Raširenost oštećenja sluha u pomoraca

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THE PREVALENCE OF NOISE-INDUCED HEARING LOSS IN SEAMEN

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Hearing was analysed in 231 seamen with the length of sea service longer than five years. Among 107 seamen in deck service, 86 seamen in engine service, and 38 seamen in radio and general services statistically significant differences in relation to age, total length of service and the length of sea service were not established. There were no differences in the degree of hearing loss among those groups of seamen either. Based upon calculated simple regression coefficients, a statistically significant correlation was established between age, total length of service or length of sea service with the average hearing loss at the frequencies of 500, 1000, 2000 and 4000 Hz in the left ear in seamen from all ship services. Correlation was best pronounced at 2000 and 4000 Hz. In seamen from deck, radio or general services, a significant multiple correlation was established between age, total length of service and length of sea service, and the degree of hearing loss at 4000 Hz in the left ear. The same correlation, likewise, was true of seamen from deck service at 2000 Hz in the left ear and at 4000 Hz in the right ear.

Key terms:
age, length of sea service, ship duty

Noise on shipboard is a phenomenon that has come to present a problem since the introduction of steam replacing the wind as the ship motive power. The intensity of noise in the engine-rooms of most present-day ships is beyond

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acceptable limits. The limit is 90 dBA for an eight-hour exposure if no personal protection devices are used, or 110 dBA if such devices are used. These are the surroundings where most hearing damage is induced (1-5). In other spaces on shipboard noise level usually does not exceed permissible values, from 60 to 65 dBA.

Noise-induced hearing damage is, however, at the top of the list of occupational impairments in seamen (5-8). The hearing damage of seamen is also an indirect indicator of the risk of the extra-auditive effects of noise.

It is therefore essential to take notice of the hearing damage in the maritime population to be able to discover at the earliest possible stage the occupational damage and to estimate the risks with regard to the service on board. A follow-up of hearing loss is also needed to evaluate the degree of safety at work and to examine the effect of technological changes in ships upon hearing of seamen. That is the purpose of this paper.

SUBJECTS AND METHODS

In this investigation we used the work histories and audiometric curves of 403 seamen who came for a medical check-up to the Department of Occupational Medicine of the Community Primary Health Centre in Rijeka during the last three months of 1994. They came to be examined to renew the validity of their seaman's book, or to obtain certificates for particular duties on shipboard. The hearing was analysed in 231 seamen with a sea service longer than five years. These were 107 seamen from deck service, 86 seamen from engine-room service, and 38 seamen from radio and general services.

For the sake of statistical analysis of seamen in separate services, and of all the seamen together, computations were made of the arithmetic means and standard deviations for age, total length of service and length of sea service, and for the hearing damage in the left and in the right ear at each of the following frequencies separately: 500, 1000, 2000 and 4000 Hz. Computations were also made of the average hearing damages at 500, 1000, 2000 and 4000 Hz for each seaman, for the right ear, the left ear, and for both ears together, and the standard measures of variability in the same groups of seamen were established. The chi-squared test was used to analyse possible differences in the age distribution and distribution according to the length of sea service between the groups of seamen. The computed average values of all the parameters between the seamen of the different services on shipboard were compared using Student's t-test. Coefficients were computed of the simple, multiple and partial correlation between the hearing damages at the stated frequencies as the dependent variables and age, total length of service and length of sea service as independent variables.

RESULTS

There were no statistically significant differences in age distribution, distribution according to the length of sea service (Tables 1 and 2), and the average age span, average total length of service and length of sea service between the seamen of deck service, engine-room service, and the seamen of the general and radio services. In all the groups the greatest number of seamen were between 36 and 45 years old, or almost about two thirds of the seamen were above the age of 36 years. It is worth noting that the total seafaring population was generally under the age of 36.

