Spectrum

A PUBLICATION OF THE NATIONAL HEARING CONSERVATION ASSOCIATION

April 2006 *Volume 23 Number 2*

"The Emperor has no clothes" Age Correction of Audiograms

by Theresa Schulz

The effect of noise and aging on the auditory system is complex and multi-faceted. In an effort to simplify and quantify the effect of aging and to try to tease it out and account for the change in hearing that is *not* related to noise, NIOSH proposed a method to estimate the amount of hearing change that is due to aging. It has been simplified as the age correction tables and methods included in the 1983 Hearing Conservation Standard and other regulatory documents. But even those are not very simple. Alfred Lord North, a 17th century mathematician said it best when he said "seek simplicity, and distrust it."

Applications of age correction

The term "age correction," as applied to audiometric thresholds refers to a method to estimate the amount of hearing loss due to the aging auditory system as opposed to other causes of hearing loss. That concept is used in other tests of sensory acuity such as visual acuity, but in a different way. Optometrists have developed estimates of expected visual acuity based on age but they use those as a starting point to measure individual level of presbyopia. Other medical tests that measure changes over time are compared to ranges of normal for a given age; if results fall outside that range, further investigation is warranted to determine what factor other than aging could have caused the change.

In determinations of work-relatedness, disability, or compensation, we may use the same data used in the NIOSH age-correction tables or the International Organization for Standardization (ISO) ISO-1999 databases along with other information in our clinical decision (like optometrists in the example above). "Allocation is not age correction; the practice of age correcting an audiogram prior to calculation of a hearing handicap score is fundamentally unfair. Allocation is an exercise of informed clinical judgment, requiring a solid understanding of the epidemiology of age-related and noise-induced hearing loss." (Dobie, 1997)

History of age correcting audiograms.

The original NIOSH criteria document of 1972 states that "The best way to make this correction is to use data from a non-noise exposed group from the same area tested in the same manner as the group under consideration. Quite often this is not possible; therefore, it is necessary to establish an age correction

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that can be used universally." (NIOSH, 1972, p. III-6)

If you can compare to a non-noise exposed group, you can compare to the equivalent age group in the non-noise exposed and not require age corrections at all, since the non-noise exposed group is aging as well.

Most of the studies of age-associated hearing loss are cross-sectional, looking at all age groups at one point in time rather than longitudinal, looking at rates of change in hearing thresholds over time (Pearson et al, 1995). Cross-sectional studies assume that the 56-year-old of 1970 has the same age-related hearing loss as the individual who was 20 in 1970 will have now at age 56 in 2006 (NIOSH, 1998). The NIOSH-based tables were developed from a cross-sectional study (NIOSH, 1972).

The NIOSH tables do include the variable rate at which changes in hearing due to aging occur over time, in that the total correction values used from year to year are usually only about 0-2 dB per year for males up to age 45, but after age 48 the rate of change from year to year is about 2-4 dB for males. Gender differences are also included since there is a separate table for females. The table predicts a rate of changes in hearing due to aging in females of 0-1 dB per year up to age 34, and 1-2 dB per year above age 35.

Other methods

Other methods of age correction have been proposed. Some try to consider the many variables that affect an appropriate age correction. Corso (1980) describes the concept of variable ratio. The proportion of the hearing loss due to noise vs. aging is dependent on the age at which the noise exposure occurs and existing amount of hearing loss. Essentially a variable ratio is used at each frequency and the threshold is multiplied by the appropriate ratio. The product (in decibels) is then subtracted from the audiometric value at that frequency. The result is the value of hearing level attributable to noise exposure alone (corrected for age). This method was too complex for practical use but now that virtually all audiograms are collected with computerized equipment, the calculation could be applied more easily.

The ISO 1999 model, the ANSI S3.44 model (derived from ISO 1999) and the earlier Burns and Robinson model have been found to give reliable predictions of hearing thresholds resulting from the combination of aging and noise exposure (Royster et al, 2000). These models are also complex and time-consuming to calculate by hand. However, computer programs can make the rapid predictions.

The math

Confusion exists about details of the age-correction method allowed by OSHA and MSHA and other regulations. Remember that age correction is allowed but not mandated in these standards.

The original NIOSH recommendation in 1972 called for comparison to both the baseline and to the previous audiogram. Age correction was used for the comparison to the baseline but not to the previous

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audiogram. The recommendation in the 1972 criteria document was to complete a baseline audiogram within 30 days of assignment to noise; an additional audiogram was to be taken every second year and a new baseline established every sixth year. (Note the errors mentioned in the caption of Table 1.)

