ARIC Manuscript Proposal #H3565 (Amended)

PC Reviewed: 5/17/22 **Status: _____** **Priority: 2**
SC Reviewed: _____ **Status: _____** **Priority: ____**

1.a. Full Title:
Hearing Impairment, Physical Function, and Physical Activity in Older Adults: Baseline Results from the ACHIEVE Trial

b. Abbreviated Title (Length 26 characters):
Hearing and physical activity

2. Writing Group:
Writing group members:

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I, the first author, confirm that all the coauthors have given their approval for this manuscript proposal. __Y.C.___ **[please confirm with your initials electronically or in writing]**

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3. Timeline:

Proposal timeline	Jan. 2020	Feb. 2020	Mar. 2020	Apr. 2020
Proposal approval	x			
Data Analysis		x		
Manuscript preparation and submission			x	x

4. Rationale:

Starting at approximately age 50 years, the prevalence of hearing loss increases with every decade (Lin et al., 2011). According to statistics from 1999-2010 National Health and Nutrition Examination Survey (NHANES), one in three adults aged 65 to 74 had hearing loss, and almost half of adults aged 75 and older reported difficulty hearing (National Institute on Deafness and other Communication Disorders [NIDCD], 2018). Previous studies have reported that older adults with hearing impairment experience social isolation, impaired physical functioning, and mobility limitations (Chen et al., 2014; Choi et al., 2016; Li et al., 2013; Mick et al., 2014; Polku et al., 2015; Martinez Amezcua et al., 2021), but very few studies have examined whether hearing impairment may also contribute to constrained participation in physical activity in older adults (Chen et al., 2014; Gipsen et al., 2014). In addition, previous studies investigating the association between hearing loss and physical activity have used mainly coarse measures of self-reported physical activity, which may not adequately capture time spent in light activities and may be biased by problems with recall, particularly in older adults (Schrack et al., 2016).

Accelerometers provide the opportunity to capture physical activity quantities and patterns in greater detail than questionnaires, but their use in older adults with hearing impairment has been limited. Gipsen and colleagues (2014) examined the relationship between hearing impairment and accelerometer-measured physical activity in adults aged 70 and older, but focused solely on time spent in moderate and vigorous activities per week. Moreover, novel physical activity metrics such as activity fragmentation and diurnal patterns of physical activity have been linked with measures of functional status and mortality over and above traditional measures of total volume and intensity of daily physical activity (Schrack et al., 2014; Schrack et al., 2019; Wanigatunga et al., 2019). In addition, diurnal patterns of daily activity may provide additional important information on timing of daily activities, such as activity peak and nadir, which may shed light on health outcomes (Schrack et al., 2014; Wanigatunga et al., 2019). Collectively, these measures will provide novel insights into the relationships among hearing impairment, physical function, and physical activity and provide a basis for future longitudinal analyses.

The ACHIEVE study collected baseline wrist-worn 7-day accelerometry data using the Actigraph Link in all participants and completed functional performance testing (grip strength, short physical performance batter (SPPB). We propose to use the baseline data to investigate the cross-sectional association between hearing impairment and daily physical activity volume (total daily activity, active time, and sedentary time), fragmentation, and diurnal patterns in older adults.

5. Main Hypothesis/Study Questions:

1) Is severity of hearing impairment associated with volume of total daily physical activity, daily active time, and daily sedentary time in community-dwelling older adults?

   Hypothesis: Older adults with more severe hearing impairment will have fewer daily activity counts, less active time, and more sedentary time.

2) Is severity of hearing impairment associated with fragmented physical activity (defined as the probability of transitioning from an active to a sedentary state) in community-dwelling older adults?

Hypothesis: Older adults with more severe hearing impairment will have more fragmented (higher active-to-sedentary transition probability) physical activity patterns.

3) Do diurnal patterns of physical activity differ by severity of hearing impairment in community-dwelling older adults?

   Hypothesis: Older adults with moderate (or greater) hearing impairment will exhibit delayed and diminished diurnal patterns of physical activity compared to those with mild hearing impairment.

