

Effect of hearing intervention on three-year change in brain morphology

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Abstract

Background: Prior longitudinal studies among older adults have documented associations between hearing loss and changes in brain morphology. Whether interventions involving hearing aids can reduce age-related atrophy is unknown. A substudy within the Aging and Cognitive Health Evaluation in Elders (ACHIEVE, Clinicaltrials.gov Identifier: NCT03243422) randomized controlled trial tested the effect of a best-practices hearing intervention versus health education control on three-year change in cortical thickness among older adults with hearing loss.

Method: The ACHIEVE study enrolled 977 community-dwelling adults aged 70-84 years at baseline (2018-2019) with untreated hearing loss (better ear pure tone average [0.5-4 kHz] ≥ 30 and < 70 dB HL) and without substantial cognitive impairment from four sites across the U.S. (Jackson, MS, Forsyth County, NC, Minneapolis, MN, Washington County, MD). Participants were randomized to a hearing intervention (provision of hearing aids and related technologies, counseling, and education) or a health education control (individual sessions with a health educator covering topics relevant to chronic disease and disability prevention). Three-dimensional magnetic resonance imaging was performed on 3 Tesla Siemens scanners in a subsample of 445 participants at the ACHIEVE baseline and three-year follow-up. Linear mixed effects models were used in intention-to-treat analyses to estimate three-year change in cortical thickness. All models adjusted for baseline measures of hearing loss, recruitment source, site, age, sex, and education. Missing outcome and covariate data was imputed to mitigate bias caused by informative attrition.

Result: At baseline, 224 participants were women (50.3%), 52 participants were Black (11.7%), and the mean (SD) age was 76.4 (4.0) years old (Table 1). Compared to the

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health education control, the hearing intervention exhibited a nominally protective effect on three-year change in average cortical thickness (Figure 1). The greatest effect size for cortical thickness was observed in the occipital lobe, while the smallest effect size was detected in the temporal lobe. Statistically significant effects were detected in the pars orbitalis, rostral anterior cingulate, posterior cingulate, and isthmus cingulate (Figure 2).

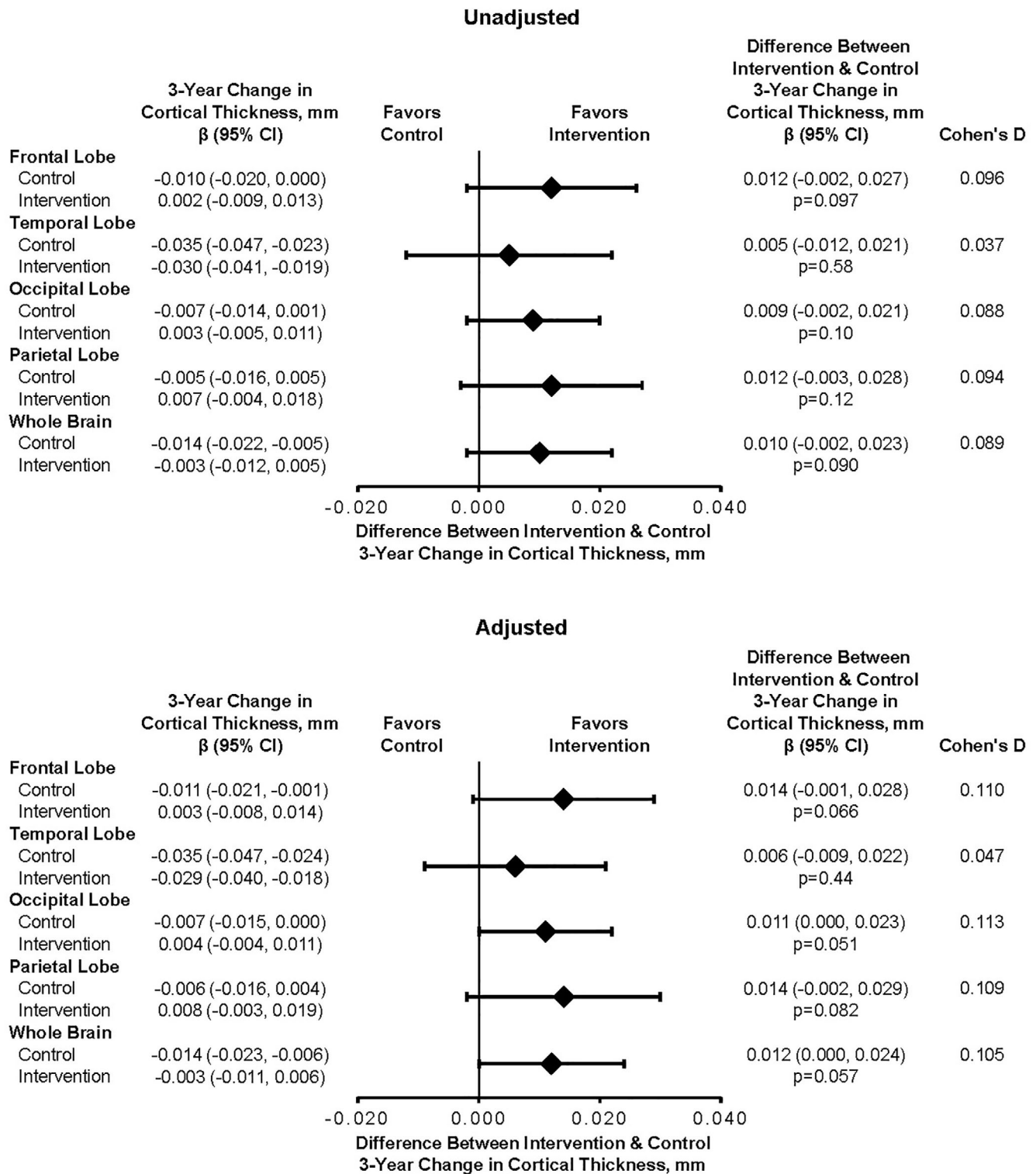
Conclusion: Hearing aid use may reduce decline in cortical thickness among older adults. The effects of hearing aids may be greatest in regions other than those associated with the auditory cortex.

