

Prevention of the Evolution of Workers' Hearing Loss from Noise-Induced Hearing Loss in Noisy Environments through a Hearing Conservation Program

Vinicius Ribas Fonseca^{1,2} Jair Marques^{3,4} Flavio Panegalli⁵ Claudia Giglio de Oliveira Gonçalves⁴ Wesley Souza⁴

¹Otorhinolaryngology, Otorrinos–Hospital da Cruz Vermelha, Curitiba, Paraná, Brazil

²Disciplina de Otorrinolaringologia, Universidade Positivo, Universidade Tuiuti do Paraná, Curitiba, Paraná, Brazil

³Department of Audiology, Universidade Tuiuti do Paraná, Curitiba, Brazil

⁴Mestrado e Doutorado em Distúrbios da Comunicação, Universidade Tuiuti do Paraná, Paraná, Curitiba, Brazil

⁵Hospital da Cruz Vermelha Brasileira, Filial do Estado do Paraná, Centro de Estudos Otorrinolaringológicos Lauro Grein Filho, Curitiba, Paraná, Brazil

Address for correspondence Vinicius Ribas Fonseca, PhD, Otorrinolaringologia, Otorrinos–Hospital da Cruz Vermelha, R. Vicente Machado, 1239 UEM–Sala 11, Curitiba, Paraná 80420-011, Brazil (e-mail: vribasfonseca@gmail.com).

Int Arch Otorhinolaryngol 2016;20:43–47.

Abstract

Introduction Noise-induced hearing loss (NIHL) is a serious problem for workers and therefore for businesses. The hearing conservation program (HCP) is a set of coordinated measures to prevent the development or evolution of occupational hearing loss, which involves a continuous and dynamic process of implementation of hearing conservation routines through anticipation, recognition, evaluation, and subsequent control of the occurrence of existing environmental risks or of those that may exist in the workplace and lead to workers' hearing damage.

Objective The aim of this study was to evaluate the effectiveness of the HCP in preventing further hearing loss in workers with audiograms suggestive of NIHL. The audiometric tests and medical records of 28 furniture company workers exposed to noise were reviewed and monitored for 2 years.

Methods This retrospective, cross-sectional study examined five audiometric tests in the medical records (on admission and every semester) of 28 workers in a furniture company (totaling 140 audiometric exams) following the introduction of the HCP.

Results Data analysis showed no differences between the audiometric tests conducted on admission and those performed every semester.

Conclusions The HCP implemented was effective in preventing the worsening of hearing loss in workers already with NIHL when exposed to occupational noise. Therefore, such a measure could be useful for the employment of workers with hearing loss in job sectors that have noise exposure.

Keywords

- ▶ noise-induced hearing loss
- ▶ hearing conservation program
- ▶ furniture

received
February 24, 2015
accepted
March 29, 2015
published online
May 25, 2015

DOI <http://dx.doi.org/10.1055/s-0035-1551554>.
ISSN 1809-9777.

Copyright © 2016 by Thieme Publicações Ltda, Rio de Janeiro, Brazil

License terms



Introduction

Hearing loss may be caused by high-intensity noise. Acoustic trauma and noise-induced hearing loss (NIHL) are examples of this type of loss. Factors such as the intensity and frequency of the sound, severe or chronic exposure, as well as association with other risk factors, such as ototoxic medication, vibration, systemic diseases or a natural tendency, can lead to NIHL. Exposure to noise at levels higher than 90 dB for more than 6 hours a day is considered harmful to the cochlea. Noise above 80 dB is considered risky.^{1,2}

In NIHL, hearing damage is not restricted to hair cells (sensory variety). Furthermore, when combined with biochemical and mechanical disturbances, neuronal loss may eventually occur. Hearing loss is clinically diagnosed as a notch (sudden hearing loss) at 3 or 4 kHz, with recovery at 8 kHz, which might increase if exposure continues until all frequencies are involved. In the early stages, the threshold of the acoustic or stapes reflex varies within a range of 0.5 to 4 kHz (around 90 dB) and gradually reduces while the loss increases (known as *recruitment*). According to this logic, a time will come at which no reflection can be produced.³

It is estimated that among the population of exposed workers, 25% have NIHL to a certain degree.³⁻⁵ There are no reliable up-to-date data on the prevalence of NIHL in Brazil, despite it being one of the most common health disorders among the working class and considering that it is mandatory to report its occurrence. It is vital to obtain reliable audiometric thresholds in the admission exam or in the reference exam. This is because the criteria that characterize the onset or worsening of hearing loss induced by noise arise from its comparison with the thresholds recorded during periodic or admission exams.⁶

