TETHERED RANDOM WALK AS A MODEL FOR STABILOMETRY

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INTRODUCTION

Stabilometry is a standard procedure for measuring movements of the centre of pressure (COP) of standing subjects. Although this method is well established, the interpretation of the results, the physiological meaning of the calculated parameters and their scaling properties with the measurement time are still open issues. To discriminate between different age groups we recently proposed the use of the index of sudden excursions (ISE) [1] that was defined as the ratio between the total sway area as determined by the Fourier analysis of the outline [2], and the one obtained by the standard principal component analysis [3]. Although it is evident that such an index reflects mostly the isolated movements of the COP outside the central region of the stabilogram, its practical use and time scaling remains to be studied. This led us to study simulated stabilometric data with well defined properties. In this work we present a simplified data model that describes the COP movements as a random walker fixed to an elastic tether. Data thus simulated at different conditions were analysed by the same procedures as the experimental ones.

METHODS

The stabilometric data were simulated by considering COP as a random walker that is tethered to a fixed central point by a tether of given length and elastic coefficient. Calculations were done by the random walk procedure, combined with Metropolis algorithm [4]. In each step the COP position was randomly moved where the maximal step length (d_{max}) was expressed in the unstressed tether length (L_0). The resulting position was then accepted with the probability $\exp(-(\Delta R^2-\Delta R_p^2)/\alpha)$, where the elastic energy difference due to the move depends on the tether extension at the current (ΔR) and previous position (ΔR_p) with elastic parameter α corresponding to twice the temperature divided by the elastic coefficient of the tether ($\alpha=2T/\gamma$). After a large number of steps thus generated trajectory samples the configurations in accord with the canonical Boltzmann distribution [4]. This model has only two independent parameters: α and the maximal possible trajectory length, defined as the maximal step length (d_{max}) multiplied by the number of simulated steps (N).

The actual calculation always started with a point somewhere inside the central region ($R<L_0=1$) and the first 50,000 points were rejected to allow the system to thermalize. After collecting the required number of data points they were analyzed with the same procedures as the experimental measurements. The computations were performed on a PC-type computer, running under Linux operating system with the data simulation program written in Fortran using the portable pseudo-random number generator ran3 [5], based on a subtractive method that has very long period and no known defects.

RESULTS AND DISCUSSION

A series of 90,000 data points was calculated with the maximal step length d_{max}= 1 which resulted in the rejection factor between 12 % and 23 %, depending on the value of the elastic parameter. These data were analysed by segments of different lengths and the average values of the parameters were calculated. As the total path length was linearly dependent on the number of analysed points at given value of the elastic parameter, it was the independent variable of choice. As seen from Fig.1 the average values of ISE depend on the total path length and this dependence is not linear. Similar nonlinear relation was also determined for the total area of the stabilogram.

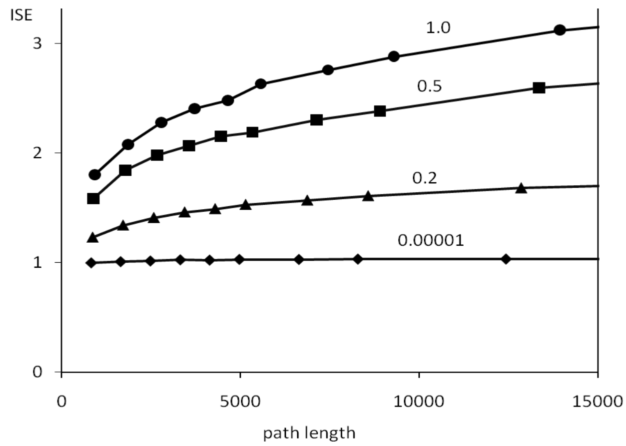

Figure 1: Index of sudden excursions (ISE) as a function of the path length for some values of the elastic parameter α.

CONCLUSIONS

Using simple simulated data, generated by tethered random walk algorithm, showed that ISE and the total stabilogram area depend nonlinearly on the total COP path length and thus on the measurement time. This must be taken into account when analysing and reporting about real stabilometric experiments.

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REFERENCES

1. Sevšek F. ICBME 2008, Proceedings **23:** 1825–1828, 2009.
2. Sevšek F. *WSEAS transactions on information science and applications* **4**: 794–799, 2007
3. Oliveira L et al. *Physiol. Meas.* **17**: 305–312, 1996.
4. Chandler D. Introduction to Modern Statistical Mechanics. Oxford University Press, 1987.
5. Press WH and Teukolsky SA. *Computers in physics* **6**: 522 –524, 1992.