Spectrogram Analysis of Respiratory Sounds in Exercising Horses

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Spectrogram analysis of respiratory sounds in exercising horses allows differentiation between normal horses and horses with laryngeal hemiplegia and dorsal displacement of the soft palate. If distinguishable respiratory sounds are associated with individual upper airway conditions, spectrogram analysis of respiratory sounds may become a valuable and simple field test. Authors’ Addresses: Dept. Large Animal Clinical Sciences, Michigan State University, East Lansing, MI 48824-1314; Dept. Physics and Astronomy, Michigan State University, East Lansing, MI 48824; Dept. Large Animal Clinical Sciences, Michigan State University, East Lansing, MI 48824-1314.

1. Introduction

Upper airway obstructions in horses are common and during exercise, obstructions are often associated with abnormal respiratory noise. Respiratory sounds in exercising horses are difficult to evaluate because the trained observer is not always in an optimal location, and the respiratory sounds are obscured by extraneous noises such as hoof beats, wind noise, or sounds associated with treadmill operation.

In human medicine, spectrogram analysis of speech is a large field of study and practical applications of this field, including speech therapy and voice recognition, are now commonplace. Indeed, spectrogram analysis of sound has been used in many species, including songbirds and marine mammals.

Attenburrow, et al. have recorded respiratory sounds of horses using a radiostethoscope and have analyzed these sounds using spectrogram analysis. However, respiratory sounds recorded using a radiostethoscope placed over the trachea do not directly relate to the respiratory sounds of exercising horses discerned by an examiner.

Idiopathic laryngeal hemiplegia and dorsal displacement of the soft palate (DDSP) are the two most common upper airway obstructions in exercising horses. In the present study, we tested the hypothesis that left laryngeal hemiplegia (LLH) and DDSP are associated with unique respiratory sounds and that spectrogram analysis of these sounds allows differentiation of these conditions.

2. Materials and Methods

Five Standardbred horses were used in the experiments. Horses were studied under baseline conditions, and after induction of LLH and DDSP using local anesthetic techniques previously described. Five Standardbred horses were used in the experiments. Horses were studied under baseline conditions, and after induction of LLH and DDSP using local anesthetic techniques previously described. We used a randomized crossover design and studies were separated by at least one week. The speed at which each horse reached maximum heart rate was
determined using a rapid incremental exercise test, as previously described. On the day of the experiments, the upper airway of horses was first examined using the fiberoptic endoscope to ensure that the upper airway functioned normally. Subsequently, the desired experimental condition was created (normal, LLH, or DDSP) and verified by endoscopic examination. After a five-minute warm-up period, horses were exercised at maximum heart rate for two minutes. Endoscopic examination was repeated immediately following exercise.

Pharyngeal pressure was measured using a pharyngeal catheter positioned at the level of the gullett pouch openings, as previously described. Pharyngeal pressure was used to determine the timing of inhalation and exhalation. Respiratory sounds were recorded as follows. The recording microphone was placed approximately 4 cm from the tip of the horse’s nose. The microphone was connected to a cassette recorder containing a compression circuit. The compression circuit was activated by the horse’s expiratory sound and squelched environmental noises associated with exhalation. The respiratory sounds were analyzed using a computer-based spectrogram program.

3. Results
Under baseline conditions, in horses exercising at a speed corresponding to maximum heart rate, expiratory sounds dominated. Expiratory sounds were maximal in a frequency band ranging from 70 to 1,500 Hz and were similar between horses. Absolute amplitudes could not be determined because of the compression.

In horses with LLH, expiratory sounds were unaffected; however, throughout inhalation, in all affected horses the respiratory sound was characterized by a frequency band up to 3,200 Hz and a signal level of approximately 20 decibels less than exhalation.

In horses with DDSP, inspiratory sounds were similar to those observed in horses exercising under baseline conditions. In contrast, during exhalation, respiratory sounds were characterized by a broad frequency band up to 8 KHz. The respiratory sound during exhalation was not homogeneous but was characterized by rapid flutterings.

4. Discussion
This study demonstrates that respiratory sounds in exercising horses on a treadmill can be recorded without interference by other sounds associated with exercise. This was accomplished by using a tape recorder with a compression circuit. This equipment is designed to record speech in difficult environments such as conference rooms. The expiratory sounds of horses are intense enough and frequent enough to activate the compression circuit, thereby squelching the ambient noise. The compression circuit maintains a flat frequency response. Therefore, the recorded spectrum is expected to be accurate. However, beyond the frequency analysis, much information is gained from the temporal dimension of the spectrogram.

The spectrogram pattern of sounds recorded in exercising horses under baseline conditions, and following induction of LLH and DDSP were markedly different. Under the experimental conditions used, in normal horses, expiratory sounds predominated. As expected, LLH was associated with inspiratory sounds with a higher frequency. The higher frequency characteristics of the sound explains the “inspiratory whistle” that has been reported in exercising horses with idiopathic laryngeal hemiplegia. Dorsal displacement of the soft palate is an expiratory obstruction. Consequently, respiratory sounds associated with this condition occur during exhalation. In horses with DDSP, the sound had a high amplitude, a broad frequency band, and was rapidly periodic, explaining the “rattling” sound frequently described in exercising horses afflicted with DDSP.

Spectrogram analysis of respiratory sounds in exercising horses may have important applications. It is possible that all of the upper respiratory conditions of horses are associated with unique spectrogram patterns. If this is the case, simple recording of respiratory sounds under field conditions could yield a diagnosis of specific upper airway conditions, thereby avoiding the need for endoscopic examinations on a high-speed treadmill. Also, upper airway conditions in horses are associated with exercise intolerance and respiratory noise production. In a series of studies, we have evaluated various surgical techniques used to treat these upper airway conditions in their ability to reduce upper airway impedance. However, reduction of upper airway impedance in affected horses does not necessarily reduce respiratory noise. For many owners, the respiratory noise associated with upper airway conditions is just as important as the upper airway obstruction. Spectrogram analysis of respiratory sounds in exercising horses now makes it possible to evaluate the efficacy of surgical techniques in reducing respiratory sounds associated with upper airway obstructive conditions.

References