Due to the incidence of NIHL, professionals in the occupational health and safety areas have been growing more concerned about prevention through the implementation of a hearing conservation program (HCP). The HCP is a set of coordinated measures to prevent the development or the progression of occupational hearing loss. It is a continuous and dynamic process of implementation of routines in companies. Wherever there is a risk to the hearing of the worker, it is necessary to implement the HCP. It is a program included in Brazilian Regulatory Standard NR-9, aiming at: "preserving workers' health and integrity, through the anticipation, recognition, assessment and subsequent control of the occurrence of existing environmental risks or of risks which might exist in the workplace." (p.29)⁴

Annex II of Brazilian Regulatory Standard NR-7 sets out the guidelines and minimum parameters for the evaluation and monitoring of hearing in workers exposed to high levels of sound pressure. In addition, it stipulates the subsidies for the adoption of hearing health preservation programs for workers, including the parameters for carrying out and interpreting audiometric tests. NR-7 also defines the ability to work, suggesting that NIHL by itself does not indicate unfitness to work and that many factors must be considered, chief among them being the demand on the worker's hearing in a particular role.^{1,3}

The aim of this study was to evaluate the effectiveness of the HCP in not increasing hearing loss in workers with audiograms suggesting NIHL. Over a period of 2 years, the assessment of the medical records and hearing tests of 28 furniture company workers were monitored.

Materials and Methods

Research Methodology

This study was submitted for approval to a research ethics committee because it is a retrospective analysis of medical records and audiometry.

A retrospective, descriptive, cross-sectional study with analysis of medical records and audiometry on admission and every semester, following the introduction of a hearing conservation program, was conducted. The aim was to find workers who presented hearing loss compatible with NIHL, its graduation, and its progression.

Data for this research were collected by researchers at the Occupational Medicine Clinic (Clínica de Medicina do Trabalho) in the state of Santa Catarina, Brazil. This study included the medical records of 28 employees, who underwent five audiometric exams each, totaling 140 analyzed tests.

Sample Description

The corresponding age group of workers was 17 to 73 years. Among the medical records of the individuals evaluated, 24 were male and 4 were female.

Inclusion Criteria

The study sampled the medical records of workers who presented hearing loss consistent with NIHL registering a notch at 3 and 4 kHz, with varying degrees of intensity. Values were registered during admission or semester examinations, which were performed after the introduction of the company's HCP.

Exclusion Criteria

The medical records of workers without hearing loss compatible with NIHL were excluded, as were those that presented data in their clinical history and physical examination that could contribute to hearing loss, such as chronic systemic diseases, use of ototoxic drugs, noise exposure, and not using hearing protection equipment.

Company Profile

The furniture company is divided physically and departmentally into the areas of machining, assembly, polishing, production, work yard, packing, boiler, office, preparation, and maintenance, all of which are exposed to a noise level of 85 dB or more.

The Audiometric Tests

The tests were performed using an Interacoustics AD 28 (Assens, Denmark) mobile audiometry device, which was taken to the industries under evaluation. All hearing tests were performed by the same speech therapist. The hearing

assessment covered the frequencies: 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz, to obtain the tonal hearing thresholds bilaterally.

The pure tone air conduction audiometric test was used and utilized headphones in a soundproof booth after a 24-hour auditory rest period. Patients were asked to remove any personal object that could hinder the passage of sound through the ear under examination. Meatoscopy of the ear was also performed to check for the presence of any impediment in the external auditory canal.

The hearing tests were divided into four groups according to their NIHL by Goodman classification.⁷ The group considered normal presented hearing ranges between 0 and 25 dB. Patients who showed mild alteration in hearing demonstrated ranges between 26 and 40 dB. Those classified with moderate hearing alteration gave values in the range 41 to 55 dB. Finally, the group considered to have severe hearing alteration had auditory ranges greater than 55 dB.

The Hearing Conservation Program

An HCP was developed and introduced due to interest from the company, following the insight of occupational medicine into the cases of NIHL and owing to the intention to include new workers with hearing impairment through the admission audiogram.

The following elements were performed in this program: (1) recognition and evaluation of risks to hearing; (2) planning and execution of audiometric management; (3) collective protection measures; (4) personal protective measures; (5) continuing education and motivation; (6) data management and program evaluation (which are part of this study).^{5,8}

Risk Agents Maps, Environmental and Noise Assessments, the Program for Medical Control of Occupational Health

(PCMSO in Brazil) and Environmental Risk Prevention Program (PPRA in Brazil) were used. In addition, work production processes were observed on the grounds that they might alter the risks to which workers are exposed. The auditory profiles of workers were described by age and length of service, hearing monitoring, sound pressure levels in the workplace, and the measures taken to control noise.

From planning to implementation, the HCP lasted 8 months, when we take the start time to be the collection of the workers' medical records (→ Table 1).

