Ambulatory monitoring of freezing of gait in Parkinson’s disease
Steven T. Moore1, Hamish G. MacDougall2 & William G. Ondo2
Neurology Departments; 1Mt Sinai School of Medicine, New York, NY, USA; 2Baylor College of Medicine, Houston TX.

BACKGROUND

Freezing of gait (FOG) and falls in Parkinson’s disease (PD) are generally thought to be closely related; both occur sporadically, are often resistant to dopaminergic treatment, and greatly diminish quality of life. Recent laboratory studies have demonstrated high-frequency components (2-6 Hz) in insole pressure during FOG, which may be preceded by higher stride-to-stride variability (Hausdorff et al. 2003). To date there is no objective measure of FOG and subsequent falls outside of the laboratory.

METHODS

We conducted a pilot study (N=10; 8 males) of ambulatory freeze monitoring. All patients had advanced PD (H&Y III-IV when ‘off’) and a clinical history of FOG, and were prescribed oral levodopa (LD). Subjects arrived in the morning in an ‘off’ state (no PD medication in the past 12 hours) and walked for a maximum length of 100 m about a series of internal hallways. They then took their usual morning dose of oral levodopa and repeated the walking task approximately every 15 min over a 90 min period. Walking trials were recorded using a digital video camera and FOG and standing events identified post-hoc by a movement disorders specialist. Patients wore a lightweight (130 grams) gait monitor (Fig. 1) on the left leg (Moore et al. 2006), which measured vertical acceleration of the shank (as well as sagittal angular velocity for determining stride length).

RESULTS

Six subjects experienced a total of 44 FOG events (range 3 -17 per subject, mean 7.3 [SD 5.1]); 4 subjects did not freeze. FOG occurred during gait initiation (14), or interrupted locomotor activity when turning or encountering an obstacle (doorways, moving around furniture etc, 30 events). Almost half (40%) of FOG events occurred prior to LD administration (Fig. 2), and a cumulative total of 82% occurred within 40 minutes post-LD. During FOG, high-frequency components (2-8 Hz band) were present in the vertical acceleration of the shank that were not apparent during quiet stance (Fig. 3). The power in this ‘freeze’ band was significantly larger during FOG when turning or encountering an obstacle relative to FOG events when initiating gait, and the power spectra during FOG were significantly larger than when quietly standing (Fig. 4). A simple freeze index (FI) at time t was defined as the area under the power spectra of a 5 s window of data (centered at time t) in the ‘freeze’ band (3-8 Hz), divided by the area under the spectra in the ‘locomotor’ band (0.5-3 Hz) (Fig. 5). This was done to minimize the influence of high frequency harmonics (> 2 Hz) during walking on freeze detection. FI was a dimensionless, continuous value (Fig. 5; lower panels - red trace) and scaled such that the largest value encountered was set to 100. During FOG, peak FI ranged from 0.05 to 100 (N=8; mean 7.2 [SD 20.2]), and was larger (p=0.03) than peak FI during periods of quiet standing (N=10; range 0.01–1.6; mean 0.12 [SD 0.3]). A global threshold was chosen at 0.1 such that an FI of equal or greater value was defined as a freeze event. As shown in Fig. 5a, the FI detected most FOG. Of the 44 FOG events, 34 (77.3%) were detected. Of the 46 periods of standing (i.e., intentional, not FOG) from the 10 subjects, 9 (19.6%) were erroneously marked as FOG. However, establishing an individual FI threshold for each subject significantly improved accuracy and sensitivity of the freeze monitor. The individual threshold ranged from 0.1 to 0.8 (N=10; mean 0.22 [SD 0.23]), and decreased FOG detection to 39 of the 44 events (88.6%) and decreased false positives to 5 of 46 stand events (10.9%).

CONCLUSION

The results from this study demonstrate the feasibility of ambulatory freeze monitoring in advanced PD.