4) Does baseline physical function (gati speed, chair stands, balance, grip strength) differ by level of hearing impairment?

   Hypothesis: Older adults with moderate (or greater) hearing impairment will exhibit lower physical function compared to those with mild hearing impairment

6. Design and analysis (study design, inclusion/exclusion, outcome and other variables of interest with specific reference to the time of their collection, summary of data analysis, and any anticipated methodologic limitations or challenges if present).

- Study Design: Cross-sectional study design
- Inclusion/exclusion criteria: All eligible participants enrolled at baseline in the ACHIEVE study.
    - Inclusion criteria: 1) age 70-84 years, 2) community-dwelling adults, 3) mild–to-moderate audiometric hearing impairment, defined as a better-hearing ear pure tone average (PTA) ≥30 and <70 dB hearing level (Deal et al., 2018), 4) MMSE ≥23 for those with high school degree or less, and ≥25 for those with some college education or more, 5) Word Recognition in Quiet score ≥60% correct in the better-hearing ear, 6) fluent English-speaker, 7) older adults who plan to remain in the area during the study period.
    - Exclusion criteria: 1) self-reported difficulty in ≥2 activities of daily living, 2) prior dementia diagnosis, 3) vision impairment, 4) medical contraindication to hearing treatment, 5) untreatable conductive hearing impairment, 6) unwillingness to regularly wear hearing aids.
- Exposure: Severity of hearing impairment. All participants in the ACHIEVE study had untreated adult-onset bilateral hearing impairment. The exposure variables will be the continuous PTA and a dichotomous variable categorizing mild hearing impairment (PTA ≥30 and <40 dB) and moderate hearing impairment (PTA ≥40 and <70 dB).
- Outcomes:
    - Baseline accelerometer-measured physical activity metrics: total daily physical activity counts, active time and sedentary time (in minutes per day), activity fragmentation index (active-to-sedentary transition probability), and diurnal patterns of physical activity (minute level activity counts summarized into time bins for morning, afternoon, and evening). The active-to-sedentary transition

probability will be calculated as the reciprocal of the mean activity bout length for each participant.
    - Baseline physical function metrics: SPPB and its components (gait speed, standing balance, chair stands), grip strength
- Other variables of interest: Baseline sociodemographic and health characteristics: clinical sites, age, sex, race/ethnicity, education, BMI, chronic conditions (cardiovascular disease, diabetes, stroke, hypertension, etc.), smoking status (current, former, never), cognitive status (measured by MMSE), and depression (measured by CES-D).
- Data Analysis:
    - Power analysis: Assuming the prevalence of mild hearing impairment among older adults with any level of hearing impairment is approximately 53%, we estimate a sample size N=850 will provide 80% power to detect 0.19 SD difference of means with a significance level α=0.05 (Gipsen et al., 2014).
    - For accelerometer data analysis, a minimum of three valid days will be required and days with more than 10% of data missing will be excluded for this analysis. For valid days ($\leq$ 10% of data missing), missing values will be imputed as the average activity counts for the same minute over all available days for each participant. To calculate daily active and sedentary time, the active state will be defined as the activity counts $\geq$ 2,303 counts/minute if the device is worn in the dominant hand or $\geq$ 1,853 for the non-dominant hand. The sedentary state will be defined as activity counts < 2,303 counts/minute for the dominant hand or < 1,853 for the non-dominant hand (Koster et al., 2016).
    - Sociodemographic characteristics, health conditions, accelerometer metrics, and physical function will be summarized using mean (SD) or frequency and percentage.
    - Accelerometers metrics and physical function will be characterized by clinical sites.
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    - Linear regression models will be used to examine the association between hearing impairment (continuous PTA and moderate vs. mild hearing impairment) and total daily physical activity counts, active time, sedentary time, activity fragmentation, SPPB score, gait speed, chair stands, standing balance, and grip strength..
        - Distributions will be checked for normality and log-transformed as needed.
    - Multilevel models will be used to test the differences in diurnal patterns of physical activity between older adults with moderate and mild hearing impairment. The time interval will be examined in bins of 4 and 6 hours (Schrack et al., 2014; Wanigatunga et al., 2018).
    - Multivariable model 1 will be adjusted for age, sex, and race/ethnicity. Model 2 will be adjusted for covariates included in Model 1 and education, BMI, chronic conditions. Model 3 will be adjusted for covariates included in Model 2, smoking status, and gait speed.
    - Mediation analysis will be conducted to examine the mediating effects of cognitive status and depression in the relationships of hearing impairment with physical function and physical activity.