The audiometric tests were repeated every 6 months as part of the HCP, to identify new hearing loss in workers with normal tests and improvement of the hearing loss in workers with NIHL. The audiometrics records of the workers since the implementation of the HCP were reviewed in a 2-year follow-up.

Results

Out of the 100 medical records and hearing tests examined, 28 workers' medical records presented hearing loss compatible with NIHL. Of those, 19 had mild hearing loss, 3 demonstrated moderate hearing loss, and 6 registered severe hearing loss.

There were 24 male workers and 4 female workers. A total of 64.3% of the workers were aged from 20 to 35 years old.

The audiometric tests of workers with hearing losses were separated according to the individuals' labor sectors, which comprised production, maintenance, assembly, work yard, cleaning, office, packaging, preparation, machining, and polishing.

From the 19 workers who presented a mild NIHL rating, 6 worked in the preparation sector, 1 in assembly, 2 in machining, 8 in polishing, 1 in the work yard, and 1 in the

Table 1 Evolution of the Hearing Conservation Program

Elements of the program	1–2 mo	3–4 mo	5–6 mo	7–8 mo
PPRA	X	X		
Environmental assessment	X			
Noise assessment	X			
Plotting of Risk Agents Map	X	X		
Collective measures for noise control			X	X
Plotting of Risk Agents Map	X	X		
Availability of ear protectors	X	X	X	X
Control of usage of ear protectors		X	X	X
Guidance on protection of hearing	X	X		
PCMSO		X	X	X
Execution of audiometric tests				X
Referrals to ENT				X
Administrative actions and notification of workplace accident				X

Abbreviations: ENT, ear, nose, and throat; PCMSO, Program for Medical Control of Occupational Health; PPRA, Environmental Risk Prevention Program.

maintenance. Only 1 worker presented alteration in the sequence audiogram, with loss varying from mild to normal in the audiograms performed after 12, 18, and 24 months. This worker operated in the polishing sector. There is no statistically significant difference among the sample (→ **Table 2**).

Of the 3 workers who had NIHL with a moderate rating, the first worked in the polishing sector, the second in machining, and the last in assembly. There were no changes in the sequence audiograms of those workers (→ **Table 2**).

Among the 6 workers who had NIHL with a severe rating, 2 worked in the assembly sector, 2 worked in preparation, 1 in machining, and 1 in the cleaning area. There was no alteration in the intensity of hearing loss in the audiograms up to 24 months after the implementation of the HCP (→ **Table 2**).

Discussion

From the analysis of the results of the hearing tests conducted, one notices that there are no meaningful changes in the audiometric levels of the intensity of the hearing loss in employees with NIHL after the implementation of the HCP in the company. This highlights the success of the program in stabilizing the hearing loss in workers with NIHL. This fact was not observed by Gonçalves and Iguti, who analyzed the HCPs in four metallurgical companies in Piracicaba, Sao Paulo state. Even with the HCP, there was an increase in the intensity of NIHL.⁵

Even before the implementation of the HCP, the manufacturing firm where the study was performed was already compliant with Regulatory Standard NR-6 (Safety

Table 2 Results of the evolution of the hearing loss after the installation of the hearing conservation program

Subject no.	Sex	Work sector	Initial audiometric hearing loss result	6-mo audiometric hearing loss result	12-mo audiometric hearing loss result	18-mo audiometric hearing loss result	24-mo audiometric hearing loss result
1*	M	Polishing	Mild*	Mild*	Normal*	Normal*	Normal*
2	M	Assembly	Mild	Mild	Mild	Mild	Mild
3	M	Preparation	Mild	Mild	Mild	Mild	Mild
4	F	Work yard	Mild	Mild	Mild	Mild	Mild
5	M	Polishing	Mild	Mild	Mild	Mild	Mild
6	M	Polishing	Mild	Mild	Mild	Mild	Mild
7	M	Machining	Mild	Mild	Mild	Mild	Mild
8	M	Preparation	Mild	Mild	Mild	Mild	Mild
9	M	Maintenance	Mild	Mild	Mild	Mild	Mild
10	M	Polishing	Mild	Mild	Mild	Mild	Mild
11	M	Polishing	Mild	Mild	Mild	Mild	Mild
12	F	Machining	Mild	Mild	Mild	Mild	Mild
13	F	Polishing	Mild	Mild	Mild	Mild	Mild
14	M	Polishing	Mild	Mild	Mild	Mild	Mild
15	M	Preparation	Mild	Mild	Mild	Mild	Mild
16	M	Preparation	Mild	Mild	Mild	Mild	Mild
17	F	Preparation	Mild	Mild	Mild	Mild	Mild
18	M	Polishing	Mild	Mild	Mild	Mild	Mild
19	M	Preparation	Mild	Mild	Mild	Mild	Mild
20	M	Polishing	Moderate	Moderate	Moderate	Moderate	Moderate
21	M	Machining	Moderate	Moderate	Moderate	Moderate	Moderate
22	M	Assembly	Moderate	Moderate	Moderate	Moderate	Moderate
23	M	Preparation	Severe	Severe	Severe	Severe	Severe
24	M	Assembly	Severe	Severe	Severe	Severe	Severe
25	M	Cleaning	Severe	Severe	Severe	Severe	Severe
26	M	Assembly	Severe	Severe	Severe	Severe	Severe
27	M	Machining	Severe	Severe	Severe	Severe	Severe
28	M	Preparation	Severe	Severe	Severe	Severe	Severe

