TABLE I.

Uncorrected Position of Peaks				
Cyanhemoglobin		Oxyhemoglobin		$\nu \times 10^{-2}$ in
λ in $m\mu$	$\nu \times 10^{-2}$	λ in $m\mu$	$\nu \times 10^{-2}$	Multiples of 60
		575	174	
545	184	540	185	3
418	239	415	241	4
351	285	345	290	5
272	368	276	362	6
229*	437	240*	417	7

*Readings in this spectral region are uncertain.

This preliminary analysis permits the following tentative deductions to be drawn: All the hemoglobin derivatives have bands which belong to a single series, the members of which may be expressed by $n = \frac{\nu \times 10^{-2}}{60}$. n represents a simple integer, such as 3, 4, 5, 6, and 7, which are demonstrable in the regions of the spectra studied. This series of bands is probably related to the general structure of the hemoglobin molecule.

The so-called α-band of oxyhemoglobin (peak at λ 575 $m\mu$) probably belongs to another series. Since a similar discrepant band is present also in the spectrum of carboxyhemoglobin this portion of the absorption curve may be related to the union of hemoglobin with O_2 or CO.

Upon the basis of this analysis the possible existence of absorption in the infra-red may be prophesied. In the case of cyanhemoglobin, for example, the first 2 members of the $\frac{\nu \times 10^{-2}}{60}$ series would be expected at approximately λ 1660 $m\mu$ and λ 830 $m\mu$.

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Velocity of Blood Flow as Influenced by Exercise and Increased Air Pressure.

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In a series of studies to determine the effect of increased air pressure on the human body, encountered in deep sea diving, one of the most important things to determine is the velocity of blood flow during rest and exercise at normal and increased air pressures.

TABLE I.

Subject	Atmospheres Pressure Used	Condition	Pulse	Blood Pressure	Pulse Pressure	Circulation Time in sec.	Injection Time in sec.	Actual Circulation Time in sec.
1	1	Rest	62	116/60	56	16	3	13
		Exercise	104	136/68	68	16	4	12
	6	Rest	70	108/64	44	23	3	20
		Exercise	74	114/72	42	24	4	20
2	1	Rest	60	116/68	48	19	3	16
		Exercise	100	142/48	94	13	3	10
	6	Rest	70	128/72	56	19	3	16
		Exercise	78	144/86	58	20	3	17
3	1	Rest	80	96/50	46	18	3	15
		Exercise	110	124/50	74	12	3	9
	6	Rest	96	114/52	62	14	3	11
		Exercise	92	116/42	74	13	4	9
4	1	Rest	82	110/60	50	17	3	14
		Exercise	110	124/30	94	14	3	11
	6	Rest	72	102/80	22	13	3	10
		Exercise	88	128/74	54	15	3	12
5	1	Rest	78	126/76	50	18	4	14
		Exercise	128	130/70	60	14	3	11
	6	Rest	80	124/44	80	17	3	14
		Exercise	96	136/66	70	18	3	15
6	1	Rest	82	112/48	64	15	3	12
		Exercise	120	130/18	112	10	3	7
	6	Rest	92	112/70	42	11	2	9
		Exercise	80	130/58	72	14	3	11
7	1	Rest	76	114/64	50	16	2	14
		Exercise	108	182/42	140	15	5	10
	6	Rest	78	110/62	48	20	2	18
		Exercise	96	138/82	56	14	2	12
8	1	Rest	60	120/72	48	19	2	17
		Exercise	78	126/68	58	14	4	10
	6	Rest	54	132/56	76	19	4	15
		Exercise	72	112/56	56	19	3	16
9	1	Rest	58	102/52	50	15	3	12
		Exercise	112	164/30	134	11	3	8
	6	Rest	72	104/72	32	19	6	13
		Exercise	96	120/58	62	13	4	9
10	1	Rest	62	88/60	28	16	3	13
		Exercise	102	136/34	102	15	3	12
	6	Rest	72	92/68	24	15	6	9
		Exercise	84	112/56	56	18	3	15
11	1	Rest	54	110/72	38	20	5	15
		Exercise	96	122/74	48	15	4	11
	6	Rest	64	110/75	35	22	6	16
		Exercise	74	88/76	12	20	3	17
12	1	Rest	64	114/68	46	19	3	16
		Exercise	92	132/36	96	17	5	12
	6	Rest	59	112/58	54	21	2	19
		Exercise	86	120/70	50	15	3	12
13	1	Rest	62	124/62	62	20	2	18
		Exercise	88	136/88	48	19	3	16
	6	Rest	64	126/76	50	20	3	17
		Exercise	66	150/68	82	28	4	24
Aver.	1	Rest	68	111/63	48	17.5	3	14.5
		Exercise	104	137/51	86	14.2	3.5	10.7
	6	Rest	73	113/65	48	17.9	3.5	14.4
		Exercise	83	124/67	57	17.8	3.2	14.6

