Quantitative Wheeze Severity for Evaluating Treatment Response in Asthma

使用量化喘鳴音指標評估氣喘療效

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Wheeze has long been viewed as an important clinical sign of asthma attack. Wheeze is caused by the narrowing of airway that could be triggered by physical exercise, allergic reaction, drug use or exposure to other irritants. With the advent of computerized stethoscopes, previous reports have used the temporal and spectral features to quantify the wheeze. The quantified severity of wheeze is reported to be inversely correlated with pulmonary function (e.g., FEV_1). Some studies have used these quantitative indexes of wheeze to show the treatment response in asthma. Here, we reported two patients with acute exacerbation of asthma. The two patients were admitted to the hospital, and BiPAP was applied on both patients for breathing support. Bronchodilator inhalation therapy was given. Auscultation was performed at 8 different locations (the 2nd and 5th intercostal spaces in the bilateral midclavicular lines and the 5th and 10th intercostal spaces in the bilateral midaxillary lines) using a Littmann 3200 digital stethoscope (3M, Minnesota, US) at admission (before treatment) and at discharge (after treatment). A 15-second-long sound from each location was recorded and the sampling rate was 4,000 Hz. The sound signals were transformed to spectrograms based on short-time Fourier transform (window size = 256, overlap ratio = 0.85 and zero padding = 512). One experienced expert labeled the events of inspiration, expiration and wheeze when simultaneously listening to the recorded sound and viewing the corresponding spectrogram. Polyphonic wheezes were observed in both cases before treatment. The paired (pre- and post-treatment) quantitative indexes were compared by Wilcoxon Sign-Ranked test. The results displayed significant improvements in Δoccupation rate (-0.534±0.133, $P < 0.001$), Δpresences/breathing cycles (-0.734±0.361, $P < 0.001$), Δnormalized maximum duration (-1.292±0.536 s, $P < 0.001$), Δnormalized median duration (-0.817±0.665 s, $P = 0.002$) and Δnormalized mean duration (-0.665±0.316 s, $P = 0.004$). Conclusively, a computerized stethoscope with spectrogram visualization and quantitative indexes provides useful information to track the change of wheeze severity in asthma.

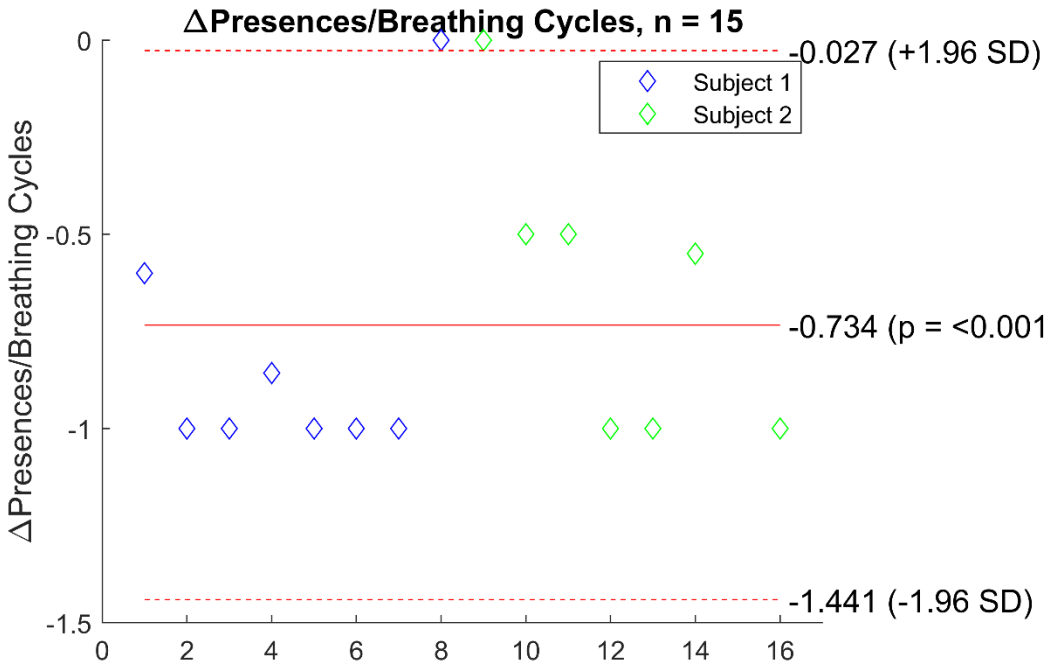


Figure 1. Bland-Altman plot of wheeze presences/breathing cycles before and after bronchodilator therapy.

