Effect of Age on Heart Rate and Heart Rate Variability during Activities of Daily Living

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Introduction

Aging is associated with increased resting heart rate (HR) and decreased heart rate variability (HRV). However, the effect of age on these measures during activities of daily living (ADLs) has not been directly explored.

Furthermore, the use of wearable sensors in activity monitoring is growing, and the integration of HR and HRV measures with accelerometer data may provide important information on cardiac function during physical activity.

In this study, we compared HR and HRV to whole-body acceleration during ADLs in young and older adults in order to understand age-related changes in the cardiac demands and autonomic control of ADLs.

Methods

Study design

17 young adults (mean age=22.6±3.3 years; 8 women and 9 men) and 17 older adults (mean age=86.5±4.8 years; 11 women and 6 men) without cardiovascular conditions underwent a 15-minute free living ADL protocol at their regular pace (Table 1).

Table 1: Free-living 15-minute protocol of activities of daily living.

<table>
<thead>
<tr>
<th>Activity</th>
<th>5 min</th>
<th>3 reps</th>
<th>2 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td></td>
<td></td>
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<tr>
<td>Stand-to-sit</td>
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<tr>
<td>Sit-to-stand</td>
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<tr>
<td>Standing</td>
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<tr>
<td>Walking</td>
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<tr>
<td>Lying</td>
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</tbody>
</table>

Measures

A wearable sensor unit (Shimmer Sensing) placed on the sternum recorded:

- Tri-axial acceleration (128Hz, range ±16g); and
- Electrocardiogram (ECG) at 128 Hz from 5 electrodes (Fig 1).

We segmented each activity by reference to captured video. For the last minute of each activity and across the whole trial, we derived average values for:

- Acceleration (m/s²): standard deviation from the mean vector sum of the 3 acceleration axes;
- Heart rate (HR) in beats per minute (bpm); and
- Heart rate variability (HRV) in ms, characterized by mean absolute deviation of the R-R peak intervals (MAD) and standard deviation of the R-R peak intervals (SDNN).

Due to skewing, HRV values were natural log transformed before undergoing statistical analysis.

Data analysis and Statistics

R peaks for HR and HRV measures were extracted, filtered, and examined from an average of Lead I, Lead II, and Lead III via wavelet analysis using MATLAB. We used ANOVA to examine the effects of age and activities on HR and HRV.

Results

Fig 1: ECG signals from three leads were averages to minimize motion artifacts. Raw data (top graph) were converted to wavelet coefficients (middle graph), from which R peaks were detected (bottom graph).

Fig 2: Estimated marginal means of MAD during different activities in young and older adults. In young adults, HRV varied with activity. Older adults showed consistently lower HRV across activities, perhaps reflecting overactive sympathetic and/or decreased parasympathetic activity.

Fig 3: Plots of HR versus MAD (left) and acceleration versus HR (right) for young and older adults. Asterisks (*) indicate significant correlation at the p<0.0005 level.

Discussion

1. Was there a significant difference in HR or HRV between and within young and older adults during different activities?

   - Between: Older had higher HR during lying and lower HRV during sitting, lying, and whole trial compared to young.
   - Within: HR during walking was higher for both young and old while HRV associated with activity only for young.
   - HR is useful for distinguishing between sedentary and non-sedentary activities in both age groups.
   - HRV aids in distinguishing between sedentary activities with near-zero acceleration values for younger adults.

2. What portion of age-estimated maximum HR did younger and older adults achieve during typical ADLs?

   - Young: ~40% during sedentary activities and ~50% while walking.
   - Old: ~50% during sedentary activities and ~60% while walking.
   - Daily activities are more physically taxing on older adults, who achieved recommended exercise intensity HR during self-paced walking.

3. What were the relationships between HR, HRV, and acceleration during activities in young and older adults?

   - Young: ↓ acceleration = ↑ HR = ↑ HRV.
   - Old: ↓ acceleration = ↑ HR.

   Young but not older adults displayed an inverse relationship between HR and HRV. This may suggest that older adults have less efficient cardiac functioning and less ability to rapidly adjust heart rate with activity level.

References


Acknowledgements

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