Acute effects of singing on cardiovascular biomarkers

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Summary of Introduction

- Cardiovascular disease (CVD) – typically hypertension, coronary heart disease, heart failure, or stroke – is the leading cause of death in most developed countries, and it is projected that by 2035, 45.1% of the US population will have some form of CVD.

- Cardiac rehabilitation programs improve health outcomes in patients with CVD; however, utilization of these programs are low. Alternative programs/therapies should be explored.

- Singing is a physical activity that involves the vagal nerves, which control cardiac autonomic regulation. Singing requires both passive and active breathing, muscle coordination and various breathing techniques, with almost no reliance on mobility or skeletal muscle strength.

- Previous studies have shown singing to be beneficial in other chronic disease populations – chronic obstructive pulmonary disease, Parkinson's disease, and cancer.

Summary of Introduction - Biomarkers

- **Peripheral arterial tonometry (PAT):** A non-invasive measure of vascular function by measuring pulse volume changes of arteries in fingertips. PAT measurements have significant predictive value for future cardiovascular events.

- **Heart rate variability (HRV):** A non-invasive measure of vascular function by measuring the variability between R-R intervals (specific measurements in an ECG test) in back-to-back heartbeats. The HRV measure is a result of a complex interaction between respiratory activity and nervous system-cardiovascular control. HRV measurements have been found to be powerful predictors of cardiac morbidity and mortality.

The Singing Heart Pilot Study

Aim: To investigate the acute effects of singing on biomarkers of cardiovascular health.

Hypothesis: Cardiac patients will have favorable improvements in vascular endothelial function and heart rate variability, after a single session of singing.

Summary of Methods

- Participants completed a questionnaire detailing their general identity characteristics and prior medical history.

- For singing, the participants were in a seated position and watched and sang along to a 14-minute pre-recorded coaching video (created by a music professor), which included vocal warm-up, and singing of the Star-Spangled Banner.

- Vascular endothelial function was measured by digital PAT; measurements were taken prior to and after the 14-minute singing video.

- HRV was measured using a chest strap/monitor; HRV recordings were taken for 1 minute at different timepoints: before, during (10-minutes into singing), and after completion of the 14-minute singing video.

- Other measurements included: singing intensity (measure by using a rated numerical scale of perceived exertion) and level of enjoyment (measured by using a rated numerical scale of enjoyment). Additionally, members of the study staff rated each participant based on their observation of how much effort the participants were using.

Results
Table 1. Baseline Characteristics (n=60 subjects)

Characteristic	Numeric Value
Average Age	61 years old (range: 24-90 years old)
Women	41 participants (68%)
Race	
White	46 participants (77%)
Black	13 participants (22%)
Asian	1 participant (2%)
Average BMI	32 kg/m²

Results
Table 1. Baseline Characteristics (n=60 subjects)

Characteristic	Numeric Value
Prior tobacco use	18 participants (30%)
Known coronary artery disease	26 participants (43%)
History of congestive heart failure	10 participants (17%)
Hypertension	36 participants (60%)
Diabetes	14 participants (25%)
Current statin use	33 participants (55%)
Prior stroke	6 participants (10%)
Chronic respiratory disease	17 participants (28%)
Chronic physical or orthopedic limitations	26 participants (43%)

Results

Table 1. Baseline Characteristics (n=60 subjects)

Characteristic	Numeric Value
Atherosclerotic Cardiovascular Disease risk factors	
$\leq$ 2 Risk factors	21 participants (35%)
Known ASCVD or > 2 risk factors	39 participants (65%)
Baseline RHI (Measure of vascular function)	
Normal > 1.67	34 participants (57%)
Abnormal $\leq$ 1.67	26 participants (43%)

Results
## Table 2. Vascular function and HRV measurements

Measurement	Baseline	During Singing	Post-singing
Vascular function			
RHI	1.99 +/- 0.10	Not recorded	2.12 +/- 0.09
fRHI	1.88 +/- 0.14	Not recorded	*2.10 +/- 0.14
HRV			
RMSSD	42.0 +/- 4.9	*32.6 +/- 4.0	40.4 +/- 4.9
SDNN	54.0 +/- 4.8	*33.5 +/- 2.8	*42.9 +/- 4.0