Various methods* for measuring the rate of blood flow have been described. The method of Winternitz and his associates[1] as modified by Gargill[2] was found most suitable. These investigators used an aqueous solution of sodium dehydrocholate, marketed as "Decholin", as the test material for intravenous injection.

Six cc. of the content of a 10 cc. ampule of a 20% solution of sodium dehydrocholate were aspirated into a sterile 10 cc. syringe using an 18 gauge needle. A vein in the antecubital space of the arm was entered and 3 cc. of the solution were injected as rapidly as possible. The time taken for injection as well as the time of onset of the bitter taste on the end of the tongue were registered by means of a stop watch. After an interval of one or 2 minutes, with the needle still in place, another 3 cc. of the solution was injected and the velocity of blood flow was again measured. Second injections were not made at 6 atmospheres pressure due to the rapidity of blood clotting when under increased air pressure.

Observations were made upon resting subjects and upon the same subjects after standard exercise, *i. e.,* subject standing, squatted on his heels simultaneously raising his arms to a horizontal position and returned to normal standing position 20 times in 30 seconds. Observations were then made upon the same subjects at 6 atmospheres air pressure under resting and exercise conditions as outlined above. All observations were made with the subjects in the recumbent position. The injections were made within 10 seconds after exercise.

Pulse and blood pressure were taken on the resting subjects just before the injections of "Decholin" were made. Pulse and blood pressure were taken immediately after standard exercise on all subjects. When the pulse and blood pressure had returned to normal the subjects again exercised and the injections were made.

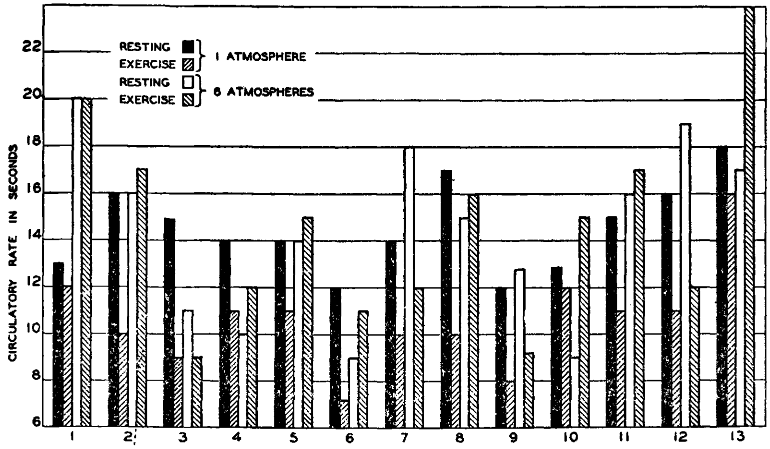
Thirteen men accustomed to working under increased air pressure acted as subjects in these experiments. The complete results of this study are given in Table I. The velocity of blood flow is shown graphically in Chart 1.

The velocity of blood flow as measured by the arm to tongue circulation time was determined at atmospheric pressure with the subjects resting and was found to average 14.5 seconds, with 12 seconds the fastest and 18 seconds the slowest rate of flow measured. These results compare favorably with those reported by

* Bibliography, see Gargill.