Table 1 *Age distribution of examined seamen according to type of service*

Age (years)	Service on board									
	Deck		Engine-room		Radio service		General service		Total	
	n	%	n	%	n	%	n	%	n	%
<25	1	0.9	2	2.3	0	0.0	1	2.9	4	1.7
26 – 35	28	26.2	13	15.1	1	25.0	10	29.4	52	22.5
36 – 45	48	44.9	41	47.7	2	50.0	1	32.4	102	44.2
>45	30	28.0	30	34.9	1	25.0	12	35.3	73	31.6
Total	107	100.0	86	100.0	4	100.0	34	100.0	231	100.0
$\chi^2 = 6.67$; df = 9; P > 0.05										

df = degrees of freedom; P = level of significance.

Table 2 *Distribution of examined seamen according to length of sea service*

Length of sea service (years)	Service on board									
	Deck		Engine-room		Radio service		General service		Total	
	n	%	n	%	n	%	n	%	n	%
6 – 11	32	29.9	25	29.1	2	50.0	10	29.4	69	29.9
11 – 20	43	40.2	37	43.0	1	25.0	13	38.3	94	40.7
21 – 30	23	21.5	20	23.3	1	25.0	8	23.5	52	22.5
> 30	9	8.4	4	4.6	0	0.0	3	8.8	16	6.9
Total	107	100.0	86	100.0	4	100.0	34	100.0	231	100.0
$\chi^2 = 6.67$; df = 9; P > 0.05										

df = degrees of freedom; P = level of significance

Analysis of the degree of hearing damage shows that there are no statistically significant differences between the groups of seamen considering each ear separately, or the two ears together (Tables 3 and 4). What comes to notice is a more marked hearing damage in the left than in the right ear in all the groups, but particularly in the group of seamen of the general and radio services.

The computed coefficients of simple correlation point to a statistically significant correlation between age, total length of service and length of sea service,

and the average hearing damage at 4000 Hz in the right ear, if all the examined seamen are taken together (Table 5). For the deck service seamen the length of sea service does not correlate with the hearing damage at any frequency. If the average value is observed at all four frequencies, then it correlates with the hearing damage at 2000 and 4000 Hz in both ears, and the total length of service with the hearing damage at 2000 and 4000 Hz in the right, and 4000 Hz in the left ear.

Table 3 *Relationship between average values of age and length of sea service, and average values of hearing damage in seamen from different services on shipboard*

	Service on board											
	Deck			Engine-room			General service and radio service			All		
	$\bar{X}$	±	SD	$\bar{X}$	±	SD	$\bar{X}$	±	SD	$\bar{X}$	±	SD
Age (years)	41.3	±	8.2	42.2	±	7.7	40.3	±	8.1	41.5	±	8.0
TLS (years)	18.9	±	8.7	19.7	±	7.8	20.0	±	7.9	19.4	±	8.1
LSS (years)	16.8	±	8.7	16.0	±	8.0	17.0	±	9.2	16.5	±	8.5
DR (dB)	16.2	±	11.7	15.6	±	6.0	16.0	±	7.2	16.0	±	9.2
DL (dB)	16.5	±	11.7	16.6	±	6.6	18.2	±	8.1	16.8	±	8.1
DRL (dB)	16.4	±	9.7	16.1	±	6.0	17.1	±	7.3	16.4	±	8.1

age = years of life; TLS = total length of service; LSS = length of sea service; DR, DL, DRL = degree of hearing damage in the right, left, and in the right and left ear together.

Table 4 *Average hearing losses according to particular frequencies in all the examined seamen*

Frequency (Hz)	Hearing loss (dB)	
	Right ear $\bar{X}$ ± SD	Left ear $\bar{X}$ ± SD
500	11.1 ± 7.0	10.6 ± 3.0
1000	11.1 ± 7.2	11.0 ± 5.9
2000	13.7 ± 10.8	14.9 ± 11.0
4000	27.9 ± 10.9	30.8 ± 11.4

In the group of engine-room seamen age does not correlate with hearing loss, and their entire length of service and length of sea service correlate only with the hearing loss at the four frequencies in the left ear.

