EFFECTS OF ACUTE HYPOXIA ON THE PERFORMANCE OF PSYCHOLOGICAL TESTS

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The effect of 'partial oxygen want' on general mental functioning of pilots flying at high altitudes has been investigated by subjecting flight cadets to different altitude conditions simulated in a decompression chamber. The study is restricted to an assessment of performance as reflected on the G.V.K. intelligence test series. The effects of hypoxia are apparent only at altitudes of 12,500 ft. and above. Oral administration of methylene blue does not seem to enhance tolerance to oxygen want.

When an air pilot ascends to high altitude during a flight, certain alterations take place in his environment which significantly influence his performance and well-being. These changes are brought about by the decrease in the partial pressure of oxygen in the atmosphere and hence in the inhaled air. Since the passage of oxygen from the alevioli to the small capillaries in the lungs is dependent on the partial pressure of oxygen inhaled, a lower partial pressure results in a restricted supply of oxygen to the capillaries and consequently to the body tissues. The condition that is brought about by a lowered concentration of oxygen in the air breathed is commonly known as 'ANOXIA', that is absence of oxygen. Since the common usage of this term implies intermediate degrees of oxygen want, the term 'HYPOXIA' is more appropriately used.

The effects of a sudden and extreme *i.e.*, acute oxygen want (HYPOXIA), as in the case of an ascending aircraft, are quite different from those of repeated or prolonged exposures *i.e.*, chronic oxygen want (ANOXIA) as in the case of troops stationed at high altitudes. The present study concerns itself with the condition of acute oxygen want when breathing air. The effects are known to be apparent at altitudes of 10,000 feet and above when the arterial oxygen[1] falls below 85%. At about 10,000 feet many subjects show impairment of such mental functions as memory and reasoning. The ability of the eye to become dark-adapted is progressively impaired. A reduction in an airman's ability to see at night takes place at altitudes as low as 5,000 feet to 6,000 feet[2,3]. The average number of words recalled in standardized tests of memory shows a significant decrease at altitudes of approximately 10,000 to 12,000 feet[4]. Certain other effects, on the subjects, that may be attributed to oxygen want are fluctuation of attention, sleepiness, headache, breathlessness, and release of normal inhibitions. Such emotional reactions as euphoria, overconfidence, pugnaciousness, or moroseness may also occur[5]. This study attempts to find out if the oxygen want at high altitudes results in a lower level of general mental functioning and if so at what altitude are the effects evident. The level of general mental functioning has been measured by the performance on the G.V.K. Intelligence test series.

Methylene blue is a dye which is readily reduced to a series of colourless compounds and may be reoxidized to the blue dye. Through these reactions it acts as an oxidizing and reducing carrier. On the theory that it would take the place of hoemoglobin as a conveyor of oxygen to the body tissues, methylene blue has been used in carbon monoxide poisoning. It is reported to improve efficiency of performance at high altitudes, if 0·02

to 0·04 gm is administered two hours before the ascent[6]. On the assumption of a possible oxygen transportation function of methylene blue, an attempt has been made in this study to determine the efficiency of this dye in enhancing the tolerance to lack of oxygen at high altitudes, it being assumed that it would compensate for the lowered partial pressure of oxygen in the air inhaled by providing additional oxygen carrying capacity in the blood.

EXPERIMENTAL PROCEDURE

G.V.K. test series

G.V.K. test series consist of the following :—

G. test—It is a non-verbal test of intelligence containing incomplete matrix type drawings. The subject has to mark the drawing which completes the matrix. There are 59 items in the test.

V. test—It is a verbal test of intelligence which contains questions involving opposites, similarities, making adjectives and nouns, picking verbs, filling blanks, punctuation and comprehension. In all there are 86 items in the test.