- All significance tests will be conducted using two-sided tests. The significance level α will be set as 0.05. All data analyses will be conducted using SAS 9.4 (SAS Institute, Cary, NC).

- Limitations:
  - Given the nature of cross-sectional study, the temporality of the relationships of hearing impairment with physical function and physical activity cannot be demonstrated in this study. Restrictions of physical activity participation may also contribute to hearing impairment in older adults.

7.a. Will the data be used for non-ARIC analysis or by a for-profit organization in this manuscript? ____ Yes __X__ No

b. If Yes, is the author aware that the current derived consent file ICTDER05 must be used to exclude persons with a value RES_OTH and/or RES_DNA = "ARIC only" and/or "Not for Profit" ? ____ Yes ____ No
(The file ICTDER has been distributed to ARIC PIs, and contains the responses to consent updates related to stored sample use for research.)

8.a. Will the DNA data be used in this manuscript? ____ Yes _X__ No

8.b. If yes, is the author aware that either DNA data distributed by the Coordinating Center must be used, or the current derived consent file ICTDER05 must be used to exclude those with value RES_DNA = "No use/storage DNA"? ____ Yes ____ No

9. The lead author of this manuscript proposal has reviewed the list of existing ARIC Study manuscript proposals and has found no overlap between this proposal and previously approved manuscript proposals either published or still in active status.
ARIC Investigators have access to the publications lists under the Study Members Area of the web site at: http://www.cscc.unc.edu/aric/mantrack/maintain/search/dtSearch.html

____X__ Yes _____ No

10. What are the most related manuscript proposals in ARIC (authors are encouraged to contact lead authors of these proposals for comments on the new proposal or collaboration)?

11.a. Is this manuscript proposal associated with any ARIC ancillary studies or use any ancillary study data? _ X___ Yes ____ No

11.b. If yes, is the proposal
_X__ A. primarily the result of an ancillary study (list number* _2016.03____)
___ B. primarily based on ARIC data with ancillary data playing a minor role (usually control variables; list number(s)* _____ _____ _____)

*ancillary studies are listed by number https://sites.cscc.unc.edu/aric/approved-ancillary-studies

12a. Manuscript preparation is expected to be completed in one to three years. If a manuscript is not submitted for ARIC review at the end of the 3-years from the date of the approval, the manuscript proposal will expire.

12b. The NIH instituted a Public Access Policy in April, 2008 which ensures that the public has access to the published results of NIH funded research. It is **your responsibility to upload manuscripts to PubMed Central** whenever the journal does not and be in compliance with this policy. Four files about the public access policy from http://publicaccess.nih.gov/ are posted in http://www.cscc.unc.edu/aric/index.php, under Publications, Policies & Forms. http://publicaccess.nih.gov/submit_process_journals.htm shows you which journals automatically upload articles to PubMed central.

References

Chen, D. S., Genther, D. J., Betz, J., & Lin, F. R. (2014). Association between hearing impairment and self-reported difficulty in physical functioning. *Journal of the American Geriatrics Society*, *62*(5), 850–856.

Choi, J. S., Betz, J., Deal, J., Contrera, K. J., Genther, D. J., Chen, D. S., … Lin, F. R. (2016). A comparison of self-report and audiometric measures of hearing and their associations with functional outcomes in older adults. *Journal of Aging and Health*, *28*(5), 890–910.

