A Comparison of the Military Entrance Processing Station Screening Audiogram with the Defense Occupational and Environmental Health Readiness System Reference Audiogram at Fort Sill, Oklahoma, in 2000

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Background: The Department of Defense Hearing Conservation Program requires that a reference audiogram be performed at initial entry training (IET), before noise exposure. In the Army, only Fort Sill, home of the field artillery, and Fort Benning, home of the infantry, are in compliance. All military applicants receive a screening audiogram at a military entrance processing station (MEPS) to qualify for service. This audiogram does not meet the Defense Occupational and Environmental Health Readiness System-Hearing Conservation (DOEHRS-HC) standard. Nevertheless, it has been proposed that the MEPS screen be used as the reference because of limited resources and time during IET medical in-processing. Methods: A total of 11,816 individual reference audiograms performed at Fort Sill 95th Adjutant General Recruit Reception Center in 2000 were identified in the DOEHRS-HC database. Results of the MEPS screening audiograms were found for 11,311 (96%) of these individuals. The two audiograms were compared by frequency and ear and by using the two Department of Defense criteria for threshold shift. Results: A total of 14.49% (95% confidence interval, 14.48–14.50%) of audiograms using the three-frequency average difference and 23.19% (95% confidence interval, 23.18–23.20%) using the four-frequency difference in either ear demonstrated a threshold shift. The mean difference in intensity between the two audiograms ranged from 5 to 12 dB and varied by frequency and ear, with the greatest differences being seen at 500 and 6,000 kHz and in the left ear, compared with the right ear. The mean threshold level was higher for each frequency in the DOEHRS-HC audiogram, compared with the MEPS audiogram. Conclusions: Approximately 15% of soldiers at Fort Sill in 2000 showed a clinically significant threshold difference between their MEPS screening and the DOEHRS-HC baseline audiogram. Methodological variations in testing and interval noise-induced hearing loss could account for these differences. The results do not support the use of the MEPS screening audiogram as the reference audiogram. Compliance with the Hearing Conservation Program in the Army would require either improving MEPS testing to DOEHRS-HC standards or performing baseline audiograms at all five IET sites.

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Introduction

In calendar year 2000, the U.S. Military Entrance Processing Command (USMEPCOM) received >365,000 active military applications at 65 stations worldwide; >188,000 personnel accessed into the active component military, and ~159,000 additional personnel accessed into the selected reserve component.[1] Part of the accession physical examination is a hearing screening audiogram. Hearing tests involve presenting to an individual pure tone sounds at various frequency levels and determining the minimal threshold (in decibels) that can be detected. Department of Defense (DoD) Instruction 6130.3 sets the acceptable audiometric hearing levels in both ears as follows: (1) pure tone levels at 500, 1,000, and 2,000 Hz of not more than 30 dB on average, with no individual level of >35 dB at those frequencies; and (2) pure tone levels of not more than 45 dB at 3,000 Hz and 55 dB at 4,000 Hz.[2]

Military applicants range in age from 17 to 35 years, with >90% being <25 years of age.[1] Military applicants who do not meet the standards are disqualified but may pursue an accession medical waiver from the service of interest. Hearing loss is a relatively common cause for disqualification, accounting for 6.8% of all disqualifications in calendar year 2000.[3] Hearing loss was one of the leading conditions of approved waivers in active component accessions, with >2,060 in 2001.[3] The Accession Medical Standards Analysis and Research Activity (AMSARA) has studied the military retention patterns of recruits with a waiver for hearing loss. Results varied by service, but in the Army and Navy accessions with a hearing loss waiver had a lower likelihood of retention than did matched nonwaived accessions.[3] The accuracy of preinduction audiograms performed at a military entrance processing station (MEPS) was evaluated by Chandler et al.[4]

The DoD Hearing Conservation Program is detailed in DoD Instruction 6055.12.[5] It recognizes that initial entry training (IET) is a noise-hazardous environment, and it requires that a reference audiogram be performed for all military personnel at basic training, before noise exposure. The prevalence of noise-induced hearing threshold shift is estimated to be 15.5% (95% confidence interval [CI[, 13.3–17.6) in the United States for 12- to 19-year-old individuals, based on Third National Health and Nutrition Examination Survey data.[6] The prevalence of hearing loss among soldiers with <2.5 years of service has been esti-

mated to be 5.4%.[7] The DoD uses the Defense Occupational and Environmental Health Readiness System-Hearing Conservation (DOEHRS-HC) as its database system for monitoring hearing, auditory readiness, and hearing loss liability for DoD military and civilian personnel. The DOEHRS-HC is an automated system that does not require manual transcription of threshold levels. DOEHRS-HC contains demographic information with each record and requires a 14-hour quiet period before the examination, as required by the Occupational Safety and Health Administration. Testing can be performed only by a licensed provider, such as a physician or audiologist, or by a certified technician of the Council for Accreditation in Occupational Hearing Conservation. The DOEHRS-HC also has a default feature that routinely checks the system's calibration and terminates operation if annual calibration is not maintained. DOEHRS-HC test results are transmitted electronically to a central data repository for archiving.[7]

