Association of Hearing Loss with Physical, Social, and Mental Activity Engagement

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ABSTRACT

This article aims to evaluate a hearing loss intervention versus an aging education intervention on activity engagement in the Aging and Cognitive Health Evaluation in Elders pilot (ACHIEVE-P). Forty adults (70–84 years) with hearing loss recruited from the Atherosclerosis Risk in Communities Study and de novo participated. Participants were randomized 1:1 to a best practices hearing intervention or a successful aging intervention. Hearing was measured with pure-tone audiometry. The Community Healthy Activities Model Program for Seniors questionnaire measured self-reported time engaging in activities at baseline and 6-month follow-up. At baseline, greater hearing loss was associated with reduced time per week on mental activities (−3.0 hours per 10 dB of hearing loss, 95% confidence interval: −5.8, −0.2). Mental activity engagement increased (mean: +1.3 hours, SD = 6.6) for the hearing intervention group but decreased (mean: −1.1 hours, SD = 4.8) for the aging education group (Cohen's *d*: 0.41). Hearing loss may be associated with reduced engagement in mental activities. Whether hearing loss treatment impacts activity will be studied in the full-scale ACHIEVE trial.

KEYWORDS: hearing loss, activity engagement, mental, social, physical

Maintaining social, mental, and physical activity engagement is important for healthy aging. Physical activity has numerous health benefits including reduced cardiovascular disease,[1] stroke,[2] and all-cause mortality.[3] Social activity engagement is associated with lower levels

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of loneliness,[4] and lower risk of incident mobility disability.[5] Furthermore, engagement in mental activities is associated with reduced cognitive decline[6] and a lower risk of dementia.[7,8]

Hearing loss affects nearly two-thirds of adults older than 70 years,[9] yet hearing aids remain vastly underutilized.[10] Whether or not hearing loss in older adults is associated with reduced activity engagement is not well established. In a representative sample of U.S. older adults, Gispen et al[11] found that objectively measured moderate-or-greater hearing loss was independently associated with reduced levels of physical activity; however, mild hearing loss was not. Among adults aged 75 to 90 years with normal cognitive functioning, Mikkola et al[12] found that self-reported "major" hearing difficulty was associated with reduced engagement in group activities such as choir or physical activity classes, but "some" self-reported hearing difficulty was not. Furthermore, Mikkola et al found no difference in the frequency of engagement in non-group activities such as attending the theater or concerts between those who self-reported hearing loss and those who did not. Thus, the type of activity assessed, and the measure and severity of hearing loss, may impact associations between hearing loss and activity engagement.

Hypothesized mechanistic pathways underlying the association between hearing loss and physical activity engagement include the effects of distorted peripheral encoding of sound on cognitive load,[13] social isolation,[11] and/or reduced awareness of the auditory environment.[11] Social activities may be reduced in individuals with hearing loss due to poor speech understanding and communication, which leads to withdrawal or disengagement from these activities.[14] Furthermore, the effects of distorted peripheral encoding of sound on cognitive load could impact attentional and cognitive resources[13,15] needed for engagement in mental activities. Importantly, these hypothesized mechanistic pathways may be modifiable with hearing loss treatment.

The present study reports data from the Aging and Cognitive Health Evaluation in Elders Pilot (ACHIEVE-P) study.[16] In this report, we aim to quantify the cross-sectional association between hearing loss and self-reported activity engagement. In addition, we sought to quantify the difference in 6-month change in self-reported activity engagement between two intervention groups.

METHODS

Study Participants

The 40 participants in the ACHIEVE-P study (clinical trials identifier: NCT02412254) were recruited from participants within the Atherosclerosis Risk in Communities Study[17] in Washington County, Maryland, and de novo from nearby communities. Demographic characteristics of participants are summarized in Table 1. All participants gave informed consent.

