MODELLING PLASMA GLUCOSE DYNAMICS DURING EXERCISE IN PATIENTS WITH TYPE 1 DIABETES

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IDENTIFICATION AND MONITORING OF ENDOGENOUS FLUCTUATIONS IN HEART RATE UNDER FREE-LIVING CONDITIONS

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ABSTRACT

Type 1 diabetes (T1D) is a chronic condition in which the pancreas produces little or no insulin. T1D needs lifelong insulin therapy by regularly monitoring plasma glucose levels and injecting insulin to maintain target glucose levels. The artificial pancreas (AP) is an emerging technology that helps control plasma glucose. Pre-clinical trials using a virtual patient simulator has the potential to accelerate the pace of development for the AP. However, the effects of exercise has not been added to the simulation environment. The aim of this project is to develop a model structure suitable to describe the dynamics of plasma glucose changes due to different types of exercise in type 1 diabetes. This will be done by proposing several models using plasma insulin, glucose and glucagon measurements collected from a previous study involving 16 subjects with T1D undergoing different types of exercise. The model parameters will be estimated using a Bayesian approach and the models will be assessed based on the goodness of the fit and the complexity of the models.

ABSTRACT

Over the past few decades, increasing scientific evidence of an internal biological clock in humans have emerged. Referred to as the circadian rhythm, a wide array of physiological systems demonstrate endogenous fluctuations in their output over the roughly 24-hours of each day. Though researchers have identified this by monitoring physiological parameters such as heart rate, body temperature and hormonal concentrations under highly controlled lab-setting environments, this study aims to identify and monitor the endogenous fluctuations of a single parameter – heart rate (HR) – in the free-living environment of everyday life. Over the course of six weeks, HR was recorded from an individual subject paired with commercially available wearable devices that employ photoplethysmographic and electrocardiographic sensors for deriving HR measurements. Using signal processing and model identification techniques, HR measurements were filtered of artifacts, averaged to generate a 24-hour HR profile and parametrized in order to define a novel subject-specific model for HR’s circadian rhythm. As expected, the subject’s sleep/wake schedule and other external factors such as exercise were identified to strongly contribute towards HR fluctuations, but more interestingly showed shifts in the subject’s subsequent endogenous HR profile. The correlation between such external factors will be further investigated, however already assisted in mapping key anchors in the model. Cross-validation was used to assess the performance and robustness of the model. The end goal of this research is to develop a universal algorithm that generates a subject-specific model for HR’s circadian rhythm when inputted with HR data collected during their daily routines. The algorithm should be adaptable to past and present HR recordings and appropriately shift the projected circadian rhythm in real-time. This information can provide great insight into how the human biological clock is affected by physical and emotional stimuli and can be used to offer meaningful information on how to optimize one’s lifestyle with respect to their personal biological time.

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