K. test—It is a test of Kinesthetic ability of the spatial relations and the mirror—image type. The test contains four parts. The first part requires the subject to sub-divide a given figure into three parts, so as to obtain the three parts of exactly the same shape and size as the three illustrated pieces. The second part consists of copying exactly, on the given dotted space, the given design. The third part requires the subject to draw given shapes, as they would appear in water, that is, to draw each shape upside down. The fourth part is very much similar to the first part except that the pieces to be drawn by the subject are different for each figure. In all there are 45 items in the test.

Design and sample

The three Psychological tests were administered to five different groups of 25 flight cadets, each at different levels of altitude conditions, simulated in a decompression chamber. The levels of altitude studied were :

(*a*) Ground level;

(*b*) 10,000 feet;

(*c*) 12,500 feet;

(*d*) 15,000 feet;

(*e*) 17,500 feet above ground level.

Each group of flight cadets was further sub-divided into two sub-groups. Members of one sub-group at each level being given one grain of methylene blue before being subjected to the assigned altitude conditions in the decompression chamber. The aim was to study the effectiveness of methylene blue in enhancing tolerance to altitude.

The subjects for this study were undergoing flying training at various flying training academies in India.

The analysis has been done on the assumption that the cadets performing at different altitudes and the cadets belonging to the two sub-groups at each altitude level are basically of the same ability, the only difference being with regard to the altitude level

and the administration of methylene blue. It was ensured that the various sub-groups matched with regard to average age, service experience and educational qualifications. The distribution of the total sample over the different conditions is given in Table 1.

The allocation of groups to altitudes and drug treatment to sub-groups in each altitude group was done at random.

RESULTS

Effects of hypoxia and altitude levels

Table 2 gives the average performance of the groups of cadets at different altitudes on the three psychological tests, ignoring the drug which had been given to a sub-group selected at random from each of the groups and which does not seem to affect the performance on the tests in a systematic manner (see Tables 3, 4, and 5). Table 2 also shows the standard deviation and size of each group.

Effect of methylene blue at various altitudes

Tables 3, 4 and 5 give the average performance of the various sub-groups of cadets at various altitudes on G.V.K. tests respectively. They also show the significance of the difference in the average performance of the two sub-groups, that is, with and without drug, at each level.

TABLE 1

DISTRIBUTION OF THE SAMPLE OVER THE VARIOUS CONDITIONS

Altitude	No. of cases	
	With drug	Without drug
Ground level	10	15
10,000 ft.	10	15
12,500 ft.	10	15
15,000 ft.	10	14*
17,500 ft.	9*	14*

*Complete data in respect of one cadet in each of these sub-groups were not available.

TABLE 2

AVERAGE SCORES OF CADETS AT VARIOUS ALTITUDES

Altitude	Sample size	G. Test		V. Test		K. Test	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Ground level	25	10·40	7·52	14·76	5·70	13·92	5·96
10,000 ft.	25	15·36	6·14	16·56	6·36	11·32	4·30
12,500 ft.	25	12·20	6·51	18·36	6·59	13·20	6·32
15,000 ft.	24	11·32	5·96	14·12	5·95	12·04	6·27
17,500 ft.	23	11·60	11·26	15·35	8·65	10·83	4·92

TABLE 3

AVERAGE SCORES ON G TEST AT VARIOUS LEVELS AND FOR DIFFERENT SUB-GROUPS

Sub-group	Ground level	10,000 ft.	12,500 ft.	15,000 ft.	17,500 ft.
With drug	12·30	14·50	13·50	11·70	14·78
Without drug	9·13	15·93	11·33	11·07	9·57
Differences	3·17	—1·43	2·17	0·63	5·21
't'	3·75	1·97	3·75	1·97	2·77
Significance	Sig. at 1% level	Not sig. at 5% level	Sig. at 1% level	Not sig. at 5% level	Sig. at 5% level

