Exploration of Vocal Acoustic Parameters as a Physics-Based Approach to Supporting Clinical Assessment of Coronary Artery Disease

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Abstract

This study explores vocal acoustic parameters as a potential source of complementary clinical information for coronary artery disease (CAD). Voice recordings from 36 healthy subjects and 33 CAD patients were analyzed using Praat across five sustained vowels (/a/, /i/, /u/, /e/, and /o/). We compared formant frequencies, harmonic-to-noise ratio (HNR), jitter, shimmer, and intensity using the Mann-Whitney U test. We found significant differences in HNR, jitter, and shimmer across all vowels, with shimmer showing the largest overall statistical differences. These findings highlight the potential of non-invasive vocal acoustic analysis for further investigation in clinical assessment of CAD.

Keyword: Vocal Acoustics · Coronary Artery Disease · Biomedical Signal Processing · Shimmer · Jitter · Harmonic-to-Noise Ratio · Praat

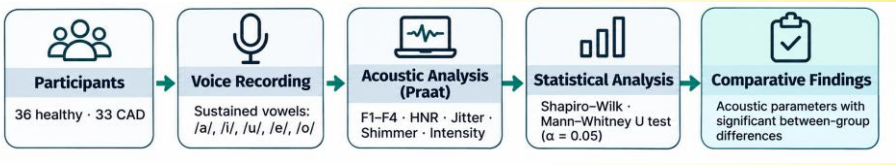
Introduction

Coronary artery disease (CAD) affects cardiovascular function and may be linked to physiological changes in respiratory and phonatory mechanisms. Human voice is generated through airflow from the lungs, vocal fold vibration, and acoustic resonance within the vocal tract. Acoustic parameters, including formant frequencies, HNR, jitter, shimmer, and intensity, can quantitatively characterize these processes. Variations in these parameters may reflect differences in voice production, although they are not specific to cardiovascular disease. Advances in digital acoustic analysis provide opportunities to investigate voice characteristics using non-invasive signal measurements.

Research objective: To investigate differences in vocal acoustic parameters between healthy individuals and patients with CAD and evaluate their potential relevance as complementary clinical information.

Research Method

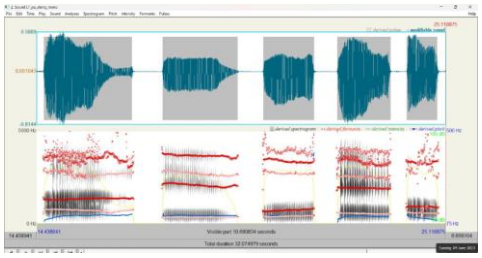
This observational comparative study analyzed voice recordings from 69 participants, comprising 36 healthy individuals and 33 patients with CAD. Each participant produced five sustained vowels: /a/, /i/, /u/, /e/, and /o/. We analyzed digital voice recordings using Praat to obtain formant frequencies (F1–F4), HNR, jitter, shimmer, and intensity. We examined acoustic characteristics using waveform and spectral representations, and summarized parameter values for each group. We assessed data normality using the Shapiro-Wilk test, then compared groups using the Mann-Whitney U test, with $p < 0.05$ as the significance threshold.



Picture 1. Research workflow

Discussion & Result

Vocal acoustic parameters differed significantly between healthy subjects (n = 36) and patients with coronary artery disease (CAD; n = 33). Harmonic-to-noise ratio (HNR), jitter, and shimmer differed significantly across all five sustained vowels ($p < 0.05$). Shimmer exhibited the most consistently low p-values, with a reported mean p-value of 0.0007, although statistical significance alone does not establish diagnostic performance.



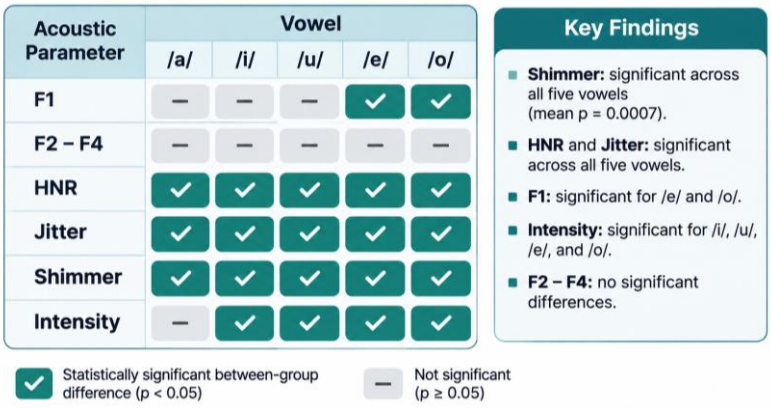
Picture 2. Example of voice signal processing results using Praat, showing the oscillogram and spectrogram of subject S1.

Significant differences also emerged in F1 for vowels /e/ and /o/and in vocal intensity for /i/, /u/, /e/, and /o/, whereas F2–F4 showed no significant differences. These findings suggest that vocal perturbation characteristics may provide useful information for further investigation. However, consider potential confounding factors, including age, sex, respiratory conditions, and recording variability, when interpreting these results.

The association between coronary artery disease (CAD) and vocal acoustic characteristics may involve physiological interactions among cardiovascular function, respiratory control, and phonation. Alterations in respiratory support, autonomic regulation, or laryngeal function could potentially influence vocal fold vibration, resulting in measurable differences in jitter, shimmer, and HNR. In this study, these parameters differed significantly between CAD patients and healthy subjects across all five vowels. However, the findings establish a group-level association rather than demonstrating that CAD directly causes these acoustic changes. Further investigation integrating cardiovascular clinical measurements and controlling for confounding factors is necessary to clarify the underlying mechanisms and assess their potential clinical relevance.

Conclusion

Vocal acoustic analysis revealed statistically significant differences between healthy individuals and patients with coronary artery disease, particularly in HNR, jitter, and shimmer. These findings suggest that voice-derived acoustic parameters may serve as potential non-invasive indicators for further cardiovascular research. However, the observed differences do not establish diagnostic accuracy or a causal relationship with CAD. Larger, clinically characterized cohorts, adjustment for confounding factors, and independent validation are required before considering their application as complementary clinical assessment tools.



Picture 3. Statistical between-group in acoustic parameters by vowel