Defence Science Journal, Vol. 4, No.2, April 1954, pp. 79-89 © 1954, DESIDOC

PRELIMINARY INVESTIGATION ON FATIGUE AMONGST THE DIVERS IN THE INDIAN NAVY*

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ABSTRACT

Studies have been made on the causes of fatigue amongst the trainees in diving in the Indian Navy. Sixty percent. of the ratings found fit for training were able to complete the course successfully. Of the 40 percent. who failed a large percentage were found unfit medically or were not suited for diving temperamentally. Only 7 per cent. were disqualified professionally. Main causes of rejection on medical grounds were ottitis media or active venereal disease. After a first few dives a beginner felt exhuasted and compression of chest. The feeling decreased with training. Greater rise in pulse rate was observed in trainees who had no previous experience in diving than in those who had undergone some training. A diver has to carry the whole weight of " Standard Diving Dress " weighing about 176 lbs. during certain stages of diving. Ratings with poor physical development cannot stand the strain of diving.

Introduction

A deep sea diver is subjected to high pressure under water. The atmospheric pressure at sea level is about 15 lb. per sq. in. The pressure of a 33 ft column of sea water is equivalent to one atmosphere. At a depth of 33 ft., therefore, the combined pressure of water and air would be about 30 lb. per sq. in. Roughly for every one foot depth the pressure increases by $\frac{1}{2}$ pound per sq. in. As a result, the pressure on the head of a diver 6 ft. in height, will be about 3 lbs. per sq. in. less than that on his feet, whatever depth of water he may happen to be in. The pressure of water is transmitted to the immersed body in the form of squeeze.

To counteract the pressure of water and to maintain constant supply of oxygen a diver during diving puts on a diving suit. Various types of diving suits are available to-day, of which the one used for the training of divers in the Indian Navy is called the " Standard Diving Dress ". The weight of this dress is about 176 lbs. and one can dive up to 180 ft. with it. For deep diving an oxygen cylinder attachment is used with the dress. The helmet of the diving dress is incompressible whilst the lower part is compressible. As the diver descends the pressure increases and tends to squeeze the air out of the lower part of the dress into the helmet. To keep the upper part of the dress over the man's chest inflated, sufficient air is pumped into it, so that the pressure of air inside the dress is equal to that of the water at the level of the chest. An escape valve fitted on the helmet allows the surplus air to leak. The valve can be adjusted by the diver to suit his convenience. A good diver can adjust the valve in such a way that he will not feel any pressure on his

*Based on a Defence Science Organisation report by the author.

chest. The pressure of the air at the mouth level is transmitted to the inside of the body and in this way the pressure inside the body remains nearly the same as that outside in all depths. The air is pumped into the dress from outside by means of a pump.

Diving Operation

The diver is dressed up in the complete 'Standard Diving Dress' in the boat with the exception of front glass of the helmet and the front and back weights of 40 lbs. each (Fig. 1).

FIG. 1

He then gets on to the ladder carrying about 100 lbs. of weight on his body. As soon as he is properly placed on the ladder the front and the back weights are put on. Lastly the front glass of the helmet is screwed up. The

diver then descends into the water (Fig. 2) where the weight of the upper part of the dress is kept off his chest by the air pumped into it, so that only the

