Accelerometer-Assessed physical activity and objectively-measured hearing sensitivity among coronary artery disease and congestive heart failure patients: cardio-auditory paradigm

Paul D. Loprinzi, Chelsea Joyner

ABSTRACT

Background: Some studies suggest an association between cardiovascular function (particularly cardiomyopathy) and hearing function, termed cardioauditory function. Physical activity is favorably associated with both cardiovascular and auditory function. However, whether physical activity is beneficially associated with auditory function among those with cardiovascular disease, is unknown, which was this study’s purpose. Methods: Data from the 2003-2006 NHANES were utilized, including 136 adults with congestive heart failure or coronary artery disease. Physical activity (accelerometry) and auditory function were objectively measured. Results: Physical activity was not associated with hearing function (OR = 1.00; 95% CI: 0.99-1.01; P=0.91). Results were similar when examining the association for those with coronary artery disease (OR = 0.99; 95% CI: 0.98-1.01; P=0.89) or congestive heart failure (OR = 0.99; 95% CI: 0.98-1.01; P=0.65). Conclusions: Unlike findings in the broader population, physical activity behavior was not associated with hearing impairment among those with coronary artery disease or congestive heart failure. However, these findings provide suggestive evidence that hearing impairment among those with coronary artery disease or congestive heart failure may not be restricting these patients free-living physical activity behavior.

KEY WORDS: Accelerometry; Coronary artery disease; Epidemiology; Hearing; NHANES

INTRODUCTION

Although not extensively evaluated, some studies suggest an association between cardiovascular function (particularly cardiomyopathy) and hearing function [1-3], termed cardioauditory function. The etiology of many otologic disorders, including sensorineural hearing loss, is suspected of being related to alterations in blood flow [4], which may be compromised among those with heart disease. We have previously demonstrated that physical activity is favorably associated with better auditory function [5-10], cardiovascular function [11-15], and has survival benefits among those with hearing impairment [16, 17]. Importantly, studies demonstrate that physical activity is inversely associated with biomarkers of cardiovascular function [18-21]. Additionally, degenerative diseases such as coronary artery disease are interrelated with the aging process and can further impair hearing [22]. Therefore, auditory-related healthy lifestyle characteristics such as physical activity may help attenuate age- and morbidity-related cardioauditory degeneration. Further, other work demonstrates that cardiorespiratory fitness may have protective effects on auditory-related morbidities, such as diabetes [23], and may help to regulate auditory function [24]. In conserving hearing due to age, other groups have also demonstrated evidence that regular exercise may play a protective role [25]. Further, in a study by Ismail et al., a 20 week long physical fitness program improved cardiovascular health as measured by peak oxygen consumption as well as baseline hearing thresholds [26]. To our knowledge, however, no study has examined whether objectively-measured physical activity is favorably associated with auditory function among those with cardiovascular and heart-related complications, which was this study’s purpose, written here as a brief report. Such a study is worthy of investigation given the aforementioned link between cardiovascular and hearing function.

METHODS

Study Design and Participants

Participants from the National Health and Nutrition Examination Survey were utilized; cycles 2003-2006 were used as these cycles included objective assessments of physical activity and hearing sensitivity. Participants who answered “yes” to the following question were considered to have congestive heart failure (N=68): “Has a doctor or other health professional ever told you that you had congestive heart failure?” Similarly, participants who answered “yes” to the following question were considered to have coronary artery disease (N=98): “Has a doctor or other health professional ever told you that you had coronary artery disease?” In these 2003-2006 NHANES cycles, 136 participants (Age mean = 64.9yrs; 59.5% male; 84.9% white) had congestive heart failure or coronary artery disease and complete data on the study variables.
Assessment of Physical Activity

Physical activity was assessed from the ActiGraph 7164 accelerometer. Participants wore the accelerometer on their right hip, with the monitor affixed to an elastic belt. The accelerometer measured the frequency, intensity, and duration of physical activity by generating an activity count proportional to the measured acceleration. The accelerometer output is digitized using an analog-to-digital converter, and once digitized, the signal passes through a digital filter that detects accelerations ranging from 0.05 to 2.00 g in magnitude with frequency responses ranging from 0.25 to 2.5 Hz to filter motion outside normal human movement. The filtered signal is then rectified and summed over a pre-determined epoch period. After the activity count is sorted into an epoch, it is stored in the internal memory and the integrator is reset to zero. Only participants with ≥ 4 days of ≥ 10 hr/day of monitored data were included in the analyses. Activity counts/min ≥ 100 was used to determine time spent in physical activity [27, 28]. The weighted mean physical activity was 276.3 min/day (SE = 9.8).

