AN ODE MODEL FOR INVESTIGATING THE SLEEP-PAIN RELATIONSHIP IN SICKLE CELL DISEASE

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Abstract

Sickle cell disease (SCD) is a family of genetic blood disorders that affects over 20 million people worldwide, whose most prevalent complication is pain. Pain crises in SCD are strongly linked to mortality, morbidity and increased medical costs. The study in Valrie et al. 2019 revealed a correlation between sleep and pain using patient reported sleep quality and pain in 88 pediatric SCD patients and we use this data to inform our model. We further investigated this sleep-pain connection using mathematical tools that incorporate a dynamical systems approach. Based on the results in Clifton et al. 2017, we created an ODE model for predicting pediatric SCD pain levels based on self-reported sleep data. Our model captures the intermittent nature of childhood pain crises and that poor sleep quality is correlated with increased SCD pain. We investigated multiple strategies for cleaning and aggregating the data to better account for sleep quality's impact on pain outcomes. To assess the utility of the model for capturing pain onset, we explored methods for categorizing pain and determining patient-specific sleep metrics. Model predictions improve when the patient population is subdivided by age into two groups: adolescents (age 12 - 18) and children (11 or younger). Our long term goal is to develop a warning system for upcoming pain events for pediatric SCD patients. This is advantageous in the digital age as noninvasive monitoring will allow physicians to treat pain crises in these patients anywhere based on personalized, data-driven recommendations.