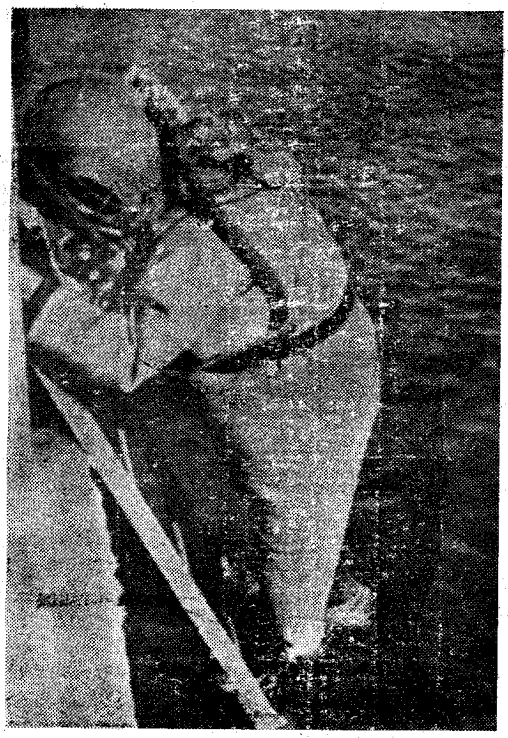
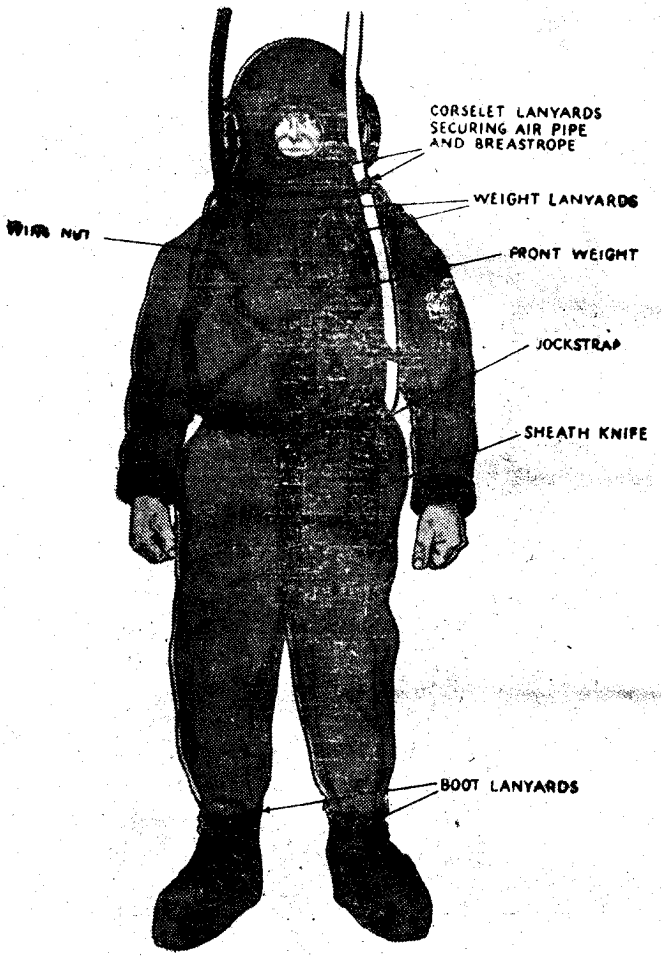


FIG. 2

weight of the boots (20 lbs each) is felt by him. On coming up, he climbs the ladder with full weight of the dress (176 lbs.) till he is in a position when the front and the back weights can be removed. This is the hardest part of the

whole diving operation, where he has to climb against gravity with this heavy weight. Front view of a diver dressed in the standard diving dress is illustrated in Figure 3[1].



DIVER EQUIPPED. FRONT VIEW

FIG. 3

Under water a diver is required to move from place to place against the current and has to work against the resistance, offered by water. The energy required for a task done under water is much more than for a similar one performed on land.

Requirements

The training for divers is being conducted in Cochin harbour where the depth of the sea does not exceed 60 ft. Therefore the diving is restricted to this level. Some divers however, do get occasional opportunities of practice in deep diving at Trincomallee. A diver is required to remain under water normally for about an hour at the maximum. If work for a longer period has to be carried out a second diver, if available, is sent to relieve him. For qualifying for Diver III course usually a task which can be completed in 30-40 minutes is given.*

Diving Courses

Class III and Class II diving courses are run by the diving school whilst Class I divers are sent to U. K. for training. The candidates for Class III course which lasts for 55 working days, are selected from amongst the seamen and stokers with 2-3 years service. In future, however the minimum qualification required for initial selection for diver Class III will be one year's sea service. The trainees for Class II course are selected from Class III divers who have had about 2 years diving experience after the initial training. The period of training for this course is the same as for Class III. Both the courses are run simultaneously and in each class there are about 4 trainees. Their number is increased to about 8 when only one course is conducted.

