Optimizing Ibuprofen Efficacy

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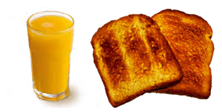
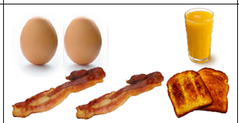
I. Introduction: What is Ibuprofen and why does it depend on food?

Ibuprofen is a nonsteroidal anti-inflammatory drug, or NSAID, used to treat pain, inflammatin, or swelling. In our body, when the drug is consumed, many factors can affect the drug's duration and effectiveness, most primarily, food. We asked how different food intakes with varying levels of nutrional content change the overall effect of ibuprofen in our bodies.

II. Ibuprofen Pharmokinetics: A Five Stock Model

We finally decided on a five-stock model in order to track ibuprofen in the body. The ibuprofen was treated as a bolus input, or initial condition of 800 mg. We tracked the disintegration of the tablet as it travelled from the stomach to food, if present, then the intestine, and finally the blood plasma. We used five differential equations to model our system. The table below shows the three food intake conditions we modelled.

Food Consumed in Parallel to Bolus Input of Ibuprofen	Type of Food Consumed	Nutritional Value
Fasted	None	0 Calories 0 g Carbohydrates 0g Proteins/Fats
Light Breakfast		254 Calories 39 g Carbohydrates 13 g Proteins/Fats
Heavy Breakfast		586 Calories 53 g Carbohydrates 56 g Proteins/Fats

III. About the Model

$$\frac{dy_1}{dt} = -ay_1$$

$$\frac{dy_2}{dt} = -b_1 y_2 \left(\frac{3000}{cal. + 300}\right)$$

$$\frac{dy_3}{dt} = p_f c_1 \left(\frac{y_2}{y_1}\right) - c_2 y_3$$

$$\frac{dy_4}{dt} = b_1 y_2 \left(\frac{3000}{cal. + 300}\right) + c_2 y_3 loss - d_2 y_4$$

$$\frac{dy_5}{dt} = b_2 \left(\frac{y_2}{y_1}\right)(1 - p_f)a + \frac{y_4}{y_2} a y_1 - e_1 y_5$$

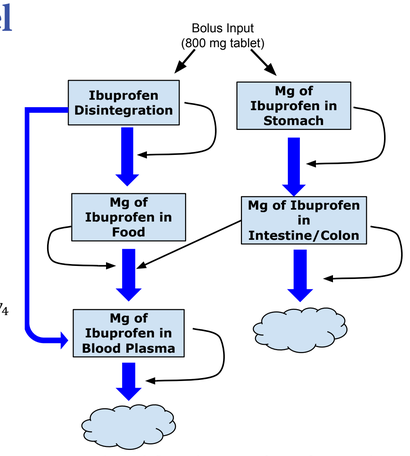


Figure 1: Stock and flow diagram from five stock model.

Abstract

We have all heard our mothers tell us to always take ibuprofen pills with food. We wanted to look exaclty why that is the case. We asked how does the effect and concentration of ibuprofen in our bodies vary with different foods in our system, more specifically, no food, simple carbohydrates, or proteins/fats. We found experimental data which demonstrated a double-peak behaviour, which we modelled using a five-stock model. We validated our model by comparing it to an alternate data set. Our results showed us that protein and fat is the key to reaching the maximum peaks of ibuprofen concentration in the body, although it takes longer to come into effect.

V. Our Model in Action

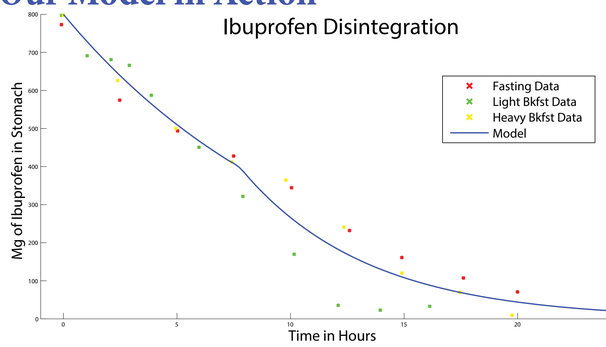


Figure 2: Ibuprofen disintegration decreases faster after reaching 50% because the outer gel coating fully disintegrates, causing a more rapid absorption