*$p<0.05$ compared to baseline
RHI: reactive hyperemia index; fRHI: Framingham reactive hyperemia index; RMSSD: root mean square of successive RR interval differences; SDNN: standard deviation of NN intervals

Summary of vascular function measurements

- There was an improvement in vascular function (fRHI) after singing, especially for participants who had abnormal baseline vascular function.

- There was an improvement in vascular function after singing for participants who had known ASCVD or more than 2 risk factors, compared to those without ASCVD or less than 2 risk factors who did not see as much improvement in vascular function.
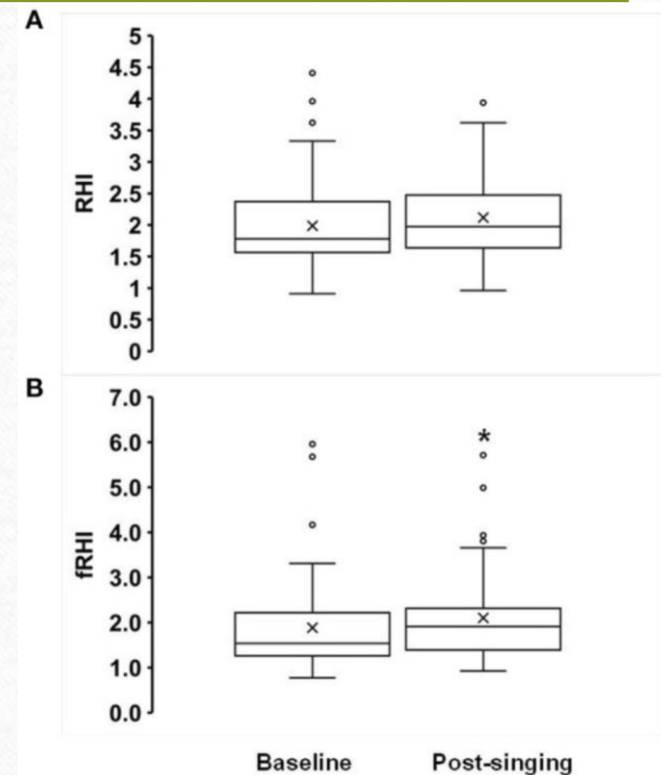
ASCVD – atherosclerotic cardiovascular disease

Summary of vascular function measurements (cont'd.)

- Women had an improvement in vascular function with singing when compared to males; however, after adjusting based on baseline vascular function, no difference was seen.

- Presence of abnormal baseline vascular function (i.e. higher risk for CVD) consistently predicted improvement with singing.

- There was no relationship between the perceived effort, level of enjoyment, or observed singing effort with an improvement in vascular function.

Summary of HRV measurements

- Measurements of heart rate variability were taken using a measurement of the standard deviation between R-R intervals (SDNN) and the root mean square of the differences between each heartbeat (RMSSD).

- There was a decrease in heart rate variability during the singing activity with a return towards baseline post-singing.