MEPS screening audiograms were obtained by using Tremetrics RA400 microprocessor audiometers (Benson Medical Instrument, Minneapolis, Minnesota) with either automated or manual transcription. No certification is required for technical personnel to perform the test. No pretest quiet period is required. Calibration is performed at variable intervals (K. Daller, personal communication).

Currently IET is conducted at nine different sites. The length of training varies according to service, from 6 weeks in the Air Force to 12 weeks in the Marine Corps.[8] The noise exposure varies according to service and among the five Army IET sites. The Navy (Great Lakes Recruit Training Center, Illinois), Marine Corps (Marine Corps Recruit Depots in Parris Island, South Carolina, and San Diego, California), and Army (at two sites, i.e., Fort Sill, Oklahoma, and Fort Benning, Georgia) perform universal DOEHRS-HC reference audiograms for recruits upon arrival. Fort Sill is the home of the artillery school and Fort Benning the infantry school. The Air Force (Lackland Air Force Base, San Antonio, Texas) performs reference audiograms at various times in IET. The other three Army sites (Fort Jackson, Fort Knox, and Fort Leonard Wood) review the MEPS screening audiograms and perform selected audiograms based on local criteria.

The argument has been made by various elements within the U.S. Army Training and Doctrine Command, USMEPCOM, and Medical Command that, because of constraints in manpower, funding, and time for IET medical in-processing, the MEPS screening audiogram should serve as a proxy for the reference audiogram. Alternative options would be to perform DOEHRS-HC reference audiograms at either MEPS or IET sites.

Methods

A cross-sectional study was performed with the purpose of assessing the comparability of the MEPS screening audiogram with the DOEHRS-HC reference audiogram performed during IET medical in-processing. Objectives of the study were to compare the two tests according to individual recruit, ear, and frequency and to estimate the frequency of statistically and clinically significant threshold shifts between these two tests.

The study design is illustrated in Figure 1. Fort Sill was chosen because reference audiograms are performed for all recruits during medical in-processing. DOEHRS-HC audiograms for Fort Sill were obtained from the U.S. Army Center for Health Promotion and Preventive Medicine Hearing Conservation Program, with approval from the DoD Assistant Secretary of Defense for Health Affairs, Tricare Management Office. Duplicate records, nonreference audiograms, non-recruit reception center records, non-Army records, officer records, and records without personal identifiers (name and Social Security number) were excluded. A total of 11,311 reference audiograms from Fort Sill were matched to the MEPS screening audiograms from datasets provided routinely to AMSARA by USMEPCOM. Fort Sill used a Bernafon-Maico model MA 1000 audiometer.

Selected demographic characteristics, including age, gender, race, Armed Forces Qualification Test results, and geographic region of home of record, were compared between Fort Sill recruits and all Army IET recruits. These data were also obtained from the applicant datasets provided routinely to AMSARA by USMEPCOM. The distribution of the time interval between the two audiograms was described.

A comparison of the mean intensity by ear and frequency was performed for the 11,311 individuals with both audiograms; 95% CIs were calculated for the mean observations. Statistical

