Navy Hearing Conservation Program: Hearing threshold comparisons to Navy SEALS and divers

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Bohnker B, Rovig G, Page J, Philippi A, Butler F, Sack D. Navy hearing conservation program: Hearing threshold comparisons to Navy SEALS and divers – Undersea Hyperb Med 2003; 30(2): 155 -162 - The study examined hearing threshold for Navy special operations personnel (SEALS (Sea-Air-Land): N=212; divers: N=165). Hearing threshold values were obtained and age adjusted using Mantel Haenzel Weighted odds ratio (MHOR) to compare with information in the Navy Hearing Conservation Database. For any threshold above 20 dB in the 500 through 3000 Hz range, the SEALS were significantly less at risk (MHOR =0.54, p=0.022) in the right ear, while the divers were significantly less at risk in the left ear (MHOR=0.61, p=0.047). For hearing thresholds at 4000 Hz above 40 dB, SEALS were significantly more at risk in both left ear (MHOR= 2.03, p=0.0043) and right ear (MHOR=2.58, p=0.000089), while divers were not different. Risk assessment based on these findings must consider the multiple exposure hazards and critical mission profiles for the Navy special operations personnel. Requirements for mission accomplishment in hazardous environments may deem these risks acceptable.

Hearing conservation, military medicine, special operations personnel, Navy medicine, diving medicine

INTRODUCTION

Several special interest work groups in the Navy active duty force have historically been considered to have high exposure to potentially hazardous noise levels and therefore would be at increased risk for hearing loss. Navy special operation forces (SEALS or Sea-Air-Land) and divers would likely be included in those groups. The SEAL community was considered at potential increased risk due to factors such as their exposure to gunfire and explosives, while the diver community was at risk for the noise exposure associated with diving equipment and underwater tool noise. We are aware of no prior study of noise induced hearing loss in SEALS, and there is a paucity of hearing loss literature on divers (1-3). Therefore, an investigation was deemed appropriate to examine the hearing thresholds for members of these Navy occupational specialties.

The US Navy has recognized a relationship between occupational noise exposure and hearing loss for over four decades. This recognition led to Navy Medicine establishing a Hearing Conservation Program (HCP) in 1955(4). The consolidation of occupational health and safety program elements led to program oversight becoming a responsibility of the Chief of Naval Operations (CNO) in 1979 (5,6); Navy Medicine continues to manage the medical aspects of the Program. Personnel from the U. S. Navy (USN) in the HCP are monitored using similar procedures at Navy medical treatment facilities and ships (7).

Several previous authors have investigated hearing loss in the Navy. In 1978, the Naval Aerospace Medical Research Laboratory (NAMRL) in Pensacola, Florida, reported on hearing

thresholds for selected USN enlisted classifications (8). In 1990, the Navy Environmental Health Center (NEHC) in Norfolk, Virginia reviewed similar information (9). Gwin and Lacroix reported mean thresholds from personnel in the USN submarine force in 1985(10). Ridgley and Wilkins reported median hearing thresholds from US Navy and U.S. Army personnel using available 1984 data (11). In 1995, Wolgemuth et al (12) reported on their review of over twelve thousand audiometric records from surface ships and submarines of the Atlantic Fleet. We have previously reported on STS in the USN enlisted population (13) as well as produced age and gender-specific mean thresholds (14). Those studies discuss the development and contents of the NEHC Hearing Conservation Database, which contains hearing threshold information from over 150,000 hearing conservation-monitoring audiograms administered from 1995-1999. However, none of these studies specifically addressed hearing thresholds in Navy special operations and diving communities in comparison with other Navy populations.

METHODS

In response to a request from the Navy Special Warfare Community, a study was designed to examine hearing thresholds for US Navy SEALS and divers. The Investigational Review Board at Naval Medical Center, Portsmouth, VA, reviewed and approved the study design. Co-authors (GR) and (JP) obtained the hearing conservation information from file audiograms in the health records of Navy SEALS and divers assigned to the Norfolk area. This information was obtained during visits to the supporting clinics, though a substantial number of personnel in these communities were deployed for operational contingencies associated with Operation Enduring Freedom. Other demographic information was obtained from the health records as needed. This data was entered into a Microsoft EXCEL® computer format, and analyzed with SPSS and EPI-INFO with a statistical significance of $p=0.05$. (15,16).