Table 1. Demographic and Clinical Characteristics at Baseline, Cortical Thickness, and Brain Volume of ACHIEVE Participants Stratified by Randomized Treatment Assignment (N=445)

	N	All (N=445)	Intervention (N=220)	Control (N=225)	P
Baseline					
Age, mean (SD), y	445	76.4 (4.0)	76.0 (4.0)	76.7 (4.0)	0.046
Female sex, No. (%)	445	224 (50.3)	112 (50.9)	112 (49.8)	0.81
Black race, No. (%)	445	52 (11.7)	24 (10.9)	28 (12.4)	0.61
White race, No. (%)	445	391 (87.9)	196 (89.1)	195 (86.7)	0.43
Center, No. (%)					
Forsyth County, North Carolina	445	104 (23.4)	56 (25.5)	48 (21.3)	0.56
Jackson, Mississippi		148 (33.3)	73 (33.2)	75 (33.3)	
Minneapolis, Minnesota		72 (16.2)	29 (13.2)	43 (19.1)	
Washington County, Maryland		121 (27.2)	62 (28.2)	59 (26.2)	
De novo participant, No. (%)	445	368 (82.7)	181 (82.3)	187 (83.1)	0.82
Education, No. (%)					
Less than high school	445	19 (4.3)	10 (4.5)	9 (4.0)	0.71
High school, GED, or vocational school		190 (42.7)	95 (43.2)	95 (42.2)	
College, graduate, or professional school		236 (53.0)	115 (52.3)	121 (53.8)	
One or more apolipoprotein E ε4 alleles, No. (%)	427	105 (24.6)	50 (23.9)	55 (25.2)	0.75
Diabetes, No. (%)	445	83 (18.7)	43 (19.5)	40 (17.8)	0.63
Hypertension, No. (%)	445	295 (66.3)	152 (69.1)	143 (63.6)	0.22
Living alone, No. (%)	442	123 (27.8)	63 (28.9)	60 (26.8)	0.62
Income, No. (%)					
Under \$25,000	435	65 (14.9)	34 (15.8)	31 (14.1)	0.75
\$25,000-\$49,999		118 (27.1)	61 (28.4)	57 (25.9)	
\$50,000-\$74,999		90 (20.7)	40 (18.6)	50 (22.7)	
\$75,000-\$100,000		75 (17.2)	35 (16.3)	40 (18.2)	
Over \$100,000		87 (20.0)	45 (20.9)	42 (19.1)	
Pure tone average, mean (SD), db	445	39.3 (7.0)	39.8 (7.3)	38.8 (6.7)	0.12
Mini-mental state examination, mean (SD)	445	28.2 (1.7)	28.2 (1.7)	28.2 (1.7)	0.64
Global cognition, mean (SD)	445	0.05 (0.94)	0.09 (0.94)	0.02 (0.94)	0.44
Language, mean (SD)	445	0.03 (0.88)	0.01 (0.89)	0.04 (0.87)	0.68
Executive function, mean (SD)	445	0.01 (0.88)	0.04 (0.87)	-0.01 (0.90)	0.58
Memory, mean (SD)	445	0.10 (0.88)	0.19 (0.89)	0.02 (0.86)	0.052