The OSHA method differs from the 1972 NIOSH procedure in several ways. The OSHA procedure correctly subtracts the age correction values associated with the age at baseline from the values associated with age at current audiogram. It uses that Δ (delta) value to adjust the annual audiogram (subtract Δ values from current thresholds rather than add Δ values to the baseline). Comparison is no longer done to the previous audiogram (that are now required annually)—only to the baseline. And, of course, the definition of STS is quite different from the original NIOSH recommendation.

Currently, NIOSH does not recommend age correction on individual audiograms citing the delay in intervention and fact that applying a median population value to all individuals is not scientifically valid (NIOSH, 1998). The current NIOSH recommendation for the definition of STS is a change in the HTL in either ear that equals or exceeds 15 dB at 500, 1000, 2000, 3000, 4000, or 6000 Hz that has been confirmed on a subsequent re-test.

Although the new MSHA regulation included some recommendations from the 1998 NIOSH Criteria Document, it did not follow the NIOSH recommendation regarding age-correction or STS definition. MSHA currently allows age-correction using the same procedure as OSHA. (Remember that MSHA uses different recordability criteria—the old OSHA criteria of 25 dB average STS from original baseline—rather than the new OSHA criteria that is a 10-dB STS that results in an average hearing loss of 25 db or greater at the STS frequencies.)

The age adjustment method shown in the 4th Edition of the CAOHC Hearing Conservation Manual is correct in the text, but the example inappropriately compares averages rather than the thresholds from each frequency.

Reasons not to age correct

It is useful and beneficial to have a way to estimate the effects of both noise and aging on hearing levels. However, the use of the 1972 NIOSH tables to age-correct individual audiograms and make decisions based on that calculation alone is not a good hearing loss prevention practice. Reasons not to age correct include:

1. Applying aggregate data to an individual. The age-correction tables use the median or average value for a group of individuals. There are a range of values that represent the varied rate of aging. Some people have "very young ears" for their age while others have "very old ears" for their age. Since we don't know the aging rate for each person, we use the average rate of hearing loss due to aging for everyone. This will over age-correct for some and under age-correct for others and, of course, be just right for some people.
2. Using only 50th percentile with no standard deviation applied. We know there is a range of age effect on hearing but we use a single (average) number as if it were precisely correct. The results of most medical exams and lab tests are reported in the context of a range of normal values. This acknowledges that each individual is different and uses a range of numbers rather than one-size-fits-all.
3. The table does not go above age 60. The original NIOSH data did not include people over 60 years old, so age corrections for workers over age 60 are even more inaccurate. There are increasing numbers of workers in this age range.
4. The table does not go below age 20. The original NIOSH data did not include people under age 20. Since little age correction is needed at these ages, we tend to over-correct by using the values for 20 year-olds.
5. The table does not consider race/ethnic differences. A database of non-noise-exposed population of back males and females (Royster et al, 1980; Royster et al, 1998) revealed better hearing than the NIOSH data when compared by sex. The NIOSH data included mostly Caucasian workers.
6. NIOSH does not recommend age correction. In 1998, NIOSH recommended against the use of the age-correction tables to apply to individual audiograms. The Department of Defense (DoD) does not use age corrections, nor do "model" hearing conservation programs in industry.
7. Taken from hearing tests of "normals" back in early 1960s. The NIOSH tables are based on 380 non-noise exposed and 792 noise-exposed employee hearing tests done from 1968 to 1971 in the "steelmaking, paper bag processing, aluminum processing, quarrying, printing, tunnel police, wood working, and trucking" industries (NIOSH, 1972). These workers may not be representative of today's noise-exposed worker.
8. Delaying the inevitable. Applying an average "age-correction" to an individual audiogram may have the effect of hiding a real noise-induced hearing loss or at least delaying its identification. When a decrease in hearing of the magnitude of an STS occurs, some intervention should be taken whether the change is due to noise, aging or some other etiology. The individual should be made aware of the change and an investigation as to its cause can be initiated. Medical treatment, new personal protective equipment, or a change in behavior may prevent more hearing impairment.
9. If you hadn't been age correcting, you might find STS (and intervene) *before* it becomes recordable. If you prevent noise induced hearing loss early, OSHA recordable cases should be rare. If you do age correct, a hearing loss may reach the recordable level before you recognize it as an STS and let the worker know that they need to do something (e.g., change behavior in some way; use better/different HPDs or better use of HPDs). In that case, you have a "hearing-loss documentation program" not a hearing conservation program.

