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"Study of the human postural control system during quiet standing using detrended fluctuation analysis"

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ABSTRACT:

The detrended fluctuation analysis is used to study the behavior of different time series obtained from the trajectory of the center of pressure, the output of the activity of the human postural control system.

The results suggest that these trajectories present two different regimes in their scaling properties: persistent (for high frequencies, short-range time scale) to antipersistent (for low frequencies, long-range time scale) behaviors.

The similitude between the results obtained for the measurements, done with both eyes open and eyes closed, indicate either that the visual system may be disregarded by the postural control system while maintaining the quiet standing, or that the control mechanisms associated with each type of information (visual, vestibular and somatosensory) cannot be disentangled with the type of analysis performed here.

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References:

- [1] J. Massion, Postural control system, *Curr. Opin. Neurobiol.* 4 (1994) 877–887.
- [2] T.E. Prieto, J.B. Myklebust, B.M. Myklebust, Characterization and modeling of postural steadiness in the elderly: A review, *IEEE Trans. Rehabil. Eng.* 1 (1994) 26–34.
- [3] J.J. Collins, C.J.D. Luca, A random-walk analysis of center-of-pressure trajectories, *Exp. Brain Res.* 95 (1993) 308–318.
- [4] J.J. Collins, C.J.D. Luca, Random walking during quiet standing, *Phys. Rev. Lett.* 73 (1994) 764–767.
- [5] J. Theiler, S. Eubank, A. Longtin, B. Galdrikian, J.D. Farmer, Testing for nonlinearity in time series: the method of surrogate data, *Physica D* 58 (1992) 77–94.
- [6] N. Yamada, Chaotic swaying in the upright posture, *Human Mov. Sci.* 14 (1995) 711–726.
- [7] T. Schumann, M.S. Redfern, J.M. Furman, A. El-Jaroudit, L.F. Chaparrot, Time frequency analysis of postural sway, *J. Biomech.* 28 (1995) 603–607.
- [8] M. Priestley, *Non-Linear and Non-Stationary Time Series Analysis*, Academic Press, New York, 1988.

- [9] M. Ferdjallah, G.F. Harris, J.J. Wertsch, Instantaneous postural stability characterization using time–frequency analysis, *Gait Posture* 10 (1999) 129–134.
- [10] K.M. Newell, S. Slobounov, E.S. Slobounove, P.C.M. Molennar, Stochastic processes in postural center-of-pressure profiles, *Exp. Brain Res.* 113 (1997) 158–164.
- [11] S. Thurner, C. Mittermaier, R. Hanel, K. Ehrenberger, Scaling-violation phenomena and fractality in the human posture control systems, *Phys. Rev. E* 62 (2000) 4018–4024.
- [12] S. Thurner, C. Mittermaier, K. Ehrenberger, Change of complexity patterns in human posture during aging, *Audiol. Neurootol.* 7 (2002) 240–248.
- [13] Y. Shimizu, S. Thurner, K. Ehrenberger, Multifractal spectra as a measure of complexity in human posture, *Fractals* 10 (2002) 103–116.
- [14] M. Duarte, V.M. Zatsiorsky, Long-range correlations in human standing, *Phys. Lett. A* 283 (2001) 124–128.
- [15] C.K.Peng, S.V.Buldyrev, S.Havlin, M.Simons, H.E.Stanley, A.L.Goldberger, Mosaic organization of DNA nucleotides, *Phys. Rev. E* 49 (1994) 1685–1689.
- [16] D.Delignieres, T.Deschamps, A.Legros, N.Caillou, A methodological note on non-linear time series analysis: Is Collins and deLuca (1993)'s open and closed-loop model a statistical artifact, *J. Motor Behaviour* 35 (2003) 86–96.
- 17] H.E. Hurst, *Long-term Storage: An Experimental Study*, Constable, London, 1965.

[18] SATEL, Manuel d'utilisation des logiciels d'évaluation des activités posturo-cinétiques, Satel, Blagnac, 2000.

[19] A. Eke, P. Herman, J.B. Bassingthwaite, G.M. Raymond, D.B. Percival, M. Cannon, I. Balla, C. Ikrenyi, Physiological time series: distinguishing fractal noises from motions, *Pflügers Arch.* 439 (2000) 403–415.

[20] A. Eke, P. Hermann, L. Kocsis, L.R. Kozak, Fractal characterization of complexity in temporal physiological signals, *Phys. Meas.* 23 (2002) R1–38.

[21] R.Jennane, R.Harba, G.Jacquet, Methodes d'analyse du mouvement brownien fractionnaire: theorie et resultats comparatifs, *Traitement du signal* 18 (2001) 419–436.

[22] D.Delignieres, S.Ramdani, L.Lemoine, K.Torre, M.Fortes, G.Ninot, Fractal analysis for short time series: An assessment of classical methods, *J.Math. Psych.* 50 (2006) 525–544.

[23] A.V. Coronado, P. Carpena, Size effects on correlation measures, *J. Biol. Phys.* 31 (2005) 121–133.

[24] K. Hu, P.C. Ivanov, Z. Chen, P. Carpena, H.E. Stanley, Effect of trends on detrended fluctuation analysis, *Phys. Rev. E* 64 (2001) 01114.

[25] H.A. Makse, S. Havlin, M. Schwartz, H.E. Stanley, Method for generating long-range correlations for large systems, *Phys. Rev. E* 53 (1996) 5445–5449.

[26] L. Xu, P.C. Ivanov, K. Hu, Z. Chen, A. Carbone, H.E. Stanley, Quantifying signals with power-law correlations: A comparative study of detrended fluctuation analysis and detrended moving average techniques, *Phys. Rev. E* 71 (2005) 051101.

[27] O. Sasaki, S. Usami, P.-M. Gagey, J. Vartinerie, M.L.V. Quyen, P. Arranz, Role of visual input in nonlinear postural control system, *Exp. Brain Res.* 147 (2002) 1–7.

[28] J.J. Collins, C.J.D. Luca, The effects of visual input on open-loop and closed-loop postural control mechanisms, *Exp. Brain Res.* 103 (1995) 151–163.

[29] W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery, Numerical recipes in Fortran 77: The art of scientific computing, Cambridge University Press, Cambridge, 1992.

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[30] L.S. Liebovitch, W. Yang, Transition from persistent to antipersistent correlations in biological systems, *Phys. Rev. E* 56 (1997) 4557–4566.

[31] C.K. Peng, S. Havlin, H.E. Stanley, A.L. Goldberger, Quantification of scaling exponents and crossover phenomena in non stationary heartbeat time series, *Chaos* 5 (1995) 82–87.