Individual based model for adipocytes size distribution

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Résumé

Obesity is nowadays a global public health issue (1). It is defined as an excess of lipids stored that harms health. The adipose tissue is in charge of this storage via its main cells : adipocytes. These cells present a singular property: their size varies from 10μm up to 150μm of diameter (which implies a large volume variation). In addition the observed size distribution is bimodal, presenting 2 characteristic sizes (around 30μm and 130μm with an inter-individual variability).
In this work we reproduce adipocyte size distributions to better understand the origin of its particular shape. The initial model we considered proposes a simple mathematical explanation of the adipose tissue size distribution bimodality (2), assuming the size of adipocytes only depends on the amount of lipids stored in. We consider a system of Ordinary Differential Equations (ODE) that aims at describing adipocyte size taking into account lipid fluxes. In this system each equation describes a cell lipid content evolution over time. The extracellular lipid amount over time is also described. However, the variability within the cell population is not described with this first model. So the modeled size distributions are not realistic (only cells of two sizes are obtained instead of a bimodal continuum as observed in the data).

By simulation, we explored two hypotheses regarding the variability origin that could lead to realistic size distributions. We assessed the following hypothetical sources: small random variations in the lipid exchanges, and intrinsic variability of cells. The first by adding a white noise to the model, and so dealing with a Stochastic Differential Equations (SDE) system. The second by varying within the population a few key parameters. Some parameters are now specific to the cell. We show that the first hypothesis is not sufficient to reproduce the data. Also, we demonstrate the plausibility of the second hypothesis, comforting the idea that variability within the adipocyte population is crucial to explain the size distribution.These results will be discussed and perspectives including adipogenesis will be presented.

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(1) Hannah Ritchie and Max Roser (2017) - "Obesity"

(2) Soula H.A.,et al. (2013). Journal of theoretical biology

Mots-Clés: obesity, lipids, adipocytes, size distributions, variability