Baseline and Follow-Up					
Time between scans, mean (SD), y	304	3.1 (0.4)	3.1 (0.4)	3.1 (0.4)	0.86
Cortical Thickness					
Frontal lobe, mean (SD), mm					
Baseline	437	2.36 (0.11)	2.37 (0.11)	2.36 (0.11)	0.30
Follow-up	300	2.36 (0.11)	2.37 (0.11)	2.36 (0.12)	0.26
Temporal lobe, mean (SD), mm					
Baseline	437	2.65 (0.13)	2.66 (0.13)	2.63 (0.13)	0.049
Follow-up	300	2.62 (0.13)	2.62 (0.13)	2.61 (0.13)	0.40
Occipital lobe, mean (SD), mm					
Baseline	437	1.87 (0.11)	1.87 (0.11)	1.87 (0.10)	0.64
Follow-up	300	1.87 (0.10)	1.88 (0.10)	1.87 (0.10)	0.43
Parietal lobe, mean (SD), mm					
Baseline	437	2.13 (0.11)	2.13 (0.12)	2.13 (0.11)	0.71
Follow-up	300	2.14 (0.11)	2.14 (0.11)	2.13 (0.11)	0.70
Whole brain, mean (SD), mm					
Baseline	437	2.30 (0.10)	2.30 (0.10)	2.29 (0.10)	0.39
Follow-up	300	2.29 (0.10)	2.30 (0.10)	2.29 (0.10)	0.35
Brain Volume					
Frontal lobe, mean (SD), cm ³					
Baseline	437	152.97 (15.34)	153.52 (15.40)	152.43 (15.29)	0.46
Follow-up	300	152.70 (15.81)	154.35 (16.39)	151.25 (15.18)	0.089
Temporal lobe, mean (SD), cm ³					
Baseline	437	104.37 (11.18)	104.87 (11.40)	103.88 (10.96)	0.35
Follow-up	300	102.56 (11.41)	103.35 (11.98)	101.87 (10.88)	0.27
Occipital lobe, mean (SD), cm ³					
Baseline	437	41.09 (5.14)	41.29 (5.22)	40.89 (5.06)	0.41
Follow-up	300	40.85 (5.09)	41.33 (5.23)	40.44 (4.95)	0.13
Parietal lobe, mean (SD), cm ³					
Baseline	437	106.07 (12.04)	106.32 (12.46)	105.81 (11.64)	0.66
Follow-up	300	105.55 (12.27)	106.82 (12.89)	104.43 (11.62)	0.093
Whole brain, mean (SD), cm ³					
Baseline	437	1047.55 (107.32)	1049.63 (113.64)	1045.50 (100.90)	0.69
Follow-up	300	1031.55 (106.18)	1039.12 (116.41)	1024.92 (96.23)	0.25
Intervention drop-in, No. (%)	224	38 (17.0)		38 (17.0)	
Intervention drop-out, No. (%)	220	3 (1.4)	3 (1.4)		

Abbreviations: ACHIEVE, Aging and Cognitive Health Evaluation in Elders; APOE, apolipoprotein E; cm³, cubic centimeters; dB, decibels; GED, General educational development credential; mm, millimeters; SD, standard deviation; y, year.

