THE EFFECTS OF IMPULSE NOISE ON THE AUDITORY SYSTEM

NIOSH #5 R01 OH01152-14

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Significant Findings

Significant progress was made on each of the three, complementary specific objectives. The first objective, **to better understand the relation between the parameters of impact noise and noise induced hearing loss**, stems from the ambiguity (and inadequacy) of our current noise standards. Currently, exposures of 115 dBA are permitted for 15 minutes, but no exposure to impulse or impact noise over 140 dBA is permitted. However, it is relatively common in industry to find impacts ranging from 100 to 140 dBA, but there is limited guidance on what is a safe exposure. An impact is evaluated in terms of the peak level equivalent but the spectral content, duration of the impact, the rate of presentation and the total number of the impacts are ignored.

Thus, the first aim was to provide a perspective on the role of spectral content, repetition rate, and duration as factors in noise induced hearing loss . A unifying principle of all the experiments is that the level, duration and number of exposures are counterbalanced so each experimental condition had the same total acoustic energy (power/time).

The first major finding is that the duration, spectral content, and rate of presentation all influence the degree of hearing. This is an important finding because our current noise standards are based solely on the peak level of the impact and the duration of time the impacts are presented.

Second, a more general significant result is the demonstration of the "critical level" phenomenon for impact noise. Specifically, for exposures below a certain peak level, the hearing loss results were consistent with the Equal Energy Hypothesis, however, for exposures with peak levels above the "critical level" hearing loss grew proportionately to the peak level of the impact. Above the "critical level" the ear is damaged by direct mechanical failure and below the "critical level" the mode of damage is more metabolic.

Resulting Publications

Henderson, D., Farzi, F. and Danielson, R. (1990) The concept of critical level and impulse noise. Environmental International 16, 353-361.

Henderson, D. and Subramaniam, M. (1993c) Toughening: Acoustic parameters. In: , Noise and Man: Proceedings of the 6th International Congress on Noise as a Public Health Problem, Nice, France.

Henselman, L.W., Henderson, D., Subramaniam, M. and Sallustio, V. (1994) The effect of "conditioning" on hearing loss from impulse noise. Hear.Res. 78, 1-10.

Henselman, L.W., Henderson, D., Shadoan, J., Subramaniam, M., Saunders, S. and Ohlin, D. (1995) Effects of noise, race and year of service on hearing in the U.S. Army soldiers. Ear and Hearing 16, 328-391.

Henderson, D. and McFadden, S.L. (1996) Ototraumatic effects of noise. In: P. Wexler (Ed.), Encylopedia of Toxicology. Appleton & Lange, Norwalk, CT, .

The second specific aim, **to better understand the biological changes in the cochlea associated with exposure to high level impact noise,** is based on the assumption that an understanding of the mechanisms of noise induced hearing loss will provide insights into the practical problem of identifying individuals who are unusually susceptible or resistant to the effects of noise. On this aim, there was also significant progress. Since impact noise causes mechanical damage to the cochlea, several of our experiments were directed at understanding the changes in F-actin a key structural protein in the cochlea. With exposures over the "critical level", the structural elements of pillar cells, and Deiter cells, as well as, tight cell junction at the cuticular plate/reticular lamina, are interrupted leading to a possible mixing of perilymph and endolymph and fundamental change in the vibratory characteristics of the organ of Corti.

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Henderson, D., Subramaniam, M. and Boettcher, F.A. (1993) Individual susceptibility to noise induced hearing loss: an old topic revisited. Ear and Hearing 14, 152-168.

The third aim, **to explore the possibility of increased resistance to impact noise with prior prophylactic exposures**, is a logical extension of our previous work showing that the auditory system can be made more resistant to the effect of a traumatic exposure by providing a prior exposure to a non-traumatic noise. One of the most exciting findings of our NIOSH grant was that a 10 day, 6 hour per day exposure to .5 kHz OB noise at 95 dB, provided substantial protection (>20 dB) from future exposure to high level impulses (155 dBA duration). This result opens up the possibility of providing protection to the ear when the subject cannot wear muffs or ear plugs.

Resulting Publications

Campo, P., Subramaniam, M. and Henderson, D. (1991) Effect of 'conditioning' exposures on hearing loss from traumatic exposure. Hear.Res. 55, 195-200.

Fiorino, F., Gratton, M., Subbanna, M., Bianchi, L. and Henderson, D. (1989) Physiological mechanism underlying the progressive resistance to noise induced hearing loss. Valsalva LXV (Suppl.1) suppl 1, 36-41.

