INTRODUCTION: Laser Doppler fluxmetry provides a non-invasive technique for evaluating cutaneous perfusion. The information gathered by appropriate laser Doppler waveform analysis is potentially useful in diagnosing and monitoring changes in cutaneous perfusion associated with disease progression in the diabetic foot. Because diabetes is characterized by both microvascular and peripheral neurological degeneration, the study hypothesis is that laser Doppler waveforms differ by spectral analysis between normal volunteers and diabetics as well as between diabetics of differing disease severity, and that these differences, indicative of autonomic function abnormalities, correlate with the presence and severity of peripheral sensory neuropathy.

METHODS: All methods were approved by the institutional IRB and informed consent was obtained from each study participant. Cutaneous perfusion in the feet of diabetic patients (n=20) and normal volunteers (n=20) was evaluated by laser Doppler fluxmetry. The study group included both insulin-dependent (n=13) and non insulin-dependent (n=7) subjects. Diabetic patients without past or current clinical evidence of peripheral neuropathy, foot ulcers, or Charcot arthropathy nor a history of lower extremity amputations secondary to diabetes at the time of testing were classified as mild (n=9), while those with neuropathy and other diabetes-associated foot morbidities were classified as advanced (n=11). The feet of both normals and diabetics were studied using cold exposure as a physiologic stressor.

Continuous laser Doppler fluxmetry monitoring was performed for 5 minutes inside a modified refrigeration unit (8-12 °C), followed by a 20-minute cooling period inside a modified refrigeration unit (8-12 °C), and finally a 20-minute rewarming period at room temperature. The data files were analyzed using Welch’s Fourier transform technique. Plots of frequency vs power were generated from the resulting Fourier spectra and compared using both one- and two-way ANOVA to analyze the differences in the laser Doppler measurements between all diabetic patients and normal volunteers as well as between diabetics of differing disease severity.

RESULTS: Gross observation of the raw laser Doppler data revealed an overall lower magnitude of baseline flow and decreased flow variability in the diabetic groups as a whole as compared to controls. Fourier analysis of the laser Doppler waveforms showed significant portions of the power spectra in the low frequency range (0.1 - 0.2 Hz), an indicator of autonomic function, for both groups. The power of these low frequency fluctuations was significantly lower in diabetic than in control subjects overall for the 45-minute testing period (Figure 1).

A reduction in low frequency power also was seen in the advanced as compared to the mild group overall (9.04±0.16 ln-mV^2 vs. 9.85±0.50 ln-mV^2, p<0.05) as well as at baseline (0-5 minutes) (6.50±0.59 ln-mV^2 vs. 9.35±0.69 ln-mV^2, p<0.05) and late cooling (20-25 minutes) (5.38±0.69 ln-mV^2 vs. 8.50±1.0 ln-mV^2, p<0.05).

DISCUSSION: Laser Doppler perfusion data provide significant information about the microcirculatory features of the diabetic foot. In the present study, spectral analysis of laser Doppler perfusion revealed significant differences in autonomic control of the microvasculature in patients with diabetes but without peripheral neuropathy. Sequential spectral analysis of laser Doppler data offers a non-invasive, repeatable, and quantifiable method of monitoring changes in cutaneous perfusion with the potential of monitoring peripheral neurologic function associated with disease progression.