VISUAL CHARACTERISTICS OF SUBMARINE SCHOOL CANDIDATES, SUBMARINERS AND NAVY DIVERS:

Information Derived from the Longitudinal Health Study

by

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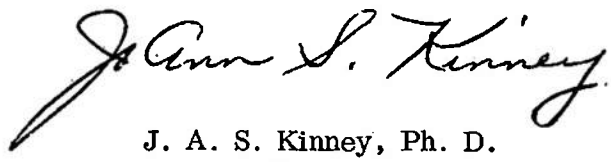

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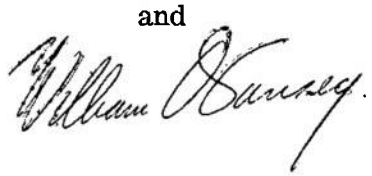

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SUMMARY PAGE

THE PROBLEM

To determine whether there are any differences in basic visual processes among Navy divers, Navy submariners, and Navy Submarine School candidates.

FINDINGS

Navy submariners require more correction for myopia than Navy divers or Navy Submarine School candidates. There were no significant differences on measures of phoria, acuity, stereopsis, retinal vessel size or intraocular pressure.

APPLICATION

These results support previous reports of increasing myopia aboard submarines and suggest a need to improve the visual environment in submarines.

ADMINISTRATIVE INFORMATION

This investigation was conducted as part of Bureau of Medicine and Surgery Research Work Unit MF51.524.006-1002BF9I. The present report is number two on the Work Unit. It was submitted for review on 19 October 1973, approved for publication on 1 February 1974 and designated as NSMRL Report No. 767.

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ABSTRACT

The visual abilities of experienced submariners, Submarine School candidates, and Navy divers were compared on several tests of visual functioning. Submariners were found to require more correction for myopia than either other group, with the divers requiring the least. There were no significant differences among the groups on measures of phoria, acuity, stereopsis, retinal vessel size or intraocular pressure. Submarine School candidates showed a closer near point (more accommodation) than either other group. They were also significantly younger.

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INTRODUCTION

Since the early 1950's there has been considerable research devoted to investigating the nature of visual tasks aboard submarines, and to assessing the visual acuity and performance efficiency of submariners. In 1954 an extensive survey of the visual characteristics of 1064 submariners was performed,[1] followed in 1966 by a longitudinal study of some of the same men.[2] The 1966 study was designed to determine whether or not prolonged exposure to a submarine environment led to changes in visual ability.

The results strongly suggested a loss of visual acuity, at both near and far distances, and a tendency to esophoria. These changes were considerably larger than those that might be expected to occur as a function of increasing age.

Greene[3] has reported a similar increase in myopia due to the restricted availability of far vision in Minuteman Combat Crew members. They stand watches in a 15'×7'×9' room sealed from the outside. Their job consists completely in near point tasks. Increases in amount of myopia were found to be related to number of years on the Crew, and not to age.

Luria, Newmark and Beatty[4] measured many of the same basic visual processes during the course of one submarine patrol. There was no decline in acuity, stereoacuity, or refractive power, but there was a significant increase in near esophoria.

Although highly suggestive, conclusions from all these results must be considered somewhat tentative since the number of men available for the 15 year follow-up was small, (51 men) and the Luria, et al. investigation covered only one patrol. A current investigation at this Laboratory, the Longitudinal Health Study (LHS), is designed to measure periodically numerous sensory (visual and auditory), medical, and physiological characteristics of a large population of submariners, following them from entrance into Submarine School throughout their careers as submariners.[5] As part of the battery of tests measures of visual performance and ocular health are administered. Results of this investigation should conclusively determine the nature and extent of visual system changes attributable to the submarine environment.

The LHS battery has been administered to Navy divers, submariners and Submarine School candidates. Although follow-up data on the same men are not yet available, it is possible to compare the visual characteristics of the three groups, and to determine if any differences might be attributable to the exposure to different environments. In the future additional

reports will present longitudinal comparisons of the same subject populations.

METHOD

The LHS battery of vision tests has been administered to over 400 men. Three groups of 50 men each, for whom complete records are available, were chosen. One group is composed of Naval submariners, one of Navy divers, and one of prospective submariners.

