
MELISSA MARIA STADT, University of Waterloo

Impact of feedforward and feedback controls on potassium homeostasis: Mathematical modelling and analysis

Dysregulation of potassium is a common and dangerous side effect of many pathologies and medications. Potassium homeostasis is primarily mediated by (i) uptake of potassium into the cells via the sodium-potassium pump and (ii) renal regulation of urinary potassium excretion. Due to the importance of potassium in cellular function and the daily challenge of undergoing variations in potassium intake, mammals have evolved several regulatory mechanisms to ensure proper potassium balance between the extra- and intracellular fluids. The multitude of physiological processes involved in potassium regulation makes its study well suited for investigation with mathematical modelling. In this project, we developed a compartmental model of extra- and intracellular potassium regulation. We included a detailed kidney compartment with the effects of aldosterone and potassium intake on renal potassium handling as well as intracellular potassium uptake stimulation by both insulin and aldosterone. Model simulations were conducted and analyzed to quantify the impact of individual regulatory mechanisms on whole-body potassium regulation. Additionally, we used this model to simulate and give evidence for a newly hypothesized signal, muscle-kidney cross talk, on potassium loading and depletion.