RESEARCH REPORT 1

A PROCEDURE FOR SELECTION OF DIVING AND AVIATION PERSONNEL RESISTANT TO DECOMPRESSION SICKNESS BASED ON TESTS IN A LOW PRESSURE CHAMBER

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SUMMARY AND CONCLUSION

1. In a group of young, lean student divers resistance to bends was determined by two 2-hour simulated ascents to 38,000 feet in the low pressure chamber, rate of ascent 5,000 feet per minute.

2. During the first exposure the most susceptible individuals, poor group (22 men) developed bends or chokes during the first hour at rest, and the somewhat less susceptible, fair group (40 men) developed bends during the exercise period of the second hour.

3. During the second exposure consisting of 2 hours with exercise at the same altitude, 50% of the most resistant individuals, good group (30 men), remained free from symptoms while 96% of the less resistant individuals, fair group (27 men), developed bends or chokes.

4. In a third exposure consisting of 2 hours of rest at 38,000 feet and serving to check the observations made during the first and second tests, 12 out of 27 men previously classified as fair failed to remain symptom free, while only 3 out of 38 men previously classified as good developed symptoms.

INTRODUCTION

The usual method of inducing experimental decompression sickness (bends), that of reducing the ambient pressure below atmospheric, affords a convenient and satisfactory means of studying some aspects of this phenomenon as it relates to both deep sea diving and aviation. A matter of considerable importance in both aviation and diving pertains to the status of exercise during the decompression period. Previously it was believed that exercise during the decompression of divers was beneficial on the ground that the augmented circulation promoted faster nitrogen elimination. On the basis of simulated altitude decompressions however, there is a greater susceptibility to bends as the result of exercise or the incident muscular strain. The question is, do the observations at altitude apply to deep sea diving?

It has been established by Behnke(1) on the basis of comparative symptoms that the decompression sickness resulting from ascent to high altitude is similar to the symptoms which follow inadequate decompression after a sojourn in compressed air. The disturbance in both conditions appears to be that of altered sensory and motor function caused by local impairment of circulation. Specifically, it appears to be a matter of intra- and extravascular accumulation of gas bubbles with carbon dioxide playing an important but less understood role.

There are certain differences in diving and aviation bends however which makes the former, in some respects, a more serious and more refractory disturbance. Piccard's calculations and conclusions postulate the belief that at altitude, bubbles although larger, are not only fewer in number but are less likely to form than those arising as a result of diving operations(3). He believed that this explained why there is greater danger for a deep sea diver in rapid ascent from a depth of 132 feet (5 atmospheres) than in an aviation ascent from sea level to an altitude of 38,397 feet (one-fifth atmosphere) even though the decompression ratio in both cases is 5 to 1. Further a difference in the percentage composition of bubbles formed under high as compared with low pressure, as computed by Behnke and Wilmon(2), renders aviation bends more amenable to treatment and consequently less dangerous than diving bends. At altitude the percentage of carbon dioxide and water vapor are proportionately higher at the expense of nitrogen in the bubble, while at diving depths the bubble contains a high percentage of nitrogen which is relatively insoluble and hence very slowly absorbed on recompression. In experimental altitude bends the severest symptoms are easily controlled and can be relieved immediately be decreasing the altitude. Diving bends on the other hand usually require many hours of recompression.

The ability of the body to rid itself of an excess of dissolved gas without bubble formation during decompression depends not only upon the amount f gas dissolved, especially in the mass of body fat, but also upon the efficiency of circulation in terms of effective blood flow through the tissues. It is apparent, therefore, that many variables including age and body weight, influence the susceptibility to decompression sickness. It was desirable, therefore, in the present study to gather data regarding the incidence of bends in relation to fat content of body as determined by the method of specific gravity and to make an estimate of circulatory efficiency as determined by the step-up test(5). It was realized at the start, however, that the subjects used were a homogeneous, preselected group of men characterized by leanness as well as better than average cardiovascular systems.

