An Evaluation of the Comparative Hearing Test

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Abstract

The purpose of this study was to evaluate the accuracy of a newly developed tool to screen hearing. The Comparative Hearing Test (CHT) is designed to screen hearing ability using a personal computer or compact disc player. The CHT compares the ability of the patient to hear pure tones and speech to that of the examiner. Hearing ability was classified as normal, mild loss, moderate loss, or severe loss. The CHT results were compared to a conventional hearing test conducted with an audiometer. Fifty adults participated in the study. The sensitivity and specificity was found to be 86% and 88% respectively. Although the CHT has fair sensitivity and specificity, it does suffer from reliance upon the hearing of the examiner. This is an important limitation of this device and examiners are advised to exercise caution when interpreting test results.

INTRODUCTION

It is estimated that almost 40% of the worldwide population of older adults have hearing loss that may benefit from amplification. [1,2,3] As the post World War II generation (baby-boomers) age that number is expected to increase significantly. However, studies continue to show that only 13-25% of hearing-impaired adults actually own hearing aids. [4] That is, in a large segment of the adult population, hearing loss goes undetected or untreated. Many older adults may be unaware of or unwilling to admit to hearing difficulties. However, it has been reported that hearing loss is a major health concern among the elderly and that untreated hearing loss results in a reduction in quality of life including an increase in the incidence of depression, paranoia, and insecurity. [5,6,7]

Many older adults seek evaluation for hearing loss and other health related issues with their primary care physician (PCP). In the United States, the PCP is the 'gatekeeper' for referral to specialized treatments. However, the incidence of hearing screenings performed by PCPs has declined in recent years. [7] Several investigators (e.g. Johnson and Danhauer[8]) recommend that hearing screenings be a routine part of patient intake at facilities that provide service to the elderly and that all health care professionals be cognizant the signs of hearing loss. The correct identification of hearing loss is critical to patient care because patients must be able to communicate effectively with health care providers in order to benefit fully from available treatment. Therefore there is a need for a quick, easy and reliable means to assess a patient's hearing ability.

The gold standard for identifying hearing loss is pure tone audiometry. However, equipment costs, and the logistics of training personnel may deter PCPs from routinely including hearing assessment in their patient evaluations. Self-assessment scales such as the Hearing Handicap Inventory for the Elderly (HHIE) and its screening version (HHIE-S) have been offered as an alternative to screen for handicapping hearing loss. [9,10] Widely used, the reliability and validity of the HHIE has been clearly established. [10,11] Self-assessment tools have the advantage of being inexpensive and simple to administer. However, self-reported hearing loss does not distinguish between degrees of hearing impairment. Recently Gates and collegues [12] compared the performance the HHIE-S and a global history measure (the single question, "Do you have a hearing problem now?) to pure tone audiometry. They reported that the HHIE was less sensitive for detecting cases of mild hearing loss.[12] In addition, the relationship between measured auditory disability and self-reported hearing handicap has been reported modest at best. [13]

The Comparative Hearing Test (CHT) developed by O'Day [14] was designed to screen hearing ability using a personal computer or compact disc player. The developer reports that the CHT is an "ideal" tool for hearing screenings in PCPs offices because it is accurate yet is low in cost (does not require the purchase of additional equipment) and is user friendly. The CHT is based on the ability of the examiner to

judge the hearing status of the patient. The test consists of pure tone and speech stimuli on a recorded compact disk. The examiner rates the hearing ability of the patient using a set of four predefined categories (normal, mild, moderate and severe). To date limited data is available on the efficacy of the CHT. Therefore the goal of this project was to evaluate the effectiveness of this screening tool. The sensitivity and specificity of the CHT was compared to a conventional hearing test conducted with an audiometer.

METHODS

A total of 50 participants were recruited from the University of Connecticut and surrounding communities. Participants ranged in age 18 to 102 years (Mean age: 58.2). Two-thirds of the participants were female (33 of 50). Hearing thresholds for each participant were measured using a portable audiometer (Maico MA-40) for the octave intervals from 500 to 8000 Hz. The CHT was administered using a laptop computer and desktop speakers. The CHT consists of 5 pure tone stimuli for the octave intervals from 500 to 8000 Hz and spondee words. Using the CHT, each participant adjusted the speaker volume until the stimulus was just barely audible. The examiner rated on a scale of 1 to 4 the level of the sound after the participant. A rating of 1 indicated that the examiner judged the participant's hearing to be normal, a rating of 2 indicated a mild loss, a rating of 3 indicated a moderate loss, and a rating of 4 indicated that the participant was judged to have a severe hearing loss. See Table 1 for CHT definitions of loudness levels. The order of testing was assigned at random. Participants were seated approximately 12-18 inches from the speakers. All testing was completed in a quiet room to be consistent with typical screening test conditions.

Table 1: Comparative Hearing Test defined loudness levels to judge hearing thresholds.