For comparison, we selected information from the NEHC Hearing Conservation Database. Although we did not control for gender in the target groups, all except one or two available records were from males, so we selected records of males for comparison who had completed annual or monitoring audiograms. There were 45 officer records within the SEAL group, including 8 with prior enlisted service as SEALS, and 14 officer records within the diver group. We elected to limit the comparison group to enlisted personnel from the NEHC database since most of the studied groups were either enlisted or former enlisted. Since thresholds typically increase or worsen with increasing age, we chose to age adjust these values by stratification. We did not directly control for variables such as occupational sub-specialty or length of service. We considered that length of service was correlated with age and therefore included with the age stratification.

Several areas were chosen for comparison between the groups. We initially chose to look at differences in the primary speech communication frequencies 500 through 3000 Hz, where values below 25 dB are considered normal. The cases and controls were grouped into those with any threshold levels for 500 to 3000 Hz greater than 20 dB (abnormal hearing), and those with no values worse than 20dB (essentially normal). This analysis was repeated for each ear. We then analyzed the threshold level at 4000 Hz, since changes at that frequency were apparent in our earlier analysis (14). We chose to categorize the data for each ear into thresholds (20 dB and less, and 25 dB and greater) in consideration of the "normal" sensitivity range. We also chose to analyze the 4000 Hz threshold levels of 40 dB and less with those 45 dB and greater since that level would more clearly define an abnormal result.

RESULTS

Information on hearing threshold levels was available for 212 SEALS and 165 divers. From Table 1, we found that the divers were significantly better than the Navy enlisted population in the left ear for any threshold above 20 dB in the areas of 500 Hz through 3000Hz (MHOR=0.61, p=0.047) while the SEALS were not significantly different (MHOR =0.69, p=0.09). From Table 2, we found that the SEALS were significantly better in the right ear for any threshold greater than 20 dB in the areas of 500 Hz through 3000 Hz (MHOR= 0.54, p=.0222) while the divers were not significantly different (MHOR=0.76, p=0.32). We interpret Tables 1 and 2 to indicate that both SEALS and divers in this study demonstrated similar or better hearing within the speech frequency range as compared to our sample of all Navy enlisted personnel. These findings were unexpected but reassuring in our overall risk assessment on hearing loss in the Navy special operations personnel.

Table 1: Left Ear Threshold Levels ≥ 25 dB at 500, 1000, 2000, 3000 HZ Compared to Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	< 25	≥ 25	<25	≥25	OR	P value	<25	≥25	OR	P value
17->24	20582	2759	38	2	*	0.22	14	0	*	0.39
25->29	11499	1755	59	4	*	0.15	30	1	*	0.11
30->34	7727	1658	46	11	1.11	0.88	40	6	0.7	0.41
35->39	5959	1837	20	5	.81	0.85	36	7	0.63	0.26
40+	2694	1293	21	6	.60	0.35	23	8	0.72	0.43
Crude Odds Ratio						0.79	COR			0.73
Mantel Haenzel Weighted Odds Ratio						0.69	MHOR			0.61
p value						0.09	p value			0.047

(*) Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated.

Table 2: Right Ear Threshold Levels ≥ 25 dB at 500, 1000, 2000, 3000 HZ Compared to Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	<25	≥25	<25	≥25	OR	p value	<25	≥25	OR	p value
17->24	21420	1921	39	1	*	0.25	14	0	*	0.62
25->29	12061	1193	60	3	*	0.24	29	2	*	0.99
30->34	8162	1223	52	5	0.64	0.45	40	6	1	0.82
35->39	6522	1274	23	2	*	0.41	37	6	0.83	0.67
40+	2944	1043	22	5	0.64	0.49	25	6	0.68	0.39
Crude Odds Ratio						0.63			COR	1.06
Mantel Haenzel Weighted Odds Ratio						0.54			MHOR	0.76
p value						0.022			p value	0.32

(*) Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated.