After 33 years of confusion about age-correcting audiograms when determining whether an STS has occurred, I think it is

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time for change. It is possible (to quote 19th century Danish author, Hans Christian Andersen) that "*this emperor has no clothes!*" If we are going to continue using age corrections, we need to:

- Determine a more accurate estimation of the rate of change in hearing thresholds due to aging
- Create a range of normal values for the aging ear based on the many variables that affect hearing
- Extend the data to include workers less than 20 years old (start at age 15 or 16?)
- Extend the data to include workers over age 60
- Include differences in race/ethnicity

OR

- **Do not use age correction at all**.

References

Corso, J. F. (1980). Age Correction Factor in Noise-Induced Hearing loss: A Quantitative Model, *Audiology 19:* 221-232.

Dobie, R. A. (1997). Allocation of hearing loss. *Journal of the Acoustical Society of America.* 102(5), p. 3127

OSHA (1983). Occupational Noise Exposure Standard. *29 Code of Federal Regulations, Title 29, Chapter XVII, Part 1910.95.*

NIOSH (1972). Criteria for a Recommended Standard – Occupational Exposure to Noise, U.S. Dept. HEW (NIOSH), Rept. HSM 73-11001. I-14, I-15, III-6, III-7.

NIOSH (1998). Criteria for a Recommended Standard – Occupational Noise Exposure, U.S. DHHS (NIOSH), Publication No. 98-126.

Royster, L H., Driscoll, D. P., Thomas, W. G., and Royster, J. D. (1980). Age effect hearing levels for a black nonindustrial noise exposed population (NINEP). *American Industrial Hygiene Association Journal* 41(2): 113-9.

Royster, L. H., Royster, J. D., Dobie, R. A. (2000). Prediction and Analysis of the Hearing Characteristics of Noise-Exposed Populations or Individuals, in E. H. Berger, L. H. Royster, J. D. Royster, D. P. Driscoll and M. Layne (Eds.), *Noise and Hearing Conservation Manual,* (5th ed., Chapter 17, pp 669-688). Fairfax, VA: American Industrial Hygiene Association.

Royster, L. H., Royster, J. D. and Thomas, W.G. (1980). Representative hearing loss by race and sex in North Carolina industry. *Journal of the Acoustical Society of America* 68(2): 551-66.

Suter, A. H. (2002). Hearing Conservation Manual, 4th edition. CAOHC, Milwaukee, WI.

AGE CORRECTION TECHNIQUE

(Developed by Dick Danielson, PhD)

1. Using 29 CFR 1910.95,Table F-1 (for males) or F-2 (for females), determine age correction values at 2, 3, and 4 kHz for:
   a. **Current audiogram**
   b. **Baseline audiogram**
2. Subtract values from 1b from values in 1a, yielding amount due to aging (**Diff Aging**) at 2, 3, and 4 kHz.
3. Subtract **Diff Aging** from corresponding thresholds at 2, 3, and 4 kHz found in **Current Audiogram**, to generate **Age-Corrected Current Audiogram**
4. Subtract thresholds at 2, 3, and 4 kHz in **Baseline Audiogram** from 2, 3, and 4 kHz in **Age-Corrected Current Audiogram**
5. Add the differences found at 2, 3, and 4 kHz. (STS, if sum found in #5 is ≥ 30dB)

NOTE

If the age correction value is greater than the actual threshold (resulting in a negative number) do not value as zero.

EXAMPLE (showing only frequencies relevant to STS determination):

MALE WORKER	2k	3k	4k	
Current Audiogram (Age 48)	25	35	40	
Baseline Audiogram (Age 30)	10	15	20	
1 Age Correction for Age 48	(8)	(14)	(20)	
Age Correction for Age 30	(4)	(6)	(9)	
2 **Diff Aging**	**4**	**8**	**11**	
3 Current Audiogram (Age 48)	25	35	40	
Diff Aging	**4**	**8**	**11**	
Current Audiogram (Age Corrected)	21	27	29	
4 **Current Audiogram (Age Corrected)**	21	27	29	
Baseline Audiogram (Age 30)	10	15	20	
5 **STS Computation**	**11**	**12**	**9**	**sums to 32dB**