Understanding Adipocyte Dynamics through Mathematical Modeling

Katrina Johnson and Fred Adler

Abstract

Adipocytes are the primary cell type in adipose tissue and are responsible for limiting the exposure of other tissues to lipid accumulation during the postprandial state and providing energy during periods of fasting. Obesity is characterized by the expansion of fat mass due to a positive energy imbalance. Obesity is associate with chronic inflammation and can lead to the development of insulin resistance and diabetes. Large adipocytes are more fragile and prone to dysfunction. Adipocyte dysfunction is a proposed mechanism of obesity associated inflammation. Understanding the relationship between inflammation and obesity is a multi-scale problem that includes interactions on the intracellular, intercellular, and tissue levels. In this project I model the size and population dynamics of adipocytes with a system of ordinary and partial differential equation. Using this model I explore how maintenance of the preadipocyte population via proliferation and ability of preadipocytes to maintain and increase the adipocyte population via differentiation contribute to obesity. Lipogenesis and lipolysis are regulated by the adipokines, cytokines, and hormones in the adipose tissue and this milieu changes during obesity associated inflammation. I use this model to explore how the rates of lipogenesis and lipolysis contribute to size and/or number of adipocytes. The development and validation of this model provides a foundation for exploring the intercellular dynamics of adipocytes and other stromal vascular cells in adipose tissue.

Keywords: adipose tissue, obesity, inflammation, mathematical model, adipocyte dynamics