Quantification of Fractal Properties of Postural Sway Patterns to Differentiate Healthy from Compromised Human Balance

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ABSTRACT

In a first step to preventing falls in the elderly, postural sway was examined by use of fractal dimension analysis to gain understanding into the different balance patterns associated with age and disease. It was thought that the complex fractal-like patterns of center of pressure displacement breakdown and change with natural aging and disease, with this breakdown associated to fall risk.

To test this hypothesis, center of pressure displacement and associated data was collected from ten healthy young individuals, ten healthy elderly individuals, and ten individuals with Parkinson's disease. Detrended fluctuation analysis was performed to determine the fractal dimension of each individual's data in both the anterior-posterior and medial-lateral sway directions, with both eyes open and eyes closed. The fractal dimension revealed the pattern of sway with respect to the equilibrium position.

It was found that for both short-term (less than one second) and longer-term time intervals, significant statistical differences in the fractal dimensions allowed some group differentiation. Most significantly, in the medial-lateral direction the long-term fractal dimension allowed differentiating of the Parkinson's group from both healthy groups with eyes open, and from the healthy elderly group with eyes closed.

This study led to a better understanding of the effects of Parkinson's disease on balance. It was found that, on average, individuals with Parkinson's disease experience more variability, resulting in a less consistent sway pattern, in the medial-lateral direction than the healthy groups. This may be to make up for a restricted limit-of-stability in the anterior-posterior direction due to rigidity associated with the disease. As individuals with Parkinson's disease are at higher risk of falling than age-matched peers, the differences in sway pattern found in this study may be responsible for the prevalence of falling in this population.