TABLE 4

AVERAGE SCORES ON V TEST AT VARIOUS LEVELS AND FOR DIFFERENT SUB-GROUPS

Sub-group	Ground level	10,000 ft.	12,500 ft.	15,000 ft.	17,500 ft.
With drug	15·30	16·70	18·80	13·10	14·44
Without drug	14·40	16·47	18·07	15·28	15·93
Differences	0·90	0·23	0·73	—2·18	—1·48
't'	1·27	0·31	0·90	3·05	1·22
Significance	Not sig. at 5% level	Not sig. at 5% level	Not sig. at 5% level	Sig. at 1% level	Not sig. at 5% level

TABLE 5

AVERAGE SCORES ON K TEST AT VARIOUS LEVELS AND FOR DIFFERENT SUB-GROUPS

Sub-group	Ground level	10,000 ft.	12,500 ft.	15,000 ft.	17,500 ft.
With drug	12·90	11·30	14·40	11·50	10·89
Without drug	14·40	11·33	12·40	13·14	10·79
Difference	—1·50	—0·03	2·00	—1·64	0·10
't'	2·09	0·06	2·43	2·22	0·16
Significance	Sig. at 5% level	Not sig. at 5% level	Sig. at 5% level	Sig. at 5% level	Not sig. at 5%level

NOTE—In the above Tables Cochran's test was applied to test the difference between the sub-groups whose variances were not homogeneous.

DISCUSSION

Effect of altitude on the performance of psychological tests

A perusal of Table 2 shows that the mean scores of the cadets on G and V tests seem, initially, to rise with the increase in altitude. In the case of G test, the rise in scores is upto a height of 10,000 feet and thereafter the mean scores tend to decrease to a level almost the same as that at the ground level. In the case of V test the rise in performance continues upto an altitude of 12,500 ft. and declines thereafter.

At 10,000 ft., the mean of the scores of cadets on G test is significantly greater than the mean score of cadets either at ground level or at 15,000 ft. or 17,500 ft. Other differences are not significant. On the V test, the mean score at 12,500 ft. is significantly greater than the mean score of cadets either at ground level, or at 15,000 ft., the other difference being not significant.

The performance on K test does not follow any regular pattern. In fact, statistical tests, when applied to mean scores at different altitudes show that the variation in the average performance at the altitudes studied is not significant and the performance at the various altitudes could be taken to be the same.

The performance of a pilot during flight is affected by two main factors operating in opposite directions. One of the factors is the instinctive sharpening of the senses as soon as a pilot is airborne. This tends to raise the efficiency of the senses and an improvement in performance results. The other factor which tends to decrease the level of performance of an airborne pilot is the setting in of hypoxia due to lack of Oxygen. It appears that upto an altitude range of 10,000 ft. to 12,500 ft. the instinctive sharpening of senses consequent on being airborne, neutralizes the effect of hypoxia beyond the 12,500 ft. level, however, the hypoxial effects predominate and the instinctive compensatory mechanisms no longer suffice to counteract the effect.

Effect of methylene blue

A perusal of Tables 3, 4 and 5 shows that there is no systematic effect of the administration of one grain of methylene blue on the performance of the three psychological tests. In most cases the average performance of the sub-group treated with methylene blue is not significantly different from that of the sub-group not so treated. Even in cases where the average performance of the sub-groups does differ significantly, the performance of the group treated with methylene blue is not always greater than the corresponding sub-group not so treated. It may be concluded, therefore, that this dosage of methylene blue does not have any effect on the performance of these psychological tests at the levels of altitude studied.

It is likely that the dosage given to the cadets was not sufficiently large to produce the desired effect. It would be worthwhile to study experimentally the effects of varying dosages. The sample for this study was rather small and it would be worthwhile to repeat the experiment on a larger sample.

CONCLUSIONS

The effects of hypoxia are apparent only at altitudes of 12,500 ft. and beyond. Upto 12,500 ft., the performance increases due to instinctive sharpening of senses as soon as a pilot is airborne.

The dosage of methylene blue administered viz., one grain, does not seem to enhance tolerance to altitude. Further experimentation with higher dosages may be taken up.

It would be worthwhile to carry out the study on a larger sample and to study the effect of varying dosages of methylene blue.

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