As can be seen from Tables 3 and 4 using stratification at the 25 dB cut point for 4000 Hz, threshold levels for SEALS were not significantly different in the left ear, but were significantly greater (worse) in the right ear (Mantel-Haenszel weighted odds ratio (MHOR)= 1.96, p=0.00012). For both ears, the largest difference was apparent for those with ages 30-34, and the numbers from that age group had a large effect on the overall analysis. Threshold levels for Navy divers were not significantly different in either ear with the 25dB cut points.

Table 3: Left Ear Threshold at 4000 Hz for ≥25 dB Compared to the Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	<25	≥25	<25	≥25	OR	p value	<25	≥25	OR	p value
17->24	21489	1852	39	1	*	0.37	14	0	*	0.62
25->29	11668	1586	57	6	0.77	0.55	29	2	*	0.57
30->34	7542	1843	36	21	2.39	0	36	10	1.14	0.86
35->39	5612	2184	17	8	1.21	0.65	34	9	0.68	0.38
40+	2345	1642	14	13	1.33	0.46	20	11	0.79	0.65
Crude Odds Ratio						1.61			COR	1.29
Mantel Haenszel Weighted Odds Ratio						1.33			MHOR	0.77
p value						0.12			p value	0.24

(*) Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated.

Table 4: Right Ear Threshold Levels at 4000Hz for ≥25 dB Compared to Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	<45	≥45	<45	≥45	OR	p value	<45	≥45	OR	p value
17->24	23028	313	39	1	*	0.41	14	0	*	0.67
25->29	12928	326	63	0	*	0.41	31	0	*	0.37
30->34	8918	467	46	11	4.57	0	46	0	*	0.12
35->39	7170	626	21	4	*	0.14	40	3	*	0.88
40+	3451	536	23	4	*	0.78	29	2	*	0.42
Crude Odds Ratio						2.55			COR	0.76
Mantel Haenzel Weighted Odds Ratio						2.03			MHOR	0.43
p value						0.0043			p value	0.089

(*)Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated.

From Tables 5 and 6 using stratification at the 45 dB cut point for 4000 Hz, thresholds for Navy SEALS were significantly greater (worse) in the left ear (MHOR=2.03, p=0.0043) and right ear (MHOR= 2.58, p=0.000089). The 30-34 year old group also contributed most of the demonstrated difference, though many of the cells had expected values less than 5. Again, no significant differences were apparent in the diver community with that cut point.

Table 5: Left Ear Threshold at 4000 HZ for ≥ 45 dB Compared to Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	<25	≥25	<25	≥25	OR	p value	<25	≥25	OR	p value
17->24	22150	1191	39	1	*	0.76	14	0	*	1
25->29	12132	1122	57	6	1.14	0.76	29	2	*	1
30->34	8024	1361	36	21	3.44	0	37	9	1.43	0.33
35->39	6199	1597	17	8	1.83	0.15	34	9	1.03	0.94
40+	2675	1312	14	13	1.89	0.09	22	9	0.83	0.64
Crude Odds Ratio						2.34			COR	1.6
Mantel Haenzel Weighted Odds Ratio						1.96			MHOR	1
p value						0.000012			p value	0.919

Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated

Table 6: Right Ear Threshold Levels at 4000 HZ for ≥45 dB Compared to Navy Enlisted Population

	All Navy Enlisted		SEAL Comparison				Diver Comparison			
Age group	<45	≥45	<45	≥45	OR	p value	<45	≥45	OR	p value
17->24	23122	219	39	1	*	0.31	14	0	*	1
25->29	13009	245	63	0	*	0.63	31	0	*	1
30->34	9020	365	46	11	5.93	0	45	1	*	1
35->39	7327	469	21	4	*	0.06	42	1	*	0.51
40+	3516	471	23	4	*	0.55	28	3	*	1
Crude Odds Ratio						3.3			COR	0.99
Mantel Haenzel Weighted Odds Ratio						2.58			MHOR	0.55
p value						0.0008			p value	0.25

(*) Since cells included with expected value less than five, Fischer's exact test used and no odds ratio calculated.

