ENERGY BALANCE AND WEIGHT CONTROL

It is well known that approximately 70% of Americans have a Body Mass Index (BMI) in excess of 25 and hence fall into the overweight($25<BMI<30$) or obese($30<BMI$) category. This increase in weight of the average American has occurred within the last half century and in particular in the last decade. What is the cause of this? The answer is clearly that our jobs are now much more sedentary than in the past , that we are consuming more high calorie junk food than earlier, and are not getting enough exercise. To analyze this problem from a mathematical viewpoint one can describe things via the first order differential equation-

$$\frac{dW}{dt} = I - E$$

, where W is an individuals weight, t the time, I the food intake, and E a person's energy expenditure. I and E are measured in kilocalories (Kcal) and the weight W in pounds(lb). A kilocalorie corresponds to the energy required to raise one liter of water by one degree centigrade. Also one pound of body fat contains about 3500Kcal of energy. A typical value for I is about 3000Kcal per day and the energy expenditure about E=2900Kcal. The result is that there will be a weight gain of about 1lb in 35 days or 10lbs in a year. We can call the quantity B=I-E the energy balance factor and have the following-

Weight Gain: B>0, Weight Unchanged: B=0, Weight loss: B<0

To diet, one must maintain a negative energy balance factor for an extended period of time until a desired lower weight is reached. The time τ it will take to reach the new lower weight W_1 from the original weight W_0 is given by-

$$W_1 = W_0 - \int_{t=0}^{\tau} B\, dt = W_0 - \int_{t=0}^{\tau} (I - E) dt$$

Now B, I, and E will vary with a person's weight W, his daily food intake, and the type of energy expenditure. To get a feel for these quantities we present a short table for I and E in kilocalories for a 150lb individual.. Here is the table-

Food Intake I in Kcal	Energy Expenditure E in Kcal/hr
Slice of Bread-85	Sleeping-80
Boiled Potato-160	Sitting-120
Cup of Rice-210	Walking-230
3oz of Pork Chops-220	Gardening-250
Piece of Apple Pie-410	Cycling-280

100gm Chocolate-530	**Jogging-650**
BigMac and Fries-750	**Running-850**

The numbers for E will scale in direct proportion to ones weight. Thus rapid walking for a 200lb person will consume about 250*200/150=335Kcal per hour. Vegetables, fruits, and salads (with no dressing) are generally low in calories. Alcohol has intermediate values (1 bottle beer=150Kcal), and fried or sweet fast foods are high in calories (large milkshake=1100Kcal, triple Whopper with cheese=1230Kcal).

With these values for I and E, one can see why the country is seeing an obesity epidemic. People are consuming ever larger amounts of fast food while they are living more sedentary lives spending ever greater amounts of time in front of their computers, televisions, and other electronic devices without sufficient vigorous exercise. There is relatively little which can be done about increasing E because of imposed time and job constraints. Attempts at more golf, sports participation, jogging, and machine exercise are usually hard to maintain over longerperiods of time. The I portion of B is probably the easiest to do something about. A simple way to reduce I is to cut back one's normal food intake by say 10%. This amounts to about 300Kcal/day and will end up with a 30 lb weight loss in a year. It does not matter what one eats as long as B remains negative. However, replacing high calorie fast food with lower calorie food will aid in this effort. Most people when they diet will first follow a B<0 routine vigorously but after a while will slack off and let things reverse to mostly regain most of their lost weight (ie-the Oprah or Christie Alley Effect) . Strong willpower is required to maintain a B=0 level at the new lower weight W_1. Those individuals who have maintained a desired weight throughout their life have clearly been able, both consciously and subconsciously, to maintain an equality balance between their food intake I and their energy expenditure E so that dW/dt remains essentially zero.