Deal, J. A., Goman, A. M., Albert, M. S., Arnold, M. L., Burgard, S., Chisolm, T., … Lin, F. R. (2018). Hearing treatment for reducing cognitive decline: Design and methods of the Aging and Cognitive Health Evaluation in Elders randomized controlled trial. *Alzheimer's and Dementia: Translational Research and Clinical Interventions*, *4*, 499–507.

Gispen, F. E., Chen, D. S., Genther, D. J., & Lin, F. R. (2014). Association between hearing impairment and lower levels of physical activity in older adults. *Journal of the American Geriatrics Society*, *62*(8), 1427–1433.

Hearing Loss and Older Adults | NIDCD. (2018). Retrieved December 20, 2019, from https://www.nidcd.nih.gov/health/hearing-loss-older-adults

Koster, A., Shiroma, E. J., Caserotti, P., Matthews, C. E., Chen, K. Y., Glynn, N. W., & Harris, T. B. (2016). Comparison of sedentary estimates between activPAL and hip- and wrist-worn ActiGraph. *Medicine and Science in Sports and Exercise*, *48*(8), 1514–1522.

Li, L., Simonsick, E. M., Ferrucci, L., & Lin, F. R. (2013). Hearing loss and gait speed among older adults in the United States. *Gait & Posture*, *38*(1), 25–29.

Lin, F. R., Niparko, J. K., & Ferrucci, L. (2011). Hearing loss prevalence in the United States. *Archives of Internal Medicine*, *171*(20), 1851–1852.

Martinez-Amezcua, P., Powell, D., Kuo, P. L., Reed, N. S., Sullivan, K. J., Palta, P., Szklo, M., Sharrett, R., Schrack, J. A., Lin, F. R., & Deal, J. A. (2021). Association of Age-Related

Hearing Impairment With Physical Functioning Among Community-Dwelling Older Adults in the US. JAMA network open, 4(6), e2113742. https://doi.org/10.1001/jamanetworkopen.2021.13742

Mick, P., Kawachi, I., & Lin, F. R. (2014). The association between hearing loss and social isolation in older adults. *Otolaryngology - Head and Neck Surgery*, *150*(3), 378–384.

Polku, H., Mikkola, T. M., Rantakokko, M., Portegijs, E., Törmäkangas, T., Rantanen, T., & Viljanen, A. (2015). Self-reported hearing difficulties and changes in life-space mobility among community-dwelling older adults: A two-year follow-up study. *BMC Geriatrics*, *15*(1), 1–7.

Schrack, J. A., Cooper, R., Koster, A., Shiroma, E. J., Murabito, J. M., Rejeski, W. J., … Harris, T. B. (2016). Assessing daily physical activity in older adults: Unraveling the complexity of monitors, measures, and methods. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *71*(8), 1039–1048.

Schrack, J. A., Kuo, P. L., Wanigatunga, A. A., Di, J., Simonsick, E. M., Spira, A. P., … Zipunnikov, V. (2019). Active-to-sedentary behavior transitions, fatigability, and physical functioning in older adults. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *74*(4), 560–567.

Schrack, J. A., Zipunnikov, V., Goldsmith, J., Bai, J., Simonsick, E. M., Crainiceanu, C., & Ferrucci, L. (2014). Assessing the physical cliff: Detailed quantification of age-related differences in daily patterns of physical activity. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *69*(8), 973–979.

Wanigatunga, A. A., Di, J., Zipunnikov, V., Urbanek, J. K., Kuo, P. L., Simonsick, E. M., … Schrack, J. A. (2019). Association of total daily physical activity and fragmented physical activity with mortality in older adults. *JAMA Network Open*, *2*(10), e1912352.

Wanigatunga, A. A., Simonsick, E. M., Zipunnikov, V., Spira, A. P., Studenski, S., Ferrucci, L., & Schrack, J. A. (2018). Perceived fatigability and objective physical activity in mid- to late-life. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *73*(5), 630–635.