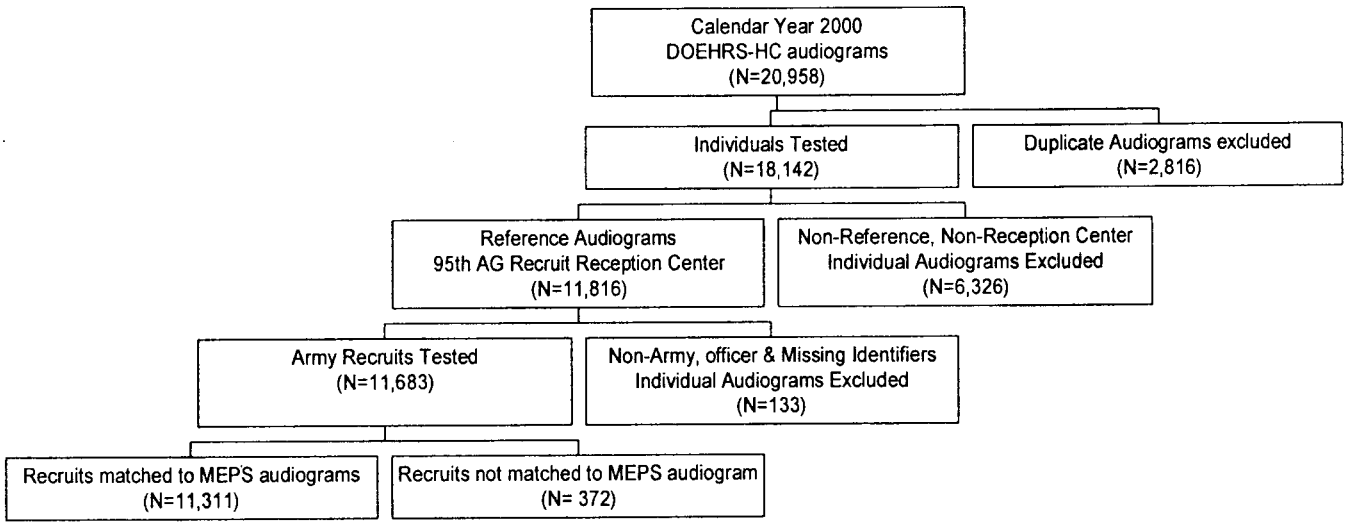

Fig. 1. Study design. AG, Adjutant General.

significance between the means for a given frequency was determined with nonoverlapping 95% CIs. A comparison of the mean of the individual differences between the two audiograms was also performed. The frequencies of positive, negative, and zero differences in intensity by ear across all frequencies were calculated.

The percentages of records with clinically significant threshold shifts between the two audiograms in either or both ears were estimated by using the two DOEHRS-HC clinical definitions.[6] The first criterion, developed by the Occupational Safety and Health Administration, is a three-frequency average of ±10 dB or more at 2,000, 3,000, and 4,000 Hz.[9] The second criterion used was a difference of ±15 dB or more at any of the following frequencies: 1,000, 2,000, 3,000, or 4,000 Hz; 95% CIs were calculated for these point estimates.

Results

A comparison of selected demographic characteristics between the Fort Sill recruit study group and the general Army active duty recruit population is shown in Table I. The Fort Sill recruits were slightly older, a larger percentage were Caucasian, they had lower Armed Forces Qualification Test scores, and they were more likely to be from the North Central region. These findings were statistically significant ($p < 0.01$) because of the large sample size, although the magnitudes of the differences were relatively small.

The mean elapsed time between the two audiograms was 3.0 months (SD, 8.5 months), with a range of −16 to +78 months (data not shown). The median time interval was 3.0 months, and the mode was 1.0 month. Ten percent of the time observations were >13 months. Five observations were excluded because they were <0 months and 12 were excluded because there was no MEPS examination date.

TABLE I

DEMOGRAPHIC CHARACTERISTICS OF FORT SILL RECRUITS VERSUS ALL ARMY RECRUITS IN 2000

	Fort Sill Recruits (N = 11,311)	All Army Recruits (N = 62,375)
Age[a]		
Mean (years)	19.9	19.7
17–24 years (%)	91.4	92.3
≥25 years (%)	8.4	7.7
Gender (%)		
Male	79.5	79.1
Female	20.5	20.9
Race[a] (%)		
Caucasian	68.5	61.3
African American	21.7	23.0
Other	9.6	15.6
Armed Forces Qualification Test[a] (%)		
I	3.5	3.8
II	29.2	31.4
IIIA	27.6	30.1
IIIB	37.2	32.9
IV	2.3	1.9
V	0.0	0.0
Geographic region[a] (%)		
Northeast	13.4	14.6
North Central	21.7	19.8
South	39.6	42.6
West	18.4	23.0

[a] Statistically significant difference in distribution by the χ^2 test of independence ($p < 0.01$).

Figures 2 and 3 show the comparisons of the mean intensities by ear and frequency for the two audiograms; both figures show a U-shaped curve with greatest mean intensities at 500 and 6,000 Hz. In both ears, the differences in hearing threshold levels (i.e., intensity) were significant at 500 and 6,000 Hz, with the Fort Sill audiogram thresholds being higher than the MEPS levels by an average of 2 to 3 dB.

