by a gain in body weight. *A priori* the blood should participate in this general well-being by an absolute increased number of red corpuscles.

Without further discussion of the several factors determined in these experiments, the following conclusions seem warranted:

1. Cold is an important factor in accounting for the blood changes due to high altitude. That cold is the only factor, however, is not maintained.
2. In general the specific gravity, the hæmoglobin, and the volume of cells follow the increase or decrease of the red blood cells, although this is not invariably the case.

¹ It may be stated that Captain Whitcomb claims a warmer temperature for the camp than for Albuquerque. This is accounted for by the fact that the camp is located in a cañon sheltered from the cold winds.

3. Although the data are too few for a final conclusion, there is no evidence that a decrease in the size of the cells accompanies an increased cell count. The contrary, however, is indicated, and this factor probably varies directly with the others.