METHOD OF PROCEDURE

The present study was conducted at room temperature utilizing a naval recompression chamber adapted for use as a low pressure unit. The pressure was reduced at a rate of 5,000 feet per minute to simulate an altitude of 38,000 feet. Oxygen was inhaled by the subjects during the ascent and throughout the entire period at altitude. A total of 110 men were exposed for the most part for three flights, each of two hours maximal duration or until such time within the two-hour period that a subject suffered intolerable bends or chokes. Frequently a flight would have to be terminated and repeated on another day because of abdominal pain arising from the expansion of intestinal gas. The subjects were robust individuals between the ages of 18 and 25 years with a mean of 23.9 years. All individuals had been found physically qualified or general naval service and further were qualified for deep sea diving.

In the first test the subjects sat at rest reading or writing letters for the first hour, and then performed exercise at intervals during the second hour. The standard exercise consisted of 3 squats and the 3 arm thrusts holding a 3 1/2 pound sand bag ineach hand. This procedure was repeated every 10 minutes.

During the second test exercise was begun 10 minutes after reaching 38,000 feet, and was repeated every 10 minutes during the entire two-hour flight. The subjects included in this run were those who remained symptom free or whose bends occurred in the second hour of the first test.

In the third test the subjects remained at rest for the entire 2-hour period. The participants were the survivors of the first flight and included those men who showed no symptoms or those whose bends occurred during the second hour.

The body fat of the subjects was determined by the method of specific gravity(4). For measurement of circulatory efficiency the step-up test (5) was performed on two occasions, at the beginning of the diving school term and again upon the completion of the students' course four months later. The cardiovascular score was computed as the sum of the pulse rates counted 5 to 20 seconds and 105 to 135 seconds following exercise.

RESULTS

The following tables 1, 2, and 3 present the results of the three altitude tests and tabulate values for specific gravity, cardiovascular score, age, height, and weight.

The data in summary are;

Test 1 (one hour at rest and one hour at exercise)

Poor group - 22 men (22%) who failed in first hour.
Fair group - 40 men (40%) who failed in second hour.
Good group - 38 men (38%) who completed two hours.

Test 2 (two hours exercise)

Poor group - no flights.
Fair group - 26 men (96%) out of 27 failed.
Good group - 15 men (50%) out of 30 failed.

Test 3 (two hours at rest)

Poor group - no flights.
Fair group - 12 men (44%) out of 27 failed.
Good group - 3 men (8%) out of 38 failed.

COMMENTS

It was observed that there was no difference between the poor, fair, and good group with regard to specific gravity values, age, height, weight and cardiovascular scores. As a result of these tests it is believed that the men most resistant and those who are most susceptible to bends have been selected.

The procedure for selection of personnel can, therefore, be incorporated into two tests,

1. 1 hour rest and 1 hour exercise at 38,000 feet.
2. 2 hours exercise at 38,000 feet.

The most susceptible men are eliminated in the first hour of the first test while the most resistant men will not develop symptoms during the second test.

The authors acknowledge their indebtedness to Dr. A.C. Ivy for the outline of the first procedure and a general discussion of the problem.

TABLE NO. 1

DURATION OF STAY OF GOOD GROUP AT ALTITUDE WITH REFERENCE TO TEST PROCEDURES 1, 2, and 3.

JBJ. NO.	AGE	LBS. WT.	2 hour rest at 38000 ft. (min) (test 3)	1 hour rest, 1 hour ex. 38000 ft. (min) (test 1)	2 hour exercise 38000 ft. (min) (test 2)	CARDIO-VASCULAR SCORE *	SPECIFIC GRAVITY
1	25	160	120	120	120	61	1082
2	24	148	120	120	120	68	1100
3	19	147	120	120	120	59	
4	18	153	120	120	120	75	
5	19	149	120	120	120	66	
6	26	129	120	120	120	76	1107
7	22	134	120	120	120	68	1083
8	22	172	120	120	120	70	
9	27	174	120	120	120	70	1064
10	29	156	120	120	120	75	1084
11	26	147	120	120	120	65	1103
12	25	161	120	120	120	62	1090
13	22	155	120	120	120	74	1085
14	28	150	120	120	120	66	1081
15	19	143	120	120	120	71	1097
16	27	181	120	120	91	66	1066
17	29	175	120	120	83	68	1074
18	23	184	120	120	75	55	1062
19	22	156	120	120	43	63	1069
20	34	144	120	120	61	51	1100
21	27	163	120	120	45	74	1081
22	27	148	120	120	45	68	1087
23	19	170	120	120	54	70	1083
24	29	132	120	120	54	67	1088
25	24	150	120	120	70	62	1077
26	27	162	120	120	60	65	1082
27	21	166	120	120	84	62	1091
28	23	159	120	120	53	61	1095
29	22	155	120	120	45	66	1091
30	20	165	120	120	48	59	1069
Average	24	156	120	120	89	66	1084

* Sum of the pulse rates 5 to 20 seconds and 105 to 135 seconds following exercise.