Criteria for inclusion in the ACHIEVE-P study have been described elsewhere,[16] which, in brief, included being aged between 70 and 84 years, having adult-onset three-frequency (0.5, 1, 2 kHz) pure-tone average (PTA) thresholds $\geq$30 and $<$70 dB HL in the better-hearing ear, not currently using a hearing aid, being community dwelling fluent English speakers, and being free of cognitive impairment. Exclusion criteria included medical contraindication to the use of hearing aids, conductive hearing impairment, unwillingness to wear hearing aids on a regular basis, self-reported hearing aid use in the past year, self-reported disability in two or more activities of daily living, and vision impairment.

Design

A screening session ascertained eligibility to participate. Audiometric testing and a self-report measure on the frequency and duration of physical, social, and mental activities were completed at a baseline session and at a 6-month follow-up session. The Johns Hopkins University School of Medicine Institutional Review Board approved the study.

Interventions

Participants were randomized 1:1 to one of two interventions. Randomization was stratified based on hearing loss severity.

Table 1 Summary of Baseline Demographic Characteristics of Participants in the ACHIEVE-P Study

Characteristic	Hearing intervention ($N = 20$)	Successful aging intervention ($N = 20$)
Age	76.7 (4.1)	78.2 (4.0)
Female	15 (75)	12 (60)
Race: white	20 (100)	20 (100)
Education: less than high school	1 (5)	4 (20)
Education: high school graduate	7 (35)	7 (35)
Education: more than high school	12 (60)	9 (45)
History of hypertension	12 (60)	16 (80)
History of diabetes	3 (15)	8 (40)
Former smoker	9 (45)	8 (40)
Never smoker	11 (55)	12 (60)
Hearing loss[a]: four-frequency better-ear pure-tone average (SD)	43.6 (5.8)	47.1 (10.1)
Hearing loss[b]: mild	5 (25)	8 (40%)
Hearing loss[b]: moderate	15 (75)	11 (55)
Hearing loss[b]: severe or greater	0 (0)	1 (5)

Note: Number in parentheses indicates percentage unless otherwise stated.
[a]Four-frequency (0.5, 1, 2, and 4 kHz) pure-tone average threshold in the better ear.
[b]Hearing loss defined as mild (>25 dB and <40 dB), moderate (>40 dB and <70 dB), or severe or greater (70 dB +) based on the four-frequency (0.5, 1, 2, and 4 kHz) pure-tone average threshold in the better ear.

Best Practice Hearing Intervention

The best practice hearing intervention was developed at the University of South Florida and consisted of four individual sessions, approximately 1 hour in duration, which an audiologist conducted in the 10 to 12 weeks after the baseline session. Participants received binaural receiver-in-the-canal hearing aids, were offered assistive listening devices, and were provided with rehabilitative materials to support self-management of hearing loss and communication.

Successful Aging Education Intervention

The successful aging education intervention used the 10 Keys to Healthy Aging[18] materials. This program was developed from evidence-based research and contains guidelines based on current recommendations from leading groups such as the United States Preventive Task Force, Centers for Disease Control and Prevention, and the National Academy of Medicine. A research nurse certified to administer the program met participants individually for four visits in the 10 to 12 weeks after the baseline session. Each session lasted approximately 1 hour and focused on a "key" chosen by the participant (e.g., lowering systolic blood pressure, stopping smoking, participating in cancer screenings, getting immunized regularly, regulating blood glucose, lowering cholesterol, being physically active, maintaining healthy bones, maintaining social contact, and combating depression).

Audiometric Assessment

Pure-tone audiometry was performed at baseline by an audiologist according to ACHIEVE-P protocols. Testing was performed in a sound-treated booth and air conduction thresholds were obtained for each ear between 0.25 and 8 kHz and a re-test of 1 kHz was performed. If the re-test differed from the initial test by more than $\pm$ 5 dB, testing of that ear was repeated. Hearing sensitivity was defined by the four-frequency (0.5, 1, 2, and 4 kHz) PTA in the better-hearing ear.