- These HRV patterns mirror those of light-intensity exercise.
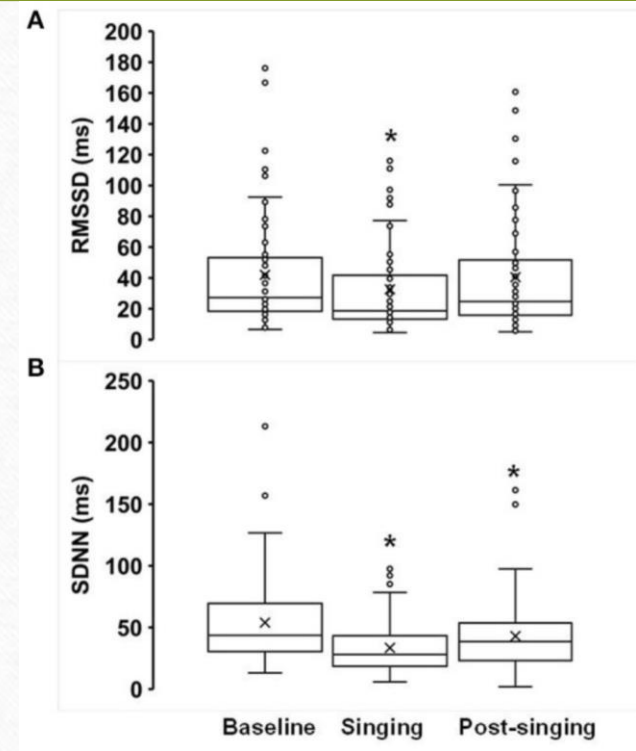
Summary of HRV measurements (cont.)

- There were positive correlations between level of enjoyment and heart rate variability, which means that the participants who enjoyed singing had more improvement in heart rate variability.
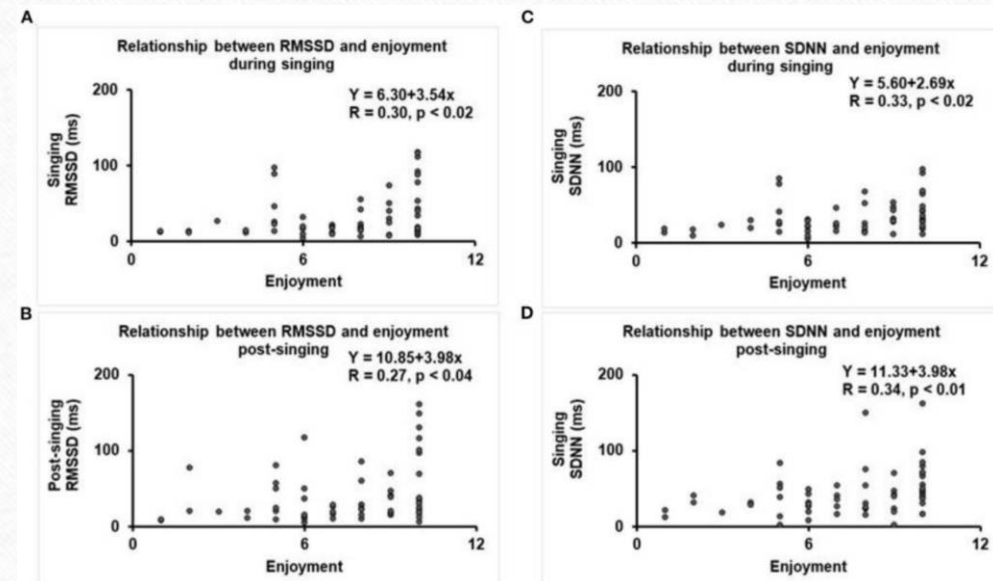
Discussion

- Participants with abnormal baseline vascular function and/or at highest ASCVD risk demonstrated the most significant improvement in vascular function with singing compared to participants with normal baseline vascular function and low ASCVD risk.

- Active singing did not significantly impact vascular function in healthy participants with normal baseline vascular function, which suggests that subjects with healthier vasculature may need a larger stimulus to affect change.

- There was significantly more interest in singing participation in women than in men, which could serve as a more appealing therapy incorporated into traditional cardiac rehabilitation for older women (who have historically low participation rates).

- The pattern of HRV changes observed were similar to those seen with exercise activity whereby exercise elicits a reduction in HRV, followed by a recovery toward baseline HRV post-exercise.

Conclusion

- A short duration of singing improves vascular function, especially for individuals with ASCVD or at-risk for ASCVD.

- Heart rate variability responses to singing are similar to those seen with light-intensity exercise.

- While a short duration of singing may be predictive of vascular improvement with a more sustained singing intervention (weeks), further studies are needed to confirm this.