In the group of general and radio service seamen age correlates with the hearing loss at 4000 Hz, or with the average hearing loss at the four examined frequencies in the left ear, and with the average hearing loss at all the examined frequencies in both ears.

In all the examined seamen as a uniform group the partial and multiple correlation coefficients demonstrate the presence of a significant multiple correlation of hearing loss at 2000 or 4000 Hz in both ears, of the averages of hearing loss computed from the hearing loss at all the four frequencies in each ear separately and in both ears together as dependent variables and the age, the total length of service and length of sea service as independent variables (Table 6).

Table 5 *Simple correlations of age, total length of service and length of sea service with values of hearing losses*

Parameter	Deck			Engine-room			General service and radio service			All		
	r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3	r_1	r_2	r_3
DR 500	–	–	–	–	–	–	–	–	–	–	–	–
DR 1000	–	–	–	–	–	–	–	–	–	–	–	–
DR 2000	0.23*	0.23*	–	–	–	–	–	–	–	0.22**	0.20*	–
DR 4000	0.31*	0.29*	–	–	–	–	–	–	–	0.24**	0.25*	0.17*
DL 500	–	–	–	–	–	–	–	–	–	–	–	–
DL 1000	–	–	–	–	–	–	–	–	–	–	–	–
DL 2000	0.27*	–	–	–	–	–	–	–	–	0.26**	0.24**	0.25**
DL 4000	0.42**	0.38**	–	–	0.30*	0.29*	0.40*	–	–	0.35**	0.35**	0.29**
A	–	–	–	–	–	–	–	–	–	0.21**	0.32**	0.17**
B	0.36**	0.32*	0.29*	–	0.27*	0.26*	0.44*	0.43*	0.41*	0.34**	0.27**	0.30**
C	0.31**	0.29*	0.23*	–	–	–	0.41*	0.39*	0.37*	0.29**	0.32**	0.24*

DR500–DR4000 = hearing damage in dB at 500–4000 Hz in the right ear, DL500–DL4000 = in the left ear; A = average hearing damage at frequencies of 500–4000 Hz in the right ear, B = in the left ear, C = in both ears; * = level of significance $P < 0.05$; ** = $P < 0.01$; r_1, r_2, r_3 = coefficient of simple correlation of the value of hearing loss with age, with the total length of service and length of sea service.

Table 6 *Partial and multiple correlations of age, total length of service and length of sea service with values of hearing loss*

Parameter	Deck				Engine-room				General service and radio service				All			
	r_{p1}	r_{p2}	r_{p3}	r_{m1}	r_{s1}	r_{s2}	r_{s3}	r_{m2}	r_{o1}	r_{o2}	r_{o3}	r_{m3}	r_{t1}	r_{t2}	r_{t3}	r_{m4}
DR 500	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DR 1000	–	–	–	–	0.84***	–0.85***	–	0.47***	–	–	–	–	–	–	–	–
DR 2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.22**
DR 4000	–	–	–	0.36**	–	–	–	–	–	–	–	–	–	–	–	0.26**
DL 500	–	–	–	–	0.48*	–0.48*	–	0.33*	–	–	–	–	–	–	–	–
DL 1000	–	–	–	–	–	–	–	0.44***	–	–	–	–	–	–	–	–
DL 2000	–	–	–	0.28*	–	–	–	–	–	–	–	–	–	–	–	0.28***
DL 4000	–	–	–	0.42**	–	–	–	0.32*	–	–	–	–	–	–	–	0.36***
A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.23**
B	–	–	–	0.37**	–	–	–	–	0.41*	–	–	0.47*	–	–	–	0.34***
C	–	–	–	0.31*	–	–	–	–	0.37*	–	–	–	–	–	–	0.30***