Activity Engagement

Self-reported engagement in physical, social, and mental activities was obtained with the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire.[19] The CHAMPS questionnaire assesses the frequency and duration of activities undertaken in the previous 4 weeks. The CHAMPS questionnaire focuses on activities that are typically undertaken by older adults, such as lighter rather than very energetic activities. For each activity, participants were asked three questions: (1) if in a typical week during the past 4 weeks they had done that activity, (2) how many times they did that activity, and (3) how many total hours a week did they usually do that activity. Consistent with previous research,[20] the activities were categorized as physical, mental, or social. Activities that focused on a physical domain (e.g., tennis, dancing, and swimming) were assigned to the physical category. Mental activities (e.g., using a computer, reading, playing a musical instrument) consisted of typically solitary activities that require some mental effort. Social activities were composed of activities that typically involved another person (e.g., visiting with family/friends, attending club/group meetings, and going to a senior center). The numbers of hours spent on activities within each category (mental, social, and physical) were summed to calculate category-specific activity levels. In addition, the total number of hours spent on all activities was calculated.

Other Study Variables

Questionnaires administered by interviewers were employed to gather data on demographic (age, sex, education) factors. In models, age was treated as a continuous variable and education was categorized as (1) high school or less or (2) more than high school.

Statistical Methodology

The cross-sectional association between PTA and hours of total, physical, social, and mental activity engagement was assessed in regression analyses adjusting for age, sex, and education. Effect sizes for the differences between the groups in the mean number of hours of activity engagement between baseline and 6 months were calculated. All analyses were conducted with R version 3.3.3 software.

RESULTS

In an unadjusted model, greater hearing loss at baseline was cross-sectionally associated with reduced total hours of activity (−7.3 hours per 10 dB of hearing loss, 95% CI: −13.5, −1.1). Wider confidence intervals were observed after adjusting for age, sex, and education (Table 2). In these adjusted models, greater hearing loss at baseline was associated with reduced hours per week of mental activity (−3.0 hours per 10 dB of hearing loss, 95% CI: −5.8, −0.2) but not with differences in hours of social or physical activity.

Table 3 displays the mean number of hours of activity engagement at baseline and change from baseline at 6-month follow-up for the hearing intervention and successful aging

Table 2 Association Between Hearing Loss Severity[a] and Hours of Activity as Measured with the CHAMPS[b] Questionnaire in ACHIEVE-P Participants at Baseline ($n = 40$): β (95% CIs)

Activity	Unadjusted		Adjusted for age, sex, education, and baseline level of activity	
	β^c (95% CI)	p	β^c (95% CI)	p
Social	−0.21 (−0.46, 0.05)	0.116	−0.20 (−0.48, 0.08)	0.164
Mental	−0.31 (−0.58, −0.04)	0.032	−0.30 (−0.58, −0.02)	0.046
Physical	−0.21 (−0.54, 0.11)	0.207	−0.07 (−0.44, 0.29)	0.700
Total	−0.73 (−1.35, −0.11)	0.028	−0.57 (−1.25, 0.11)	0.113

Abbreviation: CI, confidence interval.
[a]Hearing loss defined as the four-frequency (0.5, 1, 2, and 4 kHz) pure-tone average threshold in the better ear.
[b]Community Healthy Activities Model Program for Seniors questionnaire.
[c]β indicates the change in the number of hours of activity per 1 dB worsening in the better-ear pure-tone average.

Table 3 Mean Hours of Social, Mental, Physical, and Total Activity as Measured with the CHAMPS[a] Questionnaire at Baseline and 6-Month Follow-Up by Intervention Assignment (Standard Deviation in Parentheses)

Activity	Hearing intervention		Successful aging intervention		Cohen's *d*
	Baseline $N = 20$	6-mo change $N = 20$	Baseline $N = 20$	6-mo change $N = 19$[b]	
Social	9.6 (7.5)	−0.5 (6.3)	7.7 (6.3)	0.8 (4.1)[c]	0.24
Mental	10.2 (6.1)	−1.3 (6.6)	11.7 (8.8)	−1.1 (4.8)[c]	−0.41
Physical	12.9 (8.1)[c]	−0.7 (9.7)[c]	14.6 (9.4)	−2.6 (11.0)[d]	−0.18
Total	32.6 (16.4)[c]	0.6 (12.6)[c]	34.0 (18.8)	−2.3 (11.1)[d]	−0.24