VISION TESTS

A. Bausch & Lomb Ortho-Rater. The battery of vision tests administered in the vision segment of the LHS includes the standard battery of the Bausch & Lomb Ortho-Rater. The Ortho-Rater tests abilities at simulated testing distances of 26 feet (far) and 13 inches (near):

1. Measures of phoria (binocular action of the eye). Results are reported in prism diopters.

   a. near vertical phoria
   b. near lateral phoria
   c. far vertical phoria
   d. far lateral phoria

2. Measures of visual acuity (in terms of unaided retinal resolution). Results are recorded as reciprocal of the visual angle in minutes of arc subtended by the test objects.

   a. near acuity both eyes
   b. near acuity left eye
   c. near acuity right eye
   d. far acuity both eyes
   e. far acuity left eye
   f. far acuity right eye

3. A test of depth perception (stereoscopic acuity). Results are reported as percent stereopsis on the Fry-Shepherd Scale and Ortho-Rater score.

B. Near point of accommodation (the ability of the eye to alter its refracting power in order to focus at different distances) is measured using the Prentiss rule. The eye exerts its maximum accommodative effort to be able to focus at near object. The closest point that can be clearly focused is the near point. Results are reported in prism diopters.

C. Subjective refraction of the right eye (O.D.) is measured using a Bausch & Lomb phoropter. Current prescription, if available, is noted.

D. Tonometry is used to measure the intraocular pressure of the eyes. A Schiotz tonometer is used. Measures are recorded in mm. of mercury.

E. Fundus photographs are taken using the Zeiss fundus camera. Vessel size is reported in micra and artery to vein ratio is determined using technique described in the report by Kinney, McKay and Ryan.[6] Artery/vein ratio is one indication of hypertension so blood pressure measures are also recorded. The photographs provide a permanent record of the condition of the optic fundus and retinal vascular system. Additionally a photograph of the red reflex is obtained. Any noticeable abnormality is recorded.

In addition to the visual tests, data are available from a wide variety of other medical and physiological tests and questionnaires for cross comparison wherever applicable.

RESULTS

Table I presents the results for all tests on the three subject groups. None of the differences among groups are significant for any test in the battery except age and accommodation. Submarine School candidates are significantly younger than either the submariners ($t = -9.46$, $df = 98$, $p < .05$) or the divers ($t = -9.43$, $df = 98$, $p < .05$). The candidates show a closer near point (greater accommodation in prism diopters) than the submariners ($t = -4.64$, $df = 98$, $p < .05$) or the divers ($t = -.361$, $df = 98$, $p < .05$). All test values are within normal limits.

Table I. Means and standard deviations of the three groups on the LHS Vision Test Battery

Category		Submarine School Candidates	Submariners	Navy Divers
Age	$\bar{X}$	21.22	29.32	30.82
	σ	2.02	5.63	6.45
Phoria (Prism D.)				
Far Vertical	$\bar{X}$	.003 LH*	.154 LH	.162 LH
	σ	.362	.467	.344
Far Lateral	$\bar{X}$	.212 (Eso)	.494 (Eso)	.497 (Eso)
	σ	1.84	2.03	2.16
Near Vertical	$\bar{X}$	.280 LH	.103 LH	.134 LH
	σ	.423	.382	.344
Near Lateral	$\bar{X}$	-4.781 (Exo)	-5.16 (Exo)	-4.969 (Exo)
	σ	4.17	5.189	4.036
Far Acuity (reciprocal of visual angle)				
Both eyes	$\bar{X}$	.956	.942	1.028
	σ	.240	.243	.215
Left eye	$\bar{X}$	.918	.892	.974
	σ	.267	.268	.223
Right eye	$\bar{X}$	.894	.880	.952
	σ	.238	.284	.245

Table I. Means and standard deviations of the three groups on the LHS Vision Test Battery (cont)