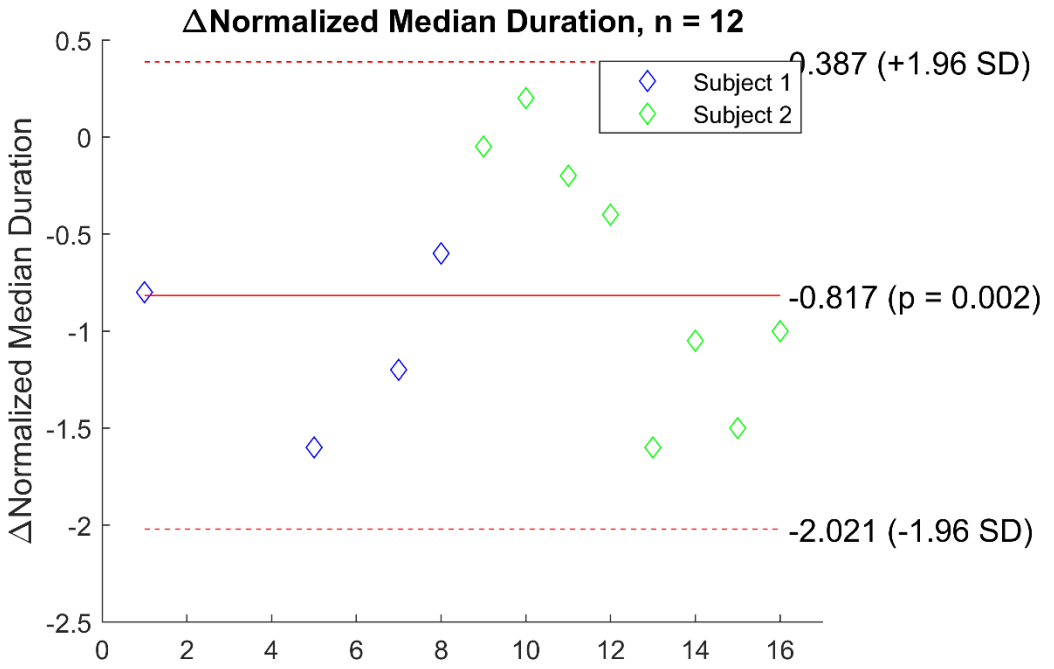


Figure 2. Bland-Altman plot of normalized median duration before and after bronchodilator therapy.

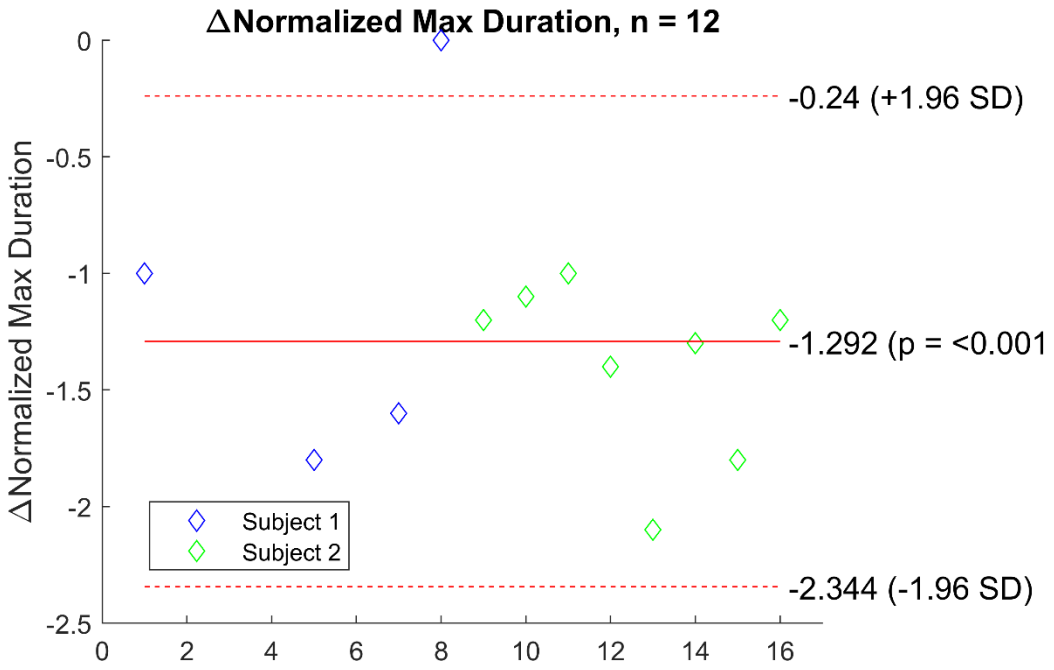


Figure 3. Bland-Altman plot of normalized max duration before and after bronchodilator therapy.