TABLE NO. 2

DURATION OF STAY OF FAIR GROUP AT ALTITUDE WITH REFERENCE TO TEST PROCEDURES 1, 2, and 3.

SUBJ. NO.	AGE	LBS. WT.	2 hour rest at 38000 ft (min) (test 3)	1 hour rest, 1 hour ex. 38000 ft. (min) (test 1)	2 hour exercise 38000 ft. (min) (test 2)	CARDIO-VASCULAR SCORE	SPECIFIC GRAVITY
1	21	158	120	79	60	58	1091
2	21	140	120	71	91	57	1087
3	22	139	120	90	21	67	1085
4	23	141	85	90	12	65	1099
5	22	140	120	71	120	72	1083
6	23	138	120	100	110	74	1097
7	26	155	120	79	27	57	1083
8	27	191	53	89	39	79	1056
9	22	161	82	88	44	70	1079
10	25	187	120	80	38	60	1063
11	25	159	120	109	38	72	1077
12	23	188	120	101	57	70	1074
13	23	161	120	111	29	63	1082
14	26	181	91	103	69	74	1081
15	23	183	77	85	69	57	1069
16	20	152	71	85	22	69	1082
17	29	184	120	93	64	69	1075
18	26	165	120	98	24	71	1093
19	23	150	21	75	22	54	1083
20	28	208	59	100	41	69	1064
21	23	157	59	97	27	82	1084
22	27	148	120	103	36	69	1097
23	22	181	42	106	24	64	1076
24	24	143	120	105	106	79	1068
25	26	156	56	88	66	63	1082
26	23	142	120	79	42	64	1094
27	29	139	106	72	90	62	1100
Average	24	161	96	91	51	67	1081

TABLE NO. 3

DURATION OF STAY OF POOR GROUP AT ALTITUDE WITH REFERENCE TO TEST PROCEDURE 1.

SUBJ. NO.	AGE	LBS. WT.	TIME AT ALTITUDE BEFORE BENDS* (min) (test 1)	CARDIO-VASCULAR SCORE	SPECIFIC GRAVITY
1	26	180	13	69	1082
2	22	145	36	77	1078
3	20	170	39	78	1087
4	22	159	22	71	1110
5	22	207	46	67	1081
6	21	153	22	82	1092
7	24	163	14	55	1080
8	29	179	18 1/2	65	1073
9	22	194	11 1/2	75	1075
10	28	176	13	77	1075
11	25	162	52	60	1079
12	21	136	52	46	1072
13	26	151 1/2	30	68	1091
14	30	148	28	53	1076
15	28	144	25	66	1085
16	23	151	15	61	1085
17	24	194	15	74	1075
18	22	167	39	69	1089
19	20	106	59	68	1092
20	24	156	54	69	1077
21	20	179 1/2	27	70	1074
Average	23.3	165.5	30	67	1082

* 38,000 feet at rest.

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13. ABSTRACT

In a group of young, lean student divers resistance to bends was determined by two 2-hour simulated ascents to 38,000 feet in the low pressure chamber, rate of ascent 5,000 feet per minute.

During the first exposure the most susceptible individuals, poor group (22 men) developed bends or chokes during the first hour at rest, and the somewhat less susceptible, fair group (40 men) developed bends during the exercise period of the second hour.

During the second exposure consisting of 2 hours with exercise at the same altitude, 50% of the most resistant individuals, good group (30 men), remained free from symptoms while 96% of the less resistant individuals, fair group (27 men), developed bends or chokes.

In a third exposure consisting of 2 hours of rest at 38,000 feet and serving to check the observations made during the first and second tests, 12 out of 27 men previously classified as fair failed to remain symptom free, while only 3 out of 38 men previously classified as good developed symptoms.