DR500–DR4000 = hearing damage in dB at 500–4000 Hz in the right ear, DL500–DL4000 in the left ear; A = average hearing damage at frequencies of 500–4000 Hz in the right ear, B = in the left ear, C = in both ears; * = level of significance $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; r_1, r_2, r_3 = coefficient of simple correlation of the value of hearing loss with age, with the total length of service and length of sea service. r_{p1}, r_{p2}, r_{p3} = coefficient of partial correlation of hearing damage values with age, with total length of service and length of sea service of deck department seamen; r_{s1}, r_{s2}, r_{s3} = of engine-room department seamen; r_{o1}, r_{o2}, r_{o3} = of general service and radio service; r_{t1}, r_{t2}, r_{t3} = of all observed seamen; r_{m1} = coefficient of multiple correlation of hearing damage value with age, total length of service and length of sea service of deck department seamen; r_{m2} = of engine-room department seamen; r_{m3} = of general service and radio service; r_{m4} = of all observed seamen.

No independent variable is by itself in any way significantly connected with hearing loss if the seamen are considered as an undivided group. The computed coefficients of partial correlation among the mentioned variables show that correlation is not statistically significant either.

The same is true also of the deck seamen if separate influence of each independent variable is considered with regard to hearing loss. However, there is a significant multiple correlation of the independent variables with the hearing losses at 2000 and 4000 Hz in the left ear, or with the averages of hearing losses at the examined frequencies in the right or in the left ear, or in both ears together.

Among the engine-room seamen a significant multiple correlation of the independent variables with the hearing loss can be seen at 1000 Hz in the right, and at 500, 1000 and 4000 Hz in the left ear. Age as an isolated independent variable shows a significant partial correlation with the hearing damage at 1000 Hz in the right, and at 500 Hz in the left ear. At the same frequencies the total length of service partially correlates with hearing damage, or the shorter the total length of service the more marked hearing damage.

For general and radio service seamen the isolated correlation of age with hearing loss is evident in the left ear only, if the hearing loss is taken as the average at all the four frequencies, or with the average at the same frequencies computed in both ears at the same time. The multiple correlation of all independent variables is marked only in relation to the hearing loss in the left ear computed as the average at all the four examined frequencies.

DISCUSSION

As already stated, no significant differences in hearing loss were found between the seamen from the various ship departments under study. One of the reasons for that may be insufficient difference in exposure levels. Although it is well known that the engine-room seamen are exposed to higher noise levels, it has to be kept in mind that all seamen on board, regardless of the type of duty, are exposed to the effect of noise for 24 hours a day, day after day, over several months (5,7). In addition, they are also exposed to vibration. Moreover, the seamen in the engine-room department are increasingly protected from the engine-room noise through the introduction of engine-room automation from control cabins where noise is at considerably lower level, or from the navigating bridge, so that the permanent presence of the engine-room personnel in the engine room is shortened (4,5,7). Some on-site studies have shown that frequent interruptions of exposure to intensive noise during the day permit a partial recovery of hearing, or slow down the damaging effect on hearing (9). Differences might have been established had the percentage of seamen with a sea service of more than 20 or 30 years been greater. However, in one of our earlier studies we failed to establish differences not only in examining a sample of similar size, but also in

