THE EFFECT OF INHALATION OF OXYGEN ON THE RATE OF THE PULSE IN HEALTH.

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None of the early workers on the effect of oxygen on the pulse seem to have noted any effect on the rate except Demarquay(1) who stated that it is generally increased, although in some cases this does not occur and in others a slight slowing is produced. In 1871 H. A. Smith(2) made some observations on twelve healthy persons. He found that in four of these there was no alteration in the pulse rate but in the remaining eight a fall occurred averaging nine beats per minute. Neither of these observers gives any account of the methods he employed. Some years later Quinquaud(3) performed seven experiments on dogs, in which oxygen was administered from a bag for 10–20 minutes. In every case the rate of the pulse was reduced; the average rate before inhalation of oxygen was 110 and at the end of the inhalation 87. Wood and Cerna(4) investigated the action of certain gases upon the circulation and came to the conclusion that the inhalation of oxygen has no effect upon the heart. The experiments are few and unconvincing; the kind of animal employed is not stated. Loewy(5) in a valuable monograph on the effects of air mixtures at various pressures, simply mentions that continued breathing of air rich in oxygen results in a reduction of the pulse rate. From four experiments on healthy men Aron(6) concluded that oxygen has no marked effect on the pulse rate but tends to *increase* it. In one experiment the rate remained the same before and after oxygen, in two the rate increased by two, and in the remaining one by four. No details are given of the methods employed. The first careful and unexceptionable investigation into "the effects on men at rest of breathing oxygen-rich gas mixtures" was made in 1911 by Benedict and Higgins(7). Mixtures containing 90 % oxygen were breathed in a respiratory chamber for 10–15 minutes. Each experiment was repeated with air in place of oxygen. Full details and figures are given

of twenty-one experiments on six subjects. The average rate of the pulse whilst breathing air was 64 and whilst breathing 90 % oxygen for 10–15 minutes it was 60.

Experiments and results. Twenty experiments and five controls were performed on ten healthy students who kindly consented to assist. No inquiry was made concerning their normal pulse rate. No experiment was repeated on the same day. The subject reclined on a bed for 30–40 minutes before any observations were made. A Mackenzie's ink polygraph (with time marker) was then connected with the wrist. Tracings were taken at intervals of five minutes throughout the experiment. Each tracing was long enough to permit a count of half a minute in experiments 1–10 and of a minute in experiments 11–25. The period as given by the time marker was measured by dividers on every tracing in order to eliminate possible variations in the rate of the clockwork. By using a polygraph the personal factor in counting was eliminated and the rate of the pulse ascertained at the end of the experiment.

Tracings were taken ten minutes, five minutes, and immediately before oxygen was given. Oxygen from a cylinder (*i.e.* commercially pure) was then administered for thirty minutes through the bag and mask of an ordinary nitrous oxide inhaler with inspiratory and expiratory valves. During the thirty minutes of oxygen inhalation, tracings were taken at the end of each period of five minutes. Three tracings were taken five, ten, and fifteen minutes after the administration had been stopped.

The five control experiments were made in exactly the same manner except that a cylinder of *air* replaced the cylinder of oxygen. The five subjects were chosen from those students in whom the "slowing" action of oxygen was most definite. They were unaware of the fact that air had been substituted for oxygen. It may be suggested that the pulse rate would fall slightly apart from oxygen, even after 30–40 minutes rest in the horizontal position. The fall in rate on giving oxygen and the rise when it was stopped are too definite for such to be the explanation, and the control experiments clearly show that this objection cannot be maintained. The rate of respiration was not measured because the method of administration through an inhaler admits of too many sources of error. A respiratory chamber would be necessary for observations on the rate of respiration and such have already been made by Benedict and Higgins(7) who found no change.

TABLE I.

The pulse rate at the end of each period of five minutes.