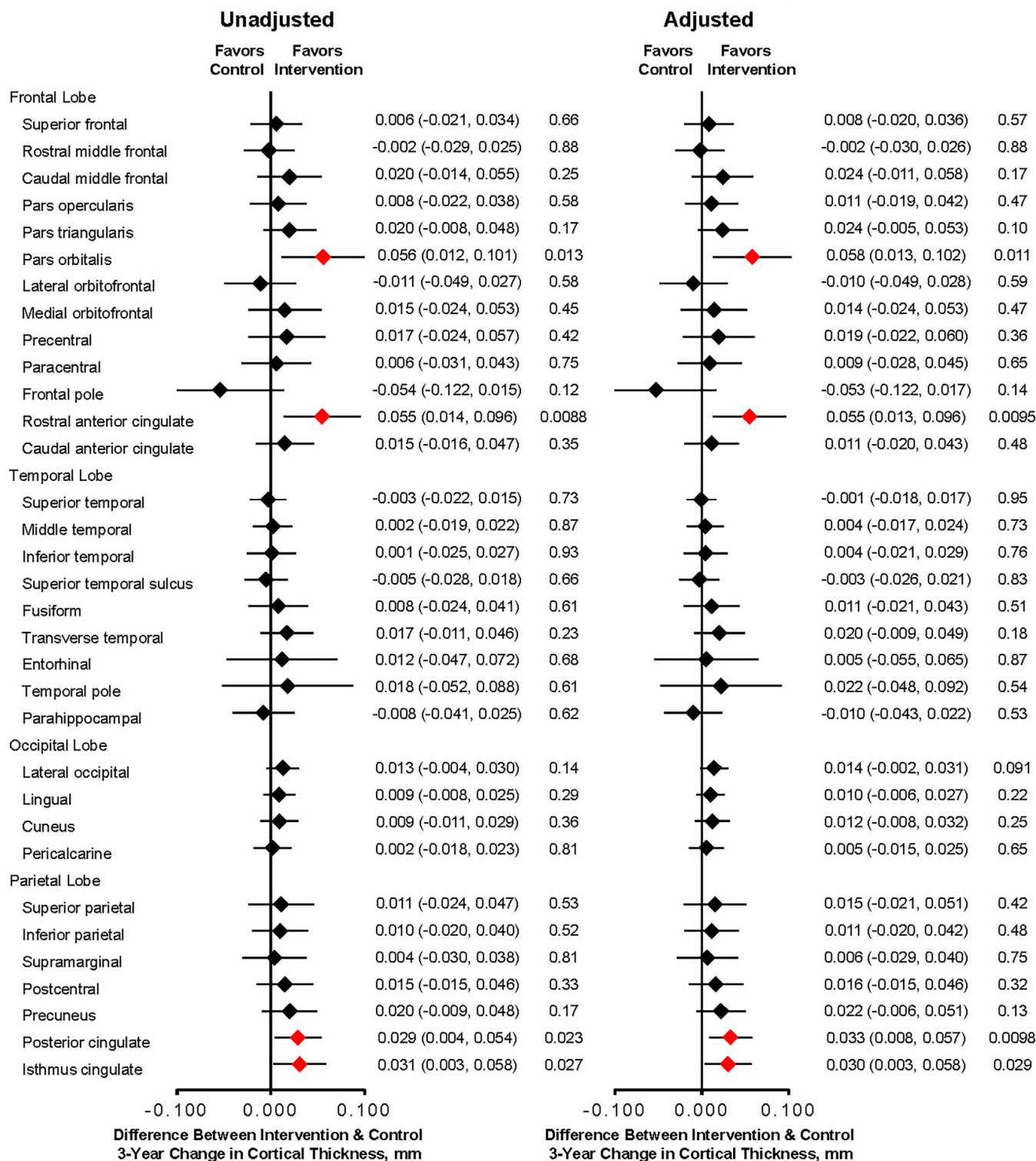
Sex (male/female) was based on self-report. Diabetes was defined as present if the participant reported using medication for diabetes or self-reported a physician diagnosis of diabetes. Sitting blood pressure was measured using a random zero sphygmomanometer. Hypertension was defined as present based on the use of antihypertensive medication, systolic blood pressure greater than or equal to 140 mm Hg, or diastolic blood pressure greater than or equal to 90 mm Hg. Income was based on participant self-report of all family income over the past 12 months. Factor scores of global cognition, executive function, language, and memory were developed using a validated latent variable modeling approach and standardized to the baseline with higher scores indicating better cognitive function.

Figure 1. Intention-To-Treat Analysis of Three-Year Change in Millimeters in Global and Lobar Cortical Thickness by Randomized Treatment Assignment (N=445)

Abbreviations: ACHIEVE, Aging and Cognitive Health Evaluation in Elders; CI, confidence intervals.

Parameter estimates, 95% confidence intervals, p-values, and effect sizes were calculated from linear mixed effects models fit to imputed data. The adjusted model included baseline hearing loss (PTA <40 dB vs 40+ dB), recruitment source, field site, age, sex, and education as covariates. An interaction with time was specified for each covariate.

Figure 2. Intention-To-Treat Analysis of Three-Year Change in Millimeters in Lobar Subregion Cortical Thickness of Dominant Hemisphere by Randomized Treatment Assignment (N=445)



Abbreviations: ACHIEVE, Aging and Cognitive Health Evaluation in Elders; CI, confidence intervals.

Parameter estimates, 95% confidence intervals, and p-values were calculated from linear mixed effects models fit to imputed data. The dominant hemisphere was defined as the left hemisphere for right-handed participants and the right hemisphere for left-handed participants. The adjusted model included baseline hearing loss (PTA <40 dB vs 40+ dB), recruitment source, field site, age, sex, and education as covariates. An interaction with time was specified for each covariate.