# Analysis and Implications of Non-Invasive Knee Acoustical Emissions in Juvenile Idiopathic Arthritis

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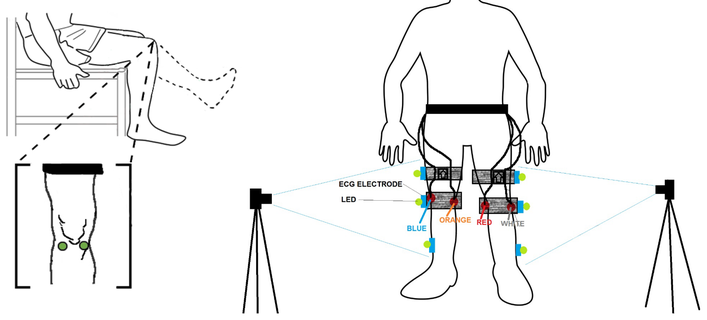
## OBJECTIVE

- Characterize the acoustic emission profile of the knees of children with JIA, and use that to propose a novel method for longitudinal monitoring, diagnosing, and prescribing for the condition.

## BACKGROUND

- Juvenile idiopathic arthritis (JIA) is the most common chronic childhood arthropathy, characterized by **persistent inflammation** of the joints, with onset prior to the age of 16 years.[1]
- Standardizing the diagnosis of JIA is difficult due to lack of specific biomarkers, variable presentation, and few objective diagnostic criteria.
- Acoustic measurements have previously been used to diagnose traumatic knee injuries[2].
- internal friction between articulating structures cause various frequencies of vibrations that propagate to the surface of the knee[3]
- Detailed characterization of the acoustic profile in children with JIA and correlation with inflammation levels and treatments has not been described previously.

## METHODS




- Subjects: 4 children with JIA, 3 healthy controls
- Motion tracking + 2 uniaxial Dytran accelerometers
- Subjects performed standard movements (e.g. seated flexion/extension) while sounds recorded.

**FIGURE 1: Time Domain Analysis**

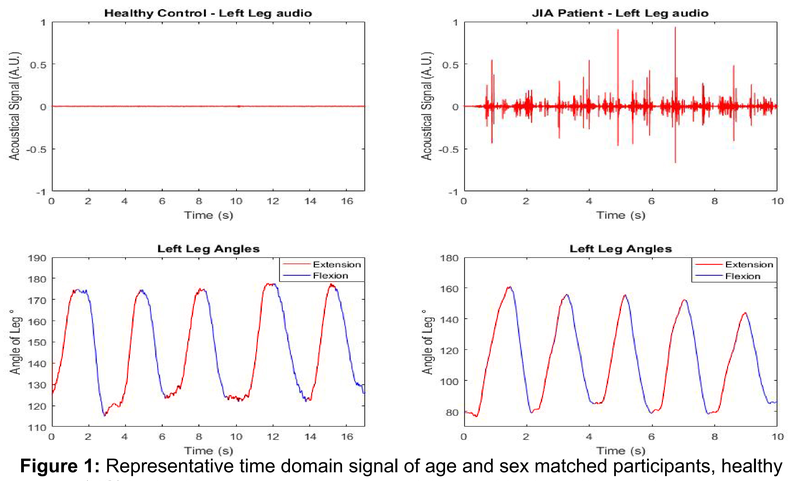



**Figure 1:** Representative time domain signal of age and sex matched participants, healthy control (HC) had virtually no sounds, whereas JIA patient had repetitive clicks.

**Figure 2: Frequency Domain Analysis**

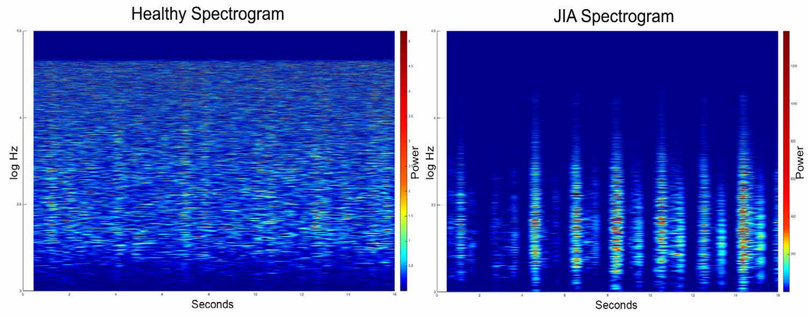



**Figure 2:** Spectrogram depicts frequency range of sound with time of the same subjects as in Figure 1. Signals were bandpass filtered (2.5-20kHz), notice the different scales of power on the right. JIA spectrogram is both more repetitive and much higher powered.

**FIGURE 3: Signal Feature Comparisons**

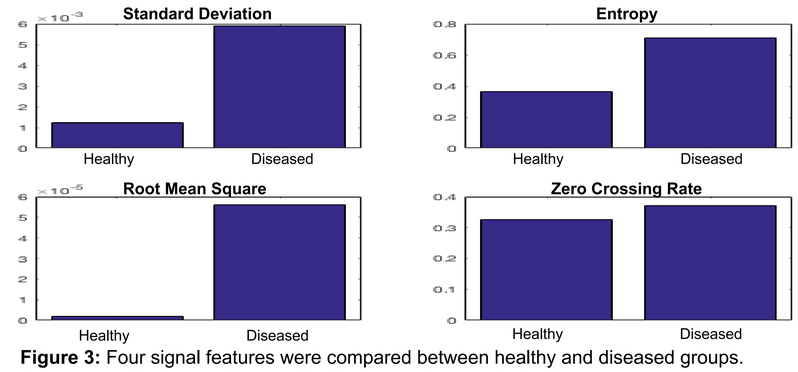



**Figure 3:** Four signal features were compared between healthy and diseased groups. Entropy and Root Mean Square (RMS) showed the greatest difference between groups. Zero crossing rate was shown to be an ineffective comparator.

## RESULTS

- There are several differences that can be seen in both the time and frequency domain between healthy control's knee sounds and patients with JIA.
- In the time domain, with a similar rate of flexion/ extension the JIA patient's sound profile appears more chaotic, with periodic high frequency "clicks".
- In the frequency domain, the JIA spectrogram was 240x more powerful, and there were periodic spikes. The healthy spectrogram had no discernible features – it resembled white noise.
- Entropy, standard deviation and root mean square all showed significant differences between the two groups. Zero crossing rate was insignificant.

## CONCLUSIONS

- Children with JIA show significantly more powerful, more repetitive, and more chaotic sound profiles compared to children with healthy joints.
- Three signal measures (std, entropy, rms) could be used as potentially diagnostic criteria in the future. In particular, they could be used to monitor the course of JIA to determine longitudinal disease course or potentially effectiveness of therapeutics.
- Wearable, acoustic sensors can provide a novel method for non-invasively detecting joint health

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## REFERENCES

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