Assessment of Hearing Function

As discussed elsewhere [5, 6, 17], hearing sensitivity was tested on both ears at seven frequencies (500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz) across an intensity range of -10 to 120 dB. Low-frequency pure-tone average (LPTA) was determined from the average of air conduction pure-tone thresholds at 500, 1000, and 2000 Hz and high-frequency pure-tone average (HPTA) was determined by the average of air conduction pure-tone thresholds at 3000, 4000, 6000, and 8000 Hz [29-32]. Ultimately, hearing loss were determined in the worse ear and defined as hearing within normal limits (LPTA & HPTA ≤ 25 dB), mild hearing loss (LPTA or HPTA 26-40 dB) and moderate or greater hearing loss (LPTA or HPTA > 40 dB) [33]. Because of cell size considerations, we ultimately categorized participants into moderate or greater hearing loss (N=106) or not moderate+ hearing loss (N=50; referent group).

Analysis

A weighted logistic regression was utilized; covariates included, age, gender, race-ethnicity, income-to-poverty ratio, measured body mass index, C-reactive protein, self-reported smoking status and comorbid illness (summed number of the following physician-diagnosed conditions: arthritis, stroke, heart attack, COPD, hypertension and diabetes). Statistical significance was established at an alpha of 0.05; analyses computed in Stata (v. 12).

RESULTS

The sample consisted of 136 adults with congestive heart failure or coronary artery disease. Characteristics of the analyzed sample are shown in Table 1. Physical activity was not associated with hearing function (OR = 1.00; 95% CI: 0.99-1.01; P=0.91). Results were similar when examining the association for those with coronary artery disease (OR = 0.99; 95% CI: 0.98-1.01; P=0.89) or congestive heart failure (OR = 0.99; 95% CI: 0.98-1.01; P=0.65). Similarly, physical activity was not associated with hearing impairment when examining different physical activity intensity levels, results were not significant when treating hearing as a continuous variable (LPTA or HPTA), and considering the duration of congestive heart failure/coronary artery disease did not influence the findings (data not shown).

Table 1. Characteristics of the analyzed sample (N=136).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Point Estimate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean years</td>
<td>64.9</td>
<td>61.7-68.0</td>
</tr>
<tr>
<td>% Men</td>
<td>59.5</td>
<td></td>
</tr>
<tr>
<td>% White</td>
<td>84.9</td>
<td></td>
</tr>
<tr>
<td>% Current daily smoker</td>
<td>18.2</td>
<td></td>
</tr>
<tr>
<td>BMI, mean kg/m²</td>
<td>29.4</td>
<td>28.2-30.6</td>
</tr>
<tr>
<td>CRP, mean mg/dL</td>
<td>0.48</td>
<td>0.38-0.58</td>
</tr>
<tr>
<td>Comorbidities, mean</td>
<td>2.3</td>
<td>2.0-2.6</td>
</tr>
<tr>
<td>% Moderate or greater hearing loss</td>
<td>73.6</td>
<td></td>
</tr>
<tr>
<td>LPTA (right), mean dB</td>
<td>22.9</td>
<td>20.2-25.6</td>
</tr>
<tr>
<td>LPTA (left), mean dB</td>
<td>23.6</td>
<td>19.8-27.5</td>
</tr>
<tr>
<td>HPTA (right), mean dB</td>
<td>45.6</td>
<td>41.2-49.9</td>
</tr>
<tr>
<td>HPTA (left), mean dB</td>
<td>48.6</td>
<td>44.6-52.6</td>
</tr>
<tr>
<td>Total physical activity, mean min/day†</td>
<td>276.3</td>
<td>255.8-296.7</td>
</tr>
</tbody>
</table>

† Inclusive of all ambulatory movement (light to vigorous physical activity)
BMI, body mass index
CRP, C-reactive protein
LPTA, low frequency pure tone average
HPTA, high frequency pure tone average

DISCUSSION

Unlike findings in the broader population [6, 10], the present study demonstrates that physical activity behavior was not associated with hearing impairment among those with coronary artery disease or congestive heart failure. A limitation of the present study was the non-objective measure of heart disease; thus, it was not possible to ascertain such parameters as ejection fraction. Further, although the present study was a cross-sectional study design, rendering inferences about causality not possible, these findings do not provide suggestive evidence of a potential protective effect of physical activity on hearing function among those with coronary artery disease or congestive heart failure. However, these findings provide suggestive evidence that hearing impairment among those with coronary artery disease or congestive heart failure may not be restricting these patients free-living physical activity behavior. Ultimately, this may prove useful as cardiovascular disease risk factors in midlife are associated with hearing loss later in life [34]. Although speculative,
physical activity behavior may potentially help attenuate hearing impairment later in life among this vulnerable population. Studies do suggest cardiovascular disease risk factors, including higher levels of triglycerides and history of smoking (in men), higher BMI (in women), and higher resting heart rate are related to poorer hearing, whereas clinical cardiovascular disease in general was not [35]. Ultimately, increasing physical activity in vulnerable populations is encouraged because of the many benefits associated with physical activity. Regular physical activity contributes to longevity and overall life satisfaction which is an important consideration when providing interventions for those with a hearing impairment and coronary artery disease or congestive heart failure.

In conclusion, the present study did not demonstrate an association between physical activity and hearing function among those with coronary artery disease or congestive heart failure. Future replicative work on this topic using a larger sample size and prospective study design, is warranted.

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REFERENCES