Aim of the present study

It was reported that Indian Navy Divers got exhausted in a relatively shorter period than those of Royal Navy. This was considered to be due to dietetic factors. The investigation of the problem on a scientific basis was considered essential. Before the plan of work could be formulated a preliminary visit was made to the diving school at Cochin to obtain the data on diet and physical development of divers and to study their working conditions. The following points were studied :—

(*a*) Results of the different courses run by the diving school from January 1950 to January 1953.

(*b*) Physiological measurements of ratings under training.

(*c*) Nutritional requirements of divers.

(*d*) Sea temperature at Cochin Harbour.

(*e*) Diving experience of untrained officers.

Results of the Diving Courses

Table I gives the number of students and their results in the different courses conducted by the diving school from January 1950 to January 1953.

* The training syllabus of the divers in the I.N. is the same as for the R.N.

TABLE I

Results of the Diving courses run by the Diving School, at Cochin during the period January, 1950 to January, 1953.

Course No.	Number of trainees for the course	Number passed	Number failed				Percentage of successful trainees	Percentage of unsuccessful trainees
			Medically	Temperamentally	Professionally	Total		
1	2	3	4	5	6	7	8	9
1	8	4	3	..	1	4	50	50
2	5	4	1	..	..	1	80	20
3	2	2	..	..	..	..	100	..
4	6	3	2	1	..	3	50	50
5	2	1	..	1	..	1	50	50
6	5	3	..	1	1	2	60	40
7	2	1	1	..	..	1	50	50
8	4	2	1	..	1	2	50	50
9	6	4	1	1	..	2	66·7	33·3
Total	40	24	9	4	3	16		
Percentage of the total	60		22·5	10	7·5	40		

From Table 1, it is seen that the number of trainees in each course is less than 8 except for course No. 1, and in the 3rd, 5th and 7th courses, their number is only two in each. This is beacause a larger number of volunteers, on arrival at the school were found medically unfit to undergo the training and were sent back to their ships/establishments. The candidates thus rejected have not been included in the table. On the average, sixty per cent of the ratings attending the course were able to qualify. Out of the 40 per cent who failed, 22·5 per cent were those who were declared medically unfit during the course, and 10 per cent were those who refused to dive after the first week. The latter being of neurotic temperament were afraid to dive. Only 7·5 per cent were unable to qualify professionally. No data on the physical development of the candidates who failed professionally could be obtained. It was, however, pointed out by the officer-in-charge, of the school, that all these ratings had a comparatively poor physique.

Physiological Measurements

During the visit, two courses with four trainees in each, one for Class II and the other for Class III, were being conducted by the School. Two of the students of Class II course were working as instructors in the school for about a year and the other two had qualified as divers Class III one year ago. The trainees for Class III course had no previous diving experience. The physiological measurements made on all the eight trainnees in order to compare the physiological findings on trained divers and untrained ones are as follows :—

(*a*) Height
(*b*) Body weight
(*c*) Chest expansion
(*d*) Pulse rate before and after diving
(*e*) Blood pressure
(*f*) Haemoglobin level of blood
(*g*) 40 mm mercury test[2]
(*h*) Physical efficiency test (Defence Science Laboratory Test.)[5]

The results of the above measurements have been presented in table II (appendix I). Out of all the eight trainees only one was considered unsuitable as he got exhausted quickly. He had been recruited as a boy but by the end of the boy's training was not able to attain the normal physical standard required of his age. He was under-weight for his height. His chest expansion was also poor being only $1\frac{1}{4}$". No signs of malnutrition were observed in him or in any other diver. It would be seen from table II, that except for the above mentioned diver, the body weights of all the ratings were within the normal range and all of them had normal blood pressure, haemoglobin content and 40 mm mercury test. Significant difference was observed in the " Pulse rate after diving " between the ratings of the two classes. It was higher in the students of Class III course than in those of Class II. This meant that for the same amount of work, the new divers had to exert more than the trained ones. Lastly, chest expansion was greater in the trained divers than in the untrained ones.