and Occupational Medicine) regarding the use of PPE (personal protective equipment)⁶ which according to NR-6 is “a device or product for the personal use of the worker for protection from susceptible risks threatening health and safety at work”^(p.1)⁹

At the firm, the workers of the various sectors already mentioned are exposed to risky noises during work, which makes it extremely important to ensure the mandatory use of PPE, a factor that has certainly determined low-level changes in hearing.

The variation in the magnitude of NIHL found between the groups may be related to the total working lifetime exposure to noise, a fact that was not possible to assess in this study because it involved a medical records review in which that information was not included. The literature considers the hearing loss caused by noise to reach its maximum level of injury in the first 10 to 15 years of exposure to noise.³

Regarding the PCMSO and the PPRA of the company studied, these were already in place when the HCP was implemented. However, they were reviewed in the first 4 months, and additional measures were taken to reduce environmental noise and vibrations, such as the use of noise-reducing air nozzles, which benefit jobs collectively. The company has chosen to adopt hearing protection, which should be considered as a palliative but not preventive measure and not definitive in hearing preservation. There was no calculation of the noise dose that each worker receives on a given working day, making it impossible to make a comparison with the officially recommended exposure limits.

The fact that there was a worker with alternating audiometric thresholds classified as mild NIHL for an audiometry considered normal should be considered an isolated factor and statistical analysis should not be applied in this case. Such fluctuations in audiometry may have been due to lack of compliance with the preexamination hearing rest period or factors intrinsic to the specific worker.

Conclusion

The HCP implemented was effective in preventing the progression of hearing loss in workers already suffering from NIHL when exposed to occupational noise. In this way, such action can be useful for the inclusion of workers with hearing loss in job sectors exposed to noise.

References

- 1 Davis A. The prevalence of deafness. In: Ballantyne J, Martin A, Martin M, eds. Deafness. London, UK: Whurr Publishers; 1993: 1–11
- 2 De Brito VPS. Incidência da Perda Auditiva Induzida por Ruído em trabalhadores de uma fábrica [Monografia de conclusão de curso]. Goiânia, Brazil: Centro de Especialização de Fonaudiologia; 1999
- 3 Bergström B, Nyström B. Development of hearing loss during long-term exposure to occupational noise. A 20-year follow-up study. *Scand Audiol* 1986;15(4):227–234
- 4 BRASIL—Perda Auditiva Induzida por Ruído (Pair) Série A. Normas e Manuais Técnicos. Available at: http://bvms.saude.gov.br/bvs/publicacoes/protocolo_perda_auditiva.pdf. Accessed November 21, 2007
- 5 Carnicelli MVF. Audiologia preventiva voltada à saúde do trabalhador: organização e desenvolvimento de um programa audiológico numa indústria têxtil da cidade de São Paulo [dissertação]. São Paulo, Brazil: Pontifícia Universidade Católica; 1988
- 6 Gonçalves CGO, Iguti AM. Program for hearing loss prevention in four metallurgical factories in Piracicaba, São Paulo, Brazil. *Cad Saude Publica* 2006;22(3):609–618
- 7 Goodman A. Reference levels for pure-tone audiometer. *ASHA* 1965;7:262–263
- 8 Gobbato LHFG, Costa EA, Sampaio MH, Gobbato FM Jr. Estudo do efeito aprendizagem em exames audiométricos sequenciais de trabalhadores de indústria metalúrgica e suas implicações nos programas de conservação auditiva. *Braz J Otorhinolaryngol* 2004; 70(4):540–544
- 9 Brasil. NR6 - equipamento de proteção individual - EPI. Available at: [http://portal.mte.gov.br/data/files/FF8080814CD7273D014D34C6B18C79C6/NR-06%20\(atualizada\)%202015.pdf](http://portal.mte.gov.br/data/files/FF8080814CD7273D014D34C6B18C79C6/NR-06%20(atualizada)%202015.pdf). Accessed on May 13, 2015