[a]Community Healthy Activities Model Program for Seniors questionnaire.
[b]One participant died due to reasons unrelated to the study intervention before the 6-month follow-up.
[c]Based on $N = 19$ due to missing value.
[d]Based on $N = 18$ due to missing values.

intervention groups. A small-to-medium effect size (Cohen's *d*: 0.41) was observed for changes in mental activity engagement. Compared with baseline, the hearing group showed a mean increase of 1.3 hours (SD: 6.6) engaging in mental activities at 6 months, whereas the successful aging group showed a mean decrease of 1.1 hours (SD: 4.8). Both groups spent less time on physical activities at 6 months compared with baseline (Cohen's *d*: 0.18). At 6 months, mean engagement in social activities was reduced by 0.5 hours (SD: 6.3) in the hearing group but was increased by 0.8 hours (SD: 4.1) in the successful aging group (Cohen's *d*: 0.24). Overall, a small effect size (Cohen's *d*: 0.24) was observed for changes in time spent engaging in all activities. Compared with baseline, the hearing group spent more time engaging in activities at 6 months (mean change: 0.6 hours, SD: 12.6), whereas the successful aging group spent less time engaging in activities (mean change: −2.3 hours, SD: 11.1).

DISCUSSION

We observed that increased hearing loss severity was associated with reduced time spent on mental activities equivalent to 3 hours less per week per 10 dB of hearing loss. However, no association was found between hearing loss severity and the duration of engagement in physical and social activities. Small-to-medium effect sizes were observed for changes in activity engagement 6 months after baseline between the two intervention groups. The largest effect size was found for mental activity engagement indicating a positive efficacy signal of the hearing intervention.

Unlike previous research,[11,12] the current study did not observe any associations between hearing loss severity and the duration of engagement in physical and social activities. The small sample size in the present study is a limitation and differences in the type of activities assessed could account for differences in findings between this study and previous research. For instance, Mikkola et al[12] observed that the impact of hearing loss on activity engagement varied between group activities, non-group activities, and family-specific activities. In the present study, activities were categorized into mental, social, or physical based on previous research using this questionnaire.[20] However, the categorization of social activities does not differentiate between family and non-family group activities as the measure used by Mikkola et al did. Furthermore, the vast majority of participants in the present study had a mild-to-moderate hearing loss, whereas Gispen et al[11] observed only a relationship between hearing and physical activity engagement among individuals with moderate or greater hearing loss. Future research with larger sample sizes is needed to investigate the relationship between engagement in different types of activity and hearing loss severity. Previous research has indicated that increased time spent on mental activities is associated with improved cognitive functioning[6–8,21] and therefore the potential relationship between hearing loss and mental activity engagement warrants further research. In the present study, 6-month post-baseline, the mean number of hours spent on mental activities increased by 1.3 hours for the hearing intervention group and decreased by 1.1 hours for the successful aging group, but the small sample of this pilot study limits any conclusions that can be drawn on the possible benefits of hearing intervention on activity engagement. The full-scale ACHIEVE trial (clinical trials identifier: NCT03243422) that is currently being conducted with 3 years of postrandomization follow-up will allow for a more definitive determination of how a hearing intervention or a successful aging intervention could impact activity levels in older adults.

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CONFLICT OF INTEREST

A.M.G. reports being a consultant to Cochlear Ltd. N.S.R. reports being an advisor to Clearwater Clinical. F.R.L. reports being a consultant to Boehringer-Ingelheim and Autifony Inc., and a Scientific Advisory Board member for Autifony Inc.

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AUTHORS' CONTRIBUTIONS

J.B. had full access to the data and takes responsibility for the integrity of the data and accuracy of the data analysis. Study concept and design: F.R.L., J.A.D. Acquisition of data: N.S.R. Statistical analysis: T.G., J.B. Interpretation of data: T.G., A.M.G., F.R.L. Preparation of the manuscript: A.M.G. Critical review of the manuscript: T.G., J.B., N.S.R., J.A.D., F.R.L.

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No sponsor had a role in the conduct of the study; collection, analysis, or interpretation of the data; or preparation of the manuscript.

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