Category		Submarine School Candidates	Submariners	Navy Divers
Near Acuity				
Both eyes	$\bar{X}$	1.152	1.132	1.094
	σ	.095	.102	.180
Left eye	$\bar{X}$	1.126	1.088	1.068
	σ	.103	.141	.192
Right eye	$\bar{X}$	1.086	1.080	1.044
	σ	.139	.140	.208
Depth (% stereopsis Fry-Shepherd scale and Ortho-Rater score)	$\bar{X}$	86% 4.54	86% 4.50	88% 5.08
	σ	2.77	3.10	2.82
Accommodation (Prism D.)	$\bar{X}$	8.75	6.65	6.80
	σ	2.64	1.85	2.35
Tonometry, O.D. (mm. mercury)	$\bar{X}$	N.A.	16.64	15.96
	σ		2.94	3.06
Artery Size, O.D. (micra)	$\bar{X}$	96	104	100
	σ	16	16	16
Vein Size, O.D.	$\bar{X}$	132	144	136
	σ	20	20	16
Artery/Vein Ratio	$\bar{X}$	.73	.73	.73
	σ	.10	.09	.11
Blood Pressure	$\bar{X}$	124.24/77.00	123.33/75.94	122.88/76.72
	σ	11.43/ 6.30	9.53/ 8.96	9.39/ 8.64

* Left Heterophoria

Table II presents the results of the subjective refractions in spherical equivalent (the sum of the sphere plus 1/2 of the cylinder) of the three groups. For all groups the majority of men require little or no spherical correction.

Table II. Percent of each group requiring each correction

Diopters Correction Required (Spherical Equivalent)	Candidates	Submariners	Divers
-4.50 to -4.01	0	2	0
-4.00 to -3.51	2	0	0
-3.50 to -3.01	0	2	0
-3.00 to -2.51	0	2	0
-2.50 to -2.01	0	12	2
-2.00 to -1.51	2	10	4
-1.50 to -1.01	18	4	6
-1.00 to -0.51	14	8	10
-0.50 to -0.01	38	26	24
0.00 to +0.49	12	24	38
+0.50 to +0.99	6	6	10
+1.00 to +1.49	6	2	2
+1.50 to +1.99	0	0	4
+2.00 to +2.49	0	2	0
+2.50 to +2.99	2	0	0
% myopes	74	66	46

Both the submarine candidates (72%) and the submariners (66%) show a higher percentage of myopes than the

is -4.50 diopters and by a Navy diver is -2.50 diopters.

APPENDIX A

CURRENT VISUAL STANDARDS FOR SUBMARINERS AND NAVY DIVERS

Diving candidates: a minimum of 20/30 vision bilateral corrected to 20/20 shall be required.

Submarine personnel: 1. General duty line officers: Binocular visual efficiency (BVE) of 49% uncorrected, correctable to 100%, such correction shall contain no more than 1.00 diopter cylindrical correction in any meridian. Spherical equivalent (the sum of the spherical correction plus 1/2 the cylindrical correction) shall be limited to +2.00 diopters and -3.00 diopters.

2. Enlisted personnel of QM rate and all seamen and firemen not identified as strikers: BVE of 49% uncorrected, correctable to 96%. Such correction shall contain no more than 1.00 diopter cylindrical correction in any meridian. Spherical equivalent shall be limited to +2.00 and -3.00 diopters.

3. All other enlisted personnel: BVE 49% uncorrected, correctable to 90%. Spherical equivalent shall be limited to +3.00 and -4.50 diopters.

4. Staff corps officers: BVE of 20% uncorrected, correctable to 90%.

Source: Chapter 15, Manual of the Medical Department.

Binocular Visual Efficiency Table

Left Eye \ Right Eye	20/20	20/30	20/40	20/50	20/70	20/100	20/200	20/400
20/20	[100%]	98	96	94	91	87	80	76
20/30	98	92	90	88	85	81	74	69
20/40	96	90	84	82	79	75	68	64
20/50	94	88	82	77	73	70	62	58
20/70	91	85	79	73	64	60	53	49
20/100	87	81	75	70	60	49	42	38
20/200	80	74	68	62	53	42	20	16
20/400	76	69	64	58	49	38	16	3

[ ] Line Officers and divers

- - - QM seamen and firemen enlisted

▬ Enlisted men on Subs

Ortho-Rater Score	Snellen equivalent
1	20/200
2	20/100
3	20/67
4	20/50
5	20/40
6	20/33
7	20/29
8	20/25
9	20/22
10	20/20
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