To the Editor:

We read with interest the article by Cavanaugh and colleagues (1) concerning the natural ambulatory activity patterns of older community-dwelling adults. The use of nonlinear analysis to describe habitual activity is an area of emerging research, prompted by the limited value in reporting the amount of physical activity, such as the number of steps walked in a day. Timing, duration, and variability of activity may be relevant to health and successful ageing. Accelerometry enables the long-term objective monitoring of physical activity; however, the theoretical basis for the description of physical activity and the analytical techniques used to deal with the complexity of these data are lacking. Cavanaugh’s analysis is based on Paraschiv-Ionescu’s work (2); namely the application of fractal and information theory technique to look at patterns of physical activity of older adults; however, the authors’ rationale for applying these specific nonlinear measures is harder to discern.

The issue is twofold. The first concern relates to the applicability of the selected nonlinear analysis to natural activity data and the interpretation derived from the results. Entropy analysis and detrended fluctuation analysis (DFA) are commonly used in complex time series analysis. Entropy distinguishes differences in complexity of two temporal sequences, provided that the distribution of symbols or state in the sequence is stable between sequences as Cavanaugh and colleagues pointed out in their appendix. It is therefore not surprising to find that an increase in entropy-based measure with increasing step counts as the distribution of walked or un-walked minutes will be dramatically affected between groups that were classified as active (>10,000 steps) and inactive (<5,000 steps). Entropy-based measures of walked minutes time series clearly do not provide an estimate of complexity, independent of activity levels. This does not preclude their use, but correction for activity levels would have to be applied for the outcomes to be meaningful.

DFA has been shown to be robust when dealing with series of stride-to-stride or step-to-step fluctuation of gait parameters. However, minute-sampled step count series are of a different nature. Stride-to-stride walking denotes a continuous sequence of events, and the step count series presented in this article inhibit the natural scales and rhythm of stepping sequences, which are broken up unnaturally by the imposed 1-minute integration. Therefore, it is difficult to understand what the DFA results tell us about the natural pattern of stepping activity. A coefficient of around 0.8 found by Cavanaugh indicates that there is temporal clustering of stepping activity. In other words, walking activity will tend to happen around a period of heightened walking activity. An increase in stepping activity yields a greater number of steps per minute samples and therefore the production of larger clusters. It is not surprising that the authors found a significant and noticeable correlation between their DFA results and step count. The question is, what does this tell us? Moreover, the long-term correlation that \( \alpha \approx 0.8 \) may be a reflection of a universal driver, such as the diurnal and circadian patterns. DFA has been shown to be fragile when periodic trends are present (3). Nevertheless, with adequate correction, DFA might arise to be a sensitive measure as it might filter out some of the variability.

The second issue relates to the focus on stepping activity only. Recent research points to the importance of sedentary behavior to health and the selective deleterious effects of sedentary patterns on physiological and metabolic outcomes (4). Sedentary behavior is not simply the converse of physical activity but unique in its contribution to health, yet the two behaviors are ultimately linked in the natural physical
activity profile, with level and amount of physical activity influencing sedentary time. It seems very difficult to quantify appropriately the pattern of physical activity from a single record, especially when this record does alter the natural sequence of events by integration over an arbitrary time scale. Analysis of sequences of active and sedentary periods promises to be much more difficult than gait time series as accelerometry data not only measure the effect of multiple driving forces but also measure the influence of a person’s free will.

The potential exists for nonlinear analysis to illuminate the complex nature of physical activity profiles and to inform a change in public health guidelines for daily activity. However, it is important that analysis be firmly backed by a sound theoretical framework and pays respect to the nature of the data we gather.

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References