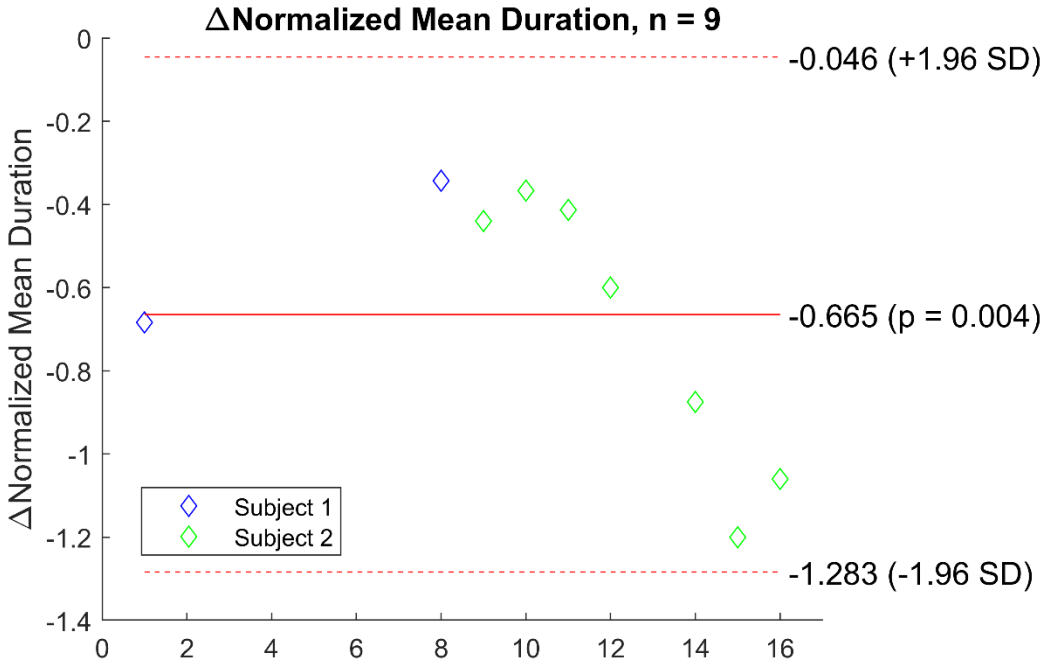


Figure 4. Bland-Altman plot of normalized mean duration before and after bronchodilator therapy.