- Normal: represents a barely heard tone presentation.
- Mild: represents a soft tone presentation.
- Moderate: represents a soft to comfortable tone presentation.
- Severe: represents a loud tone presentation.

RESULTS

Determination of hearing impairment was based in part on the recommendations of Stewart and Downs[15], that is, thresholds were judged mild, moderate, moderately-severe, severe, and profound for the ranges of 26 dB to 40 dB, 41 dB to 55 dB, 56 dB to 70 dB, 71 dB to 90 dB and greater than 90 dB respectively. The minimal hearing loss category (16 dB to 25 dB) was not included because the participants screened were adults with established speech and language skills. The prevalence of hearing loss as indicated by pure tone testing in this study was 15% mild, 6% moderate, 12% moderately-severe, 12% severe and 3% profound based on the average of thresholds (PTA) at 500, 1000, 2000 and 4000 Hz. These results suggest a slighter higher rate of severe and profound hearing loss than has been reported elsewhere.[3] However this figure may be misleading because 20% of the sample was from a nursing home facility where the incidence of handicapping hearing loss has been reported to be higher than in the general population.[16] The PTAs were 27.1 and 23.5 for the male and female participants respectively. As would be expected, the incidence of hearing loss was greater for adults over 55 years of age. The PTAs were 55.6 and 50.7 for the male and female participants respectively in this age group.

Figure 1 shows the results of the CHT. CHT rating is plotted as a function of pure tone threshold. The correlation between CHT rating and pure tone threshold was 0.90 across all the data points. Correlations between individual test stimuli and pure tone thresholds were better than 0.90 for all stimuli except at 500 Hz where the correlation dropped to 0.86. The degree of impairment was correctly classified for 75% of participants with a hearing loss. For the remaining participants with hearing loss, impairment was over predicted by the CHT for 58% of the cases and under predicted for 42%. The calculated sensitivity and specificity rates of the CHT were 86% and 88% respectively.

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DISCUSSION

The value of any screening measure is the degree to which it correctly identifies individuals with the disorder (sensitivity) while correctly noting those without the disorder (specificity). Under ideal circumstances, a screening tool will have both high sensitivity and specificity. However, inevitably some individuals with the disorder will be missed (false negatives) and others will be incorrectly identified as having the disorder when in fact they do not (false positives). The CHT was found to have fair sensitivity and specificity when compared to the gold standard of pure tone audiometry. It correctly identified more than 86% of cases

with and without hearing loss. These results are comparable to other physiologic screening measures (Yueh et al, 2003) and self-reported hearing handicap measured using the HHIE-S.[11],[12] However, the data reported are from 50 subjects and one would expect the false positive rate to increase with the larger N's associated with mass screening. Also, the degree of hearing impairment was correctly classified in only 75% of the cases indicating the one-fourth of the sample had hearing loss over or under reported based on the test results.

Furthermore, there are some important limitations to the CHT procedure. Firstly, the accuracy of the test is dependent upon the hearing ability of the examiner. The thresholds of the patient are directly compared to those of the examiner. If the examiner has normal hearing, as was the case in this study, the outcome of the screening will be reasonably accurate. If the status of the examiner's hearing is questionable the accuracy of the test will be greatly diminished. This is an important limitation to note. Reminiscent of early tuning fork tests (e.g. Schwabach test) the CHT may be considered a subjective assessment that may be seriously limited by uncontrolled variables such as the hearing ability of the examiner. [17] The subjective nature of the test could be avoided by calibrating the loudspeakers and/or earphones using a portable sound level meter although this would add to the cost of the screening tool. Secondly, the presentation of stimuli in a sound field may miss unilateral hearing loss. This occurred for one participant in this study. Sound presented through loudspeakers is picked up by both ears simultaneously. Results are indicative of the performance of the better ear.[18] The CHT can be administered under headphones, which would allow for ear specific information to be obtained. The use of headphones would require the purchase of a headphone jack splitter and extra headphones so that the patient and the examiner can hear the CHT at the same time. Again, this would add slightly to the cost. Finally, the level of background noise of the test room may affect results. Ambient noise may mask the test signals. Our tests were administered in a quiet room typical of a hearing screening environment but this does not provide the same level of sound isolation that one would expect in a sound-treated test booth.[18]

CONCLUSIONS

Hearing loss is one of the most common chronic health conditions among older adults the prevalence of which rises substantially with advanced age. Further, untreated hearing loss has been reported to negatively affect quality of life. Given the prevalence of hearing loss and its deleterious effects, it is important that older adults be appropriately screened for hearing loss and referred for treatment. PCPs need to employ a screening method that has high sensitivity and specificity to limit over referrals. Although the CHT has fair sensitivity and specificity, it does suffer from reliance upon the hearing of the examiner and degree of hearing loss was classified incorrectly in one-fourth of the sample. These are important limitations to note. There are modestly priced calibrated screening devices that offer hearing assessment without subjective evaluation. These devices may be more cost effective given the real costs that may be associated with over referrals in some health plans.

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