A comparison of the mean intensities of the paired differences by individual and by frequency and ear between the two audiograms was performed and again showed a U-shaped curve (results not shown). The differences were greatest at 500 and 6,000 Hz, i.e., ~8 and ~11 dB, respectively. At these two frequencies, the intensity was statistically higher in the left ear, compared with the right ear. The differences between 1,000 and 4,000 Hz ranged from 5 to 7 dB and were not statistically significant between left and right ears. The frequencies of positive, negative, and zero differences in intensity across all frequencies and both ears were calculated. Zero differences (Fort Sill intensity = MEPS intensity) were the most common at 43.81%, followed by positive differences (Fort Sill intensity > MEPS intensity) at 35.41% and negative differences (Fort Sill intensity < MEPS intensity) at 20.78%.

The percentage of records with a threshold shift between the two audiograms in either ear by the three-frequency average difference of more than ±10 dB was 14.49% (95% CI, 14.48–14.50%); that for both ears was 1.87%. The percentage of records with a threshold shift between the two audiograms in either ear by the four-frequency difference of more than ±15 dB was 23.9% (95% CI, 23.18–23.20%); that for both ears was 3.93%.

Discussion

This study was designed to address the research question of the comparability of the MEPS screening audiograms and the DOEHRS-HC reference audiograms administered to all recruits at Fort Sill, Oklahoma. The question was raised because of variations between the services and within the Army regarding audiometric testing prescribed by the Hearing Conservation Program. Fort Sill recruits are relatively similar to all Army recruits with respect to selected demographic criteria, some of which (e.g., age, gender, race, education, and income) are known to be associated with hearing loss.[10–12] This supports the generalizability of the findings to other Army IET sites. In most

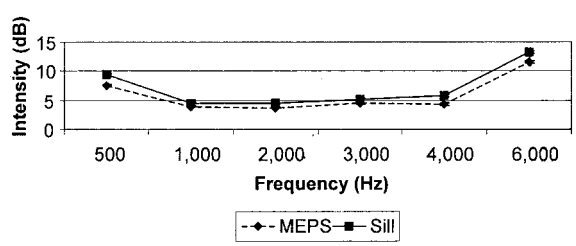

Fig. 2. Comparison of MEPS screening and Fort Sill reference audiograms for the right ear showing mean intensity according to frequency (N = 11,311).

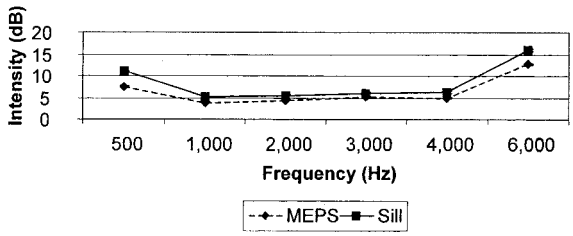

Fig. 3. Comparison of MEPS screening and Fort Sill reference audiograms for the left ear showing mean intensity according to frequency (N = 11,311).

cases, the time interval between the two audiograms was 1 month (mode); in 50% of the cases, it was ≤3 months. This relatively short interval allows for comparison of the two tests without concern for significant interval hearing loss, such as either occupational or recreational noise-induced loss.

A statistically significant difference in intensity between the two tests was seen at 500 and 6,000 Hz. Variations in threshold measurements at 500 Hz are commonly attributable to ambient noise outside the test booth, middle ear pathological conditions, Eustachian tube dysfunction, or transient upper respiratory problems. Variations at 6,000 Hz are commonly attributable to variations in earphone placement during the examination and auditory canal acoustics.[13] This observation was seen in both ears but was more prominent in the left ear. The predominance of noise-induced hearing threshold shifts in the left ear is a known observation among military populations and is attributed to differential noise exposure to the left ear because of the predominance of right-handedness in the population.[14] Job et al.[15] suggested an alternative explanation for this difference. Those investigators concluded from their research that the left cochlea may be a better sensor than the right but may be more sensitive to noise-induced hearing loss.

The mean decibel differences by individual between the two tests were calculated. These differences were statistically significant (>0 with a probability level for type I error of 0.05) across all frequencies, but only 500, 4,000, and 6,000 Hz were >5 dB, which is the commonly recognized level of intertest variability in audiograms.[13] On average, the hearing thresholds measured at Fort Sill were less sensitive (higher) than the hearing levels recorded at the MEPS.