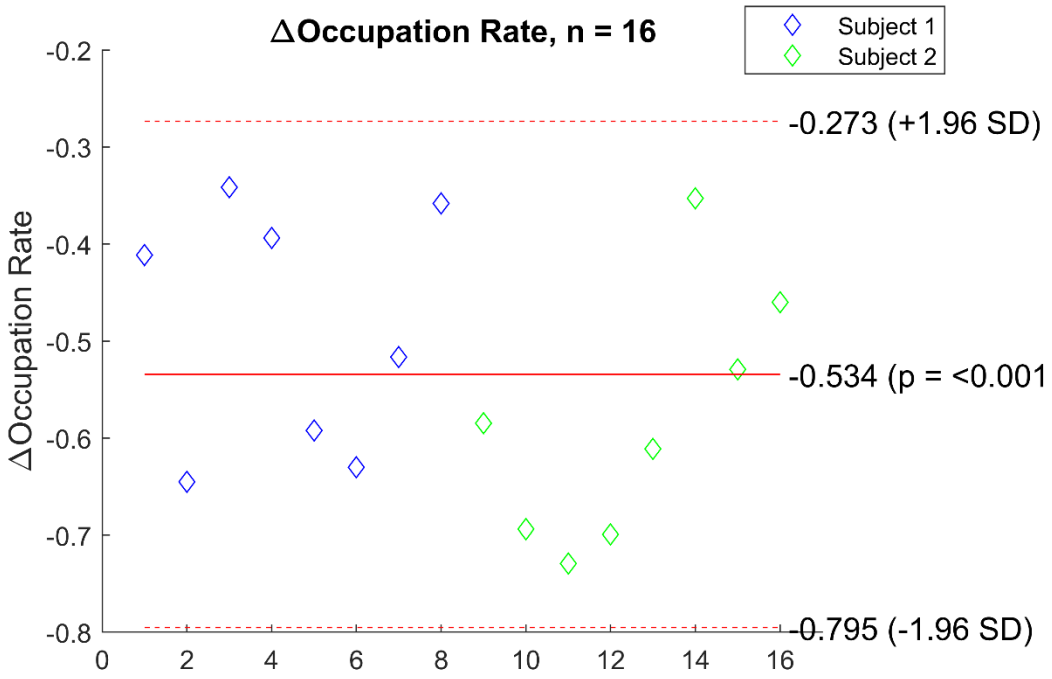
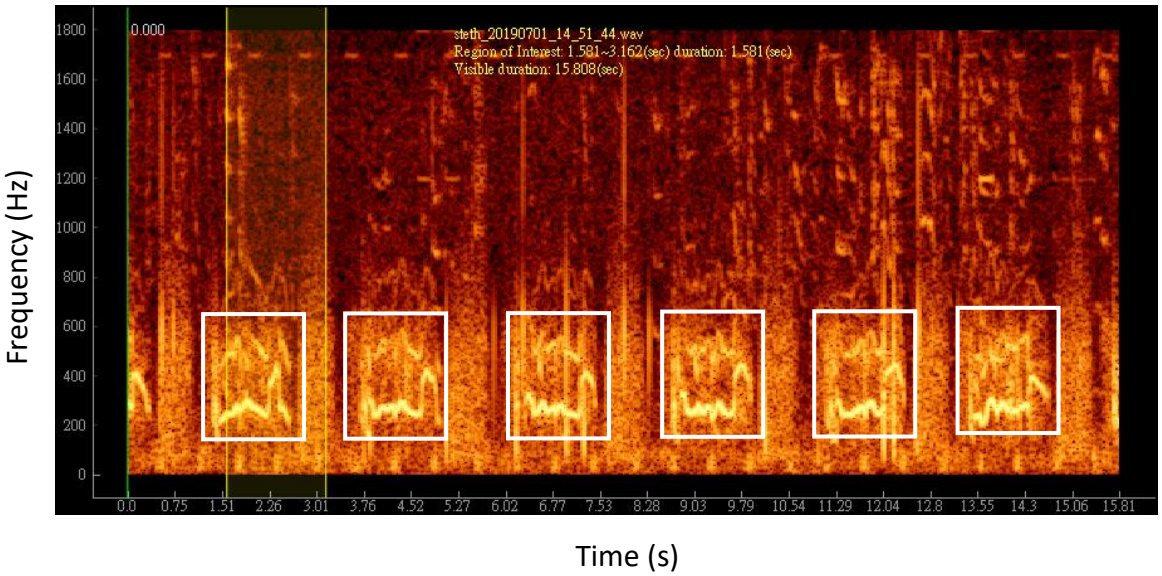


Figure 5 Bland-Altman plot of wheeze occupation rate before and after bronchodilator therapy.

(a)



(b)

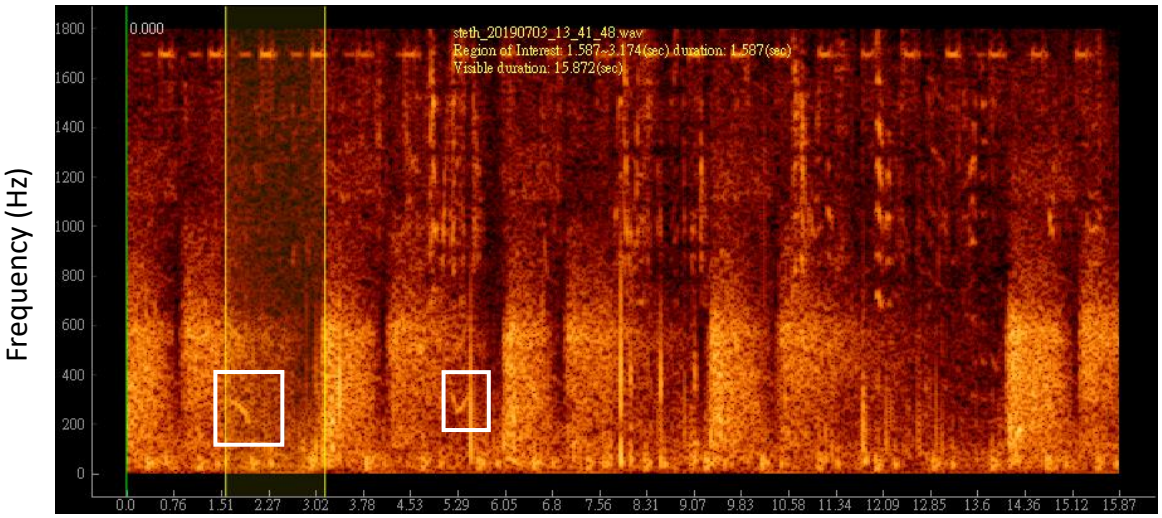


Figure 6. Spectrograms of wheeze lung sounds (a) before, and (b) after bronchodilator therapy from subject 1. The sounds were obtained at the right 2nd intercostal space in the midclavicular line.