Fractal regulation of human motor activity, hypothalamic integrity and napping during ageing.

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Introduction: Human activity exhibits a fractal behaviour, characterised by scale-invariant patterns over time scales ranging from minutes to 24 hours. Animal studies have shown that alterations of the suprachiasmatic nucleus (SCN), the circadian pacemaker located in the anterior part of the hypothalamus, are associated with a reduced scale-invariant correlation. Such reduction is also observed in ageing and Alzheimer's disease, both marked by a loss of SCN integrity. Here, we aimed at assessing the association between fractal regulation and in-vivo hypothalamic integrity in healthy older nappers and no nappers differing in their 24-hour distribution of rest-activity patterns.

Methods: 28 healthy elderly nappers and 31 age- and gender matched no-nappers (mean age (±SD): 69.0±5.3 years, 37% female) underwent a 40-h multiple nap constant routine (CR). Locomotor activity was recorded using actimetry during (13±2) days and fractal correlation, α^{circa}, was calculated using detrended fluctuation analysis. Macromolecular content of grey matter tissue in the anterior inferior region was quantified using MRI derived Magnetization Transfer saturation (MTsat) maps.

Results: Group comparison confirmed that the circadian modulation of sleep efficiency during the CR is reduced in nappers, compared to no-nappers ($p<0.05$). Furthermore, bayesian mixed-effects models indicated that fractal correlation, α^{circa}, was linked to MTsat values within the anterior inferior hypothalamic region, with napping acting as a modulating factor (MTsat : ß=0.074, HDI(95%)=[0.003, 0.114], MTsat*nap group,ß=-0.091,HDI(95%)=[-0.177,0.002]).

Discussion: Our results support the hypothesis that daytime rest is linked to circadian alteration. Furthermore, they reveal for the first time that fractal regulation of locomotor activity is linked to in-vivo assessed integrity of the anterior hypothalamus, encompassing the SCN. Napping and associated circadian alteration seem to mediate this association. Together, these data put forward the functional relevance of fractal regulation as a potential health risk (circadian) indicator.

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