a population of several thousand seamen to whom the sample belonged (5). In all probability insufficient representation of seamen with a longer sea service accounted for the relatively low average level of hearing damage which, as an average at all the four frequencies, ranged from 16.2 ± 11.7 dB to 16.5 ± 9.2 dB for the deck seamen, and from 15.6 ± 6.0 dB to 18.2 ± 8.1 dB for the seamen from the engine-room department, depending for which ear the calculations were made. The damages are nevertheless statistically more significantly marked at 4000 Hz than at the other frequencies, and have always been of a more perceptive nature, indicating the incipient noise-induced hearing damage, which is a well known fact (10-12). A certain asymmetry in the sense of more marked and noise-induced hearing damages manifested at an earlier stage at the workplace observed in this study has been found also by some other authors (13-15). Analysing the simple correlations of age, total length of service and length of sea service with the hearing loss in the examined seamen, the most marked correlations established were those of age, followed by the total length of service. The correlations of the length of sea service were marked only at the higher frequencies in the left ear in seamen from the engine-room department. This is to a certain degree an indication that a more significant connection between the length of sea service or total duration of seamen's exposure to the noise on board could be established in the case of a larger sample under examination, or when the majority of seamen were exposed to noise for a longer period of time. These results point out that occupational exposure to noise must take account also of the influence of age. The fact that none of the independent variables of our seamen - age, total length of service, length of sea service - by itself had an isolated influence upon the level of hearing damage at almost any frequency in any ear also speaks for this assumption. The influence on hearing damage was only in the form of combined variables. In support of this are also the values of the computed partial and multiple correlations shown in the Results section.

CONCLUSION

Results show that the demand for a hearing examination as part of the medical check-up seamen are supposed to take when first applying for seaman's books or of periodic medical check-ups when they come to renew their validity (16) is fully justified in spite of the differences in the total noise level to which seamen are exposed in their various duties on board.

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Sažetak

RAŠIRENOST OŠTEĆENJA SLUHA U POMORACA

U radu smo analizirali raširenost i izraženost oštećenja sluha u pomoraca duge plovidbe u odnosu prema dužini pomorskog staža, prema službi na brodu i prema životnoj dobi. U istraživanju smo se poslužili audiometrijskim krivuljama snimljenim u pomoraca koji su tijekom posljednja tri mjeseca 1994. godine došli na provjeru zdravstvene sposobnosti u Djelatnost medicine rada Doma zdravlja u Rijeci radi produženja valjanosti pomorske knjižice, odnosno radi dobivanja pojedinih ovlaštenja za dužnosti na brodu. U spomenutom razdoblju ukupno su pregledana 403 pomorca zbog navedenog razloga, a sluh smo analizirali samo u 231 pomorca sa stažem plovidbe dužim od pet godina. Studentovim t-testom nismo utvrdili statistički značajne razlike u odnosu prema životnoj dobi, ukupnom radnom stažu i ukupnom stažu plovidbe između 107 pomoraca službe palube, 86 pomoraca službe stroja i 38 pomoraca službe veze i opće službe. Međutim, nismo utvrdili niti razlike u stupnju oštećenja sluha između spomenutih skupina pomoraca. Prosječno oštećenje sluha na lošijem uhu na frekvencijama od 500, 1000, 2000 i 4000 Hz (za sve skupine pomoraca u većine je pomoraca to bilo lijevo uho), u pomoraca službe palube iznosilo je

16,5 ± 9,2 dB, u pomoraca službe stroja 16,6 ± 6,6 dB te u pomoraca opće službe i službe veze promatranim zajedno 18,2 ± 8,1 dB. Na temelju izračunanih koeficijenata jednostavne korelacije utvrdili smo statistički značajnu povezanost životne dobi, ukupnog radnog staža i ukupnog staža plovidbe s prosječnim oštećenjem sluha na spomenutim frekvencijama na lijevom uhu u pomoraca svih službi na brodu. Povezanost je bila najizraženija na frekvencijama od 2000 i 4000 Hz. U pomoraca službe palube te u pomoraca službe veze i opće službe utvrdili smo i značajnu multiplu korelaciju životne dobi, ukupnog radnog staža i ukupnog staža plovidbe s razinom oštećenja sluha na frekvenciji od 4000 Hz na lijevom uhu. U pomoraca službe palube to je utvrđeno i na frekvenciji od 2000 Hz za lijevo uho te na frekvenciji od 4000 Hz za desno uho.

Ključne riječi:
dob, ukupni staž plovidbe, služba pomorca

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