[1] Winternitz, M., Deutsch, J., and Brull, Z., *Med. Klin.*, 1931, **27**, 986.

[2] Gargill, S. L., *New Eng. J. Med.*, 1933, **209**, 1089.



Subjects.

CHART 1.

other investigators using either the "Decholin" or the radioactive method. Gargill[2] using "Decholin" in 50 subjects reported an average actual circulation time of 15 seconds.

After exercise at atmospheric pressure the rate of flow was faster in all subjects. The average was 10.7 seconds, with 7 seconds the fastest and 16 seconds the slowest measured. The average rate of flow was 3.8 seconds faster than with the subjects in a resting condition.

The average pulse in resting subjects was 68 but after exercise the average pulse was 104. The average pulse pressure of resting subjects was 48 which increased to 86 after exercise. Thus as would be expected it was found that pulse, pulse pressure and velocity of blood flow increased after exercise at atmospheric pressure, and this increase was noted in all the subjects.

The velocity of blood flow at a pressure of 6 atmospheres was measured in the same subjects at rest and was found to average 14.4 seconds with 9 seconds the fastest and 24 seconds the slowest rate of flow measured. Although this was the same average as that found in resting subjects the variation among the subjects was greater. The increased air pressure did not affect the blood flow of all the subjects in the same way for the rate of flow was increased in 3 subjects, remained the same in 6 and decreased in 4 subjects. Neither did it affect the pulse nor pulse pressure in the same way in all individuals for in some it increased and in some it decreased.

The average rate of flow in the same subjects after exercise at 6 atmospheres pressure was 14.6 seconds, 7 seconds being the fastest and 24 seconds the slowest rate of flow measured. This average was 3.9 seconds slower than after the same standard exercise at one atmosphere, and was practically the same as the average rate of blood flow in the subjects at rest either at one or 6 atmospheres pressure.

The effect of air pressure on the blood flow of the subjects after exercise was even more marked than on the resting subjects. Unlike exercise at one atmosphere the rate of blood flow did not increase in all the subjects. The rate of blood flow was increased by exercise in only 4 subjects, remained the same in one, was apparently slower in 4 and was decidedly slower in 4 other subjects. Neither did the pulse nor pulse pressure show the same degree of change after exercise at 6 atmospheres that it did after exercise at one atmosphere; the increase in the average pulse rate (Table I) was but 10 per minute following exercise at 6 atmospheres while following exercise at one atmosphere the increase in the average pulse rate was 36 per minute. The increase in the pulse pressure following exercise at 6 atmospheres was but 9 mm. Hg. while at atmospheric pressure the increase in the pulse pressure was 38 mm. Hg. Neither the pulse nor the pulse pressure was increased in all subjects, but decreased in some. It is thus shown that exercise at 6 atmospheres pressure does not have the same stimulating effect on the circulatory system that it has at one atmosphere.

Cardiac outputs as calculated by the formula of Fürst and Soetbeer[3] indicate that the minute volume of a resting subject at atmospheric pressure in most cases decreases when the same subject is at rest under increased air pressure. Although these calculations are empirical it is apparent that studies of cardiac output under increased air pressure are important. Further studies of minute volume under increased air pressure are now in progress.

Summary and conclusions. 1. Data have been presented showing the velocity of blood flow, pulse and blood pressure on 13 subjects while at rest and following exercise both at one and 6 atmospheres pressure. 2. Velocity of blood flow, pulse and pulse pressure increased following exercise at one atmosphere. 3. The velocity of blood flow was increased in 5, remained the same in 4 and decreased in 4 resting subjects at 6 atmospheres pressure. 4. Exercise at 6 atmospheres pressure does not have the same stimulating effect on the circulatory system that it has at one atmosphere. 5. Six atmospheres of pressure does not have the same effect on the velocity of blood flow in different individuals either at rest or after exercise.

[3] Fürst, T., and Soetbeer, F., *Deut. Arch. fur Klin. Med.*, 1907, **90**, 190.