Detection of a statistically significant difference was expected, given the large sample size and the difference in technology between the two hearing tests. The question of a clinically significant difference between the two tests was addressed with the calculation of the threshold shift. The two definitions of threshold shift yielded different point estimates, with the definition of four frequencies of greater than ±15 dB being ~60% greater than the three-frequency average of ±10 dB. The latter definition is presumably less sensitive but more specific for threshold shift. The absence of a standard method to detect a threshold shift has led to the development of numerous criteria. The relative accuracy of eight criteria was evaluated in a large audiometric database by Daniell et al.[16]

This study has several limitations. The large sample size resulted in high power to detect differences in the two tests, but ~18.0% of the recruits processed in 2000 could not be matched with the two audiograms, most often because of missing personal identifiers such as name and Social Security number. These missing data are not thought to yield a differential bias in the detection of a threshold shift. The time interval between the two audiograms was short in most cases but was >13 months in 10% of cases. The observed threshold shift was not calculated separately for long intervals between examinations. Long intervals would be expected to be associated with an increased risk of changes in hearing, such as noise-induced loss, which would bias the results toward a positive difference. The generalizability of these results to other IET sites may be limited by the fact that Fort Sill is the artillery school and recruits with known hearing loss may be less likely to enlist for artillery occupations.

The conclusion of this study is that the MEPS screening audiogram is both statistically and clinically different from the reference DOEHRS-HC audiogram performed at Fort Sill. Therefore, the MEPS screen is a poor proxy of the reference audiogram. It is possible to replicate and to validate the findings of this study at Navy and Marine Corps recruit training sites that also perform universal reference audiograms. At present, all recruits reporting to Army basic training at Fort Benning, Fort Jackson, and Fort Sill receive DOEHRS-HC testing. At the recent direction of U.S. Army Accessions Command and Medical Command, final arrangements are being coordinated to implement DOEHRS-HC testing for trainees at the remaining IET sites; Fort Knox and Fort Leonard Wood should be phased in during 2006 (J. G. Jolissaint, personal communication). Once this testing is implemented across all IET sites, a broader follow-up investigation should be conducted to verify the comparison of DOEHRS-HC and MEPS testing on a larger Army-wide scale, to evaluate the threshold differences between audiograms, and to review the preexisting hearing loss cases that were mistakenly qualified with MEPS testing.

Acknowledgments

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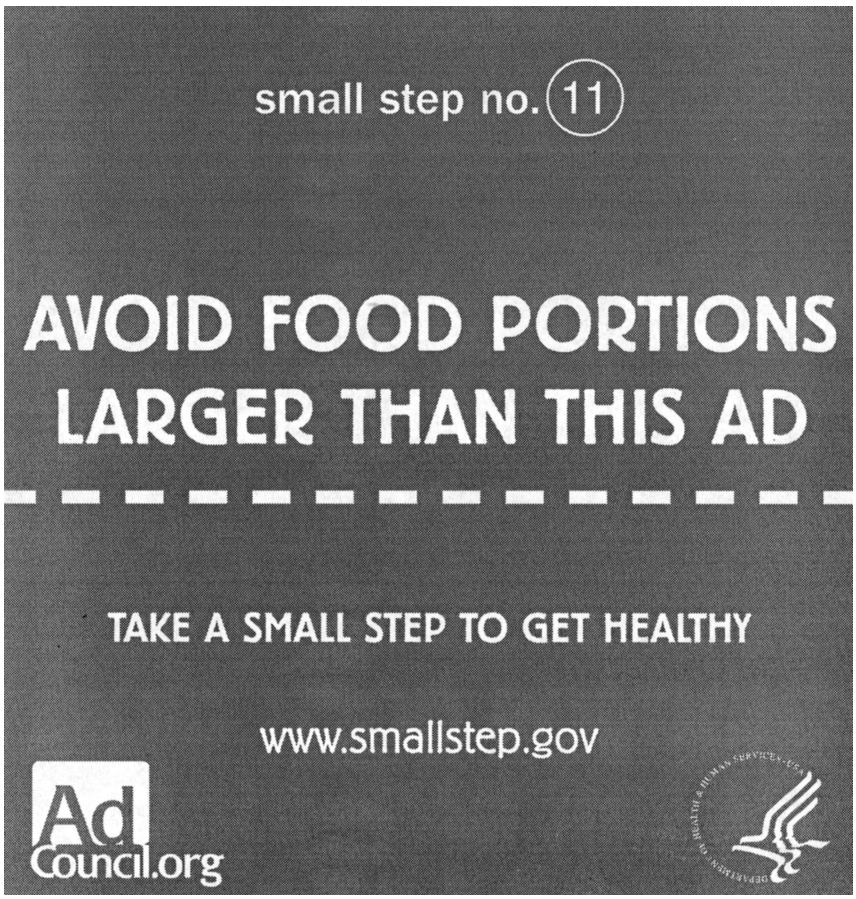
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