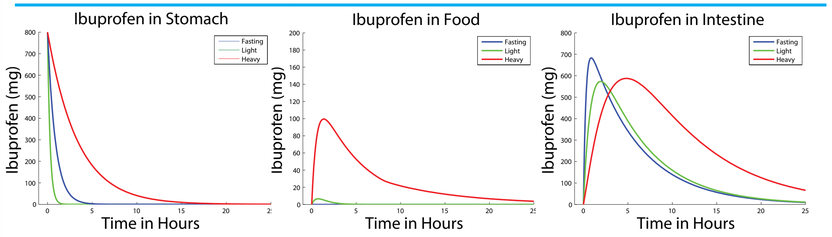
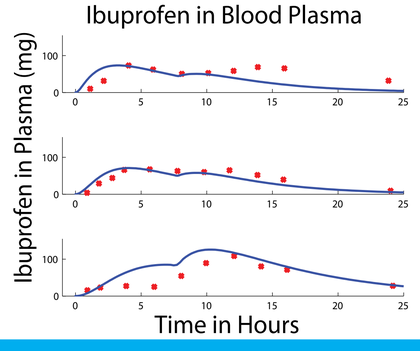


Figure 3: The three intermediate stocks, overlayed from each food intake catagory



Our exhibits the double-peak behaviour we saw in the experimental data. Logically, if ibuprofen is taken without food, it will hit quicker, but at not as long a duration or as high a concentration, as food acts as a carrier for the ibuprofen into the small intestine for absorption. Our model backs up this data and claim as show to the left.

V. Validation : Comparing to Experimental Data

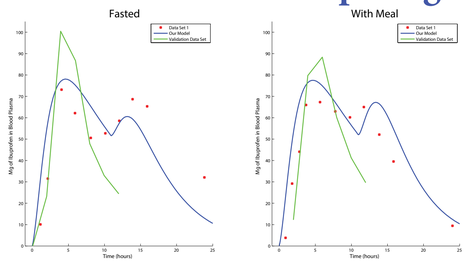


Figure 4: Our model matched with two different experimental data sets

We found numerical data from experiments tracing the disintegration of ibuprofen tablet (through radioactive tags), as well as the blood plasma concentration (through blood samples. To validate our model, we found another data set, shown in green, which reflects the first peak of our model well.

VI. Results and Discussion: Optimization

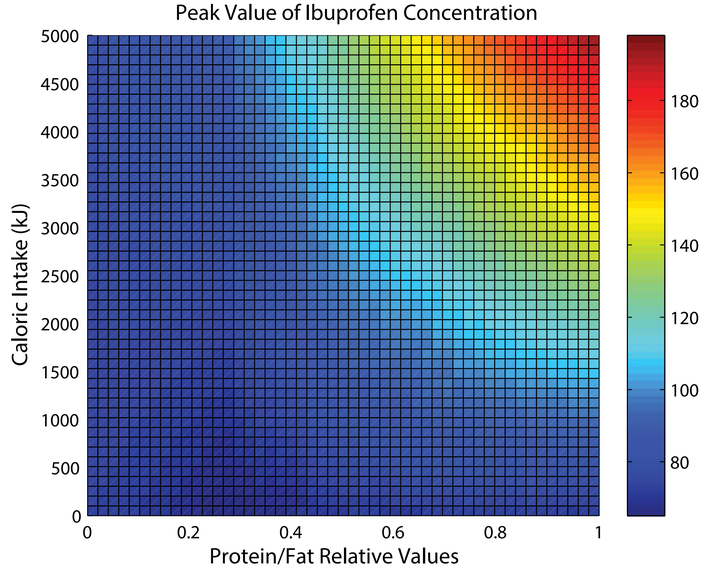


Figure 5: Optimization of our PF value to be most effective over time

To answer our question, we looked at the varying levels of protein/fat in the food compared to the overall caloric intake. The chart above acts as a guideline to food intakes with ibuprofen in order to maximize concentration in the bloodstream. We found that even with a high caloric intake, it is the proteins and fats that absorb the ibuprofen the most and must be consumed in ordre to reach the highest levels of efficacy in our bodies.

VII. Limitations/Future Work

Our model could improve in the fine tuning of parameters in order to better represent the first, low peak in the heavy breakfast blood plasma graph. It was difficult to model this behaviour. In the future, we would like to plan out specific meals that would be optimal for different ibuprofen needs.