Nutritional Requirements

If the energy expenditure is known, the requirements of food can be worked out for different grades of work. The energy expenditure for a given grade of activity varies directly with the body surface of an individual, a tall and a thin man requires more energy than a short and fat one. Based on known nutritional principles, the energy requirements of a diver weighing 150 lbs. have been worked out with the help of standard data quoted by Ray Sarkar[6], and presented in table III. In the present investigation, all the subjects except two, weighed less than 150 lbs.

From Table III it is seen that the energy requirement of a diver weighing 150 lbs is nearly 3,500 calories. The calorific value of the standard ration for the ratings after allowing for 5 per cent cut is 3,900 calories, out of which about 10 per cent, *i.e.*, 390 calories are lost in cookig etc. The net calorific value of a rating's diet comes to about 3,500 calories.

TABLE III

Daily energy requirements of a diver weighing 150 lbs.

Time	Hrs.	Activity	Calories Per hour	Total Calories
0600-0630	0·30	Personal toilet	110	55
0630—0730	1·00	Gardening and cleaning the school etc. ..	180	180
0730—0830	1·00	Breakfast	110	110
0830—1030	2·00	Attendant to diver	180	360*
1030—1130	1·00	Diving	350	350*
1130—1245	1·15	Cleaning the suits and returning gear	180	225
1245—1400	1·15	Lunch	110	135
1400—1545	1·45	Attend lectures	140	245
1545—1700	1·15	Tea and rest	110	140
1700—1800	1·00	Games	700	700
1800—2200	4·00	Personal toilet, supper, recreating strolling etc.	110	440
2200—0600	8·00	Sleep	70	560
Total	24			3500

*The requirements for attendant to diver and for diving have been provisionally worked out.

The divers were watched during the meal hours to find out plate wastage, if any. Most of the divers were able to consume the whole of the ration given to them and the two weighing about 150 lbs. took some extra helping from the galley. The latter used to take voluntary physical exercise for one hour daily in the evening. Weekly weights of all the divers were recorded for three consecutive weeks to find out if there was any reduction in their weights during the training period. No significant loss in weight was observed.

Environmental Temperature

The temperature of sea water near Cochin harbour according to local sources of information varies from 80°F to 86°F. There is very little variation in temperature upto depth of about 600 ft. The mean temperature of the sea water during the present visit was 82°F.

Diving Experience of Untrained Officers

To get first hand knowledge of the difficulties experienced by the divers and their feelings under water, all the trainees were interviewed and watched after a dive. In addition Gp. Captain P.P. Choudhary, D.M.S Air who happened to be on tour at Cochin at that time, Surg. Lt. Comdr. Kochhar, S. M. O., INS "VENDURUTHY" and the author himself, also volunteered to dive. It was their first experience in diving. The depth of sea water at the place of diving was about 16 ft. The results of their dive are given in Table IV.

TABLE IV

Results of dive of three officer volunteers

Volunteer	Age in years	Weight in lbs.	Duration of stay under water	Pulse rate after dive	Physiological condition observed	Subjective feeling
D. M. S. Air ..	54	200	3 mts.	170	Almost breathless.	Slightly exhausted.
S. M. O. (Venduruthy)	33	155	3 mts.	148	Entirely breathless.	Very exhausted.
Author	32	182	15 mts.	140	Almost breathless.	Exhausted.

All the above volunteers felt exhausted after the dive and of the three, S. M. O. was worst affected. He felt giddy and had to keep lying for about 15 mts. in the boat before he could recover. Under water, the pressure was felt on the abdomen and the lower extremities. The dress was pressing at these places, but was lifted off the chest and head by the air pumped into the diving suit. Walking under water was not difficult, because the bottom of the sea was hard. While coming out, the greatest difficulty was experienced on climbing the ladder and their was feeling of compression of chest. This was probably due to the resting of front and back weights on the chest after the air had escaped from the dress. The trainees of Class III course had a similar experience in the beginning. They felt a good deal of pressure on their chests during the first 3-4 dives, but it became less and less during the subsequent ones. The Class II trainees did not feel any pressure on their chests. It was observed that after a dive the sweating was profuse. The sensation of warmth was, however, felt only outside the water. Under water the thermal feeling was very comfortable. The mean temperature of air inside the dress was 94°F and that of sea water was 82°F.