		Before oxygen			During oxygen						After oxygen		
	Minutes:—	10	5	Immediately	5	10	15	20	25	30	5	10	15
Exp. 1	H.S.C.H.	65	68	65	68	64	61	59	59	65	66	58	60
,, 2	,,	—	74	76	77	73	74	74	75	77	74	78	76
,, 3	S.A.F.	—	70	70	69	66	65	64	63	64	66	65	64
,, 4	,,	70	71	71	69	67	67	60	63	66	65	65	63
,, 5	H.D.B.	90	88	90	82	85	83	85	82	83	83	84	84
,, 6	,,	79	84	77	66	64	69	72	67	70	73	79	81
,, 7	J.R.R.	54	56	54	53	55	53	53	55	57	56	58	62
,, 8	,,	71	64	62	62	63	56	59	57	61	65	64	79
,, 9	P.A.	70	72	69	69	70	69	70	65	63	65	69	66
,, 10	,,	68	68	64	61	62	65	64	60	59	67	62	68
,, 11	V.T.	57	60	58	53	58	59	58	62	59	71	66	64
,, 12	,,	42	45	46	45	47	49	47	47	44	51	48	51
,, 13	C.B.	67	65	68	69	66	61	59	62	60	62	61	66
,, 14	,,	65	64	65	61	63	63	60	59	56	58	64	59
,, 15	T.H.T.	80	75	76	75	73	70	71	67	71	57	74	74
,, 16	,,	80	79	77	80	78	79	79	80	72	85	74	79
,, 17	G.M.C.	75	69	68	64	64	63	62	64	62	68	65	64
,, 18	,,	68	65	63	61	61	60	58	60	59	61	62	62
,, 19	A.R.M.	63	60	60	60	60	61	58	59	57	60	59	60
,, 20	,,	69	69	66	65	65	67	60	62	61	63	63	62
Average		68·5	68·3	67·2	65·4	65·2	64·7	63·6	63·4	63·3	66·8	65·9	67·2

Calculating from these average figures the rate of the pulse was:—

68 before oxygen
64·2 during oxygen
66·6 after oxygen had been stopped.

TABLE II.

(*Control Experiments.*)

		Before *air*			During *air*						After *air*		
	Minutes:—	10	5	Immediately	5	10	15	20	25	30	5	10	15
Exp. 21	S.A.F.	64	61	61	62	61	62	60	63	59	59	60	61
,, 22	C.B.	53	52	49	60	56	57	56	60	60	53	53	57
,, 23	J.R.R.	54	53	59	56	53	55	57	54	54	54	51	56
,, 24	G.M.C.	68	64	65	67	65	63	63	61	63	61	63	63
,, 25	A.R.M.	59	59	61	57	58	61	57	60	57	58	60	61
Average		59·6	57·8	59	60·4	58·6	59·6	58·6	59·6	58·6	57	57·4	59·6

Calculating from these average figures the rate of the pulse was:—

58·7 before administration of *air*
59·1 during administration of *air*
58 after administration of *air* had been stopped.

These results prove that the rate of the pulse in health is usually reduced by the inhalation of oxygen. The experiments on V. T. (11 and 12) showed in one case an increase in the average rate by two beats and in the other no change. His pulse is always unusually slow in rate and shows extra-systoles. In H. S. C. H. and J. R. R. one experiment showed a definite reduction in pulse rate and the other no change. The remaining experiments all showed reduction in the rate. A reference to Table I suggests that the change usually begins in the first few minutes of the inhalation and the rate continues to fall slightly throughout the thirty minutes of administration. After the oxygen is stopped the pulse rate at once increases and almost regains the original rate in fifteen minutes.

The explanation of this action of oxygen is difficult. It does not appear to be due to interaction of the respiratory and cardio-inhibitory centres for there is no evidence that the respiratory rate is affected by oxygen (see Benedict and Higgins(7)). Nor is there evidence that any alteration in the blood-pressure occurs. In Experiments 1, 3, and 5 and in two other subjects the blood-pressure was measured by a modified Riva-Rocci Sphygmomanometer before and after the inhalation of oxygen for half an hour; no change was observed. Although the viscosity of the blood is said to be reduced by oxygen inhalations in polycythæmia from various causes, it has not been claimed that in health any such effect on the blood is obtained.

It is probable that the heart muscle supplied with excess of oxygen itself works at greater advantage and also provides the amount of oxygen needed by the tissues with less expenditure of energy, *i.e.* by fewer beats. Whatever the explanation may be, this effect of oxygen on the pulse rate is further evidence that the blood, even in health, will take up additional oxygen when an excess is offered. The oxygen must be absorbed before it can affect the cardio-vascular system. In those cases of disease of the heart and lungs in which the rate of the pulse is increased, the administration of oxygen will be found as a rule to reduce the rate. Doubtless the greatest effect is produced when the heart is ill supplied with oxygen, but reduction in rate must also be attributed in part to this pharmacological action of oxygen.

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