Henderson, D., Campo, P., Subramaniam, M. and Fiorino, F. (1992) Development of resistance to noise induced hearing loss. In: A. Dancer, D. Henderson, R.J. Salvi and R.P. Hamernik (Eds.), Noise Induced Hearing Loss. Mosby Year Book, St Louis, pp. 476-488.

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Henderson, D., Subramaniam, M., Henselman, L.W., Portalatini, P., Spongr, V. and Sallustio, V. (1996a) Protection from continous impact, or impulse noise provided by prior exposure to low-level noise. In: A. Axelsson, H.M. Borchgrevink, R.P. Hamernik, P.A. Hellstrom, D. Henderson and R.J. Salvi (Eds.), Scientific basis of noise-induced hearing loss. Thieme Medical Publishers, Inc., New York, pp. 128-142.

Henderson, D., Subramanim, M., Papazian, M. and Spongr, V.P. (1994c) The role of midddle ear muscles in the development of resistance to noise induced hearing loss. Hear.Res. 74, 22-28.

Hu, B.H., Henderson, D. and Spongr, V. (1996) Changes in F-actin in the hair cell of the chinchilla cochlea following noise exposure. Abstract of Association for Research in Otolaryngology.

Hu, B.H., Zheng, X.Y., McFadden, S.L., Kopke, R. and Henderson, D. (1997) R-PIA attenuates noise-induced hearing loss in the chinchilla. Hear.Res.

Jacono, A., Kople, R., Vungmyster, L., Steinman, H., Rowe, J., Hu, B.H., Van De Water, T.R. and Henderson, D. (1996) Changes in cochlear antioxidant enzyme activity levels after conditioning noise exposures in the chinchilla. Abstr.Assoc.Res.Otolaryngol.

McFadden, S.L., Campo, P. and Henderson, D. (1997a) Age-related differences in susceptibility to noise-induced loss of auditory sensitivity and cochlear damage in chinchillas. .

McFadden, S.L., Henderson, D. and Shen, Y.H. (1997d) Low-frequency 'conditioning' provides long-term protection from noise-induced threshold shifts in chinchillas. Hear.Res. 103, 142-150.

Usefulness of Funding

Our current noise regulations are based on demographic data that are over 30 years old. The regulations are particularly weak in the areas of guidance for impulse and impact noise. Our project provides clear evidence that : (1) the simple rules for evaluating impact noise do not cover the orderly contribution of impact duration, spectrum and the repetition role to hearing loss from exposures to impacts; (2) the arbitrary upper level of 140 dB is likely to be way too high to protect individuals from impact noise. Our data show that above 119-125 dB impacts cause direct mechanical damage. These two observations argue for a re-evaluation of our noise regulations so that they more accurately reflect the hazards of exposures to impact noise

On a more prospective theme, our data showing that the ear can be made more resistant to impulse noise opens the possibility of developing prophylactic exposures to prevent hearing loss in situations such as construction where workers often do not wear personal protection devices because of the fear of accidents.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service
Centers for Disease Control
and Prevention (CDC)

Memorandum

Date: May 31, 2001

From: Roy M. Fleming, Sc.D., Director, Research Grants Program RMF
Office of Extramural Programs, NIOSH, D30

Subject: Final Report Submitted for Entry into NTIS for Grant 5 R01 OH001152-14.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications

Hu BH, Zheng XY, McFadden SL, Kopke R, Henderson D: R-PIA Attenuates Noise-induced Hearing Loss in the Chinchilla. Hear Res 113:198-206, 1997

McFadden SL, Campo P, Henderson D: Age-related Differences in Susceptibility to Noise-induced Loss of Auditory Sensitivity and Cochlear Damage in Chinchillas. Hear Res 111:114-126, 1997

McFadden SL, Henderson D, Shen YH: Low-frequency 'Conditioning' Provides Long-term Protection from Noise-induced Threshold Shifts in Chinchillas. Hear Res 103:142-150, 1997

Hu BH, Henderson D: Changes in F-actin in the Hair Cell of the Chinchilla Cochlea Following Noise Exposure. Hearing Research 110:209-218, 1997

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Henselman LW, Henderson D, Shadoan J, Subramaniam M, Saunders S, Ohlin D: Effects of Noise, Race and Year of Service on Hearing in the U.S. Army Soldiers. Ear and Hearing 16:328-391, 1995

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Title: The Effects of Impulse Noise on the Auditory
Investigator: Donald Henderson, Ph.D.
Affiliation: State University of New York
City & State: Buffalo, NY
Telephone: (716) 829-2001
Award Number: 5 R01 OH001152-14
Start & End Date: 4/1/1991–3/31/1997
Total Project Cost: $2,388,849
Program Area: Hearing Loss
Key Words:

Abstract:
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