DISCUSSION

From the preliminary study on the divers it is seen that a large percentage of trainees were rejected on medical grounds before the commencement of the course. It appears that all the volunteers were not sent for proper medical examination before being drafted to the diving school. During the training

also, quite a high percentage became medically unfit (22·5%) or refused to dive (10%). The failures due to professional reasons were relatively few (7%). The main causes of rejection on medical grounds were Ottitis media and active venereal disease. It is found that the ratings with a good physical development especially with a chest expansion of 3″ or more proved to be better divers with training than those of poor physique. For selection of the volunteers special consideration should be given to the physical development, chest expansion, examination of ears and the previous history of venereal disease. Ratings weighing less than 120 lbs. or with chest expansion less than 2″ do not make suitable divers. Emotionally unstable individuals or those showing neurotic traits should be rejected. To keep them fit during the training period, compulsory games in the evening and P. T. in the morning should be included in the daily programme.

The daily energy requirements of a diver as provisionally worked out is 3,500 calories which he gets in his normal service ration. Moreover, no loss of weight or signs of nutritional deficiency were observed in the trainees who had been diving for about a month. On purely physiological grounds, it does not seem necessary to supplement the diet of a diver. It is, however, believed that a nutritive and refreshing drink containing salt after a dive will greatly help to relieve the exhaustion experienced by the trainees in the beginning of their training and thereby may reduce the wastage due to this cause to some extent.

ACKNOWLEDGEMENTS.—The author is thankful to those who volunteered as subjects for the above trial. He is also much indebted to Comchin and officer-in-charge, Naval Diving School, who gave him all the co-operation and facilities for carrying out the above investigation.

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TABLE II

APPENDIX I

Physiological Measurements of divers under training in the Indian Navy Diving School at Cochin

Serial No.	Name	Rate	Trg. for class of diver	Age in yrs.	Service	Hb. in gm. % age	B.P.	Pulse rate		40 mm mercury test	Physical efficiency test	Chest	Height	Wt. in lbs.	Province or State	Remarks
								Before diving	After diving							
1	R. Welles ..	A. B.	II	26	8	13·5	110/54	78	126	Type *i*	*	34″-37″	5′-10½″	148	W. Bengal	V. good diver Instructor.
2	B.A. Crasto	A.B.	II	24	4	15·5	110/70	78	120	Type *ii*	89%	33″-36″	5′-7″	131	Madras	V. good diver Instructor.
3	K. Singh ..	Stock Mech.	II	20½	2-3/12	14·25	114/64	90	128	Type *ii*	72%	36½″-39	5′-9″	152	Rajasthan	V. good diver.
4	C. B. Singh	Stock Mech.	II	21	4	15·00	104/64	84	128	Type *ii*	78%	33¼″-36″	5′-7″	138	U. P.	Good diver.
5	M. Majumdar	O. D.	III	19	2½	13·25	120/80	90	144	Type *ii*	59%	33″-36″	5′-9¼″	138	Bihar	Satisfactory.
6	Ram Nath	O. D.	III	23	2-9/12	14·25	98/70	84	130	Type *ii*	76%	32½″-34½″	5′-8″	138	Punjab	Satisfactory.
7	S. A. Hu[illegible]	Stock mech.	III	20	4	14·00	118/76	78	140	Type *ii*	76%	32″-34¼″	5′-4½″	123	U. P.	Satisfactory.
8	S. K. Dass	O. D.	III	19	2½	14·00	102/60	80	140	Type *ii*	58%	30¼″-31½″	5″-5½″	106	W. Bengal	Not satisfactory.

*Test not performed because of injury to his foot.