DISCUSSION

This study analyzed available records for Navy SEALS and divers in comparison with Navy enlisted personnel. This study found that SEALS and divers were no more likely to have abnormal thresholds at 500 through 3000 Hz than the comparison group. When adjusted for age and gender in comparison to Navy enlisted populations, the SEALS were significantly more likely to have elevated (worse) thresholds at 4000 Hz. Divers did not demonstrate abnormal hearing at that frequency. For the SEALS, the significant differences apparent at frequencies closely identified with exposure to impact/impulse noise were not unexpected. However, the actual level of threshold changes was less than might be expected in light of the multiple potential sources of acoustic trauma.

The statistically significant differences demonstrated at 4000 Hz for the SEALS bring to light a challenging risk assessment consideration. While the hearing conservation goal for the SEALS would preclude them from demonstrating any excess rate of threshold shifts, that desire must be tempered with the hazardous nature of their activities and requirements for training and mission accomplishment. Such a risk assessment may consider these findings as demonstrating an acceptable level of hearing threshold maintenance. The risk assessment would also need to incorporate other hazards to that group, including factors such as orthopedic injuries that may have a much larger adverse impact on continued career service. The largest age stratification difference was apparent in the 30-34 age-group for SEALS, which is also a highly productive period due to the experience and training invested in the personnel involved. Replacing that capability is neither easy nor inexpensive, so retention of these personnel with their special skills is important. Navy special operations personnel, along with other high-risk occupational groups, may be candidates for prophylactic medications for hearing protection that are under development and testing(17). These findings support continued surveillance for these groups as well as appropriate education and protective equipment. They also support efforts to define sub-populations at greater risk who are likely to warrant more complex equipment for hearing protection.

This study design incorporates several limitations that warrant comment. Our selection process included only personnel from the Norfolk area, one of two primary SEAL assignment locations. While differences associated with geography cannot be ruled out, training and operations are similar at both SEAL locations. Since Norfolk is the Navy's largest Fleet concentration area, the sample of divers probably represents a reasonable cross section of that community. We considered increasing the sample size for SEALS and divers, however we had exhausted the local population and identifying additional personnel would require travel to other locations with additional costs. The potential for selection bias cannot be ruled out, since some SEAL personnel were deployed during the selection period. However, SEAL deployments tend to be in teams that rotate periodically, so we would expect this to be a reasonably random sample of the population. We also cannot rule out some kind of healthy worker effect, where people with significant hearing loss were removed from the selection pool. We compared the SEAL and diver information to Navy enlisted population values, since the officer population was small and a comparable officer population not readily apparent. For convenience, we used historical data for comparison from an available database rather than looking for contemporaneous controls, although we are aware of no substantial change in hearing health risk factors compared to the 1995-1999 monitoring period of the comparison group. Finally, cited literature describes a substantial risk of hearing loss to the Navy enlisted population during their career, so these findings compare values to that baseline rather than civilian environment. As noted in our previous manuscript, the goal should be to limit hearing loss in the military population rather than consider the comparison group as demonstrating an acceptable level of hearing loss(14).

Within the past few years, the Department of Defense has fielded an automated system of hearing testing and data storage and analysis called the Defense Occupational and Environmental Health Readiness System (DOEHRS). Future studies should be possible on broader samples of the Navy special warfare population, as well as other subgroups of the Navy active duty force (18). When fully implemented, that capability will allow longitudinal studies for these populations as well. This will improve monitoring of hearing conservation programs in various populations and provide for the assessment of the overall hearing threshold changes for service populations of interest.

CONCLUSIONS

This analysis of records for 212 Navy SEALS and 165 Navy divers with age adjusted comparison to enlisted personnel in the Navy HCP. The SEALS and divers were not worse than comparable Navy personnel in the 500 through 3000 Hz frequencies most closely associated with verbal communication. The SEALS were significantly more likely to demonstrate deviation in hearing thresholds at 4000 Hz than the Navy enlisted population. Most of the effect was apparent in the 30-34 year old age group. Navy divers did not demonstrate any significant deviation in hearing thresholds at 4000 Hz. Risk assessments based on these findings must consider the high threat training and operational environment of the SEAL community, and these results may be considered an acceptable risk profile.

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